The Institute of Cost Accountants of India
(Statutory body under an Act of Parliament)

PERFORMANCE ENABLERS FOR MSMEs - 3P MODEL PERFORMANCE, PRODUCTIVITY AND PROFITABILITY

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FOREWORD

Worldwide, micro, small and medium enterprises (MSMEs) have been accepted as the engine of economic growth and for promoting equitable development. MSMEs constitute over 90% of total enterprises in most of the economies and are credited with generating the highest rates of employment growth and account for a major share of industrial production and exports.

In India too, the MSMEs play a pivotal role in the overall industrial economy of the country. MSMEs in India account for more than 80% of the total number of industrial enterprises and produce over 8000 value added products. It is estimated that in terms of value, the sector accounts for 45% of the manufacturing output and 40% of the total export of the country and employs over 6 crore people.

Further, in recent years the MSME sector has consistently registered higher growth rate compared to the overall industrial sector. The major advantage of the sector is its employment potential at low capital cost. As per available statistics, this sector employs an estimated 6 crore persons spread over 2.6 crore enterprises and the labour intensity in the MSME sector is estimated to be almost 4 times higher than the large enterprises.

Micro and small enterprises largely comprise first-generation entrepreneurs, who have had a limited structured training on costing, resource planning, capital management and labour management. As a result, lack of managerial competence often shows in poor resource and cost management which further inhibits the growth of these enterprises. The emphasis on management accounting in SMEs tends to be on control information rather than aiding decision-making; there is a tendency to make decisions without adequate cost information or analysis; There is considerable variation in the amount and type of management accounting practices followed by the MSMEs.

As a professional Cost and Management Accounting body, the Institute is actively engaged in supporting growth of MSMEs through various initiatives. The institute jointly with ASSOCHAM organizes SME Excellence awards every year. A Cost Accounting Standard specifically for the MSMEs is also being developed by the Cost Accounting Standards Board of the Institute. Seminars and conferences are organized from time to time for capacity building in the MSME sector.

I am happy that the CMA Committee headed by CMA M. Gopalakrishnan, have thought it fit to compile in a capsule form a brief of the best Cost and Management Accounting practices followed by various MSMEs for achieving cost competitiveness.

I am sure this pilot project which has been attempted this year, will lead to more such updated versions in future with a view to progressively lending knowledge support to the MSME sector units. I complement the CMA Committee Secretariat led by CMA Nisha Dewan, and able guidance provided by CMA Dr. S K Gupta, Technical Director and, Shri. B Kumar of Technical Directorate Extension Centre, Chennai who have done a commendable job in this compilation.I also appreciate the dedicated professional support of the external expert CMA. K.S Subramanian for editing the final manuscript and building up a proper framework for the compendium.

CMA (Dr.) A.S. Durga Prasad
President
The Institute of Cost Accountants of India
31st March 2015

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PREFACE

The MSME sector is one of the key sectors of the economy which provides maximum employment and is a major contributor to the economic growth. This is specially true for India, which has a large population of youth who are waiting in the wings to acquire the necessary skills and get employment. This sector also provides an opportunity for vertical growth from one level to another provided the business is successful in the earlier ventures. There are many success stories of leading groups who started as SMEs and exponentially grew into conglomerates.

The exclusive profile of the MSMEs, requires a completely different approach than that of the large enterprises. The information flow in the large companies are complicated and the importance is given to the system and data flow, which identifies and flags the deviations for action. Due to this the time gap between the monitoring and corrective action may also be more. Large industries can afford this time gap as the defects during the action period gets spread over a large volume of production, thus minimising the cost impact. This sector also can afford automated solutions, which though needing investments, may justify such investments.

In the MSME sector, the competition is so fierce that almost instant corrective action only will warrant survival. With a lean operation team, the multi skilled operator himself identifies the defects at the source and is a part of the correction system also. They also cannot afford a data flow mechanism and the luxury of time gap in identification of deviation. Since the owner himself is the ultimate stakeholder, he does not need the reports to find out what happened on the shop floor. As long as cash is ringing in continuously, order book is full and goods are despatched regularly he knows that the going is good. The Government has also put in lot of measures which protect this vital sector and large industries also go overboard to develop a strong and vibrant vendor base through MSMEs so that their assembly and manufacturing line does not get disrupted. They are also ready to transfer the best practices to their vendors, who almost get the latest practices free of cost and are able to ramp up their customer base with quality output at reasonable cost, thereby improving their cost competitiveness.

The cost gets managed in MSMEs, through good quality systems, good manufacturing practices and continuous improvement initiatives as all of them aim at increasing productivity, efficiency and cost effectiveness. The 5S techniques and Lean concepts which till some time back were restricted to large industries have reached the last mile in the manufacturing supply chain viz., MSMEs also recently. One of the most active players on this in India have been Kaizen Institute and we are proud that CMA. S.Dorairajan, who was associated with them in the past and now heading his own organisation, Kanzen Institute Asia – Pacific Pvt. Ltd. has agreed to share his knowledge base with the Institute. The CMA Committee is deeply indebted to experts like him, who have been the pillar of strength in the competency building initiatives of the Institute.

I am sure that this Compendium will be of major use to the CMA professionals who are in industry as well as in practice to realise the direction in which the CMA profession of the future can add value to the industry and service sector.

CMA M. Gopalakrishnan
Chairman
Cost & Management Accounting Committee
31st March 2015

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1 MSME : General Engineering- Machined Cast Iron Components

BACKGROUND

The unit is a leading manufacturer of Machined Cast - Iron Components and Sheet Metal Fabricated Components, the major products being various types of Pulleys, fly wheels in all grades, fabricated cooling fans, fan pulley assemblies, and precision machined components. They are an OE Manufacturer for Elgi Compressors and have recently started supplying to global major United Technologies.

The lean journey commenced with a meeting with the Directors to understand their vision, strategy and business goals for the next 2-3 years. Unit's immediate focus areas are to enhance value adding products and in this respect they have started supplies to Milton Roy, a United Technologies group company. The goals for 2011-12 are summarized below:

1. Increase the productivity of Elgi fan pulley line by completing the target output of 50 Nos./day in 8 hours shift instead of current 10 hour shift.
2. Increase the Overall Equipment Effectiveness (OEE) of CNC (Computer Numerical Controlled) machines to world class level thereby acquiring the capability to supply the anticipated increased quantities.
3. Develop an excellent manufacturing system that will enable a good score in UT supplier assessment and become a Gold Category supplier in order to be the preferred global vendor for their products.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported Bestomech through the year 2011-12 in achieving the said goals.

Diagnostic Study

The Lean journey commenced with a current state assessment and road map setting exercise.

A VSM (Value Stream Mapping) was made for the Elgi fan pulleys using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target		
Customer requirement	(Nos / month)	1032	1165	Working days per month	25
Demand rate per day	Nos	41.3	46.6	Working hours per day	9.5
Takt time (min)		13.8	12.2		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Seating	2	2	9	40	5	69.04	100	
Inner	2	2	8	20			100	
Rough Grooving	2	2	8	30			100	
Finish Grooving	1	1	6	25			100	
Boring	1	1	6	30			100	
Drilling& Tapping	1	3	7	20			100	
Primer Coating	1	2	3	20			100	
Key Way Broaching	1	1	4	5			100	
Assembly	1	2	3				100	
Balancing	1	2	15				100	

	Cycle time	C/O time	WIP
Total time per unit output (minutes)	50.8	190.0	69.0
Throughput time	309.8	minutes	
VA (Value adding) ratio	16 %		
Plant capacity (bottleneck)	87.7		
Constraint	No		
Bottleneck process(es)	–		

***Baseline Study* - Elgi Line**

The target was to produce 47 units per day in 8 hour shift as against the current average of 41 units per day in 10 hour shift which translated to a takt time of 12 minutes per unit. (Takt-German word Taktzeit-calculated by dividing the total time available for production with the demand by the customers).

Focus Areas Identified

Cycle Time - VSM showed that the only constraint was the balancing operation which had a cycle time marginally above the takt time.

Through put Time - Value adding ratio was only 3% which meant that of the total time that the material spent in the factory no work was being done on it for 97% of the time. There was a lot of material cluttering in the broaching, assembly and balancing areas.

Material Handling and Transportation - The material travels approximately 230 ft. inside the plant from RM stage to FG stock area.

Inventory Holding - Customer requirement and production plan is based on two bin Kanban – one bin of finished pulleys and second bin of to be assembled pulleys. We observed a mismatch between the two components to be assembled as also with the specified levels in the Kanban.

Baseline Study – CNC

The Unit is supplying 2 products to Milton Roy of which only GB Housing will continue from February 2011.

Current production rate : 3 Nos./day
Target production : 6 Nos./day (150 Nos. per month)
Takt time : 75 minutes

Focus Areas

Changeover (C/O) time - The Change over time at VMC (Vertical Machining Centres) 03 was 120 minutes and that of second VMC 06 240 minutes which brought down the machine availability considerably when manufacturing alternate models on the same set of machines.

Cycle Time - While there was no constraint in producing 6 units per day, the cycle time difference between the two CNC operations meant that VMC -03 would be under utilised by 22% during the production runs of GB Housing.

Machine Availability – While data was not available on this, physical observation of CNC machines showed up dirt, oil spillages and potential causes for breakdowns.

System Potential

Elgi Line – Through a combination of cycle time reduction, line balance and layout modifications, there was a clear potential to increase productivity by 60% thereby freeing up resource which could be used for other value added products. It was therefore very much possible to achieve the business goals by implementing lean.

Milton Roy – The CNCs have the potential to make 10 Nos. / day or 250 Nos. / month considering one changeover every day.

Based on the VSM and above analysis it was clear that The Unit could achieve their goals by Implementing Lean. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP-SMED (Single Minute Exchange of Die)

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	**High Change over Time in VMC Machines** – 120 and 240 minutes respectively in VMC 03 and VMC 06.	Apply SMED principles and reduce changeover time to < 30 minutes.									Increase machine availability and flexibility to do other pro do other products.
2	**Cycle Time Mismatch -** 9 mins variation between 1st and 2nd operations in the VMC machines.	Synchronise the two operations such that the cycle times are as close as possible.									VMC 03 utilization increase by 22% during the production runs.

S. No.	Current State Observation (Muda Identification)	Action Plan								Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
3	**Cycle Time is Higher than Takt Time** in balancing operation for ELGI fan pulleys.	Reduce cycle time to 9 minutes by improving workstation design.									Plant capability increases to 6 Nos. / hr.
4	**Mismatch of Kanban Stocks** – it is difficult to physically count the FG stock as well as to access the same.	Systematic arrangement of semi-finished and finished items with visual controls using 5S concept.									Improved customer service level and reduced inventories.
5	**Material Movement for Elgi Components –** One component moves approxi-mately 230 ft within the plant.	Modify layout to minimize material handling and transport – balance processes for single piece flow.									Reduction in throughput time by 90%. Sustained productivity of 6 Nos. / hr.
6	**Information relating to Daily Operations –** production, quality and deviations is not readily available to top management.	Visual monitoring systems to be put in place with feedback to top management – Visual Management.									Better process monitoring and control – information for decision making.
7	**Equipment Condition** of CNC machines - dirt, leakages, abnormalities observed	Improve condition through Autonomous and Planned Maintenance.									Ensures equipment availability for production and increases OEE.
8	***Synchronisation***	Align support activities with flow production.									Standardised process that can consistently deliver target quantity.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams (CFTs) were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, and quality. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation / experience sharing sessions at the start and end of each day of the workshop.

Standardisation of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Reduction in cycle time in assembly and balancing.
2. Reduction in Setting Time of CNC machines.
3. Process Optimisation through Kaizen.
4. 5S for standard work practice.

Improvement Projects

Project 1 - Reduction in Cycle Time of Assembly and Balancing in ELGI Line

Assembly and balancing was the only constraint identified and the existing process was observed by a cross functional team to identify *Muda*. (Japanese term) The team then analysed the data and implemented suitable solutions to improve the flow in these downstream processes. (Muda-Waste, Muri-Overburden, Mura-Unevenness).

Observation (Muda/Muri/Mura)

Assembly operations are done on floor in uncomfortable position. Pulleys had to move back and forth between assembly and balancing and broaching, more WIP in between operations.

Action Taken

New workstation designed to ensure strain free working and minimize transportation. One piece flow concept introduced between assembly and balancing.

Material Movement - One component moves approximately 230 ft. within the plant. Lot of criss cross movements observed in assembly areas.

Reduced component movement by creating assembly work station near to balancing machine. Uni directional movement in flow mode introduced.

Project Results:

- Material movement has been reduced from 230 ft. to 170 ft.
- Doubling of assembly production capacity.

Project 2 - Reduction in Change Over time

The setting time observed in the VMC was 96 minutes, which reduced the available time of the machine.The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified and appropriate solutions implemented to minimize them. Internal and External activities are separated and operator and helper trained.

Before: Tools were scattered and setter had to search for required tools and tool bits during the changeover.

All activities related to changeover done after the machine is stopped.

After : SMED table made to keep necessary tools and fixture, etc. in an organized way providing search free and movement free access to the setter.

External activities like tool bit checking, tool preparation done before the machine completes its last component of previous run.

Project Result: Change over time has been reduced from 96 minutes to 25 minutes.

Project 3 - Process Optimization through Kaizen

The Unit team was keen to optimize the manual processes through kaizen. They tried for two components and achieved the same.

Observation

After CNC process, the components are transported to a separate work table for deburring, cleaning and oiling activities. Here a team of five persons would do the deburring, cleaning, oiling and packing at his spot in a batch process leading to delay in material getting ready for dispatch.

Valve plug cleaning

Before

After

Action Taken

The team observed that the operator is generally idle during the CNC operation cycle. Hence, workstation was designed so that the operator could himself complete these activities while the machine was running.

Result: Through put time has been reduced from 3 days to 1 day. Also, optimum utilisation of human resources has taken place.

Drilling Operation

Observation

The operator had to locate the component by sitting on his haunches. This involved a lot of strain and also increased the possibilities of error in locating the spot.

Before

After

Action Taken :

The team observed the process and made a suitable fixture in such a way that the operator need not bend down and can comfortably do it in the standing position.

Result : Cycle time reduced from 8 minutes to 6 minutes.

Project 4 - 5S for Standard Work Practice

At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office were included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion. Teams were formed and practical training on 5S and AM given to team members by the management consultants. The changes made were fine tuned and standardised through audits in the month of September.

Before : Storage in assembly area was a big hindrance to assembly flow.

After : Bay created for each type of product and it allowed flow in assembly.

Material Mix-up

Before: Mix-up of materials was taking place and the quantities mixed–up holds and the company orders for fresh material without knowing the availability.

After: Materials cleared and kept separate bin for each component and proper identification created to avoid any mix-up.

Before

After

Before : Dispatch ready materials kept on the floor at different place.

After : Suitable Rack fabricated and kept the materials according to its variation.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Changeover time in VMC	96 min	25 min	75% reduction
Material movement (meter)	230	192	17.6% reduction
Cycle time for GB (Gasket Seal Bag-in/Bag-out) housing in second Operation (min)	65	34	52.3% reduction
5S Score	50%	55%	10% increase
Balancing time reduced in Fan pulley assembly (A020056)	3 Minutes	1.70 Minutes	56 % increase

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (No's/day)	70	80	12.5%

The targeted quantity of ELGI fan pulleys is now completed in 8 hours itself.

2 MSME : General Engineering– Hydraulic Power Pack

BACKGROUND

The unit is a manufacturer of Hydraulic Power packs and equipments formed in 1978. All components are bought outs except for the manifold which is machined in house. The final assembly, painting, testing and packing of the power packs is done in the unit. The unit is able to get good orders for SPM power packs from different type of Industries with its technical expertise and after sales service.

The lean journey started with an initial discussion with the CEO and the major issue identified was delivery delays leading to blocking up of working capital and space. The goals for the lean implementation were set accordingly:

1. To improve on time delivery performance to customers to at least 50% on time from existing status of zero on time delivery.
2. To improve the working capital position by reducing inventories in the plant.
3. To inculcate the habit of problem solving and improvement amongst the Unit's employees.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The Lean journey commenced with a current state assessment and road map setting exercise. Since the company makes Power packs which are unique in nature, it was agreed that the concept of lean would be implemented and demonstrated on project basis. It was agreed that implementation could be for two projects and extended later by the internal team to other projects as and when they are executed. The data on projects recently completed are shown below:

S. No.	Customer	Order Date	Started On	Completed On
1	Godwell Industries	–	20/12/10	07/01/11
2	Honeywell	11/10/10	17/12/10 (66 days)	26/12/10 (10 days)
3	Scan Machinery	01/11/10	31/12/10 (60 days)	06/01/11 (07 days)
4	Nataraj	09/10/10	11/12/10 (62 days)	17/12/10 (07 days)

Baseline study

As the power packs were custom built based on customer requirements, there was little possibility of repetition of same or even similar orders. Hence, each order was considered as an individual project whose work flow included order processing, design and drawing, procurement, in house manufacturing and assembly.

Focus Areas

Synchronization – Data showed that in house work took only about 10-12% of the total time. The remaining time was spent in design and procurement of components or waiting for components to arrive from vendors.

Value Adding Ratio – Even in house, the actual value adding time for a power pack was about 2 days but in actual about 7-10 days were spent on it.

Space – The unit is occupying a small shed in a congested area. Within the premises, only 20% of the space was actually utilised for value addition while the rest of it was blocked by WIP and unwanted materials.

System Potential

By improving the work flow and synchronising the procurement it was felt that it was possible to achieve the twin targets of improving on time deliveries and reducing working capital requirement to the tune of 50%. A Lean road map was then prepared to achieve the stated goals.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	Synchronisation issues – time spent in waiting for materials, drawings is much more than in house manufacturing	Develop System to work a detailed project execution schedule from order receipt to dispatch. Identify and improve bottleneck areas.									Clarity on order execution time. Reduce inventory of components which will not be procured before they are required to be assembled.
2	There are no records available for monitoring the project status. Cycle times are also not available.	Implement system for monitoring each project status from order receipt.									Control on project execution time.
3	Material movement and traceability – operations are set far apart leading to movement of the power packs. It is very difficult to tell the material status visually.	5S and workstation design concepts to be implemented to have a compact and effective layout.									Reduced throughput time during in house manufacturing by 50%.
4	Material waiting - observed 2 power packs waiting for components in semi-finished	Stores management – analyse and fix standard inventory of standard parts.									
5	Synchronisation	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Standardised manufacturing system capable of consistently delivering required output.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

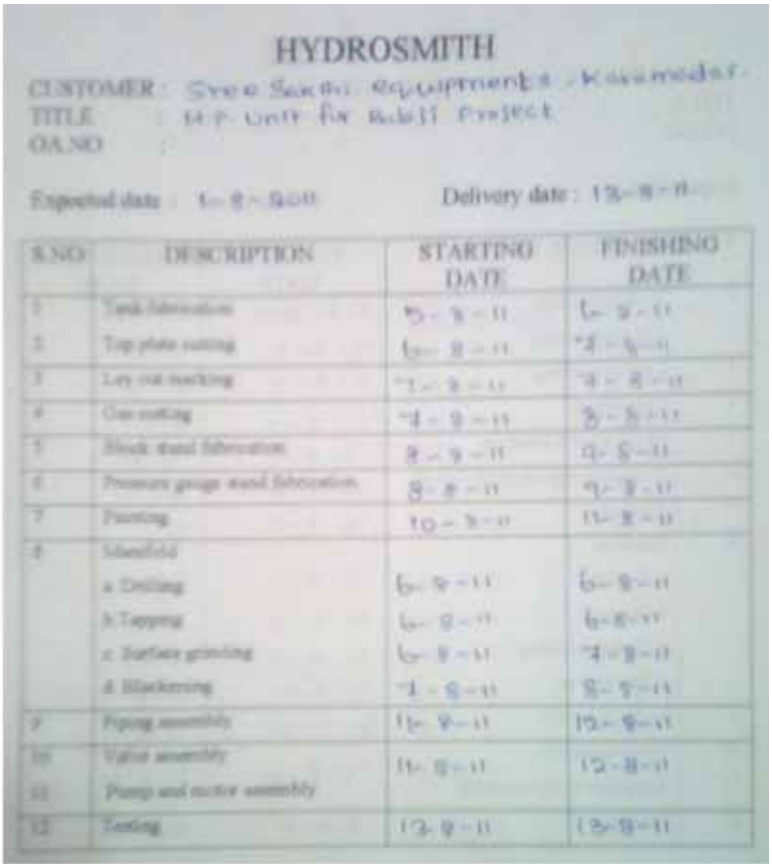
In each workshop, a cross-functional team worked on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including quality, stores and marketing/service. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (Owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by his physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardisation of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. The champion learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Project based Lean planning, scheduling and materials management.
2. Reduction in Throughput Time.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.


HYDROSMITH

CUSTOMER : Sree Sakthi equipments, Kalamedu

TITLE : H.P. Unit for Robit Project

O.A.NO :

Expected date : 6-8-2011 Delivery date : 13-8-11

S.NO	DESCRIPTION	STARTING DATE	FINISHING DATE
1	Tank fabrication	5-8-11	6-8-11
2	Top plate cutting	6-8-11	7-8-11
3	Ley out marking	7-8-11	7-8-11
4	Gas cutting	7-8-11	8-8-11
5	Stock stand fabrication	8-8-11	9-8-11
6	Pressure gauge stand fabrication	8-8-11	9-8-11
7	Painting	10-8-11	11-8-11
8	Manifold		
	a. Drilling	6-8-11	6-8-11
	b. Tapping	6-8-11	6-8-11
	c. Surface grinding	6-8-11	7-8-11
	d. Blackening	7-8-11	8-8-11
9	Piping assembly	11-8-11	12-8-11
10	Valve assembly	11-8-11	12-8-11
11	Pump and motor assembly		
12	Testing	12-8-11	13-8-11

Improvement Projects

Project 1. Lean Planning, Scheduling and Materials Management

The power packs manufactured by the company is unique in nature and it has lot of variations in design, function etc., the company has to give independent treatment to each order. At the start of the lean journey, the team observed that there were several power packs in semi-

finished condition while at the same time no order was being delivered on time. The root causes were identified and appropriate actions taken to address them.

1. Lack of a formal planning methodology both for delivery as well as for material procurement.

   Actions Taken

   ✓ The team prepared a procurement plan and assembly schedule for two power packs. The planning was worked out backward is based on the delivery date.

   A project monitoring system was set up with each activity in the project sequence given a target date. Any deviation is monitored and necessary action taken to avoid repetition.

   ✓ Visuals – the project status was displayed on a whiteboard for all concerned to monitor and act upon.

2. Delay in release of final drawing for assembly – after materials were procured, the final drawing would be released to the production operators. Several changes in pipe lengths, fitting had to be done just before assembly.

   Action Taken: The drawing is completed before all the materials arrive and assembly cold be started immediately.

3. Delay in procurement of materials and lack of clarity on missing items leading to semi finished power packs.

Action taken: Material kitting done for each project and concept of "No kit No cut" introduced.

Project Results

Because of this the company could achieve their delivery performance. They could deliver 7 power packs and started to increase in delivery performance.

Project 2. Reduction in Throughput Time

1. Top Sheet Fabrication

Observation : The layout drawing for the top sheet to be fitted on base tank fabricated usually takes place after the completion of base fabrication. This led the operation to a delay in start for the assembly.

The tanks kept are waiting for the top sheet.

Action Taken: The team decided to design the layout and complete the drawing before sending the sheets for cutting and welding for the base and send the top sheet along with the base sheet. The company receives the total fabricated tank ready for assembly.

Project Result: The company could complete the assembly process within two days and make the power pack ready for inspection. This resulted in saving in time to the tune of 6 days.

3. Eliminating Non Value Adding Activities through Kaizen

Observation : Assembly was being done on the floor creating lot of strain to the operator and also automatically increases the cycle time as well as possibility of improper fitting quality.

Root cause: Assembling on the floor level means operator has to sit down and therefore bends to the maximum possible for ease of reach.

Action Taken: A stand of suitable height fabricated such that the operator can do the assembly comfortably in a standing position.

Observation (before) – MUDA

Observation: The operator frequently left his workspot in search for the tools and every to go and take requisite materials for assembly. This was a strain to him and also increased the assembly time.

Root Cause: The assembly station did not have any provision to keep the tools and the materials.

After Kaizen

A tools trolley which was available in the company being used for this purpose. The requisite tools and materials can be kept on the trolley and can be moved to the spot.

Observation (before)

There was no defined workstation for assembly and work was done wherever space was available resulting in a lot of strain to the assembler.

After Kaizen

A proper work station was made by which work clarity has been created and strain reduced.

Project4. 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimised the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Tools were scattered at various locations; operators had to search for tools.

After 5S

Tool board made and all tools placed in marked location making it search free and visible.

Observation (Before 5S)
Stores components are mixed up, leading to searching and over purchasing in some cases.

After 5S
Stores components are properly arranged and identified.

Observation (Before 5S)
Sheets lying scattered at the plant entrance in mixed up state.

After 5S
Sheets arranged in a rack size wise and identified.

Observation (Before 5S)
Manifold marking area

After 5S
Rack placed nearby to keep the templates and manifolds.

Project Result: 5s score has increased from 27% to 57% from first audit to second audit.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material movement (feet)	100	10	90% reduction
5s score	27%	57%	30%

Business Level Benefits

The process level results in turn combined to benefit The Unit's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos./month)	5	12	120%
On Time In Full Delivery %)	20%	70%	50%

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

3 MSME : General Engineering- Threshers for Paddy Producers

BACKGROUND

The Unit manufactures Threshers for paddy producers. They have been in this field for the last 20 years and earned a very good name and supplying all over India. They are looking to increase their market share and are in a position to book additional orders. The lean journey was started with an opening meeting with the Managing Director.

However the factory is not geared up to meet additional volume and has poor on time delivery performance even at current level of production. At the time of lean implementation the company was facing competition from other players. The business goals stated by the Director include:

1. To increase production capability by 100%.
2. Reduce working hours from 12 hours to 10 hours to reduce strain.
3. To streamline the factory and set up a system driven manufacturing process.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map. (VSM)

The VSM was made using actual cycle times measured for each activity involved in the compressor manufacturing process. The inventories, number of operators involved were also physically verified on the shop-floor. The summary of the VSM is shown below.

Measure	**UoM**	**Current**	**Target**
Customer Requirement	(Nos/month)	25	50
Demand Rate	Nos. per day	1.0	2.0
Takt Time (one batch every)	Minutes		**360**
	Available Resources		**Cycle Time**
	Machines/ Workstation	**Manpower**	**(min)**
Process 1 – Auto Box	1	2	105
Process 2 - Frame	1	2	245
Process3 – Walker	1	1	50

Process 4 – Congo	1	2	15
Process 5 –Cylinder	1	2	95
Process6- Top box	1	2	110
Process7 – Tray fitting	1	2	20
Process 8- Final sheet	1	2	25
Process 9 - Assembly	1	3	600
Process 10 - Painting			270
		Total time per unit output	**1425 min**

Baseline Study

Current production rate : Average one unit (four-walker) per day

Target production : Two units per day

Takt time : 360 minutes per Walker

There are several sizes of threshers and we have focussed on the high volume Four Walker product for our pilot lean implementation.

Focus Area

Productivity – The operators spend 56% of the total time on actual value addition, for the remaining 44% of time they are performing other activities or waiting.

Cycle Time – There are three main sets of processes namely fabrication, assembly and painting. Highest cycle time is 535 min for assembly.

Throughput Time – Total work time is around 17 hours for all the operations put together; however throughput time is double of this.

System Potential

Based on the VSM and our analysis, it is felt that the company is capable of making 4 machines per day with the existing resources. This is seen from the data of the highest cycle time activity being 2.5 hours and the target working time is 10 hours.

It was therefore very much possible to achieve the business goals by implementing lean. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	**Bottleneck Process –** Assembly time is 535 minutes and this decides the production capability. Observed thresher often waiting as operator and helper move around searching for things or doing offline work.	Eliminate Muda of motion, searching etc. through workplace arrangement. Do ECSR as well as parallel activities to improve process flow.									Cycle time < 5 hours giving capability of 2 threshers per day.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
2	The operations are located far apart resulting in excessive material movement and handling. 	Flow layout within fabrication area. Also introduce workstation concept in assembly and painting to ensure one unit flow.									No material waiting. Reduced strain for workmen.
3	Monitoring of manufacturing process is non existent as there are no formats or BOM visible on the shop floor. Some threshers waiting for materials.	Develop system for "No Kit No Cut" and put monitoring format in place.									No idle WIP. Reduced throughput time.
4	The operations and material status are not identified. There are lot of excess materials stocked. 	Use 5S and visual management techniques to arrange materials systematically and easy to identify and access.									Inventory control.
5	Synchronisation	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Standardised process capable of delivering atleast 2 units per day consistently.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardisation of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/PlannedMaintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Reduction in cycle time through workstation design.
2. Work station- Identified for different assembly.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

Improvement Projects

Project 1. Reduction in Cycle Time through Workstation Design

The cross functional team started to observe the assembly process. They could infer that pre-process before assembly was also taking place in some of the sub-assembly work, it was taking more time and the assembly time being delayed.

The team recorded that the material moves 80 ft. altogether inside the premises.

The team analysed and found the root cause that there was no planning to match Thrasher final assembly with that of Sub-assembly. It could be seen, minimum of 3 thrashers in semi-finished condition lying on the floor by reducing the value adding place in the assembly area. This has resulted in creating lot of strain to the human resource and also more transport of materials.

The team changed the layout for main assembly. The team marked the total area and the place to keep the sub-assembly parts to ease the strain. Also Bill of Materials and Bill of Activity prepared to avoid any delay in materials process or to keep the thrasher in semi-finished condition.

Before Lean

After Lean

Bill of Activity

Bill of Activity

Activities	Materials	Sub-Assly	Purchase	Job order items

Sub-Assembly

Items	Materials	Process

Project Results

By changing the layout, the material movement has reduced from 80 feet to 10 feet.

Proper utilisation of space and work station discipline created.

2.Work Station Identified for Different Assembly

During the VSM exercise, a cross functional team did a detailed observation of the different thrashers assembly and Heavy machine.

1. Separate Workstation

Observation: During the observation it was found that lot of areas used for different assembly and sub-assembly activities and creating confusions on the work for which thrasher the work being carried out.

Root Cause: No proper arrangement for the materials and also BOM not available.

Action Taken:

- First, single work station created for particular type.
- Bill of material prepared.
- The concept of 'No kit no cut' introduced. Stores issues materials only in kit form.
- Pre-process activities are completed wellahead of the assembly.

Project 3. Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the entire process Walker fabrication to final assembly. The team observed the value adding and non-value adding activities. The non-value adding activities included Muda like operator movement, marking and setting before the cutting/drilling/bending operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analysed in detail and kaizen based solutions were discussed and implemented for these.

Observation (before)
Walker fabrication being carried on the floor.

After Kaizen
Proper table fabricated and also fixture for walker fabrication created.

Observation (before)
Welding process being carried on the floor.

After Kaizen
Proper table fabricated for welding.

Project Result: Throughput time reduced considerably and also strain to the worker.

Project 4. 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)
Systematic arrangement of pulleys not there.

After 5S
Systematic arrangement of pulleys and in countable form.

Observation (Before 5S)

Proper storing of materials not followed.

After 5S

Storing system improved with proper identification.

Observation (Before 5S)

Proper storing of concaves and boxes not followed.

After 5S

Parts stored in the rack and given identification.

