

Lean Implementation in a forging MSME in India - A case study