Observation (Before 5S)

Walker woods kept in an hazardous way.

After 5S

Stored in the rack with proper identification.

Project 5. Lean Planning, Scheduling and Material Management

Observation:

The company does not have any standard orders, and it solely rely on the orders from the customers who place as and when they require. This created lot of mis- match between Sub-assembly and Final assembly. Automatically delayed the delivery and also lot of WIP on the floor.

Action Taken :

- Following the improvements made during lean implementation, the unit now has a defined capacity of minimum 2 Four walker per day. However, the market requires different type of walkers. In order to achieve 100% customer service levels, Minimum of 5 Sub-assembly parts are to be kept ready and based on the order the team will start the assembly.
- Kanban quantity has been fixed at 5 thrashers of each fast moving model.
- As soon as order is received, it is fulfilled by doing the final assembly by taking the appropriate sub-assembly parts from the kanban store. Accordingly machining of components and outsourcing being planned and kept all the items ready as a kit.

- As soon as the sub-assembly is used up, the same is planned for fabircation / machining and kanban refilled.

  We have synchronised the material flow based on orders. Only materials which require more lead time or quantity based orders (ex., castings) are only kept stock. The lead time for most materials is < 2 days and these are made available as and when required.

Project Result :

This system is really working out for the company. The company is in a position to deliver in time. The company has started to supply 2 thrashers per day.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material movement (mtr.)	80	10	80% reduction
Cycle time in Fabrication (hrs.)	10	3	300% reduction

Business Level Benefits

The process level results in turn combined to benefit Coimbatore Compressor's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos./day)	1 No	2 No	200%
On Time In Full Delivery %)	20%	70%	50%

The benefits obtained have spurred. The unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

4 MSME : General Engineering- Fabricated Machine Parts

BACKGROUND

The Unit is supplying heavy fabricated and machined parts and structures to prestigious organisations like ISRO,VSSC, etc. for the past several years. The company is recognised for its ability to make complex custom build products of very large sizes and this is reflected in its full order book.

The lean journey commenced with discussions with the Directors to understand the vision, strategy and business goals for the next couple of years. Though SVH had plenty of orders, they were finding it difficult to deliver in time and often paid penalties due to LD clause. Hence, the goals set for the lean initiative were:

1. To improve the on time delivery performance to customer from current level of 20% to at least 60% thereby minimizing the losses due to LD clause.
2. To reduce WIP inventory and related costs which affect the working capital position.

With these goals in mind a diagnostic exercise was carried out and a lean improvement roadmap made for the year long project.

Diagnostic Study

Each order received by SVH was unique in terms of application, size and complexity and the product was custom built with lead time generally of the order of several months. The data on five recently completed projects was analysed in terms of delivery performance. Detailed analysis was also done for an ongoing project with respect to material movement and cycle time in various operations.

The project analysis showed that **only 10% of projects** of ISRO are completed on time. Some projects are delayed by several months mainly on account of procurement delays with respect to castings. The table below shows the details of the five projects.

Project Completion Analysis

Item	Order No.	Order Date	Actual Receipt	Customer Delivery Date	Actual Despatch	Remarks
1. Model Incidence mechanism	506220 090009 480000	17.03.10	24-03-2010	30.06.10	25.09.10	Component from subcontract received on 20.07.10
						Inspection call 7.7.10
						Inspection delay at customer end.

Item	Order No.	Order Date	Actual Receipt	Customer Delivery Date	Actual Despatch	Remarks
2. Mandrel for 260 ignite case	170020 100217 70100	21.07.10	04-08-2010	30.09.10	12.10.10	Stage inspection 14.08.10 Inspection call letter 29.09.10 inspection 09.10.10
3. 4ps3 Ti Mould Assembly	454320 101134 0100	04.08.10	10-08-2010	03.12.10	11.12.10	On time Inspection call 29.11.19 Inspection 06.12.10
4. Malabar Cements mono cable sheet	485941	08.02.10	01-03-2010	31.08.10	06.12.10	Casting received on 04.09.10 ordered on 01.03.10
5. Ongoing project	454320 100040 950000	19.11.10		19.01.11		Extension asked due to fabrication delay

Baseline Study

By analysing the causes for delay and observing the material movement and cycle times in ongoing project, the focus areas for lean were identified.

Focus Areas

Throughput Time - The time taken for completion of the ongoing project is more than 200% of the sum of all cycle times required for the complete process. There are gaps between the operations where material is waiting for the next operation or other components.

Inventory – In the order analysed, 5 different components were waiting at different stages. The inventory of steel in the plant that day was 50 MT and 10 MT of scrap.

Sub Contract– 2 of the 5 orders analysed had extraordinary delays in receipt of components given outside on subcontract. The main delay was due to foundry castings.

Synchronization - An item requiring 21 hours to process and another requiring 180 hours are lying on the shop floor at the same time.

Cycle Time – Within an operation, the loading and unloading of the large components was time consuming and depended on cranes. Levelling and adjustment also took up significant time within the cycle.

System Potential

Based on the analysis, there seemed to be a potential to reduce the throughput time by 40% and reduce WIP inventory by a similar proportion. Since each order and product was unique, it was decided to try out lean based concepts on two different orders of different types. SVH team could then build on the success in these projects and standardize the methodology for all orders in future. A lean roadmap was then prepared on these line.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	**Project Completion** - The time taken for completion of the ongoing project is more than 200% of the sum of all cycle times required for the complete process.	Develop a system for working out detailed Lean schedule for executing each order working backwards from delivery date.									1. Increased throughput. 2. Reduced inventory by 33%. 3. Reduced inventory carrying cost by 33%. 4. Better control on lead time leading to on time deliveries.
2	**Material Traceability** - The operations and material status are not identified. It is very difficult to identify the material by project number and which operation the material is waiting for.	Use 5S and visual management to identify materials and their status.									
3	**Process Flow Monitoring**- No tools or formats used for monitoring the order completion status.	Develop and put up a visual display for monitoring each order through various stages of processing.									
4	**Synchronisation** – Components are waiting for machine while at other points machines are waiting for material.	Have a system for booking machine time based on ongoing project schedules.									Reduced waiting time of machines and material. Increased throughput.
5	**Material Handling and Transport** – Most components are very large and weight several tons but they have to be moved large distance both inside and outside of the shed.	Re-layout and reorient machines based on generic process flow.									
6	Delay in Machining due to low machine availability.	Improve equipment condition by starting Autonomous Maintenance and Planned Maintenance.									Increased availability of machines for production.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and Problem Solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions

major functions including stores, maintenance and planning cell. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardisation of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/PlannedMaintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An Internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as participated in all workshops as he would be responsible for sustaining and building upon this initiative in the long run. The champion therefore learnt all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Lean planning, scheduling and material management.
2. Reduction in Through put time.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.
5. Machine Engagement.

Improvement Projects

Project 1 - Lean Planning, Scheduling And Material Management

Observation

The team observed that there was significant delay in planning and procuring the materials, which resulted in the order not being processed continuously. On the one hand materials were waiting at different points on the shop floor while on the other some machines were idle.

Actions Taken

Step 1 – Planning & Scheduling

An activity based plan and schedule was worked out for the projects to be started. Starting from the promised delivery date, the schedule was worked out backwards with start of each activity giving the target for finish of preceding activities. Sub assemblies were also worked out in the same manner. Finally procurement of various materials was linked to the activities where they would be required.

Step 2 – Project Execution & Monitoring

The project schedule is given to each person involved in the project. The planner monitors the project at each stage and discusses the deviations with the team and sets the course for corrective action. A Project monitoring board was also placed on the shop floor for better visual identification and control and to give a clear idea on the status to the machine operators.

Project Monitoring Boards

***Project Result**:*

The company could complete 3 projects on time and further projects are also planned on time delivery.

Project 2 - Reduction in MUDA

The components being both heavy and large in size, loading and un-loading itself takes a long time and depends on availability of crane. Similarly once the component is loaded, levelling and setting for machining is also time consuming.

1. Material Transport

Observation : Test Ring, a huge beam for VSSC project is carried from one shed to the other for marking and returned back for drilling. This process was taking nearly 2 days per beam.

Action Taken: The team observed the same and worked out a solution to carry 4 beams at a time for marking with the help of mobile crane and also over-head crane. This helped the company to engage the machines till the completion of all the beams.

Result: The company could achieve the entire process within 4days for the total of 11 beams. This has resulted in the throughput time saving of 18 days.

Materials scattered all over Observation : The operator has to search the materials for next job and it increases the time.

Action Taken: The team placed the stand carrying the Information like project name, material name and waiting for which process.

Levelling

Observation : The operator used to search and use different type of materials like metal pieces, scrap bits etc. to adjust the component height. Repeated adjustments had to be made using these temporary height pieces in order to level the component.

Result was improper levelling leading to quality issues and even if properly done a lot of machine time was used up without value addition.

Action Taken: Screw jacks manufactured for level adjusting and this resulted in saving in time and strain. Automatically cycle time reduced.

Tools for machine operation

Observation: The operator has to roam around in search of tools for every now and then. Generally, most of the tools are not available nearby. This created lot of strain and also delay in the process.

Action Taken: A board was provided near the machine and kept the required tools and also measuring instruments. This has really helped the operators to speed up the process and reduced their strain.

Observation (before)

For any adjustments on the machine, the operator has to climb with available stand not in condition was creating lot of strain and also safety aspect.

After Kaizen

Proper stand fabricated and the operator could make any adjustments without any strain

Project Results :

- Reduction in cycle time.
- Reduction in strain.
- Less errors means better first time right quality which also reduces the cycle time.

Project 3 - 5S for Standard Work Practice

Once the project schedule was established and unnecessary activities avoided / minimized through kaizen, the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Machine scrap spill on floor creating unsafe condition.

After 5S

Proper guard fabricated and fixed on the machine to contain scrap spill.

Observation (Before 5S)

Machine jigs and fixtures kept without any identification. The operator has to search for the same.

After 5S

Proper arrangements made and identified.

Observation (Before 5S)

All the inward materials kept at the entrance of shop floor.

After 5S

All the materials shifted to the respective area and kept project wise.

Observation (Before 5S)

Movement of machine bed front and back causing hindrance to the passers and it is not visible also.

After 5S

Proper safety guard placed.

Project Result: 5s score has increased from 38% to 66%.

Project 4 - Machine Utilisation

Observation

With the project schedule and bill of materials in place, the next important aspect was utilization of the machines. While some machines were fully utilized resulting in waiting of materials other machines were idle waiting for the material to come from the preceding operation.

Actions Taken

- ✓ The analysis showed that three machines viz., Horizontral boring, VTI and drilling are the bottleneck machines. Most of the materials were waiting are for these machines. A decision was taken to outsource non critical materials waiting for horizontal boring.
- ✓ A machine engagement plan was prepared the input for which was taken from all the live project schedules. Booking status of each machine was worked out and next plan also made based on the project schedules machine had its engagement plan displayed for understanding of the operators and monitoring by the planner.

Project Result

For the selected project, total process time reduced from 40 days to 21 days where parts were outsourced instead of kept waiting for the machine.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the project level since the focus was on improving flow of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material Movement (feet)	100	30-50	50-70 %
Throughput time for Test ring	22	4	82%
5s score	38%	66%	28%

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
On Time Delivery %	20%	60%	200%

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

5 MSME : General Engineering- Fabrication of Pressure Vessels

BACKGROUND

The Unit is Manufacturer and Exporter of Pressure Vessels, Fuel Storage Tanks, Special Purpose Machines and Process Equipment, to Cement Plant, Pulp Plant & Iron Steel, Chimneys and Textiles. The products are custom built against specific designs and some of these generate repeat orders.

During the diagnostic, we identified three sets of products – namely, 1) Machined products, 2) Mould and Press related products and 3) Fabrication related products.

A meeting with the Director and Plant Manager provided the company's strategies and business goals for the next couple of years.

The unit would like to achieve the following:

1. Increase the Suzlon mould box production to 2 units per month from the current level of 1.5 units per month and
2. To establish system driven manufacturing with visual controls.

While the unit has a number of product groups, it was mutually agreed that the pilot lean implementation would be done on the Suzlon mould box since there was a regular order for the whole year ahead. The concept was then extended to other similar mould boxes as Suzlon orders were held up within three months of starting lean. The unit then applied their learning to other custom built products and developed a similar standard process to be used for any new order which is received.

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced in January 2011 with a current state assessment and road map setting exercise for Mould Boxes the high volume and high growth potential product family. Keeping in mind the twin business goals, the current state of the manufacturing process was defined in a Value Stream Map that was made using actual cycle times measured for each activity involved in the manufacturing process . The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target	
Customer reqmt	(No / month)	1.5	2	Working days per month
Demand rate	Nos per day	0.06	0.08	Working hours per day
Takt time (one batch every)	Mins	15500	11625	

Operation/Process	Available resources		Cycle time	C/O time	WIP	WIP	Availity	Effective capacity
	W. stns	Man	(min)	(min)	(nos)	(min)	(%)	(nos/ day)
Material Testing	3	2	480	0			90%	5.2
Marking	1	4	480	0		60	90%	1.7
Inspection	1	2	480				90%	1.7
Bug Cutting (Manual)	6	6	720				90%	7.0
Flat Cutting (Hand Cutting)	2	6	930				90%	1.8
Accessories	3	6	240				90%	10.5
Main Box Drilling	3	6	1800			180	90%	1.4
Machining of accessories	2	2	5580				90%	0.3
Indv. Outer Wall Fit Up	3	12	1920		1920		90%	1.3
Side Wall Fit up	3	4	1920	120	1920	240	90%	1.3
Side wall Inspection	2	2	240				90%	7.0
Side Wall Welding	6	10	2880		2880	120	90%	1.7
Final Fit up	3	12	960	300	960	180	90%	2.6
Final Fit up Inspection	3	2	240				90%	10.5
Final Full Welding	3	10	2400	360	2400	240	90%	1.0
Mac. Comp. fit up	3	6	480	120	480		90%	5.2
Inspection	1	1	60				90%	14.0
Mesh Fit up	3	6	960	120	960	120	90%	2.6
Inspection	1	2	60				90%	14.0
Mac. Comp. Welding	3	6	1440		1440	60	90%	1.7
Mesh Welding	3	6	1680		1680	60	90%	1.5
Dowel Pin Marking & Fit up	3	6	600	120	600	60	90%	4.2
Dowel Pin Welding	3	6	360		360		90%	7.0
Slot Marking	3	6	600	120		60	90%	4.2
Dowel Pin & Slot Mark Insp	3	1	30				90%	83.7
Slot Cutting	3	6	780				90%	3.2
Cleaning & Grinding	3	10	1800	180		120	90%	1.4
2 boxes trial assembly	1	10	480	120		120	90%	1.7
Red Oxide	3	6	300			60	90%	8.4
Final Inspection	3	2	180				90%	14.0
Loading	1	5	180				90%	4.7

Baseline Study

At the time of the diagnostic study, the production rate for Suzlon mould box was on an average 1.5 units per month with the production lead time of 24 days per mould box. While the company enjoyed the confidence of customers, it was repeatedly penalised for late deliveries under the Late Debit Clause (LD Clause). Based on the business plan for FY 2011-12, it was decided that the production target would be set at 2 units per day which translated to a takt time of 13 days per box. The diagnostic assessment now focussed on whether the company had sufficient potential within the existing resources to achieve this level.

Focus Area

Cycle Time – Each set of mould box involves three groups of activities of which the assembly and welding is the bottleneck. Total work content here is 21 days at present but this is distributed over parallel activities including machining of accessories which takes almost 5 days.

Value Adding Ratio – After considering the parallel activities, it was found that nearly one thirds of the total time was spent in non value adding activities like waiting for materials/parts, crane, etc.

Productivity – *Operators* spend nearly 30% of their time in support activities which are not value adding.

Material Handling and Transport - The mould box is a very large and heavy item whose movement is solely depends on cranes. Waiting for cranes also increases the lead time.

System Potential

Based on the VSM analysis and observation we felt that Ananda could produce 3 sets of mould boxes per month utilizing the existing resources. During the cluster lean Implementation, we demonstrated capability of at least 2 sets per month by better work flow, eliminating Muda and Muri and some process modifications. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	**Cycle Time** – Assembly is the bottleneck process involving 20 sub activities. Each activity is done by different number of people and this varies from time to time.	Detailed observation of process flow; do ECSR analysis and execute activities in parallel.									50% reduction in cycle time for assembly (includes welding).
2	**Welding** is a major activity consuming 120 hours (7 days). Many points are in difficult to access positions causing strain to the welders.	Improve welding process by workstation design and kaizens.									

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
3	**Material handling and movement** depends on cranes and takes a lot of time. Heavy item is difficult to move. 	Develop material flow with workstation concept such that requirement to move is minimal.									Reduced throughput time by 10% from 37 days to 33 days.
4	Machining of accessories takes more time total cycle time of 6 days. 	Establish flow and reduce the cycle time by applying Kaizen principles.									50% reduction in cycle time and 10% reduction in throughput time.
5	Accessories have to be synchronized with the assembly process to avoid waiting for components. Assembly is already the bottleneck process.	Synchronize and level schedule based on Delivery Date. Improve the monitoring system through 5S.									Reduced throughput time by 10%
6	Variation in time and delivery – varying number of people work on the mould box set on different days or orders.	Align support activities with established production – Establish SOPs, visual management, monitoring systems, etc.									Standardized process that can consistently deliver one set of mould box every 15 days.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner)

commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance / Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Lean planning, scheduling and material management.
2. Eliminating non value adding activities through Kaizens.
3. 5S for standard work practice.

Improvement Projects

Project 1 - Lean Planning, Scheduling and Material Management

Assembly (welding) is the bottleneck process involving 20 sub activities. Each activity is done by different number of people and this varied from time to time. A cross functional team did a detailed observation of the welding operation and recorded the data in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

Root Cause : The team then analysed the root causes for delay in assembly. It was found that, at the time when one of the parts was assembled other parts laid idle while at other times the assembly is waiting for the appropriate part.

Solution : The box welding was split into panel welding – welding to be done in each of the four panels in parallel. An activity scheduling chart was prepared based on ensuring seamless flow of activities and shorten the production lead time.

ACTIVITY SCHEDULING CHART

S. No.	Activity	Resources		Days															
		Man	Machines	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	Plate Marking	3	Scale, M Tape																
20	Plate Cutting	2	Gas Cutting Machine																
30	Flat Marking	3	Scale, M Tape																
40	Flat Cutting	2	Gas Cutting Machine																

S. No.	Activity	Resources		Days														
		Man	Machines	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
50	Assembly Fit up (Indv. Frame)	4	2 Welding machines																
60	Indv Frame Welding	4	2 Welding machines																
70	Tuniun Rod Machining	2	2 Lathe																
80	60th plate Machining	2	2 Lathe																
90	Indv Frame Cleaning & Grinding	2	2 Grinding Machine																
100	Gussed & Hooke	3	Grnding, Gas Cutting																
110	Indv Frame with Truniun & Welding	2	1 Welding Machine																
120	Weld TMT bar indv. Frame Fitup & Wldng	2	1 Welding Machine																
130	Indv frame Painting	1	Painting Gun																
140	Box Assembly Welding	4	2 Welding machines																
150	Mesh Fit up	2	1 Welding Machine																
160	Mesh Welding# (top and bottom box)	2	1 Welding Machine																
170	3 Box Matching & Inspection	2																	

Each of the three welding groups worked on one box– top, middle and bottom in parallel (upto activity no.160).

Order wise activity scheduling for mould box assembly was implemented as part of our horizontal deployment. The same has been extended to the processing of all types of orders across all stages including machine shop. The schedule and follow up table was made visual and displayed in the workstations.

Avtivity scheduling at machine shop.

Other improvements on reducing material waiting time.

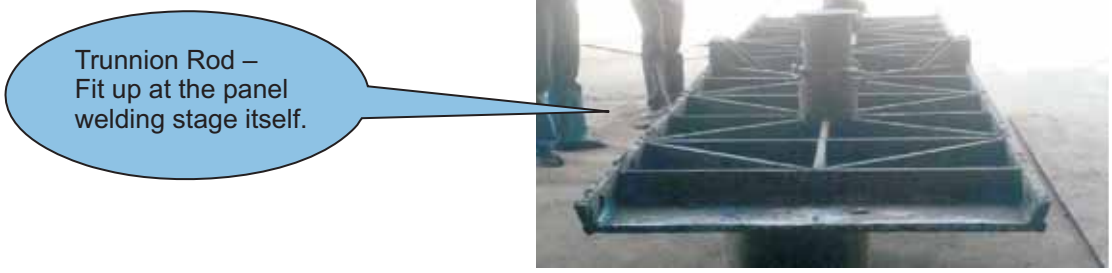
One of the major activities in the welding process was the trunnion fit up. During the scheduling it was decided to rearrange this activity to reduce time further.

Observation

Trunnion machining component fit up carried out after final assembly; it took lot of handling time. (Separate activity consuming 2 days with 4 people).

Action taken

Trunnion fit up can be done in individual sidewalls itself to reduce handling & welding time. Planned in the activity sequence for next set of boxes.



Project Results: As a result of implementing the above changes, the throughput time for the mould boxes reduced by 33% from 24 days to 16 days; a similar kind of reduction in throughput time was achieved in all the areas, where this concept of lean scheduling has been horizontally deployed.

Project 2 - Eliminating Non Value Adding Activities through Kaizens

Welding is a major activity consuming 120 hours (7 days), and actually is the bottleneck in the entire process.

Observation

Many points are in difficult to access positions causing strain to the welders who are found sitting in awkward position and doing welding.

Action Taken

Welding table designed to reduce strain and operator fatigue.

Tool board designed to minimise operator movement.

Observation

Operator moves several times to the machine from the work area to adjust voltage in the machine takes time.

Action taken

The voltage regulator brought near the welding spot so the adjustment can be done from there itself.

Observation

Gas cutting machine firing done using welding spark.

Action taken

Lighter (domestic) provided for the purpose.

Observation

Welder handled the torch with the cable weight throughout the day, it causes strain & consumes time.

Action taken

Appropriate stand is provided nearby welder to hold the torch hose.

Material Handling and Movement

Observation

Material handling and movement depends on cranes and takes a lot of time. Heavy item is difficult to move.

Action taken

Re-layout was created for easy operation flow. Identified shortest routes for material movement including cut sheets, gas cylinders, etc.

Observation

Sub assemblies & Raw materials blocked main entrance area.

Action taken

Plantation done in the main entrance / raw materials & sub assemblies kept in the relevant places

Observation

Operations involve many movement and transportation (Muda). Materials are stored randomly blocking the movement.

Action Taken

Lay out is marked according to the flow of activities at welding and work station was designed.

***Project Result**:*

1. Welding cycle time reduced from 120 hours to 100 hours.
2. Material movement reduced from 48 hours per box to 32 hours.

Project 3 - 5S for Standard Work Practice

5S was implemented by the team keeping in mind the arrangements required for the lean manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Before : Drill Jigs/Templates were scattered in different areas causing time loss of searching and bringing the dies during change over.

After: Drill Jigs/Templates are stored In the separate rack with proper identification.

Before : Instruments / Consumables were kept in stores without proper identification in different places.

After: Separate racks are provided for different items with proper identification in the rack itself.

Visual Management

Materials are stored in their respective locations as per 5S standards. But since, the orders are new every time, identification of components becomes difficult even though they are stored at designated places. Hence, identification boards were provided for easy identification of components and their process status.

Project Results :

- The unit started with a 5S score got of 43% in first audit which went upto to 64% in second audit.
- Searching time reduced by 90% as a result of enhanced traceability.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After	Improvement	Impact on Business
Materials Handling & Movement (Hours)	48	31	33% reduction	Reduced strain and increased productivity
Welding Time (Hours)	120	100	20% reduction	Increased output
Assembly / Fit up time (Hours)	90	80	11% reduction	Increased output
5S Score (%)	43	64	21% Increase	Reduced strain, improved inventory control, safety and morale.

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Delivery time (25MT of 1 Set Mould Box)	24 days	16 days	35% reduction	Turnover goes up by fulfilling more orders
On Time Delivery %	70	85	15% Increase	On time delivery and reduced LD Clause

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

6 MSME : General Engineering- Tools, Boring Bars

BACKGROUND

The Unit is manufacturing various types of tool, Boring Bars and accessories some of which are custom built while the rest are standard catalogue products. The company is having 2 units adjacent to each other, one for Tool Holders and the other for Precision Components.

The Directors stated the following as their business goals for the next 2 years:

1. To increase by the volume in tool holders by two thirds (67%).
2. To increase by 50% the volume of precision components.
3. To reduce the lead time from the current 6 - 8 weeks to 4 weeks.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The Lean journey commenced with a current state assessment and road map setting exercise. Since the company makes multiple products, it was agreed that the concept of lean would be implemented and demonstrated for the product family of BT-40 Tool Holders, which constitutes significant portion of the total volume (70%). It was agreed that implementation would later be extended by the unit's team to other product families and subsequently in the next year to the Precision Components Division.

Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map for the BT-40 tool holders . The VSM was made using actual cycle times measured for each activity involved in the manufacturing process . The inventories, number of operators, machines involved were also physically verified on the shop floor. The summary of the VSM is shown below.

Customer reqmt	(No / mon)	3000	5000	Working days per month	25
Demand Rate	No / day	120	200	Working hours per day	16
Takt time (one batch every)		480	288	sec	

Operation/Process	Available resources		Cycle time (min)	C/O time (min)	WIP (Nos)	WIP (min)	Avlblty. (%)	Effect. capacity (Nos)
	Mcs/ station	Man power						
Cutting	1	1	7	10	102	816	100%	137.1
I OP Turning	1	1	6	60	0	0	87%	160.0
II OP Tunring	1	1	8	90	0	0	91%	120.0
Conv Turning	1	1	3	15	0	0	87%	282.4
CNC Milling	1	1	3	45	0	0	96%	314.8
Bench Work	3	3	5	0	34	272	100%	576.0
HT	1	-	-	0	0	0		
Incom Insp	1	1	1	1	0	0	100%	960.0
Bench Work	1	1	5	0	0	0	100%	192.0
Shot Blasting	1	1	5	0	210	1680	100%	192.0
Blackening	1	2	3	30	0	0	100%	
Center Grinding	1	1	6	30	0	0	90%	160.0
Taper Grinding 7/24 Rough	1	1	4	90	0	0	75%	240.0
Hot Part Turning	1	1	7	150	100	800	90%	147.0
Taper Grinding 7/24 Finish	1	1	6	60	85	680	81%	150.0
Pull Stud Bore Grinding	1	1	7	15	0	0	82%	137.1
Pull Stud Face Grinding	1	1	6	60	0	0	79%	160.0
Bore Grinding Taper	1	1	7	60	0	0	88%	137.1
Face Grinding	1	1	5	30	0	0	82%	192.0
Marking	1	1	1	5	0	0	100%	1920.0
Final Inspection	1	2	5	5	150	1200		192.0
Packing	1	3	1	-	0	0		960.0

	Cycle time	C/O time	WIP
Total time per unit output (minutes)	101	756	5448
	2	12	86
Throughput time	6305	minutes	
	6.6	days	
VA ratio	2%		
Plant capacity (bottleneck)	120.0		
Constraints	Turning I / II Bench Work Grinding Changeover time		

Baseline Study

At the time of initiation of our project, the production rate was 3000 Nos per month (120 Nos/day) and the business target was 5000 Nos per month (200 Nos /day) which meant a a takt time of 5 minutes.

Focus Areas

Throughput Time - Value Adding Ratio is only 2% which means that of the total time the component spends in the factory no work is happening on it for 98% of the time.

High Cycle Time - As per the available data, the bottleneck processes were turning OP II and all the grinding processes which have cycle time about 20-40% more than takt time. Bench work was also a constraint which also disrupted the flow of the product.

Productivity - People spent only 47% of their time in actual value addition.

Machine Availability - Reduced by 15-20% in critical turning and grinding operations due to high changeover times and more breakdowns.

System Potential

Considering the VA ratio of only 2% and availability of manpower resource time, a 67% increase in production to 5000 units per day utilizing the existing resources was very much feasible. By improving the above focus areas through systematic application of relevant lean tools and techniques, the employees would also be trained on continual improvement and in future be able to make improvements themselves. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***MUDA*** – Each tool holder travels 594 feet within the unit premises, is handled 67 times and stored in 19 different points.	Change layout to achieve single piece flow before Heat Treatment and same after heat treatment.									67% Reduction in throughput time 25 % Reduction of lead time Resources freed for value adding work.
2	**High Cycle Time** - Turning OP II cycle time is much higher than takt time. Grinding operations cycle time is about 20-30% higher than takt time.	Observe, analyse and eliminate the MUDA in cycle through kaizen. Single piece flow with some improvement in workstation design.									Cycle time < 5 minutes, increased production volume by 60%.
3	**Machine Availability** - Change over time is 150, 90 and 90 min respectively in hot part turning, II op turning and Taper grinding which are high cycle time operations.	Reduce changeover time to (<30 minutes) by applying SMED principles to one machine. Deploy concept to other machines.									Increase in production volume by 100 pcs per month.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
4	**Machine Availability** - The availability of turning and grinding machines are low due to breakdowns.	Improve equipment upkeep through autonomous and planned maintenance.									Increase in productivity by 10 pcs per day.
5	**Process Reworks** - Bench work is done twice during the process, which is removing the burs manually.	Problem solving to minimize occurrence of burrs and reduce requirement of bench work.									Increase productivity by freeing up manpower resource from becn activities.
6	**Heat Treatment is done at Subcontractor –** Coordination to ensure consistent flow of material is difficult.	Supermarket before and after heat treatment to ensure smooth flow and no stock-outs.									Pull based production.
7	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Standardized manufacturing system capable of consistently delivering required output.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore

learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

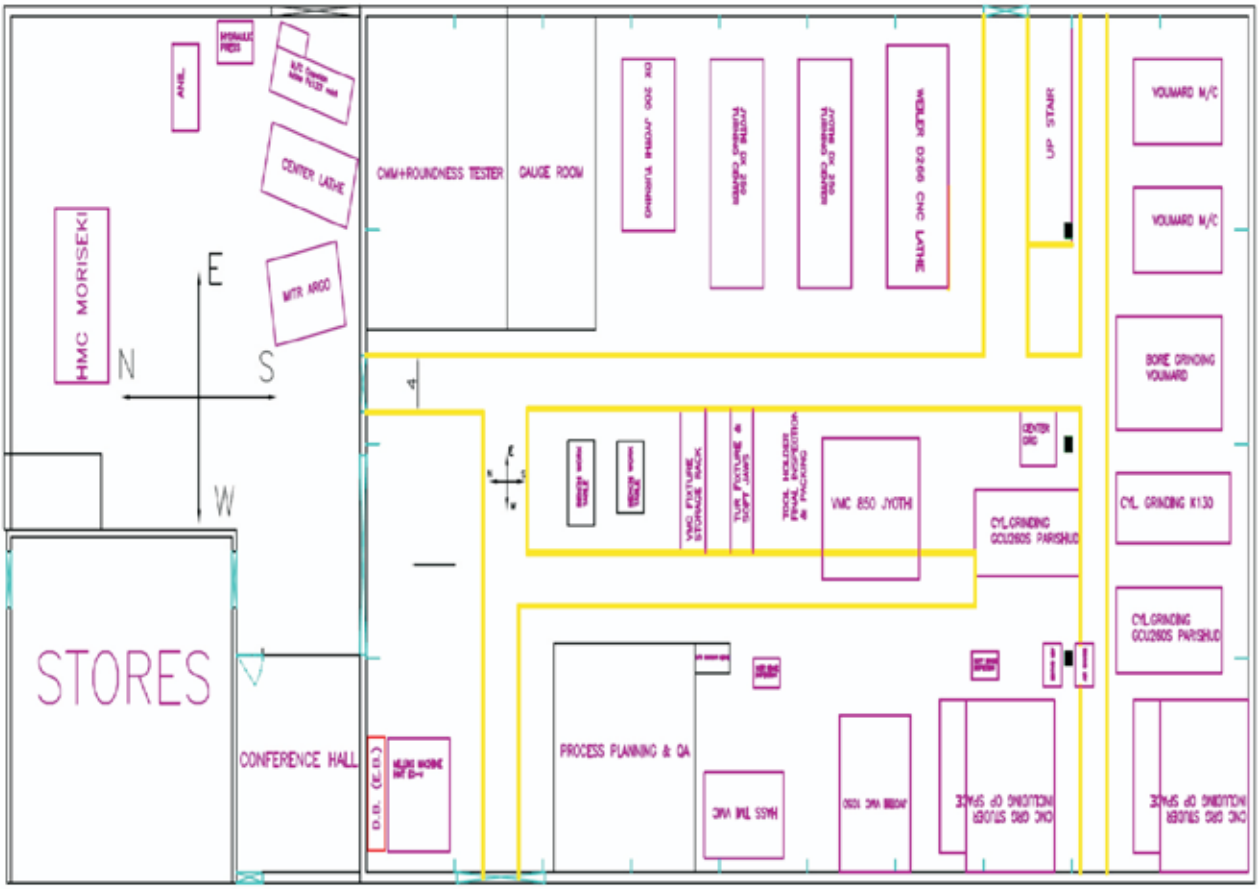
A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time in bottleneck activities through workstation design.
3. Reduction in Change Over time.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

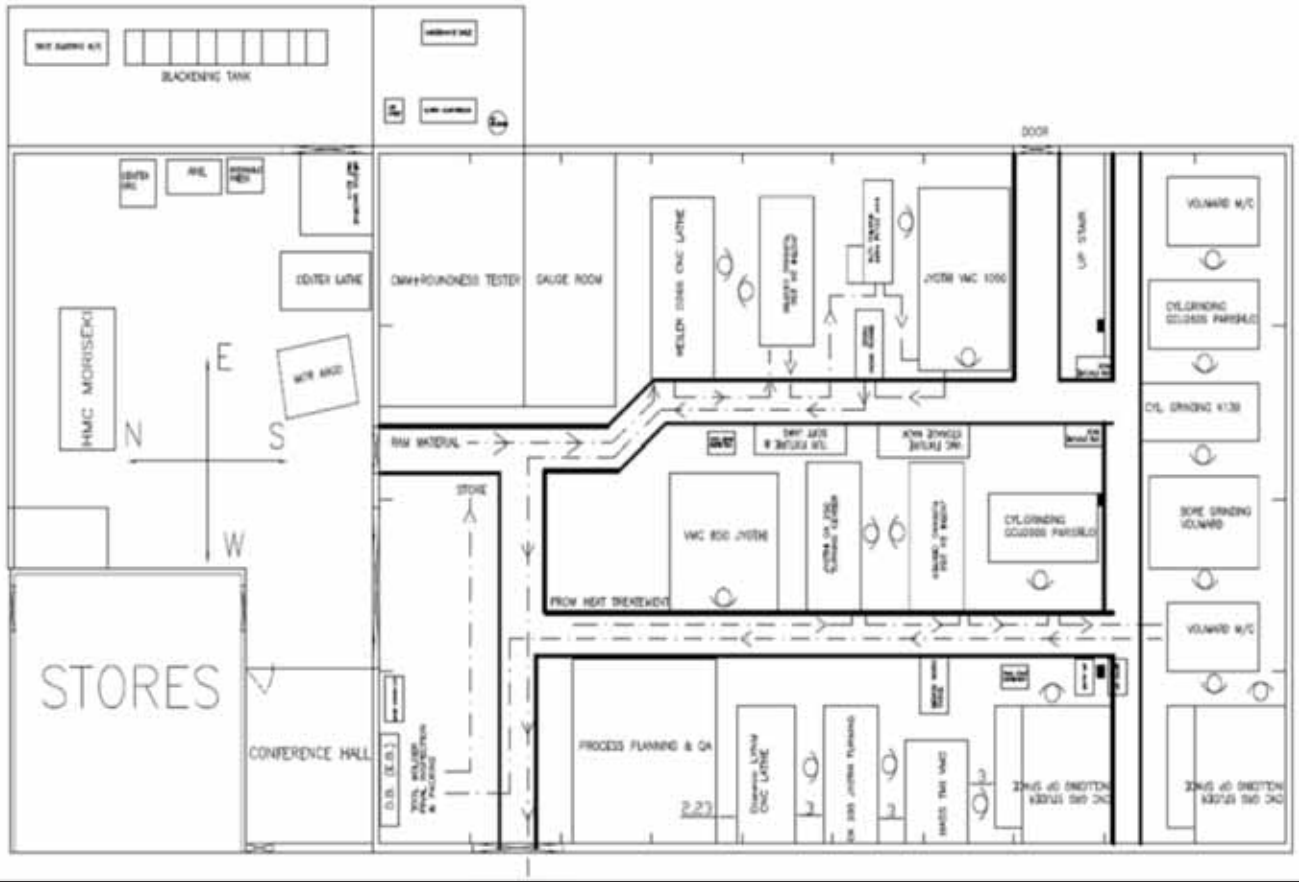
Improvement Projects

Project 1 - Change to Single Piece Flow Layout

Before: Layout – Each tool holder travelled 594 feet within the unit premises, was handled 67 times and stored in 19 different points.



After: To achieving flow manufacturing, the layout was modified such that all pre-heat treatment operations can be done in sequence. The material goes out for heat treatment and post chemical treatment; the finishing operations are laid out in sequence. Assembly and packing follows in line and packed goods are stored in dispatch area.



Before: Cut RM and WIP stored near the CNC machines hindering the material movement and clutter the flow. No control on RM and WIP quantity.

After: Area between Machines and Gangway detracted by bringing in the yellow line. No room for keeping the materials near the machines.

Before : Cut RM and WIP stored near the CNC machines hindering the material movement and clutter the flow. No control on RM and WIP quantity.

After: Tool rack moved near to the CNC machines in support to the gangway. Final inspection and packing moved towards FG stores creating space to keep the WIP. Standard WIP area earmarked for 2 pallets and 4 trolleys.

Project Results :

- Material transport reduced from 594 ft to 300 ft.
- Material handling reduced from 64 times to 40 times.
- Accumulation of WIP in between machines and operations is completely eliminated.

Project 2 - Reduction in Cycle Time of Bottleneck Operations

From the VSM study, we found that a number of operations were having cycle time more than the takt time, hence we decided to implement the cycle time reduction kaizens simultaneously in several operations. A cross functional team did a detailed observation of the operations and recorded the data in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

Three operations – turning II, bench work and grinding cycle time reduction.

Before : High cycle time of BT40 turning II operation – high loading time component picked up from floor, clamping and de-clamping takes more time due to unthreading of bolt.

After : Reduced Muda - material movement, marking input -output, area and increasing the raw material height for easy pick & unload the finished component, modifying clamping and de-clamping arrangement.....etc.

Before : De-Burring and Packing C/T time is more than 10 minutes. Excessive operator movement and material build up as operations were not in sequence.

After : By re-arranging the work stations and introducing systematic work flow, cycle time reduced to 5 minutes.

Observations and action taken are tabulated below.

SL.NO.	OBERVATION	TIME	COUNTER MEASURE
1.	SK40 CCH ER 40 070 – TUR I OP (INCLUDING V GROOVE)TOTAL CYCLE TIME	5.15 MIN	CHUCK PRESSURE REACHES ONLY 22 BAR,IF THE CHUCK CHANGE DEPTH OF CUT WILL INCREASE,
2.	SK40 CCH ER 40 070 – TUR II OP	4.52 MIN	IN II OP CLAMPING WILL DEMAGE THE PULL STUD THREAD, SO THE CLAMPING STUD WILL BE CHANGE.IT WILL REDUCE THE FITTING TAP WORK.

Project Results :

The following results have been established following the implementation of actions :

Parameter	Before	After
Cycle time SK-40 Model (minutes)	8	5
De-Burring and Packing Cycle (minutes)	10	5
Finishing and packing cycle time (minutes)	12	5
Output (Pre-heat treatment) Nos. per hour	7.5	11

Project 3 - Reduction in Change Over time

Before : Change over time is 150, 90 and 90 min respectively in hot part turning, II op turning and Taper grinding which are high cycle time operations. Due to searching of tools, jig's fixtures, after switching of the machine.

After: Applied SMED Concept in FN222 machine,FN207 machine,FN205 machine, and detailed observation has been done and based on the observations non value adding activity like searching for tools, fixture, jig's...were arranged near to the machine.

Observations and action taken are tabulated below.

SL.NO.	OBERVATION	TIME	VA	NVA	COUNTER MEASURE
1.	SK40 CCH ER 40 070 – TUR I OP				TO REDUCE BORE ROUGHING TIME D.O.C. & TOOL MUAST BE CHANGEG
	CLAMPING	03.0 SEC		03.0 SEC	
	OD ROUGHING	1.54 MIN	1.54MIN		
	CENTRE DRILL	05.0 SEC	05.0 SEC		
	14mm S.C.DRILL	43.0 SEC	43.0 SEC		
	STEP BORING TOOL	35.0 SEC	35.0 SEC		
	M16X2 TAP	21.0 SEC	21.0 SEC		
	TAPER FINISHING	36.0 SEC	36.0 SEC		
	UNCLAMPING & CLAMPING	23.0 SEC		23.0 SEC	
			4.09 MIN	26.0 SEC	
2.	SK40 CCH ER 40 070 – TUR II OP				WE MUST CHANGE THE 'V' GROOVE OP TO Ist OP
	OD ROUGHING	1.37 MIN	1.37 MIN		
	OD FINISHING	28.0 SEC	28.0 SEC		
	Ø25 'U' DRILL	57.0 SEC	57.0 SEC		
	BORE ROUGHING	4.02 MIN	4.02 MIN		
	BORE FINISHING	1.55 MIN	1.56 MIN		
	'V' GROOVE	1.10 MIN		1.10 MIN	
			8.0 MIN	1.10 MIN	

SL.NO.	OBERVATION	TIME	VA	NVA	COUNTER MEASURE
3.	SK40 CCH ER 40 070 – CON. TUR				
	TURRET LATHE INDEXING	02.0 SEC		02.0 SEC	
	HOLDER FIXING IN FIXTURE	10.0 SEC		10.0 SEC	
	THROUGH THE HOLDER AFTER FIXING	25.0 SEC		25.0 SEC	
	5mm CENTRE	05.0 SEC	05.0 SEC		
	Ø13.5mm DRILL	1.10 MIN	1.10 MIN		
	Ø26.5mm DRILL	1.20 MIN	1.20 MIN		
	M28X1.5 TAP	25.0 SEC	25.0 SEC		
	DIAMANDLING HOLDER FROM FIXTU.	10.0 SEC			
4.	SK40 CCH ER 40 070 – VMC				
	WORKPIECE CLAMPING	1.05 MIN		1.05 MIN	
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	TOOL CHANGING	03.0 SEC		03.0 SEC	
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	Ø10 CUTTER DRIVE SLOT ROUGHING	1.32 MIN	1.32 MIN		
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	TOOL CHANGING	03.0 SEC		03.0 SEC	

SL.NO.	OBERVATION	TIME	VA	NVA	COUNTER MEASURE
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	Ø10X45 CHF CUTTER CHAMFERING	29.0 SEC	29.0 SEC		
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	TOOL CHANGING	03.0 SEC		03.0 SEC	
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	Ø10mm FINISHING CUTTER	48.0 SEC	48.0 SEC		
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	TOOL CHANGING	03.0 SEC		03.0 SEC	
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	Ø8 MARKING CUTTER	19.0 SEC	19.0 SEC		
	TABLE MOVEMENT	05.0 SEC		05.0 SEC	
	UNLOADING	28.0 SEC	28.0 SEC		
	M28X1.5 TAP	58.0 SEC	58.0 SEC		
	M16X2 TAP	1.51 MIN		1.51 MIN	
	DEBURING	5.34 MIN		5.34 MIN	
	PUNCHING	30.0 SEC	30.0 SEC		

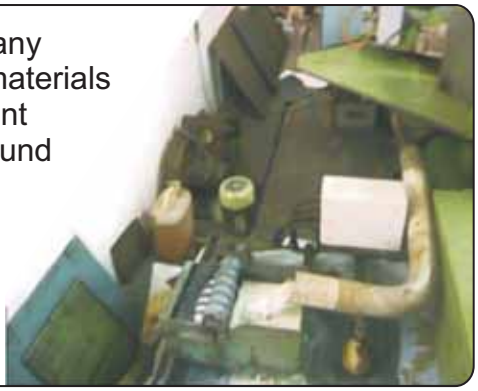
Project Results :

Machine & Process	Before	After
Machine : FN222 Component : BT40 CCH ER32 100 Operation : TUR II SETTING	109.2minute	61.02 Minute
Machine : FN207 Component: HSKA50 FIXTURE Operation : TOP SLOT SETTING	82minutes	29 minutes
Machine : FN205 Component: HSKA100 Operation : TAPER GRINDING SETTING	56.27Minutes	16.5 minutes

Project 4 - 5S for Standard Work Practice

5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Before : Many unwanted materials and irrelevant materials found around the machines, especially behine the machines.



After : All the unwanted materials cleared off the area. The area visibility got improved. Space created behind the machines and accessing the machine for cleaning and maintenance became easy.

Before : Tools for CNC machines are stored in the rack kept far from the machines. Racks are not identified, tools are stored such that searching was inevitable.

After: The rack was moved near to the machines. All the racks are identified with name and material indices. All the tools were labeled and their area is marked so that the vacant space can be traced to the tools. Results in reduction in change over time.

Before : Hand Tools for CNC machines are stored on the tool table near the machines. Tools are not identified and are stored such that searching was inevitable.

After: Tool boards are made and displayed near the machine so that the tolls can be reached within foots of movement. Shadow marking is done on the boards so that it is easy for the operators to ensure all the required tools are available before the time of use. Searching is literally eliminated.

Before : All the tools were scatteered together. Picking up a required tool consumed a minimum of 5 minutes. Possibility of tools getting damaged.

After : 2S was done. Tools were arranged systematically with identification and location indicators. Index of tools inside the rack was marked on the doors. Picking up and replacing of a tool became easy and consumes less than a minute.

Project Results :The unit got a5S score of 55% in first audit which shot up to 83% in the second audit. 5S had a major role to play in sustaining the results obtained in changeover time reduction and flow manufacturing in the new layout.

Project 5. Lean Planning, Scheduling and Material Management

Organisation & Responsibilities

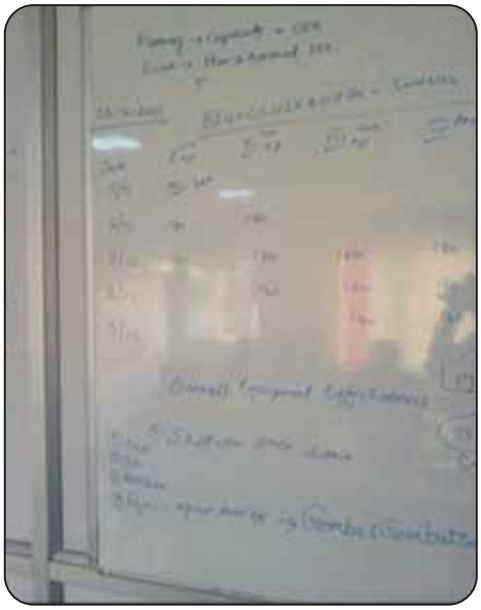
Before : After making the plan, the Planning Department used to do the machine scheduling activity. This resulted in lot of follow up activities by planning to monitor and ensure job completion.

After : The procedure was reorganized such that the planning department will plan the product requirements as per the customer orders. This will be communicated to production. Production has to schedule and execute the orders based on the machine availability and give the feedback on job completion to planning.

Cell Level Scheduling

Before : Each machine had its own schedule of orders and these were scheduled in batches. This lead to large In-process inventories, high lead time for an order (3-4 weeks) and increased follow ups and firefighting to deliver the orders.

After: Following the layout change, Lean Scheduling process was initiated after training on the same.



Trial 1 - Part number BT40CCHER40070 with a order quantity of 500 numbers. Scheduling was done for pre-heat treatment processes, i.e, I operation to IV operation with the releavent machines. A photo of the draft schedule is attached.

Trial 2 - Batch with 100 no. order quantity was taken and processed based on *Cell level scheduling.* Lead time can be brought down to 1 week with lean scheduling. The team has also started monitoring percentage of each day production volume achieved against the schedule as a trend graph.

Project Results

Lead time for reduced to 1 week (incl. pre & post heat treatment processes) from more than 2 weeks.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After	Improvement	Impact on Business
Material movement (Ft)	594	300	50% reduction	Reduced strain and increased productivity
Cycle time SK-40 Model (minutes)	8	5	38% reduction	Increased output
De-Burring and Packing Cycle	10	5	5o% reduction	Increased output
Finishing and packing cycle time	12	5	58% reduction	Increased output
5S Score	53	81	25% increase	Increased safety and morale, increased output

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	After	Improvement	Impact on Business
Output per hour	7.5 Nos.	11 Nos.	45%	Turnover goes up by fulfilling more orders.

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

7 MSME : Light Engineering- Cooling Towers, Heat Exchangers, etc.

BACKGROUND

The Unit is in the business of manufacturing cooling towers, Refrigerated Air Dryers, heat exchangers and radiators for industrial applications. Refrigerated Air Dryers is the main category of the product line constituting to nearly 50% of the volume.

We had an initial discussion with the promoters of the company to understand the vision and mission of the organization. It was agreed mutually that the lean implementation would focus on the assembly of Refrigerated Air Dryers which are carried out in 2 cells each producing 7 units per day. The following goals were fixed for the lean implementation:

1. To improve the productivity of the Refrigerated Air dryer cells to manufacture 14 units per day per cell. This would double the current capacity.
2. To streamline the production process which would reduce the work-in-progress.
3. To use the space effectively, thereby reducing the material and men movement.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. The Management Consultants did a plant walk through to understand the processes, the operations and the value stream of the refrigerated Air dryer cells. Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map. The VSM was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop-floor. The summary of the VSM is shown below.

Value Stream for Refrigerated Air Dryers

Measure	UoM	Current	Target
Customer Requirement	(Nos/month)	350	525
Demand Rate	Nos per day	14.0	28.0
Takt Time (one batch every)	Minutes	**34.3**	**17.1**
	Available Resources		**Cycle Time**
	Machines / Workstation	**Manpower**	**(Minutes)**
Process 1 – Assembly	1	1	27
Process 2 – Brazing	1	1	7
Process 3 – Nitrogen	1	1	17
Process 4 – Gas Charging& Insulation	1	1	17
Process 5 – Electrical pre-assembly	1	1	30
Process 6 – Electrical connection	1	1	25
Process 7 – Testing	1	1	25
Process 8 – QC testing	1	1	15
Process 9 – Finishing	1	1	6
Process10 – CC testing	1	1	25
Total Time per unit output			**194**

Baseline study:

At the time of the diagnostic study (January 2011), the production rate for Air Dryer was 7 units per day per cell. Based on the business plan for FY 2011-12, it was decided that daily production target would be set at 14 units per day per cell which translated to a takt time of 17 minutes per Air Dryer. The diagnostic assessment now focussed on whether the company had sufficient potential within the existing resources to achieve this level.

Cycle Time: The bottleneck operations include assembly (valve, condenser and compressor), electrical connections pre-assembly and connections and CC Testing.

Throughput Time: While the work content per dryer is 194 minutes, the actual through put time was calculated to be 1255 minutes which meant a value adding ratio of 16% only. WIP before the electrical connection and testing area is a major cause. Also some of the assemblies are held up waiting for parts.

Space: Only 8% of the total space is used for value addition, the rest of the shop floor is cluttered with material.

People: The assembly workers utilized only 35% of their available time for value addition.

System Potential:

Based on the VSM and above analysis of the assembly area, there was a clear potential for making 14 units per cell per day with the existing resources. This would make the output, 28 no's per day which is double the current capability. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Creating Flow:*** Condenser assembly, compressor assy, electrical connections and CC testing are the bottleneck operations – more than 17 minutes.	Debottlenecking of the mentioned operations through ***process study and Muda elimination.***									Doubling the current throughput capability.
2	Reduce the through-put time of the cell from 192 minutes.	***Load levelling*** of the operations and balancing the lines.									50% reduction in the through-put time.
3	Brazing operation is carried out in the shopfloor – near the PUF panels – Safety concern.	Workstation / process design will be suggested so as to make the operation safe for the plant – ***Work Place Design.***									Improvement in safety.
4	Employee has to bend down to assemble the components – increases fatigue.	Suitable arrangement would be made to eliminate fatigue and improve productivity.									Improvement in productivity.
5	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke.***									Pull based production.
6	***Synchronisation***	Align support activities with flow production – Establish ***SOPs, visual management, monitoring systems***, etc.									Lean Manufacturing.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were

introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Reduce throughput time by one piece flow production.
2. Reduction in cycle time of bottleneck operations through workstation design.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.
5. Pull based material management.

Improvement Projects

Project 1. Reduce Throughput Time by One Piece Flow Production

The existing process was observed by a cross functional team right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant.

The team analysed and found the root cause that the material planning was lagging and this has created lot of Semi-finished dryers lying on the floor by reducing the value adding place in the shop floor. This has resulted in creating lot of strain to the human resource and also more transport of materials. Also, FIFO system could not be followed and the U shaped cell was a real congestion and affecting the flow.

The team changed the layout. This really reduced the distance of material movement. U shaped has been changed to single flow straight linewith provision for FIFO based production especially pre and post vacuum and leak testing which is a batch process.

Layout

Before Lean - U shaped cell - No FIFO

After Lean - Single line flow - FIFO

Project Results :

By changing the layout, the material movement has reduced 1000ft to 500ft and also clarity of work area has been achieved. Floor area has been utilised properly could follow FIFO system.

Project 2. Reduction in Cycle Time

During the VSM exercise, a cross functional team did a detailed observation of Air Dryer assembly operation and recorded the data in standard operations table format. Each bottleneck operation was observed in detail and recorded in operations analysis table format. Root cause analysis was done and appropriate solutions implemented.

1.Creation of Workstation

Observation: During the observation it was found that the assembler has to move around in search of tools and also for assembly materials.

Root Cause: No proper arrangement for the materials and also BOM not available.

Action Taken: First, work stations created for each type of activity in the assembly process. Sub-assembly is processed in advance to support the main assembly to achieve the takt time.

Trolley has been arranged for tools and also for fasteners, etc.

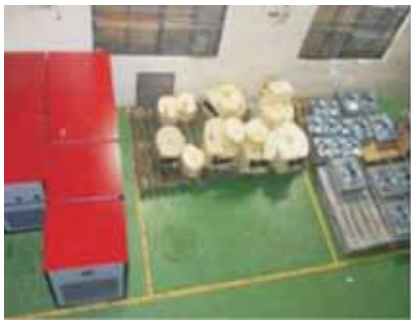
2. No Kit No Cut Concept

Observation : 1) The operators do their job with the materials available and keep the Air dryers in semi-finished condition if there is shortage of few materials.

Root cause: 1) Material synchronization difficult as parts are produced in different plant as well as purchased from vendors.

Action : 1) Parts kit prepared and sent along with the Air dryer assembly trolley. The concept of 'NO KIT NO CUT' was implemented to avoid any WIP choking the line.

2) Dryer box arrives from sheet plant with the door screwed on, the assembler has to un-screw and remove the door for doing his work. The door is again rescrewed at the end of the line.



Action: Dryer box started to come in the form of kit and saving the operators time. Suitable fixtures also made to ease the process.

Doors in kit form →

Project Result: The type of activities has reduced the assembly process cycle time. The cycle time has reduced from 68.5 minutes to 34.5 minutes with 2 work stations thus achieving time of 17 minutes per operation as per target.

Project 3. Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the entire process from tank fabrication to final assembly. The team observed the value adding and non-value adding activities. The non-value adding activities included Muda like operator movement, bending operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analysed in detail and kaizen based solutions were discussed and implemented for these.

Observation (before) The operator bending to do some assembly work.

After Kaizen The operator has been given stool to sit on it to do the assembly.

Project Result: The operator is free from strain and able to do the job precisely.

Project 4. 5S for Standard Work Practice

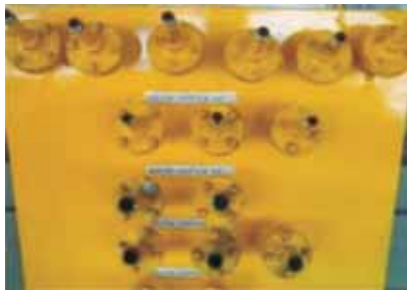
Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Flanges kept as it is, without any identification.

After 5S

Flanges kept in the board and suitable identification given.



Observation (Before 5S)

Materials kept at the assembly area creating hindrence to the flow.

After 5S

Stored materials removed and shifted to respective area and cleared for the flow.

Observation (Before 5S)

The line was not clear and FIFO could not be followed.

After 5S

Flow line has been clearly marked and FIFO could be followed.

Project Results : Operators strain reduced. Line clarity created and FIFO flow has been achieved

Project 5. Pull System for Internal Components

Base Frame with Sheets Fabricated for the Air Dryer Box

The fabrication is done in the sheet plant in the same premises. The team carried out a detailed observation and modified the fixtures used for fabrication. This resulted in the cycle time reduction from 40minutes to 20 minutes and in-turn increased the out-put to match the higher requirement of the lean assembly line.

The team also introduced the system of Pre-assembly of the box before it is sent for powder coating. This will allow the powder coating section to send all the sheets forming the box in kit form to assembly area.

Heat Exchangers

Heat Exchanger was identified as the critical component for assembly. The team observed a lot of variation in the model and heavy physical strain during the process. This led to the delay in supply to assembly. Also, the system of puf filling was tedious and the operator has to wait for the curing to continue is work for the next one.

With the lean concept and kaizen knowledge gained through the assembly implementation, the GEM team could themselves implement the lean flow in this section. They separated the area for the bigger heat exchanger and for the smaller one. In the area of puf filling the team created two or three fixtures for puf filling. This resulted in on time In full supply of heat exchangers to assembly line.

Other Components

A bill of activity has been introduced along with the bill of material as per the variation in the model of the Air dryers. The assembler has to verify the materials with the bill of materials and take them for assembly. This has really reduced the Semi-finished Air dryers on the shop floor.

Pull: Specific areas have been earmarked for each component with space for one day stock.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After	Improvement
Material Movement (ft)	1000	500	50% reduction
Cycle time in Ref Dryer Assembly (min)	68.5	34.25	50% reduction
5S Score	48%	64%	16% increase

Business Level Benefits

The process level results in turn combined to benefit Gem Equipment's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos/day)	7 per cell	20 per line	285%
On Time In Full Delivery %)	80%	100%	25%
Manpower Productivity	34	46	35.3%

The benefits obtained have spurred, the unit company to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

8 MSME : General Engineering- Solar Energy Products

BACKGROUND

The Unit manufactures solar energy based products like water heaters, street lamps and home lighting systems. Solar water heater is the main product and MAS manufactures two types - Evacuated water tube heater and Flat plate collector based heaters.

The lean journey commenced with an initial discussion with the Director of the company to understand the vision and mission of the organization. It was mutually agreed that focus would be on making a lean value stream for evacuated water heaters which could later be replicated by MAS to other product families as and when required.This was followed by a process walk through and study of the key processes that comprise the value stream of the evacuated tube heaters. The goals finalized for the lean implementation project.

1. To improve the productivity of the evacuated tube heaters from 40 nos per month to 80 nos per month.
2. To reduce the through put time from 4.5 days to less than 2 days.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map. Evacuated water heaters are produced 10 units per week. Production is carried out in batch processing. Cutting, bending and welding are carried out in the batch of 10 nos. powder coating is done externally.

The VSM was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

Measure	UoM	Current	Target
Customer Requirement	(Nos/month)	40	80
Demand Rate	Nos per day	1.6	302
Takt Time (one batch every)	Minutes	**300**	**150**
	Available resources		**Cycle Time**
	Machines / Workstation	**Manpower**	**(Minutes)**
Process 1 – cutting	1	1	1
Marking, drilling, bending	1	1	12.7
Process 2 – welding	1	1	16
Process 3 – Power coating- Out Sourced			
Process 4 – Tank cutting, punching	1	1	4
Process 5 – Folding	1	1	4
Process 6 – Welding	1	1	78
Process 7 – Leak test			
Process 8 – Outer Tank assembly		1	10
Process 9 – Puff filling	1	2	5
Process10 – Cleaning & packing		1	5
Total time per unit output			**135.7 min**

Total time per unit output	135.7 minutes
Throughput time	52.3 days (25095.7 minutes)
VA Ratio	0.54%

Baseline Study

At the time of the diagnostic study (January 2011), the production rate for Evacuated Tube heater was on an average 1.5 units per day; while the market potential was much higher, the company actually having to limit orders taken. Based on the business plan for FY 2011-12, it was decided that daily production target would be set at 4 units per day which translated to a takt time of 120 minutes per heater. From the diagnostic assessment it was clear that there were no constraints to achieve the target.

Focus Areas

Cycle Time: Welding is the critical activity, the total welding operation taken 94 minutes and there is only 1 welder. Improving the method would help reduce strain and cycle time.

Inventory: Semi finished components are waiting before welding, pre and post powder coating and even before packing. This is because of mismatch of parts required to complete a set – water heater + stand. Synchronization and maintain standard inventories will improve flow.

Strain: There was significant material movement in the shop floor (about 150 ft). Also, the sheet forming operations required 3-4 people to hold the sheet for which they would leave their regular work.

System Potential:

From the initial observations of the shop floor, a production capability of at least 40 units per week (7 per day X 6 days) could be envisaged which is four times the current production capability. Currently the value adding ratio is only 6.3% which suggests that there is a huge scope for improvement. During the year long lean implementation, it was decided to double the current capacity and have a capability to make 4 water heaters per day.

A lean roadmap was then prepared to help achieve the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Layout:*** Material is not flowing. Stagnation of material visible before and after the process – material movement – 200 ft.	**Flow *analysis, Workstation design, Muda and Muri elimination.***									Improvement in flow, 25% reduction in the material movement.
2	***Single Piece Flow:*** Establishing Single Piece Flow in pre & post powder coating operations.	Analysis of the cycle times of the operations ***and line balancing.***									Productivity improves by 100%.
3	Strenuous manual welding process resulting process variation and fatigue.	Simplify welding process, deskill to extent possible through Process study of the welding and designing of fixtures.									Reduction in cycle time, Improvement in productivity.
4	Standard work process sheets not available in any workstation.	Creation of work process sheets for standardization.									Less Process variations / reworks.
5	No specific area identified for raw materials and Finished goods.	Systematic arrangement of raw materials & Finished Good area with product kits (ready to dispatch).									Easy traceability and visual controls.
6	Accumulation of WIP for Powder coating process.	Supermarket / system for handling outsourced activity of powder coating-Kanban.									WIP reduction – before and after powder coating area.
7	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke.***									Pull based production.
8	***Synchronisation***	Align support activities with flow production – Establish ***SOPs, visual management, monitoring systems***, etc.									Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all employees in the unit. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by the physical presence of the owner during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An Internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as participated in all workshops as he would be responsible for sustaining and building upon this initiative in the long run. The champion has therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time in bottleneck activities through workstation design.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

Improvement Projects

Project 1. Change to Single Piece Flow Layout

The team observed the flow of materials from raw material to finished goods. The movement of material is zig-zag. This was creating lot of material transportation and human strain. This is because of few machines kept out –side.

We shifted those machines inside and placed to have clear Lean flow. The movement of material is automatic and passes through in the same premises.

Then, further activities like Folding, Welding, Leak test, Outer tank assembly, Puff-filling, Cleaning and Packing are taking place at the adjacent place. The criss-cross movement of material is avoided.

Project Results

By changing the layout, material movement has reduced from 150 feet to 15 feet.

Project 2. Reduction in Cycle Time of Bottleneck Operations

Welding of the tank was found to be the bottleneck operation during the VSM exercise. A cross functional team did a detailed observation of the welding operation and recorded the data in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

1. Welding

Observation : Sheets are initially tag welded. After checking the correctness, the full welding takes place. This is a case of over processing and the double activity increased the cycle time of welding operation. The welding was done on the floor with one person had to holding the rolled sheet to maintain uniform gap - this was highly unsafe and error prone activity.

Action Taken : A welding stand has been used.

2. Welding on Floor

Observation : In-let and out-let pipe has to be welded on the cover and the same has to be again welded on the tank. This is more time consuming activity and very streneous job. If suppose the holding is not correct, there is every chance of cross welding and will not be able to match the tank.

Action Taken: Welding fixture was designed to work at a comfortable level without bending. Fixture was made such that the operator should work on one side of frame only once. This reduced the strain and could get quality welding.

Project Result: Welding cycle time reduced from 15 minutes to 12 minutes.

Project 3. Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the sheet preparation process. They came out with non-value activities like operator movement, marking and setting before the cutting/drilling/bending/ punching/Pressing, etc., operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analysed in detail and kaizen based solutions were discussed and implemented for these.

Observation (before)

Four people are needed to lift and hold the sheet while doing the pressing.

After Kaizen

Suitable table fabricated to hold the sheet, only 2 people can do the pressing now.

Observation (before)

Punching activity is being carried out with the help of 4 people.

After Kaizen

Suitable stand fabricated to hold the sheet.

Project 4. 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit were included and the concerned people trained. Two 5S audits were done by the management consultant to support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Stands for water heaters kept on the floor.

After 5S Proper stand fabricated and the stands are kept and according to the capacity wise. Stock position can be seen at a glance.

Observation (Before 5S)

Puff filling wood cark scattered around and there is chance of missing.

After 5S

Puff filling wood cark arranged in a fabricated rack and any cark missing is avoided.

Observation (Before 5S)

Earlier Dies and Fixtures are not placed at one particular place. It was creating lot of strain in searching the same.

After 5S

Dies and fixtures are properly placed with a marking.

Observation (Before 5S)

Ther is oil spill on the floor.

After 5S

Oil collector placed under the machine at the exact place.

Project Results: The unit scored 38% in the first 5S audit which rose to 80% in second audit.

Project 5. Lean Planning, Scheduling and Material Management

Having started one piece flow manufacturing of heater, the planning and scheduling also needed to be changed to be Lean. The system was redesigned to fit in and increase flexibility as well as support customer deliveries on time in full.

The company started a production planning especially, weekly planning and where-in they plan to produce the heaters based on the delivery dates.

The material flow based on orders. Only materials which require more lead time or quantity based orders are only kept stock. The lead time of most of the materials is < 2days these are made available as and when required. The concept of ' No Kit No Cut' has been established

- Work stations created with clarity .
- Place of activity has been specified.
- Material storing racks has been fabricated and materials are identified.
- Post powder coating stock will be based on kanban system.
- Man- Hours production monitoring system established
- Production monitoring board has been placed.
- SOPs available for each critical operation.
- Process flow chart displayed.

Project Result:This has helped the company to achieve 4 Evacuated Heaters per day.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material Movement (Feet)	150	15	
Cycle time in Welding Operation (min)	15min	12min	20% reduction
5S Score	38%	80%	42%increase

Business Level Benefits

The process level results in turn combined to benefit Modern's business as a whole in the following aspects:

Parameter	*Before*	*Current*	*Improvement*
Production rate (Nos/day)	*2*	*4*	*200%*
On Time In Full Delivery %)	*50%*	*100%*	*200%*

The benefits obtained have spurred Mas Solar System to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

9 MSME : General Engineering-Hospital Furniture

BACKGROUND

The Unit is manufacturing hospital furniture including cots, ICU cots and related accessories like trolleys and tables with the brand name of Meridian. The company owned and managed by Mr. Rajamahendran and Mr. Thirugnanam who have been in the field for over a decade.

At the time of initiating lean implementation, the company was facing severe delays in deliveries and as a result losing its reputation with customers. While the order book was full, Modern was unable to deliver the requirement on time and in full quantity. The management had its fire fighting on a daily basis to follow up and dispatch material and spending a lot of time in pacifying customers. Prioritizing orders each day based on customer urgency led to a vicious cycle resulting in unfinished material stranded everywhere on the floor. Because of this, Modern was unable to take new orders and have slowed down their marketing activities.

The main issue being delivery delays and inability of the factory to handle additional volumes, the owners set the following business goals for the year 2011-12:

1. To increase production capability by 100%.
2. To streamline the factory and set up a system driven manufacturing process.

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported Modern through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Since the company makes multiple products, it was agreed that the concept of lean would be implemented and demonstrated for hospital cots which is the high volume and high growth potential product family. It was agreed that implementation could be internally extended later to other product families by Modern. Keeping in mind the twin business goals, the current state of the manufacturing process was defined in a Value Stream Map for the Hospital Cots.

The VSM was made using actual cycle times measured for each activity involved in the cot manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

Measure	UoM	Current	Target
Customer Requirement	(Nos/month)	50	100
Demand Rate	Nos per day	2.0	4.0
Takt Time (one batch every)	Minutes	**240**	**120**
	Available resources		**Cycle Time**
	Machines / Workstation	**Manpower**	**(Minutes)**
Process 1 - Tube cutting for cot parts	1	2	4155
Round Pipe Processing - Leg Support, bows, screw cover and nut	1	2	475
Process 2 - Sheet Cutting for cot head & bed	1	2	5535
Process 3 - Angle Cutting	1	2	665
Process 4 - Flat Cutting	1	2	750
Process 5 - Frame welding	1	2	1450
Process 6 - Head Piece Welding	1	2	2500
Process 7 - Final Frame Assembly			
Process 8 - Powder Coating – Outsourced			
Process 9 - Final Packing	1	2	900
Total time per unit output			**135.7 min**

Baseline Study

At the time of the diagnostic study (January 2011), the production rate for hospital cots was on an average 2 units per day; while the market potential was much higher, the company actually having to limit orders taken. Based on the business plan for FY 2011-12, it was decided that daily production target would be set at 4 units per day which translated to a takt time of 120 minutes per Cot. The diagnostic assessment now focussed on whether the company had sufficient potential within the existing resources to achieve this level.

1. Value Adding Ratio

Out of 81 activities noted for cot assembly, during the day, only 56 activities were value adding and the other activities included *Muda* like material transport, motion, marking and setting. This meant that there existed a scope to eliminate or minimize about 30% of the total activities and thereby reduce the cycle time.

2. Space

Of the total available covered Floor Space Area (FSA) totalling 6475 sft., the space utilized for value addition came to only 1100 sft or about 17% of the total available FSA. Sufficient space was therefore available for any expansion required to produce at a higher rate.

3. Human Resources

33% of the total man-hours was spent on non value adding activities and this meant that this time could be freed up for actual conversion work by eliminating the *Muda*.

System Potential

Based on the VSM and above analysis it was clear that Modern could produce at least 6 cots per day using the existing resources. It was therefore very much possible to achieve the twin business goals by implementing lean. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	Out of 81 activities noted for cot assembly, during the day, only 56 activities are value adding others are being movement, marking and setting.	Eliminate the non-value adding activities of movement by work station design and re layout and establishing the flow.									Reduction of throughput time by 10% from 226 mins to 200 mins.
		Reduce the setting / marking time by using Kaizens and SMED principles.									Further reduction of through put time by 30% from 200 min to 140 mins.
2	**Cutting and Welding** are the major activities consuming 47 minutes and 23 minutes respectively.	Improve the processes and reduce the cycle time by workstation design and kaizens.									Doubled output from 2 cots to 4 cots a day.
3	Holding materials in the form of Semi-finished goods for completing the urgent orders.	Establish the Heijunka or Level scheduling and Kanban, minimise the inventory level (WIP and OSP components).									Reduction in inventory carrying cost by 33% and freeing up of floor space by 20%.
4	Create Pull	Takt based production, Kaizen, 5S, Poka-Yoke									Pull based production.
5	Synchronisation	Align support activities with flow production – Establish SOPs, visual management, customer order monitoring systems, etc.									Lean Manufacturing – streamlined and system driven process delivering required output.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their

physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time in bottleneck activities through workstation design.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

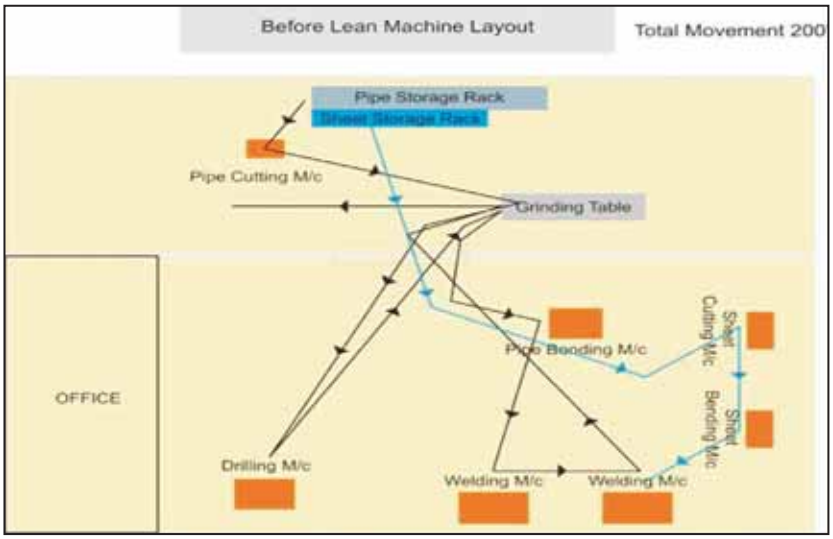
Improvement Projects

Project 1 - Change to Single Piece Flow Layout

The existing process was observed by a cross functional team right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant. The processing has three main parts:

1. Sheet, tube preparation and welding of cot frames.
2. Powder coating (done outside at a vendor unit).
3. Final assembly and packing.

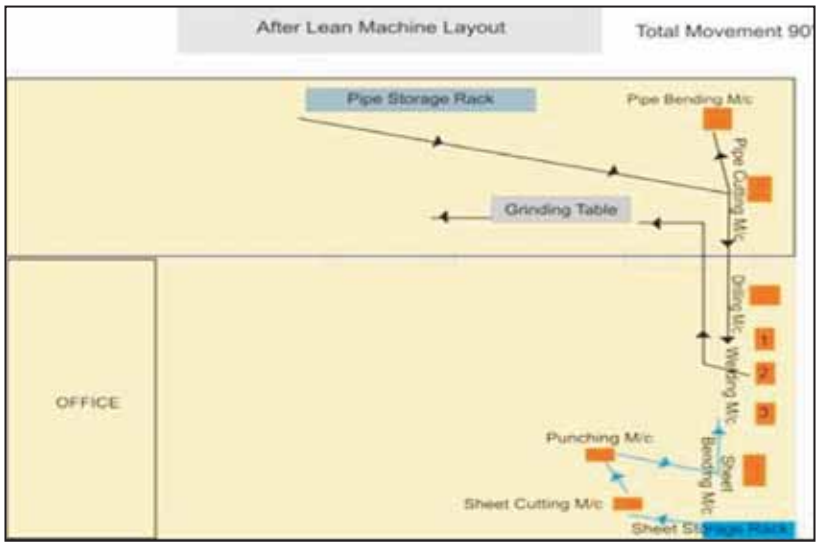
The team recorded that the material moves 200 ft altogether inside the premises during the process and prepared a material flow diagram (shown below).



The team analysed and found the root cause(s) of the material movement to be

1. Grouping of machines type wise for e.g. all welding machines together.
2. As machines were added, they were located wherever space was available.

The solution implemented at once – machines / workstations were moved and aligned in accordance with the sequence of operations. The space cleared by reducing WIP was utilized to bring down the stores from the mezzanine floor. The changed layout is shown below:



Project Results

By changing the layout, material movement has reduced from 200 feet to 80 feet.

Project 2 - Reduction in Cycle Time of Bottleneck Operations

Welding of the cot was found to be the bottleneck operation during the VSM exercise. A cross functional team did a detailed observation of the welding operation and recorded the data in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

1. Tag Welding

Observation : Frames are initially tag welded. After checking the squaring correctness, the frames are welded on the fixture. This is a case if over processing and the double activity increased the cycle time of welding operation.

Root Cause: No provision to ensure 90 degrees corners

Action Taken : A fixture with clamping arrangement was made on a work table. The frames were then fixed on to the table automatically ensuring the right angled corners and welded straightway avoiding tag welding totally.

2. Welding on Floor

Observation : Welding the cot frame was a tedious job – keeping tubes on floor, operator has to go in and out of the frame to several times just to weld one frame.

Root cause: Welding at floor level means operator has to sit down and therefore sits inside the frame for ease of reach.

Action Taken: Welding tables were designed to work at a comfortable level without bending. Fixtures were made such that the operator should work on one side of frame only once. Cut tubes are fed to the welding table in a trolley and the completed frames will be put on another trolley for next operation.

3. Welding Torch Handling

Observation: After each side, operator had to keep the welding torch down on the table and pick it up again which was strenuous and unsafe.

Action Taken: A stand was provided at the corner of the table to keep the Welding Torch thereby reducing the strain of reaching for the torch from the center of the table each time.

Project Result: Welding cycle time reduced from 47 minutes to 30 minutes.

Project 3 - Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the entire process from raw material cutting until completion of welding. Out of the 81 activities noted, 56 activities were found to be value adding. The other 25 activities included Muda like operator movement, marking and setting before the

cutting/drilling/bending operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analysed in detail and kaizen based solutions were discussed and implemented for these.

Measuring, Marking and Checking Each Piece

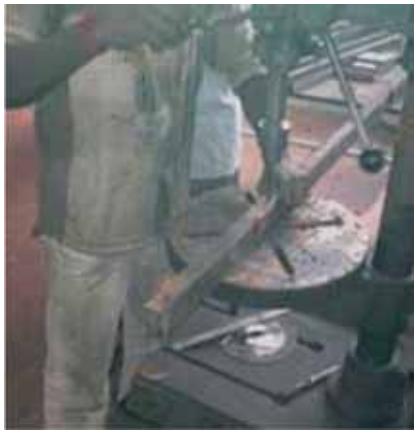
Observation	Measuring, Marking & Checking takes as much time as actual cutting or drilling
Why? 1	The material has to be cut into different lengths, holes drilled at specified distance and bending to 90 deg for frame making. The points have to be marked after measurement.
Why? 2	Without marking the point of cutting/drilling/bending cannot be accurately found out. Marking cannot be done without measurement.
Why? 3	No other provision available for directly locating the points.
Solution	Provide template based fixtures so that the tube/sheet can be directly clamped and cut/drilled/bent.

Observation (before)

Measuring and marking piece on floor before drilling operation. Strain to the operator making it likely for him to make errors.

After Kaizen

Operator using locating fixture to directly drill the piece while standing comfortably.



Observation (before)

The bows which form the head of the cot are bent and drilled separately. They are difficult to handle.

After Kaizen

A fixture was made in which the bow can be checked for proper bending and drilled simultaneously with ease.

Observation (before)

Bow hole is drilled after forming the frame; the frame is large and difficult to handle.

After Kaizen

The hole is now made during initial drilling using the template made for this purpose.

Project Result: The total number of activities reduced from 81 to 60.

Project 4 - 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Tools were scattered at various locations; operators had to search for tools.

After 5S

Tool board made and all tools placed in marked location making it search free and visible.

Observation (Before 5S)

The fly press was kept outside far from the sheet cutting and bending machines. Tools are jigs were not arranged.

After 5S

The press brought inside the flow - near to the sheet cutting and bending machines. All the jigs and tools are arranged near to the press - easy to pick up eliminating searching.

Observation (Before 5S)

There was no WIP area designated. There were more WIP and stored all over the floor.

After 5S

WIP area earmarked.

Observation (Before 5S)

The output sheets from sheet cutting machine will fall on the ground - making it difficult to pick up sheeets from the ground. Sheets will be picked up one by one and transported to punching machine or bending machine.

After 5S

A trolley was provided at the collection point so that the cut sheets will fall one above another. It became easy to move the sheets through the trolley to the next workstation.

Project Results: 5S score increased from 57% in first audit to 75% in second audit.

Project 5 - Lean Planning, Scheduling and Material Management

Having started one piece flow manufacturing of cots, the planning and scheduling also needed to be changed to be lean. The system was redesigned to fit in and increase flexibility as well as support customer deliveries on time in full.

Customer Order Processing

A system for monitoring and follow up of customer orders was designed and implemented. A format is designed with the work order number as the base and with committed date and present status for follow up. As part of visual management, this follow up mechanism is displayed in a larger board at the conference cabin - visible from the CRM / Marketing, Purchasing department cabins.

Planning and Procurement

Optimum monthly production volume was arrived based on expected demand. A matrix of product types and relative number of units planned was worked out. For the entire product mix, BOM was updated and from the BOM, the monthly raw material requirement was arrived – variant wise.

Based on supplier lead time, the materials are grouped into two –

- Daily purchase materials are those that can be procured within one day and this comprises > 95% of items. These will be procured one day before they are required as per production plan.
- Stock Materials have lead time of 15 to 30 days and constitute 5% of total items. Orders will be placed on reaching minimum defined stock level, generally once in 15 days.

It was found that in stock materials, the variants of a product family (say for example cots) share 95 % as Common Materials and only 5% are unique components. For the Common Stock Materials, their monthly stock requirements are fixed as +10% of planned quantity. For Special Stock Components, the monthly requirement was fixed as +20% of the planned quantity of the sub group.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement	Impact on Business
Material Movement (Ft)	200	80	60% reduction	Reduced strain and increased productivity.
Welding cycle time (minutes)	47	30	36% reduction	Increased output.
Cutting cycle time (minutes)	23	15	35% reduction	Increased output.
Throughput time (min)	200	80	60% reduction	Reduced inventory levels and cost, faster delivery.

Business Level Benefits

The process level results in turn combined to benefit modern's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Production Rate (Nos/day)	2	8	30%	Turnover goes up by fulfilling more orders.
Man -Productivity (cots per person per day)	0.5	2	300%	Cost per cot reduced.
Floor Space (sq. ft) usage	6000	2000	66% free	Space available for further expansion.

The benefits obtained have spurred, Modern to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

10 MSME : Light Engineering- Brake Drums

BACKGROUND

The Unit (RF) manufactures and sells brake drums for trucks and buses. Their principal customers are large OEMs. Exports constitute a significant portion of the volume – around 60%. Brake Drum manufacture involves two main processes – casting and machining. RF has a foundry unit which produces castings and a machine shop to finish the machining activity. After this, painting and packing are carried out in a separate shed located in the premises.

At that time, Foundry unit was producing enough molten metal to pour 15~16 boxes with a melt cycle time of 70 minutes. The boxes were allowed to cure for 24 hours. After this the casting is shot blasted and sent for machining. In the machine shop turning, drilling and tapping activities are carried out in the casting.

The lean journey commenced with a preliminary discussion with the Director of the company. This was followed by a plant walkthrough to study the key processes. The following goals were decided for the lean implementation :

1. To improve the machine shop output from 120 nos. to 180 nos. per day.
2. To reduce the defect rate by 25% (from 8-11% currently to less than 5%).

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Since the company makes multiple products, it was agreed that the concept of lean would be implemented and demonstrated for the high volume and high growth potential product family. It was agreed that implementation could be internally extended later to other product families by the unit. Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map.

The VSM was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target		
Customer reqmt	(Nos / month)	5000	6000	Working days per month	25
Demand rate per day	Nos	200	240	Working hours per day	21
Takt time	(min)	6.3	5.3		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Turning 1	1	1	7.00	120	35	245	90%	162.9
Turning 2	1	1	20.0	180	9	180	86%	54.0
Drilling & Tapping	1	1	5	120	12	60.6	90%	225.7
Turning 3	1	1	10	180	24	240	86%	108.0
Varnishing		1	0.5		25	12.5	100%	
Red Oxide Painting		1	0.8		0		100%	

	Cycle time	C/O time	WIP
Total time per unit output (seconds)	43.4	600.0	738.1
Throughput time	1741.5	minutes	
VA ratio	2.49%		
Cell capacity (bottleneck)	54.0		
No. of cells	3.0		
Plant Capacity	162.0		
Constraint	Yes		
Bottleneck process(es)		Turning 2	

Baseline Study: **Machine Shop**

Based on the cycle time of the bottleneck operation – turning 2, the production was about 3 drums per hour. Combined with machine availability, current production level was 20 drums per shift per machine centre and 120 drums per day for all the machine centres put together.

Focus Areas

Cycle Time: For the product observed, 3 turning operations were done and 1 drilling and tapping was done. Each operation has different cycle times (7, 20, 5 and 10 mins). This leads to material getting stagnated in the shop floor.

Setting Time: The setting times in the turning centres was anywhere from 2-3 hours, thereby reducing available time of the machine.

System Potential

By reducing cycle time of turning 2 operation and setting change time, a 50% increase in production could be envisaged.

Baseline Study: Foundry

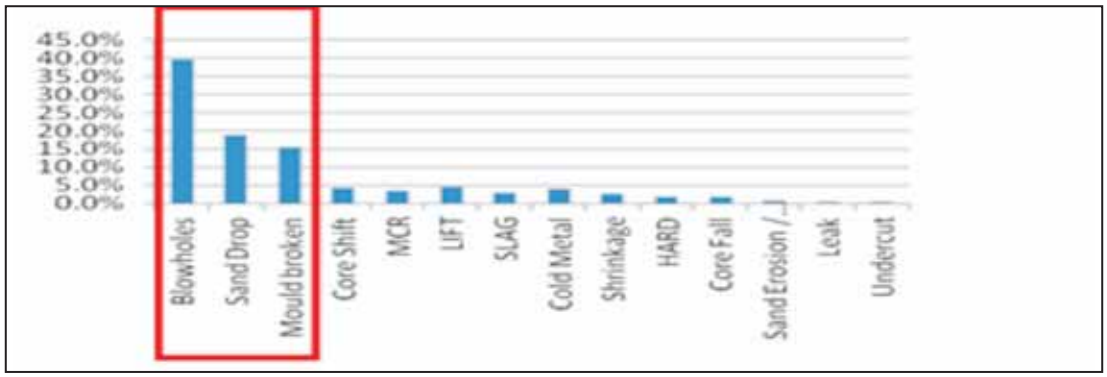
Focus Areas

Strain : The improvement in foundry working conditions by reducing the dust and sand particles in the air was identified as a key to better quality and productivity.

Temperature Variation: Molten metal is heated up to 1550°c before poured in the ladle which disperses the molten metal in small quantities to enable the pouring. Temperature at the last box reached around 1300°c (after 15 mins).

Overall there is an 11% rejection of the moulds. Blowholes, Sand drops, Mould broken are the top 3 defects constituting to nearly 73% of the defects. Addressing these 3 defects will improve the overall quality levels of the unit.

Pareto Analysis of the Defects:



System Potential

A reduction in defects to the target level is possible through controlling process variations. However, in the lean project, it was mutually decided to work on dust reduction.

A lean roadmap was then prepared to implement and achieve the final objectives.

LEAN ROAD MAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Cycle Time :*** variation in cycle times between Turning 1, 2 , Drilling and Tapping and Turning 3 operations (7, 20, 5 and 10 mins respectively) – leading to material waiting between operations.	***Line Balancing*** in the machine shop covering the turning and drilling operations.									Reduction in the cycle times – smooth production flow matching the takt time of 7 mins.
2	***Transport*** : Excessive material movement in the shop floor – nearly 120 feet movement.	***Layout modification*** in the machine shop and paint shop to reduce material movement.									25% reduction in material movement.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
3	***Setup Time:*** High setting time – nearly 2 hours – less available time for processing.	***Single Minute Exchange of Dies (SMED***) for reducing the setup time.									Reduction in setting time to less than 20 mins.
4	***Quality:*** High rejection rates – 11% - top 3 defects constitute 73% of the defects – Blowholes, Sand drop and Mould broken.	***Root cause analysis / Ishikawa diagram*** – to reduce the defects emanating from process and methodologies.									Reduction in defect rates (from 11% to 8% - overall basis).
5	Dusty, Dirty working conditions.	***Identify source of contamination and arrest the same.***									Better housekeeping and improved morale of the employees.
6	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke.***									Standardisation and Pull based production.
7	***Synchronisation***	Align support activities with flow production – Establish **SOPs, visual management, monitoring systems**, etc.									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation / experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance / Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified for each area at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Changeover time reduction.
2. Reduction in cycle time in bottleneck operation of turning.
3. Identification and elimination of sources of dust in foundry / shop floor.
4. Quality Problem solving for foundry rejections.
5. 5S for standard work practice.
6. Lean planning, scheduling and material management.

Improvement Projects

Project 1 - Reduction in Change Over Time

Loading and Unloading Time

Before

In turning 2, loading and unloading of the heavy drum occupied a significant part of the total cycle time.

S. No.	Activity	Cycle Time (min)
1	LOADING	2
2	CYCLE TIME	17.1
3	UNLOADING TIME	1
Total Time in Seconds		20.1

After

Non value adding time reduced by arranging quick loading and unloading arrangement with separate area for input & output material and keeping ready next drum during the on-going machine cycle. Between CNC 1 and CNC 2 permanent pathway arranged to avoid operators strain.

S. No.	Activity	Cycle Time (min)
1	LOADING	0.5
2	CYCLE TIME	17.1
3	UNLOADING TIME	0.4
Total Time in Seconds		18.4

Setting Time

The setting times in the turning centres are nearly 2-3 hours, which would reduce the available time of the machine.

The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified. Internal and External activities are separated. Trials were taken.

Before:

Setup time

High setting time – nearly 2 hours – less available time for processing.

After :

Single Minute Exchange of Dies (SMED)

for reducing the setup time, SMED is implemented & a SMED trolley is fabricated to keep necessary tools and fixture, etc.

Before : The tools for change over were scattered around the machine consuming more time during change over.

After: Area for tool table was marked near the machine. All the required tools are identified and earmarked on the table to eliminate searching and reducing the time for change over.

Kaizen in Change Over Time Reduction

As a part of changeover / setting time reduction in the CNC machines, the down time during chuck cleaning observed. The details are as below -

1. **Goal**: To reduce chuck cleaning which takes more than 7 hours.
2. **Observation**: Usually metal shavings and sand get trapped inside the chuck and we need to clean it every fortnight.
3. **Root Cause Analysis**: It was found that there is some gap between the clamps and the base allowing the chips and sand inside.
4. **Action Taken:** A small plate was welded to cover the gap.

Before : Scrap and sand inside the chuck

After : Welding the Plates

Project Results

1. The machining cycle time reduced from 20 minutes to 18.4 minutes and
2. Setting time in CNC machine reduced from 120 minutes to 70 minutes.
3. Time loss due to chuck cleaning (per machine) reduced from 3 hours per month (7 hours per cleaning every alternate months) to half – an – hour per month (2 hour per cleaning once in four months)

Project 2 - Reduction in Cycle Time in Machining

The production volume was constrained by the cycle time of turning 2 operation. IN addition , the variation in cycle times between Turning 1, 2, Drilling and Tapping and Turning 3 operations (7, 20, 5 and 10 minutes respectively) resulted in material waiting between operations. The existing process was observed by a cross functional team. A *Muda* observation was done and the cycle time of turning 2 operation was recorded in detail as shown below:

The team then came up with kaizen solutions for the major Muda.

Before :

Reduction in cycle time in turning operation – Machine Shop. Cycle time – 17.10 minutes.

After :

Reduction in tool travelling and indexing time – overall reduction of 1 minute. Cycle time – 16.05 minutes.

Project Results : Reduction in cycle time in turning operation from 18 mins to 17 mins.

Project 3 - Identification and Elimination of Sources of Dust in Foundry / Shop Floor

This required observation of the points of the dust generation, marking of the points and then taking action to avoid dust generation and spreading.

Observation (Muda/Muri/Mura)

The following areas were identified and actions were taken to eliminate dust formation and spreading:

Bucket Elevator (B/E) Top drum Chain sprocket Side, B/E Cell Top Side, B/E chute Side Joint, B/E Chute Side Plate Holes, B/E Chute Side Plate Gaps, Polygonal Sieve chute, Polygonal Sieve Body Hole - (North Side), Polygonal Sieve Centre Area Holes, Polygonal Sieve Inspection Door.

Action Taken

Individual areas are marked and necessary actions were taken to eliminate dust generation and spreading. Dust leakage points are marked in paint and action taken on them.

Observation (Muda/Muri/Mura)	Action Taken
About 62 leakage points were identified in the sand preparation area and foundry which creates and spreads the dust.	Nearly 53 points were closed within the three days and 18 points Significant reduction in the dust spreading. Especially from the mezzanine area of the sand preparation.

***Project Result**:* Various sources of the dust generation are identified. Corrective and preventive actions are taken in many areas. As a result, the reduction is dust level is visible in the shop floor.

Project 4 - Quality Problem Solving for Foundry Rejections

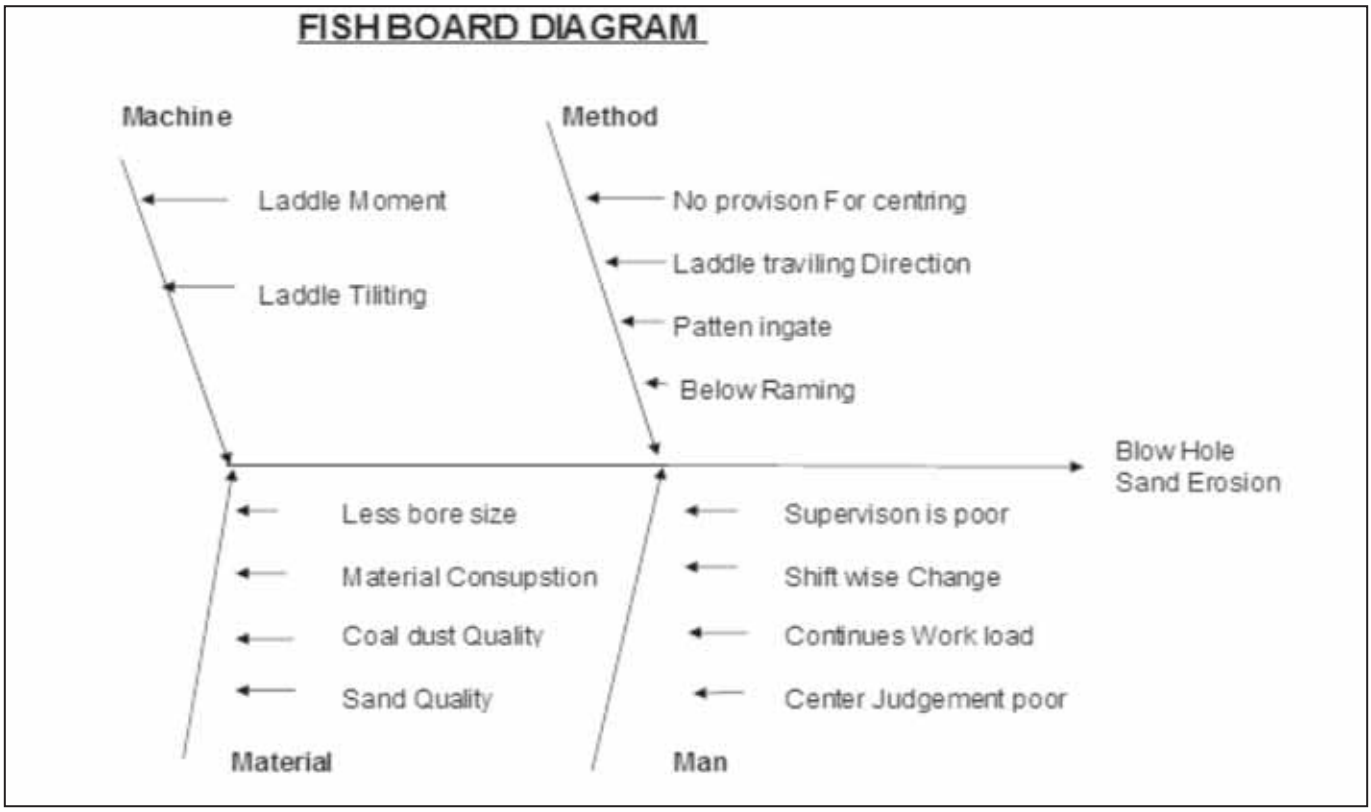
The cross functional team spent a day in observing the entire process from raw material addition into the furnace, moulding, mould making etc.

Root cause analysis / Ishikawa diagram – arrive at actions to reduce incidence of foundry defects.

Operators and Supervisors are trained on Quality Problem Solving Techniques with the Kaizen Approach and with the 6 Sigma structure of DMAIC. One of the recent quality rejection was taken as an example and root cause analysis was done with Why-Why analysis and Fish bone diagram.

Why-Why analysis

Date 18.05.11	LEAN (PROBLEM SALVING)	
	ITEM :	BD310
	Poured :	226nos
	Rejection:	46nos
	Rejection : Max - 8%	
	This item :	20.0%
	Different :	12.0%
1)	WHY :	1). Blow Hole 2). Sand Erosion
2)	WHY :	1). Blow Pouring 2). Interrupt Pouring 3). Low Temp 4). Ingate Problem 1). Sand Quality 2). Sand Moisture 3). Sand Temperature
3)	WHY :	1). No provision for centring 2). Due to operator 3). Ladle movement 4). Design fault
4)	WHY :	1). By Design 2). – 3). Movement Problem / extended movement 4). Design
	Required data For This Item :	
1).	Day wise Rejection in Foundry & Machine Shop	
2).	Compare in Bay 1 & Bay 2	
3).	Bore Size Comparison	
4).	Ladle Maintenance Data	
5).	Sand Properties Record	
6).	Continues Working for labour	
7).	Pattern ingate Comparesion	
8).	Temp°Checking Data	



Based on the analyses, CTQ parameters are identified and a system for monitoring those CTQs is devised.

The following are the corrective and preventive measures proposed based on the Kaizen Problem Solving session –

S.No.	Problem	Possible Cause	Kaizen Proposal
1	Blow Holes	Delayed pouring due to centring	To provide a funnel like structure above the mould (could be moulded during the pattern pressing) to prevent the need for centring.
2	Blow Holes	Low Temperature	It was suggested to check the temperature from last but second or third box itself (instead of checking before last box).
3	Blow Holes	Time delay in pouring. The melt in the ladle has to be poured before 15 minutes from transfer.	It is proposed to have a hooter with the time set for 15 minutes. If there is any need to pour after the set time, those boxes have to be marked and inspected with additional care.
4	Sand Dropping	Boxes hit one another on the walls.	Provisions to be made (like projections seen in between two train comportments) for the larger boxes to prevent hitting on the walls (can hit through the base).

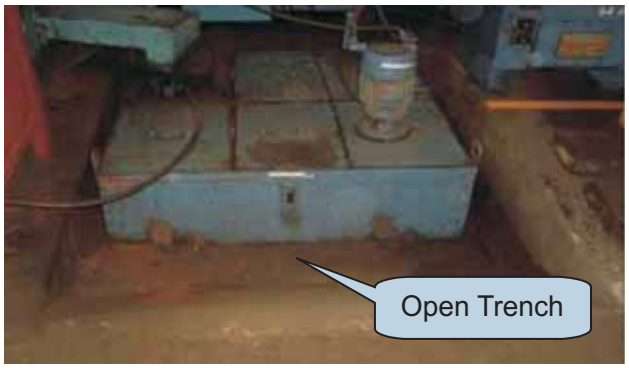
The following are CTQs and are to be monitored and monitoring system was accordingly devised.

1. Sand Quality Parameters
2. Temperature of the melt
3. Control of Mould Pattern movement (to and fro tool room for modification)
4. As a part of preventive measure, the operator dependent CTQs like
    a. quantity of sand added while making the mould.
    b. duration of pressing of moulds.
    c. no. of vibration given for settling of sand before moulding.
    d. instances of rework / patch work after removing the mould.
    e. moving the boxes on rail joints, etc.

Project 5 - 5S for Standard Work Practice

To standardize the work practices set in after improvement, 5S was implemented by the team. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by The Management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion. Teams were formed and practical training on 5S and AM given to team members by the management consultants. The changes made were fine tuned and standardized through audits in month of September.

Before : The coolant tank located near the machine below the level of the ground (trench). – Unsafe Condition.



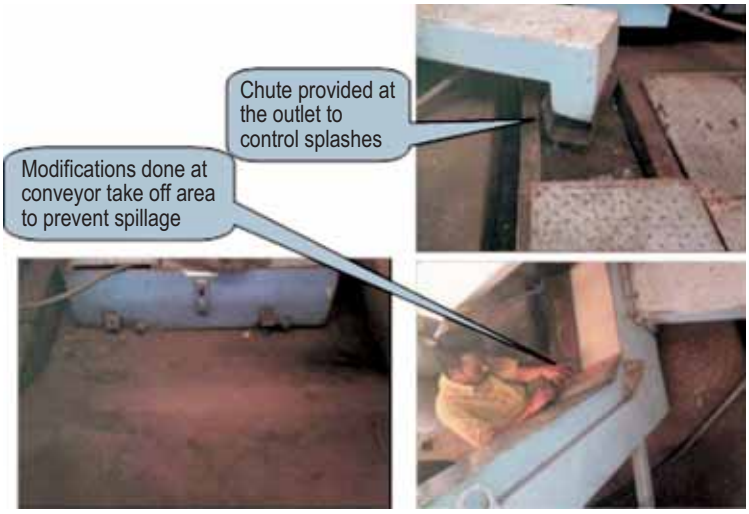
After: The trench is closed and the area around the machines is earmarked and gangways are marked for material and operator movement.

Before : The metal scrap from the machine are collected in a stationary bin and transferred to a mobile bin using a spatula. This resulted in spillage of metal shavings around the machine.

After: The scrap bin height increased – and an opening was provided in the stationary bin so that the shavings can be easily transferred to the mobile bin without spillage.

Before : The return coolant got splashed at the receiving tank. The coolant spread all over the floor around the machine. The metal shavings conveyed through the conveyor also got spilt around the machine.

After: Modifications done in the machine and conveyor trunk and outlet. Now the machine and surroundings remains clean and cleanable.



Other Improvements

There was no clear indications and location marking for the materials rejected and material under rework. Rejection and Rework areas marked.

Ear Marking and Visual Inidcations are improved.



Project Results :The unit got a 5S score of 44% in first audit which increased to 55% in second audit.

Project 5 - Lean Planning, Scheduling and Material Management

Production Planning – Machine Utilisation Chart

A machine engagement chart was prepared in the form of a matrix using which plant in-charge comes to know at a glance which machines are running and which orders are running as per plan. This chart has been made visual.

A model Machine Utilisation Chart

Production Planning And Scheduling

S. No.	Part No.	Qty	I Op	II Op (SF)		Drilling			Finishing					Total
			Bom. Lathe	VTL	Herbert	RV	HMT	Natco	Bom Lathe (III Op)	CNC-1	CNC-2	CNC-3	CNC-4	
1	BD120	84											27	27
2	8015	30										10		10
3	546	111	30		22.5			10.5	19					82
4	546	49			9.5			4	8					21.5
5	2506	38	11	17			10		3					41
6	783	23	5.25	5			6		4.25					20.5
7	774	66					13					15		28
8	541	36	9		7			3.5	6					25.5
	Total		55.3	22	39	0	29	18	40.3	0	0	25	27	

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement
Turning 2 cycle time reduction	20 minutes	16 minutes	20% reduction.
Down Time due to chuck cleaning	3 hours per month	Half hour per month	2.5 hours increase in machine availability.
5S Score	44%	55%	11% increase.

Business Level Benefits

The process level results in turn combined to benefit RF's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Production Rate (No.s/shift) @ machine shop	24	28	16%	Turnover goes up by fulfilling more orders.

11 MSME : Light Engineering- Brake Drums-B

BACKGROUND

The Unit (RSM) is in the business of manufacturing and selling of Brake drums for trucks and buses. Their principal customers are large OEMs. Brake drums are manufactured through 2 main processes – casting and machining. RSM has a foundry unit which produces castings and a machine shop to finish the machining activity. Painting and packing is carried out before the items are dispatched.

Foundry unit can produce enough molten metal to pour 25~30 boxes in 1hour 10 mins (70 mins). The boxes are allowed to cure for around 1 day. After this the casting is shot blasted and sent for machining. Turning, drilling and tapping activities are carried out in the casting, followed by painting and packing.

Following a discussion with the owner, it was decided to focus the lean implementation on the machine shop only as this was the constraint, with the following goals:

1. To improve the output from 100 nos per shift to 120 nos per shift.
2. To reduce the setting time from more than 2 hours to less than 30 minutes.

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported RSM through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. The VSM was made using actual cycle times measured for each activity involved in the manufacturing process . The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target		
Customer reqmt	(Nos / month)	2250	3000	Working days per month	25
Demand rate per day	Nos	200	240	Working hours per day	24
Takt time (min)		7.2	6		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Turning	1	1	16.00	120	100	1600	83%	75.0
Drilling	1	1	5.4	180	100	540	79%	211.1
Tapping	1	1	3	120	80	208	83%	461.5
Painting	0	1	3	180	60	180	79%	380.0

	Cycle time	C/O time	WIP
Total time per unit output (min)	27.0	600.0	2528.0
Throughput time	3515.0	minutes	
VA ratio	0.77%		
Plant capacity (bottleneck)	75.0		
Constraint	Yes		
Bottleneck process(es)	Turning		

Baseline Study

Machine Shop: For the product observed, 1 turning operation and 1 drilling and tapping were required. Each operation had different cycle times (16, 5, 3 and 3 mins). This lead to material getting stagnated in the shop floor. Also the setting times in the turning centers being 2~3 hours reduced the available time of the machine.

Focus Area

Cycle Time: Turning cycle time of 16 minutes was the bottleneck and considering 2 machining centers, the takt time per machine was 12 minutes.

Changeover Time: High changeover time for turning CNC machine lead to more WIP on shopfloor and higher throughout time.

System Potential

From the initial observations of the foundry and the machine shops, about 120 brake drums can be manufactured per day. Foundry capacity is much larger catering to another unit also. Machine shop requires a takt time of 12 minutes to support this target.

A lean roadmap was then prepared to achieve the target goals.

LEAN ROAD MAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Cycle Time :*** Variation in cycle times between Turning , Drilling and Tapping and painting operations (16,5,3, and 3 mins respectively) – leading to material waiting between operations.	***Line Balancing*** in the machine shop by improving turning and drilling operations.									Reduction in the cycle times – smooth flow matching the takt time of 6 mins – Throughput to increase by 25%.
2	***Setup Time:*** High setting time – nearly 2 hours – less available time for processing.	***Single Minute Exchange of Dies (SMED***) for reducing the setup time.									Reduction in setting time to less than 20 mins.
3	Dusty, Dirty working conditions.	***Identify source of contamination and arrest the same.***									Better housekeeping and improved morale of the employees.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
4	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke***									Standardisation and Pull based production.
5	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all the key members of the machine shop. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An Internal kaizen champion was identified who has taken over the responsibility for sustaining and building upon this initiative in the long run. The champion therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Reduction in cycle time in machining.
2. Reduction in Setting Time in Machine shop.
3. 5S for standard work practice.

Improvement Projects

Project 1 - Reduction in Cycle Time in Machining

The existing process was observed by a cross functional team A *Muda* observation was done where the team. The team recorded that there was cycle time variation between turning, drilling and tapping operations during the process.

Observation (Muda/Muri/Mura)
Machine Shop: For the product observed, 1 turning operation and 1 drilling and tapping were required. Each operation has different cycle times (16, 5, 3 and 3mins). This leads to material getting stagnated in the shop floor.

Action Taken
Line Balancing in the machine shop by improving turning and drilling operations.

Indexing and Tool travelling was observed as Muda in CNC machines 3 & 4.

S. No.	Activity	Cycle Time (min)
1	LOADING	2 Min
2	CYCLE TIME	12 Min
3	UNLOADING TIME	2 Min
Total Time in Seconds		16 Min

By observation & program change, the indexing and travelling time reduced by 1 minute.

S. No.	Activity	Cycle Time (min)
1	LOADING	18 Sec
2	CYCLE TIME	12 Min
3	UNLOADING TIME	17 Sec
Total Time in Seconds		12 Min 35 Sec

Project Results:

- The cycle time per product with turning, drilling and tapping reduced from 16 minutes to 12.35 minutes.

Project 2 - Reduction in Change Over Time

The setting times in the turning centres are nearly 2-3 hours, which would reduce the available time of the machine.

The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified. Internal and External activities are analysed. Trials were taken.

Before

Setup time

High setting time – nearly 2 – 3 hours, reducing the available time for processing.

After

Single Minute Exchange of Dies (SMED)

for reducing the setup time, SMED is implemented & a SMED trolley is fabricated to keep necessary tools and fixture, etc.

Arranged temporary table near CNC 3 and CNC 4 to reduce loading and unloading time.

The tools for change over were scattered around the machine consuming more time during change over.

Area for tool table was marked near the machine. All the required tools are identified and earmarked on the table to eliminate searching and reducing the time for change over.

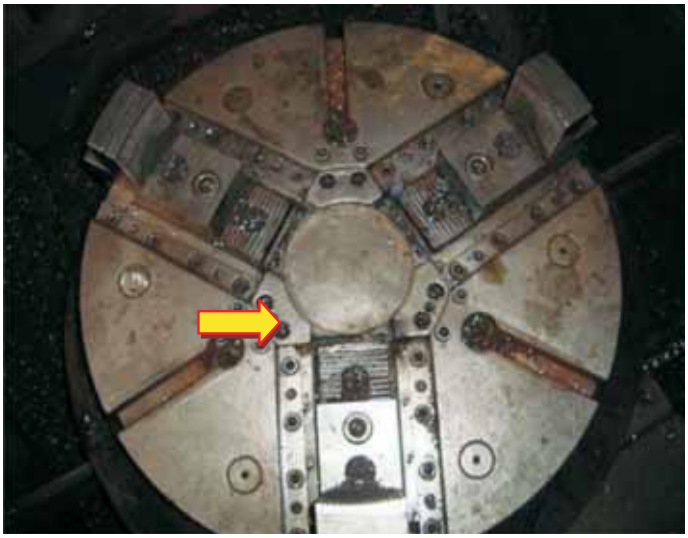
Kaizen in Change Over Time Reduction

As a part of changeover / setting time reduction in the CNC machines, the down time during chuck cleaning observed. The details are as below -

1. **Goal**: To reduce chuck cleaning which takes more than 12 hours.
2. **Observation**: Usually metal shavings and sand get trapped inside the chuck and we need to clean it every fortnight.
3. **Root Cause Analysis**: It was found that there is some gap between the clamps and the base allowing the chips and sand inside.
4. **Action Taken:** A small plate was welded to cover the gap.
5. **Result**: 10 hours per month of lost machine time can be gained by avoiding need for chuck cleaning.

Scrap and sand inside the chuck

After Welding the Plates



Project Results

- In machining, Loading and Unloading time reduced from 240 sec to 35 sec.
- Time loss due to chuck cleaning (per machine) reduced from 12 hours per month (12 hours per cleaning every months) to 1 hour per month (2 hour per cleaning once in two months).
- Improvement in productivity by 6 pieces more per day achieved.

Project 3 - 5S for Standard Work Practice

At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion. Teams were formed and practical training on 5S and AM given to team members by the management consultants. The changes made were fine tuned and standardized through audits in month of September.

Before : Storage areas are not marked with location indicators and addresses.

After: All the materials in the machine shop are systematically arranged. Gangways and material storage areas are marked with yellow lines. All the storage areas are identified.

Before : The coolant tank located near the machine below the level of the ground (trench). – Unsafe Condition.

After: The trench is closed and the area around the machines is earmarked and gangways are marked for material and operator movement.

Before : There was no place designated for handling equipment like trolleys, scrap bins, and cleaning equipment, etc. Whenever there is a need for material transport or cleaning, operators had to search for a trolley.

After: Area designated near the machines for keeping the trolleys and pallet truck during their rest. The practice got institutionalized and now there is no need for searching for a trolley or cleaning equipment.

Area designated for keeping the trolleys / pallet trucks at rest.

Before : The rejection area was away from the machines and not clearly earmarked. There are no indications and lack of total control over the rejected material.

After: Rejection area is marked near each machine so that the rejected materials are identified, analysed and disposed off every shift. The information on rejections and the trend of rejections are displayed at the machine to increase the awareness to operators.

Rejection area is marked near every machine.

Quality Board is displayed near the machines.

Project Results:The unit got a 5S score of 47% in first audit which increased to 68% in second audit.

SUMMARY OF RESULTS OBTAINED

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement	Impact on Business
Reduction in cycle time in turning operation – Machine Shop (mins)	16	12.35	23% reduction	Increased output.
Time loss due to chuck cleaning (per machine)	12 hours per month (12 hours per cleaning every months)	1 hour per month (2 hour per cleaning once in two months)	92% of cleaning time saved.	Increased output.
5S Score	47%	68%	21% increase	Reduced inventory levels and cost, faster delivery, increased Morale and Safety.

12 MSME : General Engineering-Plastic Components

BACKGROUND

The Unit is a manufacturer of various plastic components used in spinning mills, the major ones being ring tubes, bobbin holders, separators, pulleys, etc. It has 9 injection moulding machines used for making the components. Bobbin holders go through a further assembly process after which they are packed and dispatched. The assembly unit was in a different location from the moulding unit and both were shifted to the new facility along with the machine shop during February 2011.

Diagnostic Study

The diagnostic and lean road map setting exercise commenced on 30th December 2010 with an initial meeting with the Directors to understand their vision and strategic goals for the business in the next three years. The following goals were set out for the year long lean implementation exercise:

Assembly – to increase the output of bobbin holders from 1900 per day to 3000 per day.

Moulding – to increase OEE of injection moulding machines to world class level of 85%.

In Moulding unit, it was mutually agreed that the focus initially would be on making one critical machine a model and the concepts could then be laterally deployed to other machines by the unit team. Moulding machines IMM6 was chosen based on its performance; repeatedly failing to meet customer deliveries on time.

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

The VSM for assembly process was made using actual cycle times measured for each activity involved in the manufacturing process . The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM of assembly is shown below.

		Current	Target	
Customer requirement	(Nos / month)	1032	1165	Working days per month 25
Demand rate per day	Nos per day	1900.0	75000	Working hours per day 8
Takt time (min)		15	10	2100 pc/d (Takt time of 14) achieved by over time.

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Deflashing	5	5	90	1	100	25.3	100%	1600.0
Lever Assly	1	1	10	0	30	7.6	100%	2880.0
Racet Pressing	1	1	9	0	57	14.4	100%	3200.0
Jet Spring Assly	2	2	17	0	150	37.9	100%	3388.2
SS Balls Assly*	1	2	16	1	40	10.1	100%	1800.0
Stickering	1	1	4	0	150	37.9	100%	7200.0
Dust Cup Assly	2	2	16	0	100	25.3	100%	3600.0
Washer+Dimond Nut+ Con slider	1	1	16	0	20	5.1	100%	1800.0
Pinning	1	1	12	0	20	5.1	100%	2400.0
Final Inspection	1	1	5	0	0	0.0	100%	5760.0

	Cycle time	C/O time	WIP
Total time per unit output	3.3	2.0	168.5
Throughput time	173.8	minutes	
	0.4	days	
VA ratio	2%		
Plant capacity (bottleneck)	1800.0		
Constraint	Yes		
Bottleneck process(es)	Deflashing Lever Assembly SS Ball Assembly Washer Diamond nut & Cone assembly Pinning		

BOBBIN HOLDERS ASSEMBLY

Baseline Study

The average production rate was 1900 units per day; the target agreed was 3000 units per day with a takt time of 10 seconds per piece. The bottleneck processes with cycle time more than takt time are De-flashing (5 components), Lever Assembly, SS Ball Assembly & Pinning, Washer - Diamond nut & Cone assembly.

The production was done batch wise with operators sharing the load to achieve current production volume.

Focus Areas

VA Ratio

Value adding ratio is only around 2% which means that of the total time that the material spends in the factory 98% of the time, the material is idle in the form of WIP.

Cycle Time

The cycle times of the bottleneck operations are to be brought down to below 10 seconds in order to achieve the target. The assembly operations were imbalanced as a result of which the effective value adding ratio for the operators was only 48%. That meant that 52% of the time was spent in non value adding activities or waiting.

Layout

Each bobbin holder travelled a distance of 120 feet during the course of its assembly. It was stored in multiple locations (16 storage points) and handled an extra 15 times more than required for actual operation. This extra transportation, handling and storage (WIP) was one of the causes for low value adding ratio and productivity.

System Potential

Based on the VSM and physical observation **it was felt that the productivity and production volume could be doubled** through a combination of flow manufacturing, cycle time reduction in bottleneck areas and line balancing.

During the cluster lean implementation, it was targeted to enhance the production to the business target of 3000 bobbin holders per day by making improvements as per the roadmap below.

MOULDING MACHINE IMM6

Baseline Study

At the time of project initiation, the production was 6400 pieces per day average; the target agreed was 8000 per day with a takt time of 11 seconds per piece.

Focus Area

A 25% increase in production volume was required to meet the target. Observation of machine cycle time showed that 80% of the cycle was processing time while non value adding component was less than 20%. However, the current OEE is 68% and by increasing this to a level of 85% we can increase the output by 25% and meet the target. ***Hence the focus area would be to increase the equipment OEE.***

This could be done by working on and improving the parameters of availability, performance and quality and details are mentioned in the roadmap below.

System Potential

The OEE analysis and plant observations showed that **there was a potential for increasing the moulding unit output by 25%, with the existing facility and resources**.

During the cluster lean implementation, this would be demonstrated on one critical machine IMM6 and the same concepts could later be deployed to other machines to realize the overall potential.

Lean roadmaps for Assembly and Moulding were then prepared separately, which would be a step by step guide towards the final objectives.

Lean Roadmap for Bobbin Holder Assembly

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	Excessive material handling, 15 times more handling than required, 16 storages and 120 ft of movement of component due to batch process.	Establish single piece flow manufacturing / single person workstation based on suitability.									80% reduction in through put time from 174 min to < 30 min.
2	Bottleneck processes have cycle time higher than takt time.	Reduce cycle time of each process to < 10 seconds by eliminating workstation MUDA and MURI using Operation analysis and Workstation design.									Increase in production volume by 700 pcs/day.
3	De-flashing is a non-value adding activity by itself – also takes more time and effort.	Standardize input material by controlling product from moulding machine.									Reduced time and resource requirement – free resource for material feeding.
4	People have to move to storage area for picking up components. Sometime lost in searching for and accessing required items.	Use 5 S concepts to organize material storage area systematically and introduce material feeder concept.									Material feeding will increase operator availability for assembly work and help increase volume by another 400 pcs/ day.
5	FG storage is not organized and inventory levels are varying. Difficult to count FG.	**Create Pull** – define FG storage levels and create physical storage.									Reduced FG inventory by maintaining only specified levels.
6	Synchronisation	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Standardized and smooth running assembly operation consistently delivering required output.

Roadmap for Moulding Unit – Pilot Implementation on IMM6

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	**Availability** – There is a setting change in each machine every alternate day. The time per changeover 120 minutes.	Apply SMED principles and reduce changeover time to less than 30 minutes.									3% increase in availability and potential volume increase of 90 pcs/day.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
2	50% of the available space is being occupied by raw materials, Dies, tools, etc. which are stored haphazardly. Operators search for tools and open the bags of material to identify and take what they need.	Apply 5S principles to organize storage as per the requirement. Introduce visual control systems for sustenance.									Avoid searching for material. Tools, dies. Minimize movement and handling time which will help reduce changeover time.
3	***Machine Performance*** The machine gives only *3 pcs per shot* instead of 4 which comes to 75% of the rated capacity because of problem in die.	Analyze root cause and take counter measure. Planned Maintenance for dies to avoid recurrence.									20% increase in OEE and volume by 1200 pcs/day.
4	***Material Yield (Quality)*** The rejection rate is approximately 1% mainly occurring at start-up	Improve start up procedure and process control									Reduced rejection rate (<0.5%), 0.3% increase in OEE, increase in volume by 30 pcs/day
5	***Machine Downtime*** Machine breakdown is on an average 15 minutes per day.	Improve equipment condition and availability through good maintenance practices – AM and PM.									Reduced down time.
6	***Availability*** Power shut down of 2 hours plus 1 hr to preheat the input material after restart; losing 4.5 % of the available time.	Reduce the time for preheating (<10 mins) by process up gradation.									3% increase in availability. Increase in volume by 300 pcs per month.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

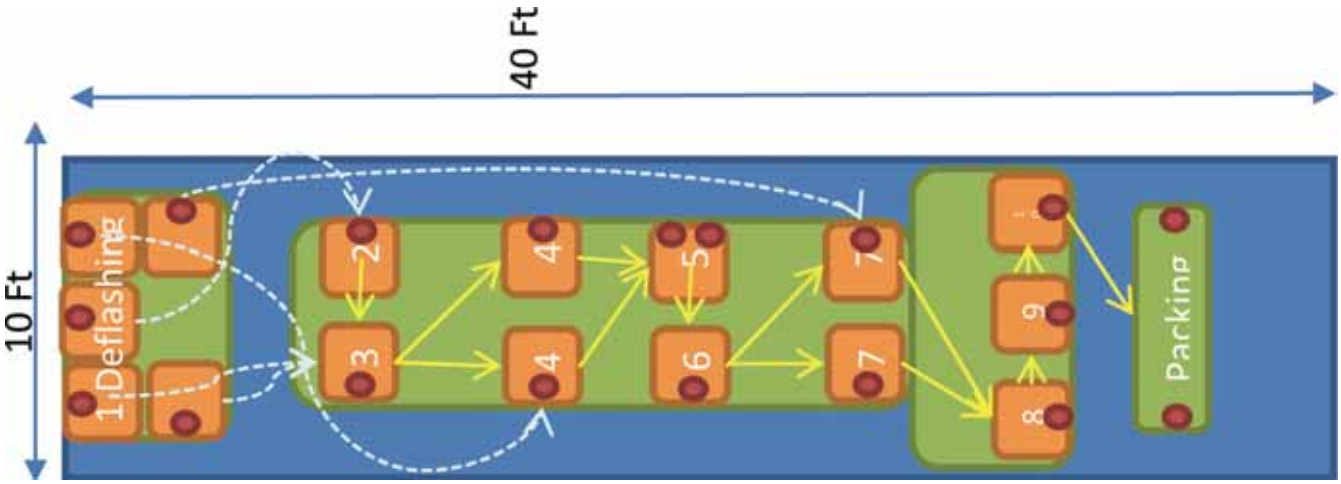
A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. In Assembly,
   a. Change from batch layout to single piece flow layout.
   b. Reduction in cycle time in bottleneck activities through workstation design.
2. In Moulding,
   a. Increase machine availability by reducing the change over time.
   b. Increase machine availability by reducing machine down time and
3. In both the areas, implement 5S for standard work practice.

Improvement Projects

Project 1a - Change to Single Piece Flow Layout in Assembly

The existing process was observed by a cross functional team. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant. It was recorded that the material moves 120 ft altogether inside the assembly floor during the process with handling of 22 times and with 16 storage points. The diagrammatic view of the layout at that time is below:



Observation (Muda/Muri/Mura)

Layout - The assembly was done in batches. Large tables occupied the assembly area both for storage and working.

Action Taken

Layout has been changed for one piece flow in the assembly.

Components were stored in a random manner causing mix up, searching, criss - cross movement of hands.

The required numbers of components were stored in small bins in the sequence of their assembly in all the workstations.

Project Results

By changing the layout, the throughput time got reduced from 174 minutes per bobbin holder to 5 minutes.

Project 1b - Reduction in Cycle Time of Bottleneck Operations in Assembly

A detailed observation was done on the cycle times of assembly process. Variation in number of activities resulted in variation of cycle time. The line was balanced through realignment of some activities such as:

- Ratchet fixing cycle time was less than that of body assembly. The activity of inserting the inner into the body was shared with the Ratchet pinning activity from the body assembly.
- Sticker pasting - with the least cycle time with 4 sec. – was made to share the first 3 activities (Washer, square washer and spring insertion) of the next process (cup assembly) with higher cycle time of 16 sec.
- In the SS ball assembly, the rotation of the bobbin was checked twice – once before pinning and then after pinning. It was changed to one time checking – only after pinning.

Project Results

The cycle time of the bottle neck operations were balanced to the takt time of 8 seconds.

Parameter	Before	After
1. Body Assembly	**17 sec**	Balanced 8 sec
2. Dust Cup assembly	**16 sec**	Balanced 7 sec

Project 2a - Increase Machine Availability by Reducing the Change Over Time

The team spent a day first observing the entire process of Moulding. There is a setting change, taking 120 minutes, in each machine every alternate day resulting in a decrease in machine availability. The team decided to reduce changeover time using SMED concepts. A mould change was observed and recorded both on camera and using the SMED activity analysis format. The major observations and implemented solutions include.

Observation (Muda/Muri/Mura)

There are no systematic arrangements of tools / dies. Dies are scattered.

Action Taken

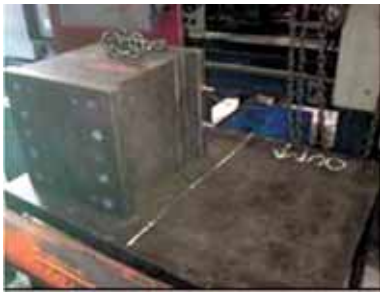
Systematic arrangements of tools and fixtures has been done closer to the machine, where die changing is done.

It was observed that strain is involved while handling the crane.

The handling arrangement upgraded for easy handling of the crane, by providing separate handle for easy turning of wheels.

The removing and fixing the dies involves strain.

Provided two separate tables of suitable height for incoming die and out outgoing die for easy change over.



Project Results :

Change over time got reduced to 25 minutes from 90 minutes, increasing the availability of the machine by half an hour every day.

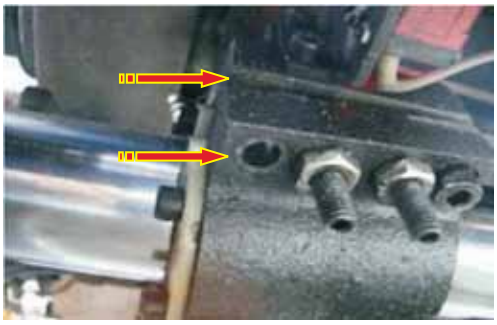
Project 2b - Increase Machine Availability by Reducing Machine Down Time

Visual COTI

The pilot machine under our study IMM4 was brought under Autonomous Maintenance and the COTI points were made visual.

The sources of contamination were identified. Powdered RM flies off from the diverting slit of the hopper during the operation. As a countermeasure, localisation of contamination was discussed and implemented.

The team then worked on identifying the root cause. A thorough cleaning of the problematic area of the machine was done by the team. It was observed that, the problem is due to improper tightening of the side screw and accelerated by the jerk of the hopper casued by screw missing in the shaft scuff. Corrective actions were taken appropriately.



Training given on visual COTI –

1. To use checklist for daily cleaning.
2. To mark the moving parts – which are to be checked for lubrication daily and to be lubricated weekly - with Green.
3. To make a list of fasteners to be checked / tightened daily and display the same on the machine and to mark the spots with stickers.
4. To prepare a one-point lesson on tightening the side screw.

OEE

The team and along with the operators of the moulding were trained on the concept of OEE.

Appropriate forms and tools for OEE data collection, calculation and monitoring were provided. Principle, Model and Method of calculation.

Overall Equipment Effectiveness

OEE = (%)	Availability x	Performance Rate x	Quality Rate
62.6			
Availability	Planned run time (Hrs)	Down Time (Min)	Change Over (Min)
82.3	24	195	60
Performance Rate	Units Produced	Design Cycle Time (Sec)	Actual Run Time (Min)
76.9	810	10.25	180
Quality Rate	Total Output	Defects	
99.0	810	8	

Daily OEE Computation Sheet (upto 4 variants per day)

Visual Monitoring : For better monitoring and control, the OEE graphs were made and displayed at the machine.

Project Results:

1. Machine down time got reduced.
2. Machine effectiveness is being monitored using OEE.

Project 3 - 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. In the same way in the machine shop, the machine down times were controlled and change over times were reduced. At this stage 5S was implemented by the team keeping in mind the arrangements required for flow manufacturing in assembly and machines in Moulding. 5S is a cultural change issue and hence all parts of the unit was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Before: Components are stored and handled all over the assemly table.

After: Appropriate bins provided at each workstation and the workstation and the maximum quantity to be stored are marked on the table.

Before : Finished, Semi Finished, incoming components were stored without identification. It was difficult to locate the required material.

After: Racks are used efficiently so that the FG stored systematically, identified and easy to handle. The Semi-Finished components are stored in bins clearly identified with bin numbers and location identified on the Location Map Board.

Before : Components are stored hapazhardly. Difficult to check the availability and stock level. Difficult to locate the materials.

After: All the component storage racks were identified and the storage area for each component is marked. Sample components were displayed in the component label itself so that items can be traced with no time without even knowing the name; especially for items which are covered / packed in boxes. Take me cards are placed to ensure FIFO.

Before : In moulding, materials are scatterly stored on the floor with out proper identification and searching for was inevitable.

After : Unwanted materials cleared off, required materials arranged systematically with proper identification and location marking. Searching is eliminated. This would help in reduction of set up time.

Before : Raw Materials were kept in stores without identification in different places.

After : The storage areas are identified and clearly marked to facilitate easy identification and picking up. Reduction of startup time loss.

Before : Dies are stored together without identification. Identifying and picking up was difficult and needed supervision during die handling. Contributed considerably to high change over time.

After : Dies are arranged systematically. All the dies are labeled and their storage locations are marked on the rack. One of the available three cranes was dedicated for handling the dies to and fro the die rack. Change over time reduced.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement	Impact on Business
Throughput time (min) in assembly	174	5	97% reduction	Reduced inventory levels and cost, faster delivery.
5S score	57	75	18%	Increased safety, morale and productivity.

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Production rate (Nos / day) in assembly	1900	2200# 3600*	#Achieved 16% *Demonstrated 90%	Turnover goes up by fulfilling more orders.
Change over time in moulding (min)	90	35	61%	Production time increased by 30 mins per day.

13 MSME : General Engineering- Fabrication of Oil Tanks

BACKGROUND

The Unit is a 20 year old fabrication unit and recognised suppliers to large organizations like Elgi Equipments and Suzlon, manufacturing products like Oil and Air receiver tanks, Wind mill spares etc. Being an OE supplier, there is immense pressure on delivering a quality product in time and at the lowest cost. Srirang has three main product groups – oil and air receiver tanks, tanks for Suzlon and railway accessories.

The lean journey commenced with a discussion with the Directors to understand the company's vision, strategy and business goals for the next couple of years. These are:

1. To increase the oil sump tank production volume by 20%.
2. To reduce the working capital burden by minimizing the WIP inventories.
3. To inculcate the habit of lean thinking and continual improvement amongst all the employees.

For the pilot lean implementation in cluster, it was mutually agreed to focus on oil sumps which is the largest volume product with potential for growth. The concepts could later be deployed by the srirang team for other products.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported srirang through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the business goals, the current state of the manufacturing process for oil sumps was defined in a Value Stream Map.

The VSM was made using actual cycle times measured for each activity involved in the compressor manufacturing process. The inventories, number of operators involved were also physically verified on the shop-floor.

Measure	UoM	Current	Target
Customer Requirement	(Nos/month)	80	100
Demand Rate	Nos per day	3.2	4.0
Takt Time (one batch every)	Minutes		**80**
	Available resources		**Cycle Time**
	Machines / Workstation	**Manpower**	**(Minutes)**
Process 1 – CNC cutting	1	1	3600
Levelling	1	2	900
Process 2 – Pressing & Rolling	1	3	1500
Process 3 – Sand blasting -Out sourced			
Process 4 – Fabrication- Assembly	2	2	23400
Process 5 – Cleaning	1	1	7200
Process 6 – Testing	1	1	3600
Process 7 – Painting	1	1	3600
Process 9 – Loading	1	2	900
Total time per unit output			**745 min**

Baseline Study

The study was carried out on the 1100/350 oil sump which is of average size and high volume. At the time of the diagnostic study, the production rate for oil sump was on an average 3 units per day. Based on the business plan for FY 2011-12, it was decided that daily production target would be set at 4 units per day which translated to a takt time of 80 minutes per oil sump. The VSM shows that the assembly process is the only bottleneck in achieving the target.

The diagnostic assessment now focussed on whether the company had sufficient potential within the existing resources to achieve this level.

Focus Area

Value Adding Ratio – is only 6% which means that of the total time that the material spends in the factory, the oil sump is idle for 94% of the time in the form of WIP.

People Productivity – 39% of time is spent in non value adding support activities including material handling and transportation.

Throughput Time – Almost 11 days, material was found waiting at different stages because of lack of flow in the manufacturing process.

Material Transport – The product being very large, the process is fully dependent on availability of overhead crane. The material flow has lot of criss cross movements which resulted in process delay due to waiting for crane.

System Potential

Based on the VSM and above analysis it was clear that the unit could produce at least 4 oil sumps per day using the existing resources. It was therefore very much possible to achieve the business goals by implementing lean. A lean roadmap was then prepared to achieve the final objectives.

LEAN ROAD MAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	Materials travelling from one end to the other end of the shop, outside for sand blasting. Lot of criss-cross movements in the welding, assembly and finishing sections as well. Depends on one crane. 	Re-layout the pre sandblasting operations and the post sandblasting operations to achieve flow.									Reduced throughput time by 50%. Increase volume to 15 sumps / day.
2	Lot of inventory observed before auto welding which is done after assembly. This is in-spite of assembly being the highest cycle time activity by far requiring 180 minutes considering two workstations in parallel.	Reduce cycle time in assembly through workstation design and connect in flow with auto-welding.									
4	Materials are heavy and difficult to handle. Materials found all over the floor without proper arrangements for storage or identification. 	Establish proper storage and handling system using 5S concepts.									Free up of space by 10%. Improved work safety and visual controls.
5	Synchronization - material is found in semi-finished state waiting for OSP components.	Synchronise components from OSP by linking schedules within house activities.									Zero loss in production due to material waiting
6	Standardization	Align support activities with flow production – Establish SOPs, visual monitoring systems, etc.									Standardized process capable of consistently delivering the required output.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all key employees of the unit. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as participated in all workshops as he would be responsible for sustaining and building upon this initiative in the long run. The champion learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change. A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time through workstation design.
3. Eliminating non value adding activities through kaizen.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

Improvement Projects

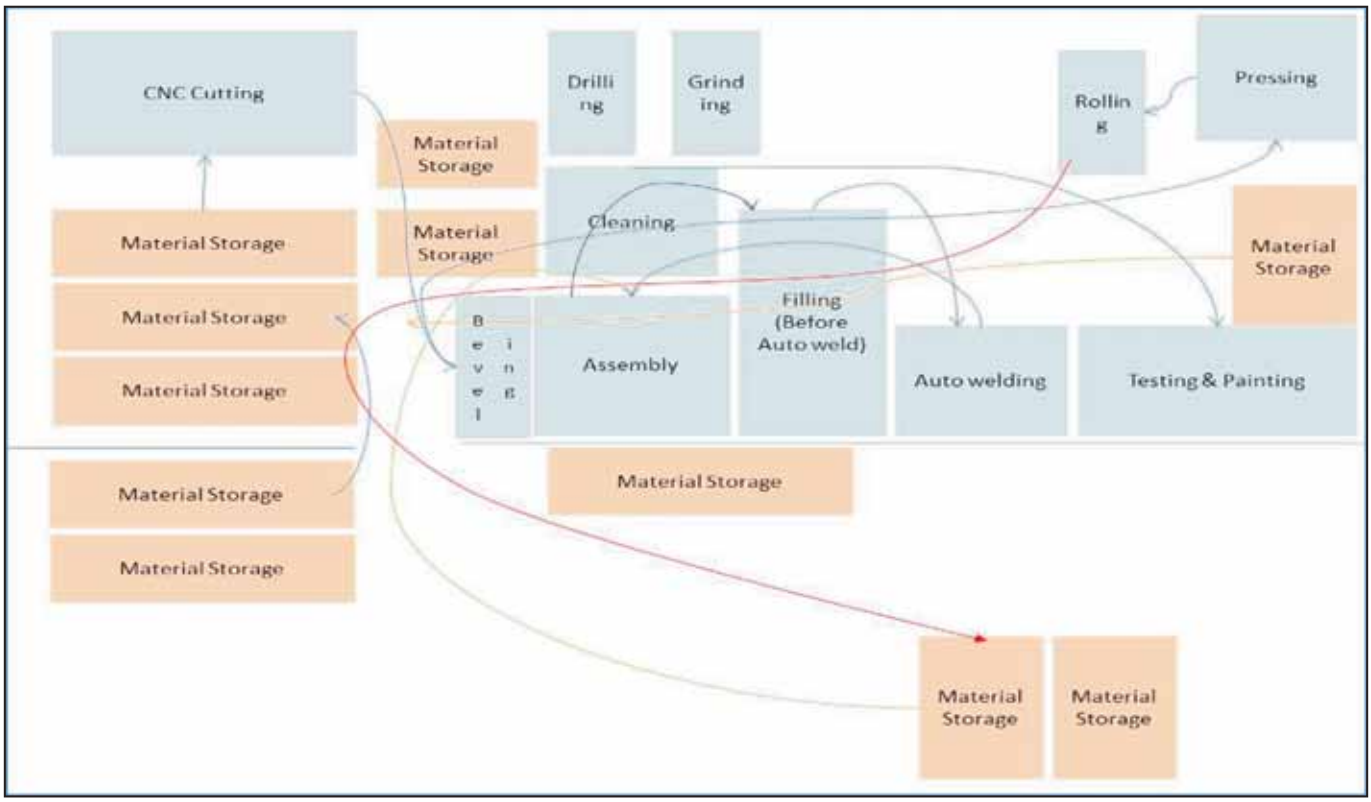
Project 1. Change to Single Piece Flow Layout

The existing process was observed right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant. The processing was done in four main stages:

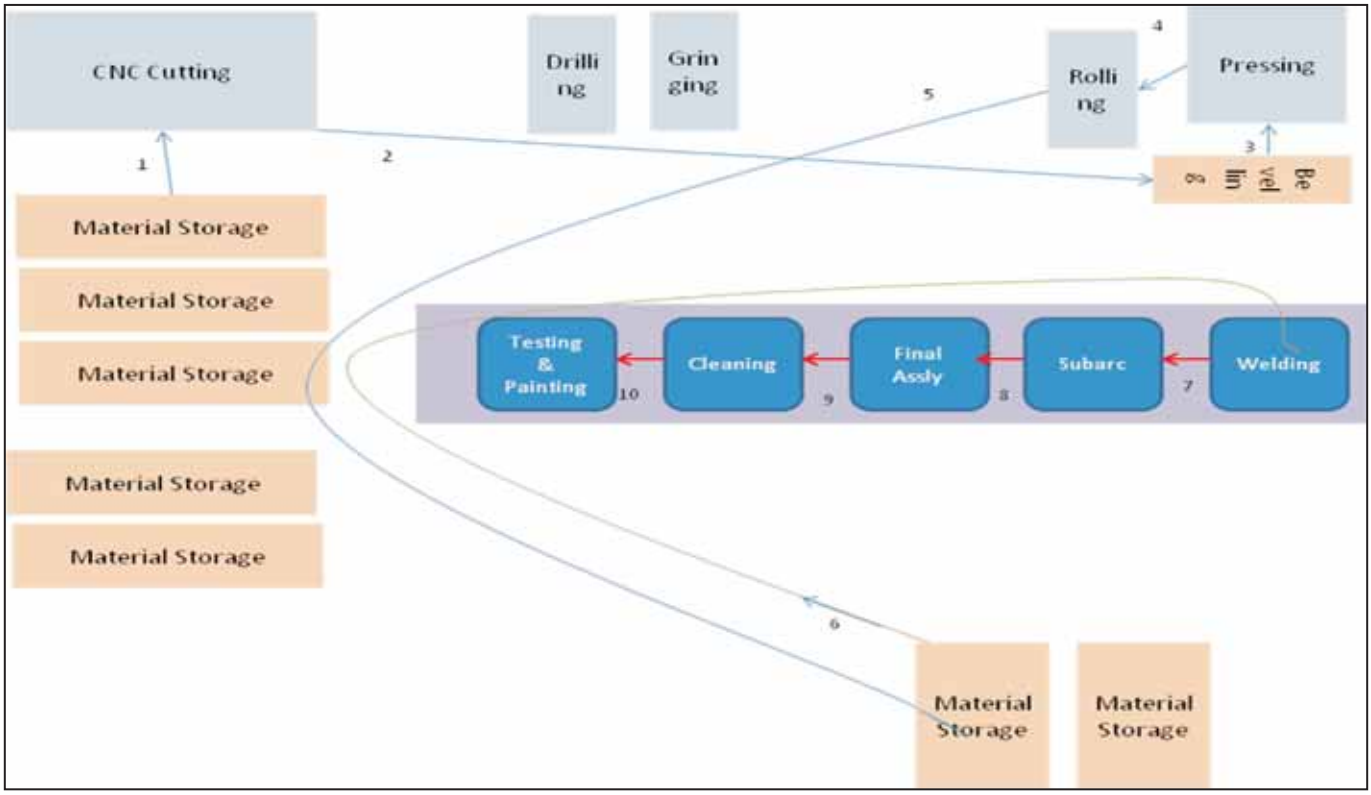
1. CNC cutting.
2. Bevelling, Pressing & Rolling – sheet.
3. Sand blasting- out sourced.
4. Final fabrication and assembly of tank/sump.

The team recorded that the material moved in a criss cross manner covering a total distance of 80 ft inside the shed itself. This was depicted with a spaghetti diagram. The team analysed and found the root cause was that the process workstations were not in the sequence of operations and were place in different parts of the shed. The team changed the layout to simplify and reduce material transport.

Before Lean



After Lean



Project Results

1. The material movement has reduced from 80 feet to just 15 feet.
2. Dependence of crane has reduced thereby minimizing waiting time and throughout time.
3. Reduced WIP means that the shopfloor could be better used for value adding activities.

Project 2. Reduction in Cycle Time

A detailed observation of oil sub tank fabrication and assembly which was the only bottleneck operation was carried out and the data recorded in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

1. Creation of Workstation

Observation (Before 5S)

Stands for water heaters kept on the floor.

Observation: During the observation it was found that lot of movement of materials from one place to other was taking place and creating lot of strain and also no clarity of activities for different tanks fabrication.

Root Cause: No defined sequence of process flow.

Action Taken: A work station created for each type of tank. The process flow was defined and welding operations were set in single work station reducing the dependence of over head crane.

Process Flow - The first welding operation, second sub-arc (or auto welding) and third final assembly welding were set up in single work station.

Single workstation for oil sub tank where all required tools provided for like cylinders, welding machine, fixtures, stands and material (kit) board.

2. No Kit No Cut Concept

Observation : The operators do their job with the materials available and keep the tanks fabricated in semi-finished condition if there is shortage of few materials.

Root cause : Material kit not available.

Action Taken: Bill of material Prepared and the materials arranged near the work station and "No Kit No Cut" concept introduced.

Material Kit

Project Result: In both the assembly process cycle time has been reduced drastically from 4hrs to 45minutes.

Project 3. Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the entire process from tank fabrication to final assembly. The team observed the value adding and non-value adding activities. The non-value adding activities included Muda like operator movement, bending operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analysed in detail and kaizen based solutions were discussed and implemented for these.

Observation (before)

Cut wastes in an un-organised way.

After Kaizen

The company used three bins one for using waste inside the factory, another for sale and the third one for scrap. This has reduced the strain in separating and transport.

Observation (before)

Discs not stored properly and creating lot of strain to the operator.

After Kaizen

Discs separated and kept in order and easy to retrieve.

Project Result: Considerable reduction in cycle time and throughput timefrom 4 hrs to ½ an hour.

Project 4. 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Shot blasted tanks waiting for fabrication - all sizes and models mixed up.

After 5S

Shot blasted tanks kept in a rack according to its variation.

Observation (Before 5S)

Production schedule not displayed,creating lot of confusion to the operator and not knowing the next job.

After 5S

Production schedule displayed and the operator is able to arrange for the next job.

Observation (Before 5S)

Quality voice board not displayed and the quality issue not known to the operators.

After 5S

Quality voice board displayed and any quality issue addressed to the operators.

Quality voice board displayed and any quality issue addressed to the operators.

Project Result: 5s score increased from 24% to 56%.

Project 5. Lean Planning, Scheduling and Material Management

Observation: Srirang was not following any formal planning system and that lead to lot of materials mis-match.In-turn creating semi-finished tanks.

Action Taken : Bill of activity prepared which helps the company to plan its activity and the materials requirements.

Bill of Activity

Activities	Materials	Sub-Assly	Purchase	Job order items
Pipe		Do	do	
Flange				do

Sub-Assembly

Items	Materials	Process
Pipe	Cut pipes	Cutting, welding, etc.,

Further the company has certain problem in procuring the materials led to delay in completion of tanks. A Why-Why analysis was done to find the root cause.

Why -1	Material process delay	
Why-2	Non-availability of material	
Why-3	Could not receive the material from laser cutting	
Why-4	Proper schedule not available	
Why-5	Customer did not release the schedule	The company has to get the schedule from the customer well in advance to avoid any process delay.

The company started to prepare the bill of activity and are in position improve its management.

Project Result : There is considerable reduction in materials and the delivery has been improved. Delivery has increased to the tune of 20%.

SUMMRAY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material movement (mtr)	100	20	80% reduction
Cycle time in Fabrication (min)	240	150	60% reduction
5s score	24%	56%	32%

Business Level Benefits

The process level results in turn combined to benefit Coimbatore Compressor's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos/day)	2.5 Nos	4 Nos	60%

There is reduction in semi-finished to the tune of 20%.

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

14 MSME : Light Engineering- Electrical and Air Horns

BACKGROUND

The Unit is one of the pioneers of electrical and air horns catering to automotive segments. The machine shop is also used to do job work for ELGI group. Currently the unit wants to stabilize the air horns segment at 500 pieces per month and focus on the job work.

At the beginning of 2011, Sundar was producing 10000~15000 pieces of job work components per month and set a goal to increase this to 25000 pieces per month. The lean implementation exercise commenced with a discussion with the company Director followed by a plant walk through. The following goals were set for the lean implementation in the unit:

1. To improve the productivity of the job work components from 15000 pieces per month to about 25000 pieces per month and
2. To stabilize the horn production at 500 pieces per month (20 pieces per day).

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the twin business goals, the current state of the manufacturing process was defined in a Value Stream Map.

Since the company makes multiple products, it was agreed that the concept of lean would be implemented and demonstrated for job work process which is the high volume and high growth potential product family.

The VSM for job work was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target		
Customer requirement	(Nos / month)	10000	25000	Working days per month	25
Demand rate per day	Nos	400.0	1000.0	Working hours per day	24
Takt time (min)		216.0	86.4		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Turning 1	1	1	59	120	50	2950	83%	1220.3
Turning 2	1	1	84	120	50	4200	83%	857.1

	Cycle time	C/O time	WIP
Total time per unit output (min)	143.0	240.0	7198.0
Throughput time	362.4	Minutes	
VA ratio	0.66%		
Plant capacity (bottleneck)	857.1		
Constraint	Yes		
Bottleneck process(es)	Turning 2		

Baseline Study

For air horns, it was decided that the target of 20 completed horns per day would be done by a single operator as against current 3 people keeping in view the shortage of operators.

At the time of project initiation, the production of job work components was around 10000~15000 pieces per month and target set to increase to 25000 pieces per month with the takt time of 87 seconds.

Focus Areas

Cycle Time: The job work component involved two turning operations after and there was a significant mismatch in the cycle times of the two turning operations (59 secs and 84 secs) which was leading to the material piling up and overall reduction in the productivity.

Changeover Time: The setting time was around two hours which reduced the machine availability. Materials were stored in bins on the ground resulting in more handling. Tools were not arranged properly leading to higher searching time.

Motion

The air horn assembly and preparatory operations were carried out by 2~3 employees at multiple locations in the shop floor.

System Potential

Considering the changeover time reduction and cycle time balance, it was possible to achieve the target of 25000 components per month.

For air-horns, there was a good scope to develop a single person workstation and make 20 horns per day and this could be supported by an organized material stores feeding the required parts .

A lean roadmap was then prepared to achieve the stated goals.

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Cycle Time:*** Imbalance in cycle times between the two turning operations.	***Process Study*** to balance the cycle times of the two turning operations.									Balancing the cycle times which would further improve the output.
2	***Setup Time:*** High changeover time of 120 minutes reduces the machine availability for production.	Setting time to be analysed and reduced using SMED concepts.									Reduction in setting time to less than 30 mins.
3	More than one employee is engaged in producing the required quantity (of horns) – more handling – Muda.	***Single person workstation*** to produce 20 horns per day.									Reduction in hand offs - job standardization, improvement in productivity.
4	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, employee teams were formed, one each for air-horns and for machine shop. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by his physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An internal kaizen champion were identified at the outset and he coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Cycle time balancing between two turning operation.
2. Reduction in change over time in CNC machines.

3. Establishing single person workstation for air horns.
4. 5S for standard work practice.

Improvement Projects

Project 1 - Cycle Time Balancing Between Two Turning Operation

There was a significant mismatch in the cycle times of the two turning operations (59 secs and 84 secs) which lead to the material piling up and overall reduction in the productivity. Trials were taken. But change could not be established as the job work business ceased, because of business exigencies.

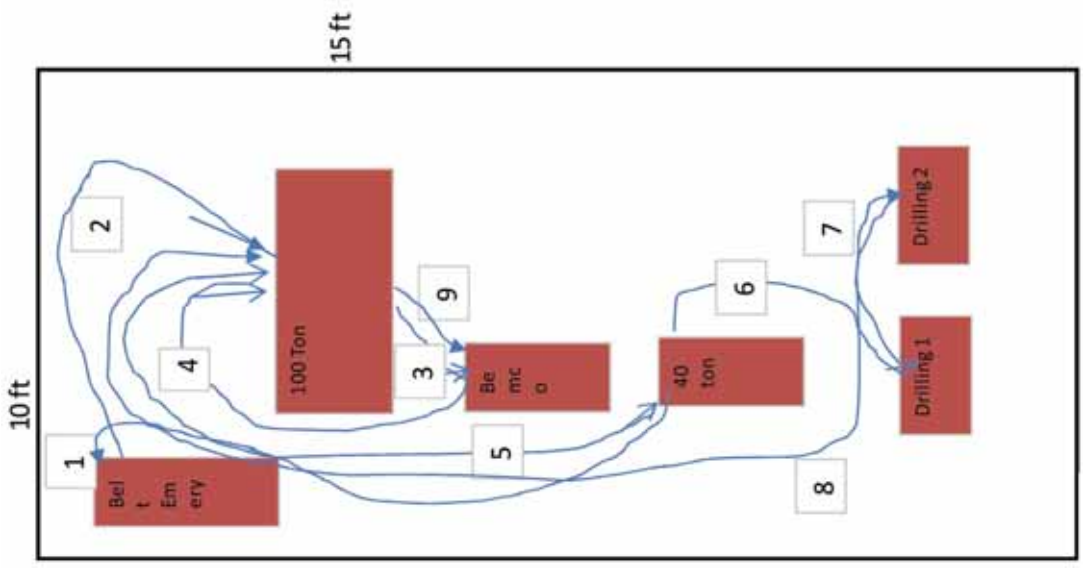
Project 2 - Reduction in Change Over Time in CNC Machines

The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified. Internal and External activities are analysed. Trials were taken. But change could not be established as the job work business ceased, because of business exigencies.

Project 3 - Establishing Single Person Workstation for Air Horns

As there was a transition of business from Electric Horns and Air Horn Production to only air horns production, the concepts were explained and people were demonstrated with planning of orders.

Production Planning concepts were instilled and people involving in planning, procurement and production were trained on Lean Planning and Scheduling. A detailed study on the value stream of existing product of that time – Electric Horns was done. The material flow was also studied and the spaghetti diagram is shown below.



The process flow of one of the component of Electric Horn – Body (Forming) was done to arrive at the optimum process sequence planning and to fix up the operation (cycle) times based on throughput time.

Body forming

S. No.	Activity	Machine	Setting Min	Cycle time Sec
1	Blanking	Powerpress (now 100 tons)	60	10
2	Deburring	Belt emery		60
3	1st Forming	100 ton	60	60
4	2nd forming	Bemco	60	60
5	3rd forming	100 ton	60	60
6	6 holes	40 ton power press	60	20
7	Trimming	40 ton power press	60	60
8	Deburring	Belt emery		60
9	4 holes	40 ton power press	60	60
10	Deburring 6H	Drilling mc		20
11	Deburring 4H	Drilling mc		15
12	Flattening - outer	100 ton	30	60
13	Flattening - inner	100 ton	30	60
14	Core pinning	Bemco	45	30
		Time (Min)	525	10.6

Throughput time 11 mins
Cycle Time 1 min
Every 1 min one pc has to come out.

Single Person Work Station at Final Assembly

The concept of single person workstation was explained to the people of all levels.

As there was no production as well as no material for assembly as per the planning, the concept was demonstrated with the available resources.

1. A list of all components required for Final Assembly was made.
2. The sequence of usage of the materials was identified and the same is marked on the working table.
3. Based on the size, bins were allocated for each material.
4. As per the cycle time calculation, one person can do upto 20 pieces per 8 hours. Hence, the number of required sets of components was fixed as 10. First 10 before lunch and next 10 pieces would be produced after lunch.

Final testing and packing were also included as part of final assembly.

Project 4 - 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Before :

All the needed and non-needed tools (dies) were stored together – difficult to identify and handle.

After:

Tools Placed in marked location making it search free and visible.

Before :

Tools (Hand tools) were scattered at Various locations; operators had to search for tools.

After:

Tool board made and all tools placed in marked location making it search free and visible.

Before :

Materials are stored on floor and qty in each bin will be 500 pcs. Muri to Operator – handling weight & bending.

After:

Bin size reduced and max qty fixed as 200 pcs. Bin locations marked and tables provided to avoid bending.

Before:

In Stores, materials are stored in bins but searching was there to find out what material is inside and available quantity inside the bins were not visible.

After:
All the bins are marked and location for the same are identified. The stock level is indicated through bin cards.

SUMMARY OF RESULTS OBTAINED

Parameter	Before	Current	Improvement
Production rate (Nos./day)	330 (batch of 1000 pcs per 3 months)	500 (by 20 pcs per day)	33%

15 MSME : Light Engineering- Electronic Auto Components

BACKGROUND

The Unit manufactures various electronic auto components of which Headlamp Relays, Melody Makers and the Musical Flashers are the main products constituting more than 40% of the volume.

A preliminary discussion with the Director of the company to understand the vision and mission of the organization was followed by a process walk through in the plant. The following goals were decided for the lean implementation in the unit:

1. To improve the productivity of the Headlamp Relays to 3000 nos per day.
2. To reduce the touch-ups / reworks resulting from dip soldering process related to Melody Makers and Musical Flashers and
3. To use the space effectively, thereby reducing the material and men movement.

The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the business goals, the current state of the manufacturing process was defined in a Value Stream Map. The VSM was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor.

Headlamp Relays are manufactured at the rate of 2000 nos. per day. Three small cells are formed with around 7 employees - each cell producing about 700 units per day. The summary of the VSM is shown below.

		Current	Target		
Customer requirement	(Nos / month)	50000	75000	Working days per month	25
Demand rate per day	Nos	20000	3000.0	Working hours per day	7.5
Takt time (min)		14	10		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity	Batch size
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)	(Nos)
Forming	1	1	0.72	2	0	0	90%	33750.0	120
Resistor Assly+Cutting*		1	12.3	0	15	3.1	90%	1970.3	

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity	Batch size
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)	(Nos)
Relay Assly		1	28	0	3	1.4	90%	874.1	
Lid Assly		1	36	0	20	12.1	90%	668.8	
Tilting upside down*		1	5	0		0	90%		
Cleaning*			28	0	40	18	90%	883.6	
Visual Inspection + Marking + Cover Fixing + Testing + 1 Testing after Sealing & Cleaning	1	1	33	3		0	90%	736.4	120
Sealing		1	20	5		0	90%	1195.1	120
Sticker + Packing		1	8	0	21	2.8	90%	3037.5	

	Cycle time	C/O time	WIP
Total time per unit output (Minutes)	2.8	10.0	37.7
Throughput time	50.6 minutes		
VA ratio	5.63%		
Plant capacity (bottleneck)	668.8		
Constraint	Yes		
Bottleneck process(es)	Relay Assembly		
	Lid Assembly		
	Cleaning		
	Visual Inspection & Testing		
	Cleaning - Seal area		

Baseline Study

At the time of the diagnostic study, the company was producing 2000 units of Headlamp Relays per day. The goal was to increase the volume to 3000 units per day with a takt time of 10 seconds.

The initial study showed that the operations of Resistor Assembly, Cutting, Relay Assembly, Lid Assembly, cleaning and Testing and sealing took more than 10 seconds.

Productivity:

Three cells, each comprising 7-8 employees worked in the assembly area. There was considerable amount of non value adding activities like material movement (approx.80 ft).

Value Adding Ratio

Value added time was only 5.6%. Most of the operations are manual with varying cycle times which resulted in piling up of inventory in some stages while people waited for materials at other stages.

Space

The shop floor was crammed with inventory in all forms making movement of people and material very difficult.

System Potential

From the study, it was clear that a production capability of 3000 units (of Headlamp Relays) per day was very mush possible. There was substantial scope to free up valuable space and make production visible by employing 5S. A lean roadmap was then drawn up for implementation of improvements identified.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Flow:*** Cycle times of Resistor Assembly, Lid Assembly, Relay Assembly, Cleaning, testing and Sealing operations are more than the takt time.	***Debottlenecking*** of the mentioned operations through process study and ***Muda elimination.***									All the operations are within the takt time of 54 seconds resulting in 3000 Headlamp Relays per day.
2	***Cycle Time:*** Cycle times of the operations are different resulting in varying inventory levels in the downstream.	Analysis of the cycle times of the operations and ***Line balancing.***									Improvement in productivity and reduction in throughput time by 50%.
3	***Quality:*** Touch-ups and reworks resulting from the Dip Soldering process.	***Process study*** of the Dip Soldering and ***Root-Cause Analysis.***									Reduction of the touch-ups and reworks.
4	***Mura:*** Process variations in the Dip Soldering activity.	***Process Study*** of the operation.									Established Dip Soldering process – resulting in lesser reworks.
5	After Lid Assembly, the components need to be tilted upside down for cleaning which increases the cycle time.	***Process Study*** of the operation.									Elimination of tilting operation before cleaning.
6	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke***									Standardisation and Pull based production.
7	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant employed their unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from line flow to single person workstation.
2. Reduction in cycle time in bottleneck activities through workstation design.
3. 5S for standard work practice.
4. Lean planning, scheduling and material management.

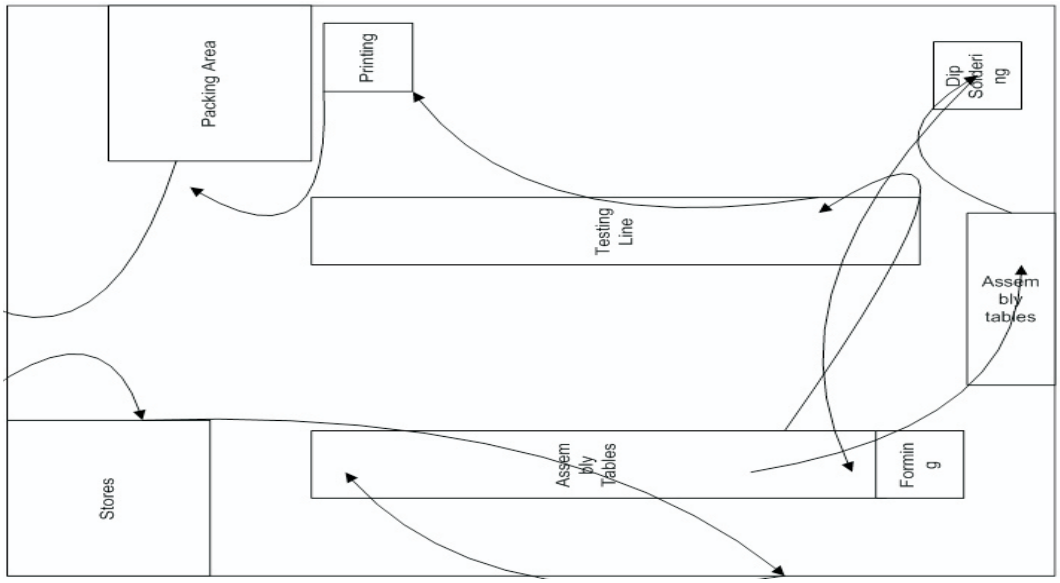
Improvement Projects

Project 1 - Change to Single Piece Flow Layout

The existing process was observed by a cross functional team right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant. The team recorded that the material moves 200 ft altogether inside the premises during the process and prepared a material flow diagram. The layout was then changed according to the various product family requirements. Both the earlier and changed layouts are show below.

Before

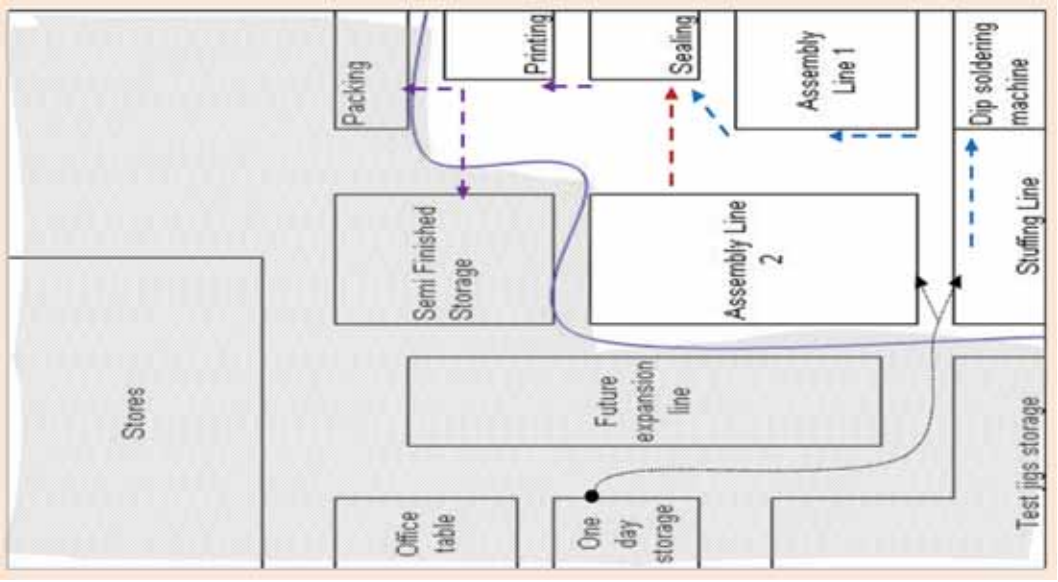
The original layout was made for batch production – while assembly alone was in line, testing, sealing and packing was located on different tables and operating in batch mode. Materials got accumulated in between the processes due to unbalanced cycle times. The WIP was stored offline and inputs for processes were taken from the buffers.



After :

Flow established with formation of cellular layout within the product family. Forming, assembly and testing were brought into the flow line, with output going in batch to sealing which is an overnight operation for curing.

Head Lamp Relay Musical Flashers Both RM flow



Before :

More than 3 days production materials, tools and bag were stored in shop floor and racks, leads to material search and shop floor un clean.

After :

All storage racks removed. One day storage system introduced and space provided for keeping the bags instead of racks, leads easy identification of WIP and shop floor clean.

All racks & excess WIP removed from shop floor

One day storage system introduced

Before :

Separate testing line with all used and unused test jigs lying on the table and operator had to move the material from one line to testing line batch wise.

After: Testing brought in-line with assembly operation eliminating material movement and separate location provided for test jig storage. Material flow facilitated.

Project Results

By changing the layout, material movement has reduced from 120 feet to 60 Feet, and a free space of 140 sq. ft created for future expansions from the overall floor space of 640 sq. ft.

Project 2 - Reduction in Cycle Time of Bottleneck Operations

A Process study was carried out for the Head Lamp Relay line to eliminate tilting of the assembly during cleaning. But it was realised that the cleaning itself is not a value adding activity.

Before :

Resistor assembly

Relay assembly, Fluxing and Soldering

Cleaning & Storage

Visual check, Cover assembly & Testing

After:

Trials were conducted with flux-free soldering wire and now the cleaning after soldering is eliminated. Similarly, based on the study the design change was done and the resistor assembly is eliminated (with the existing design, need for resistor is not there).

Relay assembly and soldering using jig

Visual check, Cover assembly & Testing

Elimination of NVAs using Kaizen in Assembly

A detailed process observation based on Kaizen Approach is done to identify and eliminate NVAs in the Assembly is done and the observations and actions are listed below.

No.	Observation (Muda/Muri/Mura)	Action Taken
1.	Liquid flux was applied in the PCB before soldering.	Eliminated the use of liquid flux.
2.	Sealing Process – Manual – sealant pours out of the groove while pouring leading to reworks.	Process study of the sealing operations done. Dispensers were modified. Worktable for holding the components were arranged. 
3.	Operators have to pull the solder wire manually holding the bobbin with the other hand.	A holder for the bobbin is provided in each workplace to eliminate handling.
4.	PCBs are tilted upside down after relay assembly for the lid assembly - handling.	A fixture is designed so that it avoids tilting of PCBs. Soldering can be done at one shot reducing the handling.
5.	Packing area was separate from the assembly lines.	Packing area was brought into the assembly line - better usage of the shop floor - reduction in transport.

Project Result:

Production rate increased from 83 units per day per person to 120.

Project 3 - 5S for Standard Work Practice

Once the layout was changed, the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Before : Raw materials were stored in gunny bags, carton boxes with more air space, leads difficult to count and maintain re order levels.

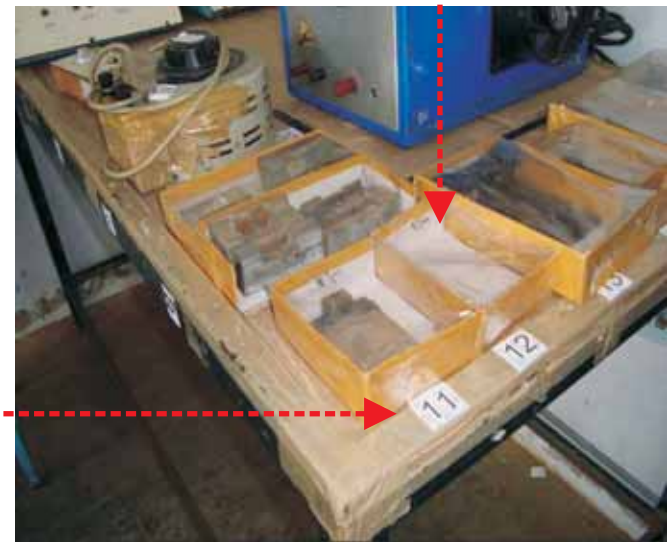
Materials stored in carton boxes

After : Raw materials stored in transparent covers with quantities and re order level marking done on the respective materials , made operator count free and easy re order level markings.

Before : Jigs and fixtures were stored on the work table, so searching was inevitable.

After: All the jigs and fixtures are identified, stored in order and location making done to make it search free and visible.

All the equipment are dentified.



Location for each Equipment is earmarked

Visual Management

Location earmarked for keeping daily rejections with the rejection register displayed for update and data retrieval.

Project Results :

The unit obtained a 5S score of 33% in first audit which rose to 91% in the second audit.

Project 4 - Lean planning, Scheduling and Material Management

Having started flow manufacturing, the planning and scheduling also needed to be changed to be Lean. The system was redesigned to fit in and increase flexibility as well as support customer deliveries on time in full.

No Kit No Cut

No kit no cut system initiated in packing. All the required components for a packing order are to be stored at the kit storage area before starting an order.

Planning and Procurement

Items made to stock are kept without packing – the packing alone is done on receipt of orders. These semi-finished items have now been placed in Supermarket in 2 bin Kanban system. Minimum stock level = 1 Kanban, maximum = 2 Kanban – Kanban quantity has been fixed item wise based on average monthly sale for past quarter.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement	Impact on Business
Cycle Time of Head Lamp Relay Assembly (Sec.)	325	225	44% reduction	Increased output
5S Score	33%	91%	58% Increase (against 100%)	Reduced strain and increased productivity

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Production Rate (Nos/Day/Person)	83	120	44% increase	Turnover goes up by fulfilling more orders.
Space Utilisation (Sq. Ft.)	640	500	140 Sq. Ft Free	Space available for further expansion

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

16 MSME : Light Engineering- Testing Equipments

BACKGROUND

VPF is a pioneer in manufacturing testing equipment for textile industry. Currently it is also doing job works for major heavy industries situated in Coimbatore. VPF also has a fabrication unit manufacturing pump components. The lean implementation project focussed on the job work part of the business involving machining of various components.

An initial discussion with the Director of the company was followed by a walk through of the plant to understand the processes, the operations and the value stream of the components. The constraints to the business were discussed and the following goals were fixed for the lean implementation:

1. To increase the production of the job work components from 8 pieces per day to about 14 pieces per day.
2. To reduce the setting time from more than 2 hours to less than 30 minutes per setting.

It was expected that these twin goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported VPF through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. The VSM was made using actual cycle times measured for each activity involved in the manufacturing process . The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

		Current	Target		
Customer requirement	(Nos / month)	200	350	Working days per month	25
Demand rate per day	Nos	8	14	Working hours per day	21
Takt time (min)		157.5	90		

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity	Batch size
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)	(Nos)
Turning-	1	1	97	420	90	8730	71%	9.2	
1			25	120	75				
2			27	120	15				
3			30	120					
4			15	60					

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity	Batch size
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)	(Nos)
Drilling	1	1	60	240			83%	17.5	
Drilling & Chamfering			30	120					
Inclined Drilling		1	30	120					
Insulation		3	30		3	90	90%	37.8	
Manual Operation		2	25				90%	47.4	

	Cycle time	C/O time	WIP
Total time per unit output (seconds)	212.0	660.0	8820.0
Throughput time	10052.0	minutes	
VA ratio	0.77%		
Plant capacity (bottleneck)	9.2		
Constraint	Yes		
Bottleneck process(es)	Turning		

Baseline study:

As per the target of 14 Nos per day, the takt time was 90 minutes. The focus areas for improvement in order to reach this target include

Cycle Time: All the turning operations were carried out in a single CNC turning center. The total cycle time of 97 minutes was 10% more than the takt time.

Changeover Time: Each turning operation required a setting change which meant 4 setting changes per batch of components. The toal machine time lost for setting was 420 minutes per batch of 23 components.

Variation: The cycle times varied widely between the turning operations and Drilling and chamfering which were done in the Vertical Machining center.

System Potential

Marginal reduction in turning cycle time and setting times would help reach the target of 14 pieces per day. By making the component handling easier for the employees, the productivity could be further increased.

A lean roadmap was then prepared to achieve the stated goals.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Cycle Time :*** Variation in cycle times between various turning operations.	***Process Study*** to balance the cycle times of the turning operations.									Reduction in the cycle times to match the takt time of 90 minutes. Increase in machine productivity by 10%.
2	***Setup Time:*** High changeover time of 120 minutes reduces the machine availability for production.	Setting time to be analysed and reduced using ***Single Minute Exchange of Dies (SMED).***									Increase in plant output to 14 pcs per day.
3	***Transport:*** More material movement – 67 feet.	***Layout change*** to reduce transport of materials.									Reduction in material movement – by 20%. Reduction in throughput time over 75% (upto curing).
4	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke***									Standardisation and Pull based production.
5	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, the VPF team worked on improvement of one strategically important area while learning the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An internal kaizen champions was identified at the outset and he coordinated with the management consultant as well as took on the responsibility for sustaining and building upon this initiative in the long run. He therefore learned all relevant tools, techniques and concepts as well as

understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Reduction in cycle time in machining.
2. Reduction in Setting Time.
3. Layout Change.
4. 5S for standard work practice.
5. Process Flow monitoring.

Improvement Projects

Project 1 - Reduction in Cycle Time in Machining

The existing process was observed by the VPF team A *Muda* observation was done where the team. The team recorded the observations, analyzed and implemented solutions.

Observation (Muda/Muri/Mura)

High non value adding time because of multiple handlings', muri, to operators, component to be lift from floor level to 1.5mts height, poor approach of crane bay, etc.

Action Taken

Separate place defined for input and output materials and a small table with height of 1.5mts was put which helped in quick loading and unloading of component Under the crane bay.

Project Results:

- Cycle time in turning one operation reduced from 30 minutes to 8.5 minutes.

Project 2 - Reduction in Change Over Time

The setting time in the turning centre was 120 minutes, which would drastically reduce the available time of the machine as each component required 4 settings.

The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified and solutions implemented to minimize them. Internal and External activities were separated and the setting team trained on them by repeated trials during the changeovers.

Before:
Searching for tools, jaws, required materials increased the setting time

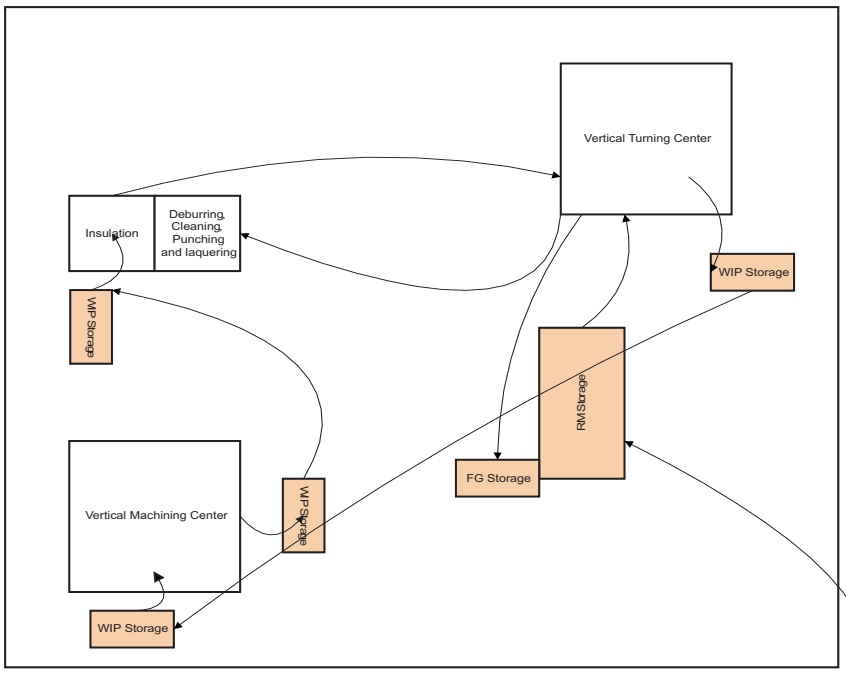
After :
Single Minute Exchange of Dies (SMED) for reducing the setup time, SMED is implemented & a SMED table is kept near the machine to keep necessary tools and fixture, etc.

Project Result: Change over time has been reduced from 120 minutes to 30 minutes.

Project 3 - Lay out At Old Premises

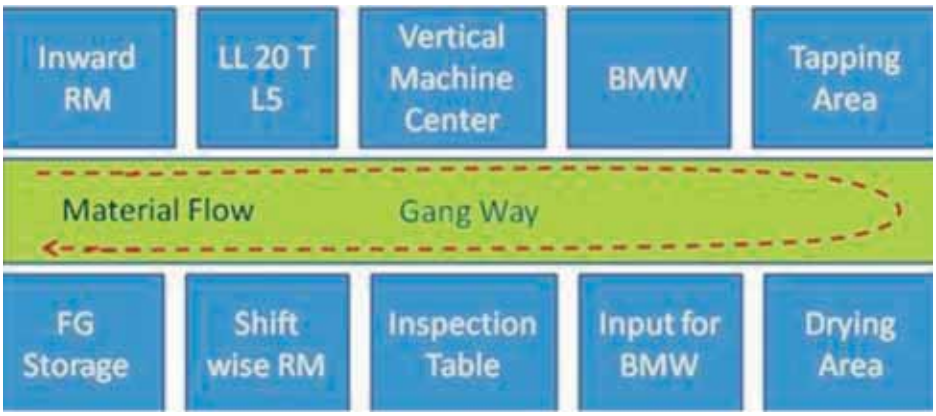
The team identified a lot of MUDA and Muri in the existing layout.

- ✓ Criss cross movement of material – total distance of 67 feet travelled.
- ✓ Heavy component requiring crane but.the crane facility did not extend to the drilling machine which had to be manually loaded.



The layout was redesigned and implemented when the machines were shifted to a new premises. Crane facility was available for all the operations here.

Lay out at new Premises



Project Result: The material transport has been reduced from 67 feet to 36 feet. Strain of manual lifting eliminated.

Project 4 - 5S for Standard Work Practice

At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. After the initial training and implementation of 1S and 2S, two 5S audits were also done by The Management Consultants to review and support the implementation. The initiative was then handed over to the internal kaizen champion. Teams were formed and practical training on 5S and AM given to team members by the management consultants. The changes made were fine tuned and standardized through audits in month of September.

Before : Storage areas are not marked with location indicators and addresses.

After : Storage area marked with location indicators and addresses.Gangway created and yellow line marked to have clear identification.

Gang way created with area marking.

Before : Jaws, Tool bits and Tool holders are not plcaed in order.

After : Suitable arrangements made and proper identification given. Jaws separated and identified.

Tool bits identified and separated. Tool holders kept near the machine.

Project Results: The unit got a 5S score of 35% in first audit which went up to 50% in second audit.

Project 5 - Lean Scheduling and Visual Monitoring

With the layout change in place, a suitable scheduling and monitoring system needed to be set up to sustain the improvements.

Process Flow Monitoring

The team identified process sequence for a particular component and displayed the flow in monitoring board.

Coding was initiated to identify the flow of material.

Each job is monitored any delay is noted and corrective action taken immediately.

Defect in the material is also identified at the source.

Simultaneous process initiated and also machines are engaged for the flow.

Job work identification reflecting on the material.

Project Result: Status of any order is immediately visible to all and follow up actions can be taken where required.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Changeover time in Turning Center	120 min	30 min	64% reduction
Material movement (mtr)	67 feet	36 feet	50% reduction
Cycle time in VTL Operation (min)	50	30	40% reduction
5S Score	35 %	50%	15% increase

Business Level Benefits

The process level results in turn combined to benefit VPF's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos/day)	8	14	80%
On Time In Full Delivery (%)	60%	90%	30%

17 MSME : Light Engineering- Centrifugal Pumps

BACKGROUND

The unit, an OE manufacturer of centrifugal pumps, started their assembly facility in 2010. At the time of project initiation, they were assembling 80 pumps per day.

An initial discussion with the managing partner of the company to understand the vision and mission of the organization, was followed by process walk through in the plant to study the processes, operations and the value stream of the components. The following were the strategic goals for The unit for 2011-12:

- To improve the productivity of the pumps from 80 units per day to 150 per day.
- To improve the material storage and handling processes.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Since, all the variants of the centrifugal pumps were manufactured at that time were having similar process steps, it was considered as one product family and the current state of the manufacturing process was defined in a Value Stream Map.

The VSM was made using actual cycle times measured for each activity involved in the manufacturing process. The inventories, number of operators involved were also physically verified on the shop floor. The summary of the VSM is shown below.

Customer Demand Rate

		Current	Target
Customer requirement	(Nos/month)	2000	3750
Demand rate	Nos per day	80.0	150.0
Takt time	(minutes)	**5.6**	**3.0**

Target for the line is deliver one pump every 3 minutes.

Process Data

Operation / Process	Available resources		Cycle time	C/O time	WIP	WIP	Availability	Effective capacity
	Mcs/W.stns	Man	(min)	(min)	(Nos)	(min)	(%)	(nos/day)
Winding	1	4	6.35	2	0	0	90%	63.7
Winding Inspection	1	1	1.3	0	0	0	90%	311.5
Varnishing		1	1	0	0	0	90%	405.0
Motor Pressing		1	1	0	20	10	90%	810.0
Adoptor Assy		1	1	0		0	90%	607.5
Rotor Cleaning + bearing pressing + punching		1	5	0	40	196	90%	82.7
Motor Testing	1	1	4.0	4		0	90%	101.3
Ceramic Fixing + Impeller Fixing + Paper Gasket		2	2	0		0	90%	270.0
Pump Testing	1	1	4.0	4		0	90%	101.3
Flange Fixing		1	0.5	3	30	14.4	90%	843.8
Painting		1	2			0	90%	242.5
Finishing		2	3			0	90%	160.1
Packing		1	4.3			0	90%	94.0

	Cycle time	C/O time	WIP
Total time per unit output (minutes)	33.2	13.0	220.4
Throughput time	626.6 minutes		
VA ratio	5.30%		
Plant capacity (bottleneck)	63.7		
Constraint	Yes		
Bottleneck process(es)	Winding		
	Motor Assy		
	Motor Testing		
	Pump Testing		
	Finishing		
	Packing		

Baseline Study

At the time of our initial observations, the plant capacity was 80 pieces per day. The target production agreed as 150 pieces per day with a takt time of 3 minutes.

Productivity

18 employees were working in the shop-floor of which 4 were in the winding section. Assembly line cycle time total was 26 minutes, which meant that only 2080 minutes of employee time is utilized against the available 8100 minutes which is about 25%. This showed the huge potential to increase output with existing resource with proper line balancing itself.

VA Ratio

Value adding ratio is only 6% which also suggested a large scope for improvement.

System Potential

From the initial observations of the shop floor, we envisaged at least 150 units per day production. Winding and testing of pumps and motors are the main bottleneck activities identified. A lean roadmap was then prepared which would be a step by step guide towards the final objectives.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	In Motor and pump testing, winding and packing - Material arrangements and multiple handling.	***Process study and Muda elimination*** to improve the productivity.									Improvement in throughput – 150 nos per day.
2	***Material Feeding:*** Materials stored in the ground – no material feeding systems.	Proper design of material storage and feeding.									Reduction in fatigue, throughput time and increase in people productivity.
3	Current workstations in the conveyors are located far away from each other resulting batching and consequent handling.	***Single Piece Flow***: Establishing Single Piece Flow except varnishing / curing, ***Cycle time balancing***.									Reduction in throughput time and increase in productivity.
4	Winding area – high WIP observed.	Implement flow production – Train the people.									Reduced WIP of the stators – to be quantified.
5	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke***									Standardisation and Pull based production.
6	***Synchronisation***	Align support activities – SOPs, visual monitoring systems,									Sustenance of Lean Manufacturing.

Implementation Methodology

The Management Consultant has a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores, marketing and HR. The participants in the workshop simultaneously learn the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

Internal kaizen champions were identified at the outset and they coordinated with the management consultant as well as participated in all workshops as they would be responsible for sustaining and building upon this initiative in the long run. These champions will have therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time in bottleneck activities through Line Balancing and workstation design.
3. Eliminating non value adding activities through kaizens.
4. 5S for standard work practice.

Improvement Projects

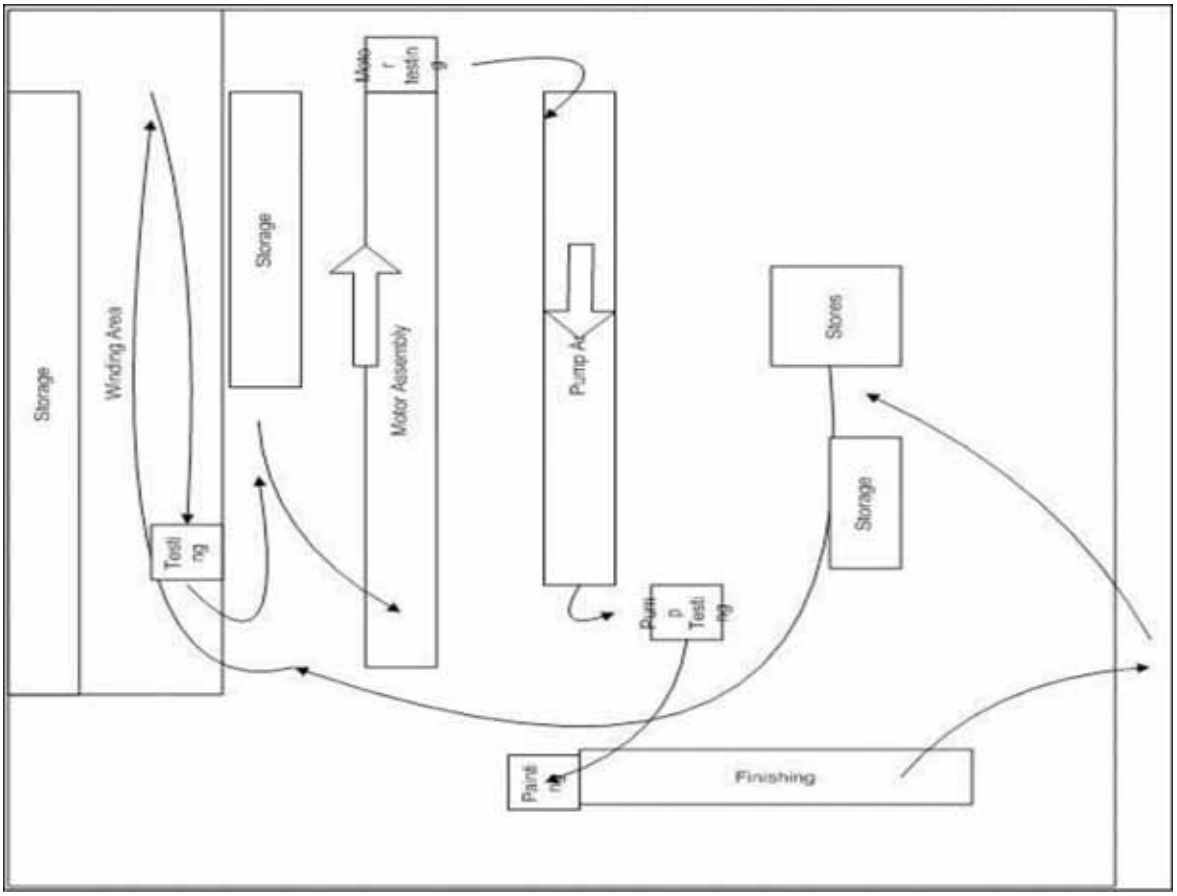
Project 1 - Change to Single Piece Flow Layout

The existing process was observed by a cross functional team right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant.

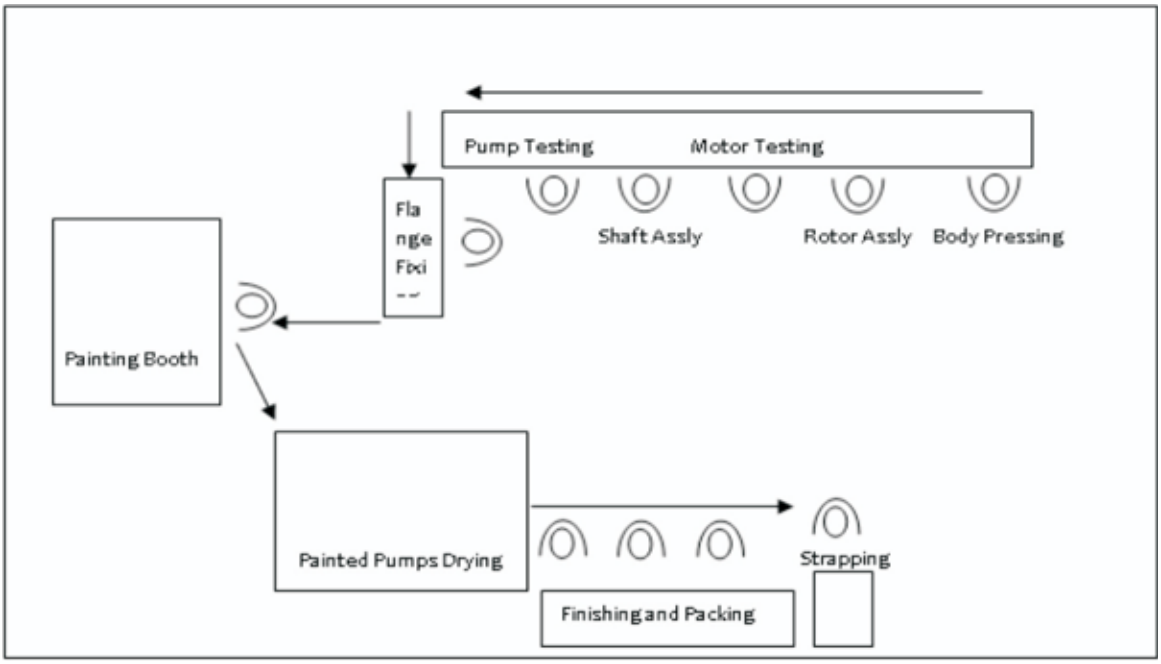
The layout was made to support batch processing; Larger tables occupying the assembly area both for storage and working. The production area was filled with WIP material blocking the way for material feeding to the assembly stations. Some materials were stored on the ground.

Layout was then changed to establish one piece flow in the assembly. The area was cleared off and a feeding system established. Mobile multi-stage opening bins were provided for material movement and storage near the point of use. The lay outs of before and after implementing second stage are shown below.

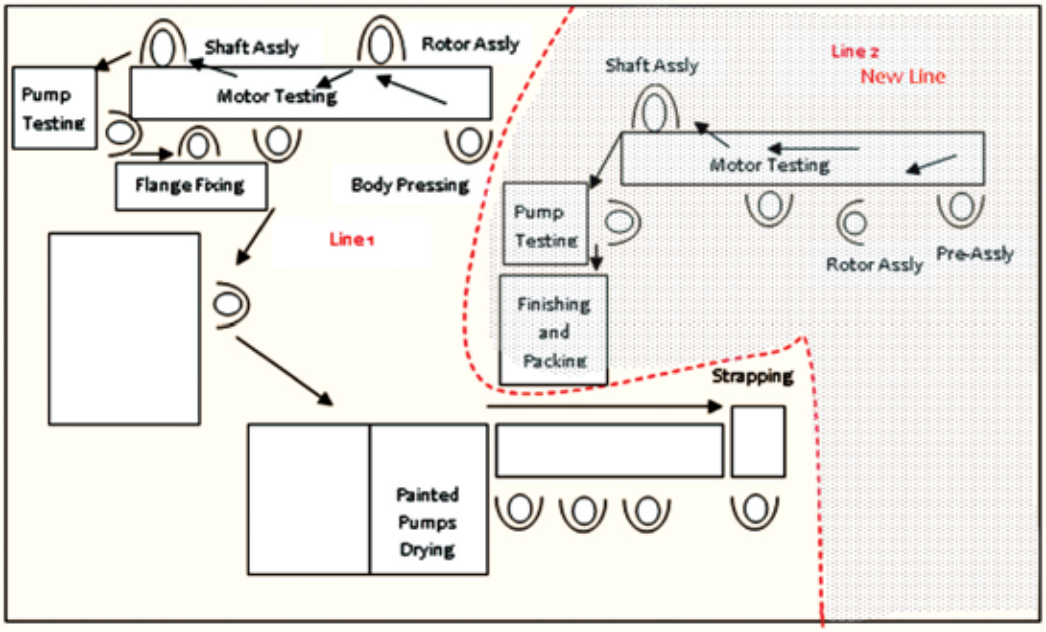
Layout - Before



Layout - After



During the project, the demand for a new product (mini pump) increased considerably again doubling the requirement from the unit. There were significant differences between the process and sequence of new model and the regular ones resulting in the need for a new assembly and packing line. During the final stage of implementation, it was also decided to reduce the length of the existing line so that the strain for the operators to pull and push the pumps gets further reduced and the entire space requirement for the line gets reduced by 40%. The layout made for the two lines is given below.



Project Results

- Assembly throughput time got reduced to 23 minutes from 37 minutes.
- Assembly throughput increased from 80 pumps per day to 200 pumps per day for one line. With second line, capacity has further increased to 400 pumps per day.

Project2 - Reduction in Cycle Time in Bottleneck Activities

From the VSM, it was clear that the cycle times of operations were not equal and the accumulation of WIP between the operations after changing the layout as per flow suggested the same. Hence, the team was assigned with the task of balancing the cycle times using the concepts of Heijunga and workstation design. The improvements done are as below.

Before	After
The motor assembly was found to be the bottleneck with a cycle time of 496 sec (8.3 min). Preceding operation body pressing had cycle time of 170 seconds and succeeding operation motor testing 114 seconds.	Load leveling (heijunka) was done – wiring activities are shared with body pressing operation and numbering is shared with motor testing and a leveled cycle times of 150, 130 and 125 seconds were achieved for the three operations.

Before

The next higher cycle time was for pump testing, which was also carried out in as an off line activity batch wise.

After

Pump testing was integrated into the assembly line, giving immediate feedback on defects to the preceding operators. The duration of running test was reduced to 2 mins from 3 mins (value based on the requirement).

Before

High level of WIP observed in the winding area, due to mismatch in cycle times.

After

The cycle times were balanced (hijunka) workstations were designed. Strained operations like wire rolling and coil pressing were assisted with autonomation.

Before

In winding, operator found searching for tools like soldering rod etc., each time.

After

Workstations were designed.

Before

In winding, operation 2, often there is confusion between two coils as they are kept together after winding.

After

Introduced clamping of different rolls of coils at winding itself - making it easy for winding by eliminate tying with thread and eliminating mix up, confusion and resulting delay.

Before

Finishing, Final inspection and Packing are done in batch process.

After

The Finishing, Inspection and Packing brought into the flow with appropriate workstation design.

Project Result:

- Winding capacity increased from 25 numbers to 125 per day.
- Packing capacity increased from 80 pumps to 150 per day.

Project 3 - Eliminating Non Value Adding Activities through Kaizen

The team spent a day in observing the entire process from raw material stage. The major observations were analysed in detail and kaizen based solutions were implemented.

Observation (before)

Operators searched for tools and accessories were stored under the table resulting in fatigue to the operators.

After Kaizen

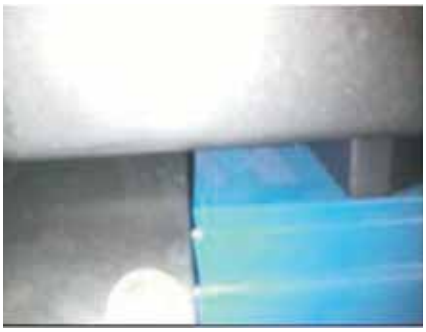
Work stations were designed to support the operators eliminating the need for searching and bending.

Before

A torch light is used to see the stator number under the thermal box.

After

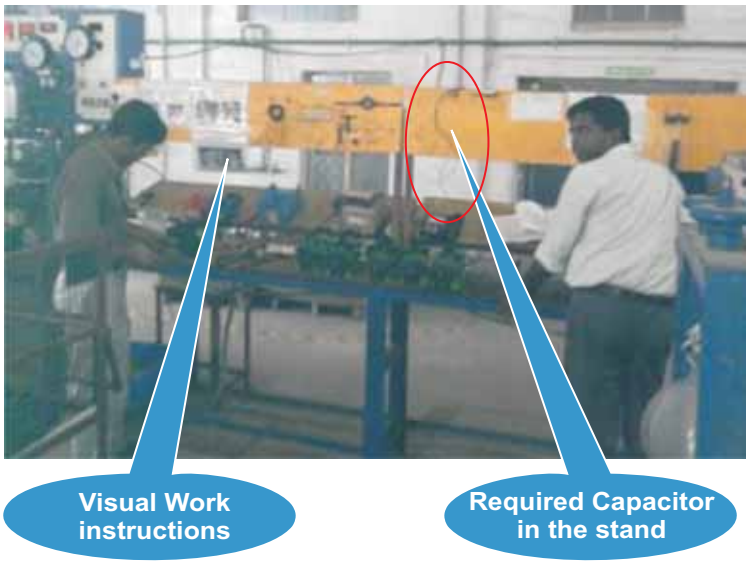
Illumination is improved and the number is visible without torch light.



Before : In the motor testing, all the capacitors are stored in a bin. The inspector had to pick the required capacitor each time for testing.

After: Required work instructions at pump assembly made visual work instruction and displayed. The assembly work station improved by storing the components in the sequence of use and left and right hand side differentiation.

The capacitors are placed on the tool board. The inspector can pick the required capacitor for the model and place it on the stand provided. So that picking up and keeping back the capacitor each time for testing is eliminated. The capacitor could be readily connected without handling it.



Project Result :

Cycle time per pump got reduced from 6 minutes to 2 minutes.

Project 4 - 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

The pumps require a drying time of minimum 2 hours. So, we need to store atleast 60 pumps on a table. After drying, pupms are stored in a stationery table. Handlng of pumps created muda and muri to operators. When the volume got increase, space for keeping painted cpmponents became a constraint.

After 5S

Multi-Layer storage provide with wheels (movable racks) saving space and eliminating the movement of operators.

Workstations designed all the tools were arranged in the sequence of their use and to ease the pickup and use.

Before

Materials are stored in the bins as received. Counting, Searching, Stock taking to reconcile materials were frequent occurences.

After All the racks are identified with rack numbers along with shelf numbers. Frequently used items are stored in the easy to access areas. Count free storage system was implemented.

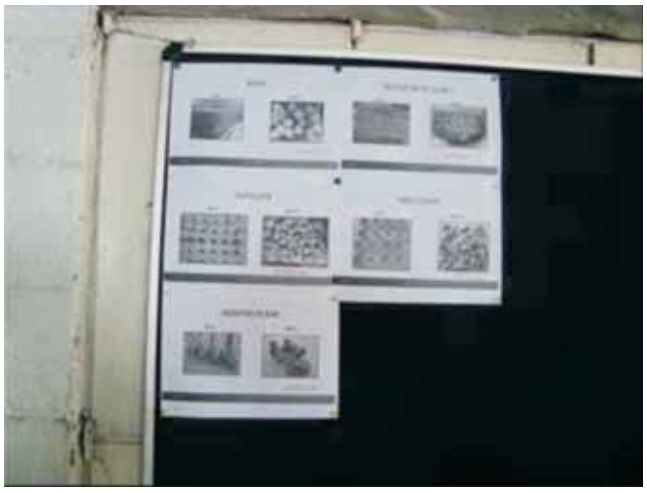
Visual Management

Management Information made visual at shop floor.

In incoming inspection, master samples of Incoming components are (approved samples) displayed as ready reckoner.

Info board system started for displaying the trend of incoming material defects.

Visual Work instructions were made and displayed at prominent locations –



At Inward Inspection

In Assembly

Results : The unit got a 5S score of 48% in first audit which went upto 60% in second audit.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	After lean	Improvement	Impact on Business
Cycle Time per pump (mins)	6	2	66% reduction	Increased productivity
5S Score	48%	60%	12% Increase (against 100%)	Increased safety and Morale and reduced strain

Business Level Benefits

The process level results in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	After lean	Improvement	Impact on Business
Production Rate (Nos./Day)	80	200	250% increase	Turnover goes up by fulfilling more orders

The benefits obtained have spurred, the unit to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

18 MSME : General Engineering- Precision Auto Components

BACKGROUND

The unit is manufacturing precision auto components for well-known companies like Pricol, TAFE, Mistuma, Sicame India etc. and has been in the business for 21 years. They are the Tire I supplier for Pricol and TAFE and also the single source for the components.

An initial discussion with the Chief Executive of the company was followed by a walk through of the plant to understand the processes, the operations and the value stream of the components. For the cluster lean implementation, it was mutually agreed to focus solely on the improvement on TAFE products value stream – moulding, assembly and packing. The following goals were fixed for the lean implementation:

1. Improve productivity of manual operations like assembly and packing thereby reducing unit cost and remain profitable in the face of declining margins.
2. Reduce the Lead time and in process inventories thereby saving space and reducing holding costs.
3. Put in place visual methods for monitoring and control of inventories.
4. Improve moulding machine availability through better maintenance practices.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the General Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported the unit through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise.

Baseline Study

320 kits of tractor knobs were assembled and packed for TAFE each day. The customer had projected an increased requirement of 500 kits per day which meant a takt time of less than a minute.

Focus Areas

Productivity - The assembly and packing productivity was 10 kits per person per hour (total 320 kits per day with 4 operators) which needed improvement considering the manpower shortage frequently affecting deliveries.

Process Flow – The unit was maintaining a WIP of month for disc component which involves multi stage moulding. This ate into the working capital.

Material Yield - The internal rejection level was significantly high at around 10% .

System Potential

By observing the existing assembly and packing process, it was felt that there existed a scope to go upto 500 kits per day with existing resources. Improvements in workstation and assembly methods would help achieve this. A roadmap for implementation was made to achieve the stated goals.

Road Map for Improvement

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1.	Productivity in assembly is low – 10 kits per person per hour. No defined workstation, operations done in batches on a table.	Improve work station design to minimize MUDAs, balance operations.									Increasing the kit assembly to at least 25 kits per person per hour.
2.	Significant inventory level – upto one month for disc components and one well for other kit components.	Define standard WIP for kit items based on kit BOM – schedule based on internal pull system.									Reduce inventory by 50%.
3	***Space Congestion*** - Materials are stored everywhere on the floor, racks in without full identification of type and quantity.	Implement 5S and visual controls for count free and search free storage.									Space freed up.
4	Higher down time of moulding machines (around 60 mins) also reduces the machine availability.	Increase the availability of the machines to 95% by reducing breakdowns through basic TPM principles – Autonomous.									
5	Synchronisation	Align support activities with flow production – Establish SOPs.									Stable manufacturing system capable of delivering required output consistently.

	Change in focussed improvement Workshops
	Ongoing Implementation

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving are accelerated thereby giving significant improvement.

In each workshop, the unit team worked on improvement of one strategically important area while learning the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by their physical presence during the presentation / experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as took on the responsibility for sustaining and building upon this initiative in the long run. He therefore learned all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Improve productivity in assembly and packing.
2. Improvement in OEE of moulding machine.
3. Reduction in WIP through pull based system and 5S based storing.

Improvement Projects

Project 1 - Improve Productivity in Assembly and Packing

The existing process was observed by the unit team A *Muda* observation was done where the team. The team recorded the observations, analysed and implemented solutions.

Observations

1. Each operator would do one activity gauging on motor, cleaning, gumming and assembly – there was a lot of criss cross hand movement.
2. Table was congested with multiple input and assembled knobs in various bags, four persons standing around and working at the same time.
3. Each kit requires 5 knobs. The knob assembly would be completed by end of the day and kitting and packing were done on the second day – throughput time was therefore 2 days.

Actions Taken

- ✓ Single person workstation created – one operator does all the assembly activities for a knob. The workstation has required assembly tools hung up for ease of access. Foot pedals are provided for operating the gauging motor in two directions.
- ✓ Required materials are arranged at convenient picking distance and in sequence of requirement.

Before

After

Project Results:

One operator is able to turnout 120 knobs per hour which is 24 kits per hour as compared to the earlier productivity of 10 kits per operator per hour.

Project 2 - Improvement in OEE of Moulding Machine

With the improvement in assembly and packing, the upstream process i.e. injection moulding has to ensure supply of the increased quantities. The OEE of the machine was therefore to be improved in all aspects.

1. Higher downtime of moulding machine – the team observed various abnormalities in the machine condition and rectified these potential causes for breakdowns.

1.	**Abnormality** Loose wire connected (unsafe) 	**Action Taken** Plug provided 
2.	Pressure gauge fouling cables 	Orientation changed 

2. The die changeover time was about 120 minutes, and each machine had a changeover every second day.

The set up change was videotaped and analysed. Various non-value added activities (MUDA) were identified and solutions implemented to minimize them. Internal and External activities were separated and the setting team trained on them by repeated trials during the changeovers.

Before:
Searching for tools, die, required materials increased the setting time.

After :
Single Minute Exchange of Dies (SMED) for reducing the setup time. SMED is implemented & a SMED table is kept near the machine to keep necessary tools and fixture, etc.

3. Performance of the machine – as per cycle time the machine has to give 60 shots per hour but is actually giving only 50 shots per hour which means performance ratio of 83%.

Observation

- ✓ Input and output materials located at a distance leading to more strain for operator to pick up and place in die.
- ✓ Variation in sequence of activities during the loading and unloading part of the cycle leading to more gap between shots.

Actions taken

- ✓ Material arranged in bins kept on stands at convenient height to pick and place
- ✓ Sequence of activities defined and operator trained on loading, unloading, inspection in such a way that machine does not wait at any point

Project Result: Machine is now giving 55 shots per hour , an increase of 10% in production.

Project 3 - Reduction in WIP through Pull Based System

With the establishment of single person assembly workstation, the production level was clearly defined. Accordingly, the materials were arranged using 5S principles of search free, count free and strain free retrieval.

BEFORE LEAN

Improvements in Storage, retrial & Stock Visibility of TAFE Knob Kits.

AFTER LEAN

1 & 2 S principal has been implement in TAFE component assembly area.

As per assembly requirement, the input of moulded knobs and discs are pulled out from the rack. Kanban system has been started whereby the pulled out knobs parts will be replaced by freshly moulded parts thereby maintaining a standard stock level.

***Project Result**:* Delivery performance has improved and WIP level which was of one month level has come down by 50%

SUMMARY OF RESULTS OBTAINED

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. The process improvements in turn combined to benefit the unit's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Increase in moulding capacity	50 shots per hour	55 shots per hour	10%
Assembly productivity	10 kits per person per hour	24 kits per person per hour	140%
WIP	1 month	< 15 days	50%

19 MSME : General Engineering- Air Compressors

BACKGROUND

The Unit (CEC) is in the business of manufacturing and selling of air compressors. CEC supplies to Indian Railways and few Institutional customers. During the initial discussion with the owner, the main issues highlighted were price competition from small players, delivery delays and working capital constraints. The following goals were set for the year 2011-12:

1. To improve the productivity from 2 compressors to 3 compressors per day.
2. To reduce the throughput time from more than 6 days to less than 4 days.
3. To reduce the WIP in the machining area.

It was expected that these goals would be primarily addressed through the year long lean implementation exercise in turn supported by strategic investments and policy changes, where required. The Management Consultant was appointed to guide the Light Engineering Cluster in implementing lean under the Government of India's NMCP scheme and thereby supported CEC through the year 2011-12 in achieving the said goals.

Diagnostic Study

The lean journey commenced with a current state assessment and road map setting exercise. Keeping in mind the business goals, the current state of the manufacturing process for tank fabrication and compressor assembly was defined in a Value Stream Map. The VSM was made using actual cycle times measured for each activity involved in the compressor manufacturing process. The inventories, number of operators involved were also physically verified on the shop-floor.

Measure	**UoM**	**Current**	**Target**
Customer Requirement	(Nos/month)	50	75
Demand Rate	Nos per day	2.0	3.0
Takt Time (one batch every)	Minutes		**160**
	Available resources		**Cycle Time**
	Machines / Workstation	**Manpower**	**(Minutes)**
Process 1 – Machining	3	3	11580
Drilling, tapping	2	2	1380
Process 2 – Boring, Re-boring	1	1	5100
Process 3 – Honing, Slotting	1	1	7200
Process 4 –Hardening- Out sourced			
Process 5 – Grinding	1	1	480
Process 6- Tank Fabrication	1	2	10800
Process 7 - Assembly	1	2	7200
Process 9 – Painting			7200
Total time per unit output			**849 min**

Baseline Study

At the time of the diagnostic study, the unit was producing an average of 2 compressors per day. Based on the business plan for FY 2011-12, it was decided that daily production target would be set at 3 per day which translated to a takt time of 160 minutes per compressor. The diagnostic assessment now focussed on whether the company had sufficient potential within the existing resources to achieve this level.

Focus Areas

Value Adding Ratio: The value adding ratio was just 1% due to *Muda* like material transport, motion, marking and setting.

Space: Of the total available covered Floor Space Area (FSA) of 750 sq.ft , only 250 sft or about 30% was utilized for value addition.

People: 59% of the total man-hours were spent on non value adding activities.

System Potential

Based on the VSM and above analysis it was clear that Coimbatore Compressor could produce at least 3 compressors per day using the existing resources. It was therefore very much possible to achieve the business goals by implementing lean. A lean roadmap was then prepared which to achieve the stated goals.

LEAN ROADMAP

S. No.	Current State Observation (Muda Identification)	Action Plan									Expected Results
		Action	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1	***Creating Flow:*** Batch Processing of components, Machining and tank fabrication – not synchronized.	***Production planning, process study and Muda elimination.***									50% increase in the productivity.
2	Reduce the through-put time from more than 3 days.	***Muda Elimination and Load leveling*** of the operations and balancing the line.									50% reduction in the through-put time.
3	Work place arrangement in Tank Fabrication area results in more time retrieve the material and causes strain.	Systematic arrangement of workstations.									Improvement in housekeeping leading to better visibility and traceability resulting in Muri reduction.
4	***Create Pull***	***Takt based production, Kaizen, 5S, Poka-Yoke***									Pull based production.
5	***Synchronisation***	Align support activities with flow production – Establish SOPs, visual management, monitoring systems, etc.									Lean Manufacturing.

Implementation Methodology

The Management Consultant employed a unique intensive workshop methodology for improvement and problem solving in strategic areas. 2-3 day workshops were conducted in each stage taking up projects in accordance with the lean roadmap. During these workshops, process improvement and problem solving were accelerated thereby giving significant improvement.

In each workshop, cross-functional teams were formed, each team working on improvement of one strategically important area. Over a one-year period, participation was ensured from all functions including finance, stores and administration. The participants in the workshop simultaneously learnt the relevant lean tools and techniques by actually implementing them. Top Management (owner) commitment is the pre-requisite for the success of any such initiative and this was obtained by his physical presence during the presentation/ experience sharing sessions at the start and end of each day of the workshop.

Standardization of the improvements made was reviewed within 3-4 weeks after each workshop. In Stage IV and V, concepts like 5S and Autonomous Maintenance/Planned Maintenance were introduced to ensure long term sustenance of all improvement made in the unit and bring in the culture of continual improvement.

An Internal kaizen champion was identified at the outset and he coordinated with the management consultant as well as participated in all workshops as he would be responsible for sustaining and building upon this initiative in the long run. The champion learnt all relevant tools, techniques and concepts as well as understood from the management consultant, the process for bringing about and sustaining change.

A list of major improvement and sustenance projects is given below; each project is detailed out in the following section for better understanding:

1. Change from batch layout to single piece flow layout.
2. Reduction in cycle time through workstation design.
3. Eliminating non value adding activities through kaizen.
4. 5S for standard work practice.
5. Lean planning, scheduling and material management.

Improvement Projects

Project 1. Change to Single Piece Flow Layout

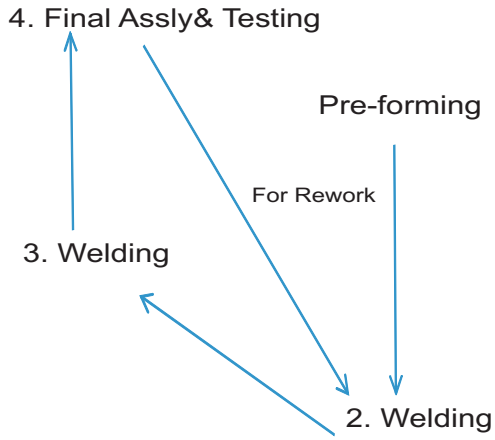
The existing process was observed by a cross functional team right from raw material receipt to finished good storage. A *Muda* walk was done where the team followed the material as it moved through various stages in the plant. The processing has three main parts:

1. Tank Fabrication.
2. Machining and out sourcing.
3. Final assembly.

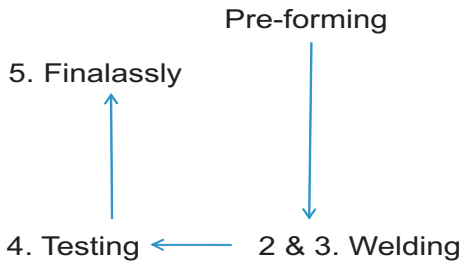
The team recorded that the material moved 40 ft altogether in the tank fabrication and final assembly area during the process and prepared a material flow diagram. The shop floor was blocked with a lot of Semi-finished tanks lying on the floor resulting in strain to the employees and excess transport of materials.

The team changed the layout and fabricated trolleys for necessary material movement, tanks and head assemblies were kept near the final assembly which was done based on the customer order.

Before Lean



After Lean



Project Results

1. Material movement has reduced from 40 feet to 15 feet.

2. 2000 SFT of floor space released of which 1000sq.ft utilised for leak test (earlier done outside) and Kanban store (for head assemblies and tanks).

Project 2. Reduction in Cycle Time

During the VSM exercise, a cross functional team did a detailed observation of the Head assembly operation and recorded the data in standard operations table format. Each major observation was then analysed and appropriate solutions implemented.

1. Head Assembly

Observation: Major non-value adding activities in the process included fetching parts and materials from store and machine shop in between the assembly process and doing sub assembly welding at the time of assembly. Large table used creating excess operator motion and strain.

Root Cause: BOM not available.

Action Taken: A single person work station created. Bill of material prepared and concept of 'No kit no cut' introduced. Stores issues materials only in kit form and pre-process activities are completed well -ahead of the assembly.

2. Final Assembly

1. Final assembly takes place on the floor and creates lot of strain to the assembler who is also shutling between stores and assembly area for material.
2. Leak test done after final assembly - tank to be moved outside.
3. Non-standard design for NRV plug resulting in re-work like distance adjustment. Safety valve requires a setting at 10kg/cm.

Action Taken:

1. Assembly work station designed for work without bending. Fixtures developed to avoid any mismatch. Bill of material prepared and the materials arranged near the work station and "No Kit No Cut" concept introduced.
2. Leak test arranged before assembly.
3. NRV plug purchased with standard setting.

Project Result : In both the assembly process cycle time has been achieved to 150 minutes.

Project 3. Eliminating Non Value Adding Activities through Kaizen

The main non-value adding activities included Muda like operator movement, marking and setting before the cutting/drilling/bending operations and Muri (strain) of lifting heavy materials and working in uncomfortable posture. The major observations were analyzed in detail and kaizen based solutions were discussed and implemented for these.

Observation (before)

Both In-put and out-put materials kept on the floor creating strain to the operator.

After Kaizen

Trolleys fabricated to keep the materials. Operator strain reduced.

Observation (before)

Sheets lying scattered resulting in searching for required items, last minute purchasing and waiting for the specific sheet.

After Kaizen

Suitable storage rack fabricated and kept different sizes of sheets according to its specification.

Observation (before)

Batch process leads to semi-finished condition.

After Kaizen

Single piece flow concept introduced.

Project Result : Through put time reduced from 6 days to 3 days.

Project 4. 5S for Standard Work Practice

Once the layout was changed and non value adding activities minimized the process was ready to be standardized and sustained. At this stage 5S was implemented by the team keeping in mind the arrangements required for the lean flow manufacturing. 5S is a cultural change issue and hence all parts of the unit including office was included and the concerned people trained. Two 5S audits were done by the management consultants to review and support the implementation after which the initiative was handed over to the internal kaizen champion.

Observation (Before 5S)

Metal shavings spread over the floor.

After 5S

Sheet guard fabricated to avoid the metal shavings spreading on the floor.

Observation (Before 5S)

Mixed up and scattered storing of materials on the floor.

After 5S

Search free and count free storing system introduced.

Observation (Before 5S)

Head assembly area parts stored all over the floor.

After 5S

Parts stored in the rack and given identification.

Observation (Before 5S)

Pattas and angles kept in an hazardous way.

After 5S

Stored in the rack with proper identification.

Project 5. Pull Based Planning

Observation:

CEC supplies compressors against customer orders and the batch production system existing had created lot of mis- match between Head assembly and Tanks. On the one hand the shop floor was full of WIP, while at the same time deliveries were delayed because the required head or tank was not available.

Action Taken :

Once the improvements were standardized, CEC now had a defined capacity of 4 compressors per day. However, the market requires different combinations of compressor tank and head. In order to achieve 100% customer service levels, a Kanban based production schedule was implemented.

- Kanban quantity fixed at 2 tanks and 2 compressor heads respectively of each fast moving model.
- As an order is received, it is fulfilled by doing the final assembly of appropriate head and tank from the kanban store. The entire assembly, testing and painting process is completed within 2 days.
- Machining of components and procurement of outsourced components is then planned to manufacture heads and tanks and replenish the kanban store.
- The raw material flow is also synchronized with the orders. Only materials which require more lead time or quantity based orders (ex., castings) are only kept stock.
- Material trolleys have been fabricated which are used for carrying the tanks from Kanban store to assembly area.

Head Assembly Kanban Store

Fabricated Tanks Kanban Store

Project Result :

The kanban system is helping CEC to deliver in time. Recently, the company has supplied 18 compressors in a single delivery schedule for the first time.

SUMMARY OF RESULTS OBTAINED

Process Level Results

The improvement projects done had a direct impact at the process level since the focus was on improving methods of work through eliminating and minimizing Muda and Muri across the value stream. A summary of the main results is given below:

Parameter	Before	Current	Improvement
Material movement (mtr)	100	20	80% reduction
Cycle time in Fabrication (min)	240	90	40% reduction
5s score	33%	56%	23%

Business Level Benefits

The process level results in turn combined to benefit Coimbatore Compressor's business as a whole in the following aspects:

Parameter	Before	Current	Improvement
Production rate (Nos/day)	2 Nos	5 Nos	2.5times
On Time In Full Delivery (%)	20%	40%	100%

The benefits obtained have spurred, Coimbatore Compressor to start taking in more orders and increased their focus on business development. An internal lean champion is now carrying on the lean initiative to sustain the gains made in year one.

Key Terms :

AM	–	Autonomous Maintenance
OE	–	Original Equipment
OEE	–	Overall equipment effectiveness
UT supplier	–	Ultrasonic Testing machine supplier
CNC	–	Computer Numeric Controlled
NMCP Scheme	–	National Manufacturing Competitiveness Programme
VSM	–	Value Stream Mapping
Takt time	–	German term meaning the time calculated by dividing the total time available for production with the demand by the customers
Kanban	–	A scheduling system for lean and just-in-time (JIT) production
VMC	–	Vertical Machining Centre
SMED	–	Single Minute Exchange of Die
Muda	–	Japanese Term meaning waste
Mura	–	Japanese Term meaning unevenness
Muri	–	Japanese Term meaning Overburden
CFT	–	Cross Functional Team

5S Concept (Japanese terms)

- Seiri meaning Sort
- Seiketsu - Sanitise
- Seiso -Sweep
- Seiton – Systematise
- Shitsuke – Self-discipline

5S	–	Sift, Set, Shine, Standardise and Sustain
Kaizen	–	Japanese Term meaning 'improvement' or 'change for the best' referring to the philosophy focusing on continuous improvement of processes in manufacturing
GB	–	Gasket Seal Bag-in
SPM Power Packs	–	Special Purpose Machines
ECSR	–	Elimination, Combination, Simplification and Redistribution

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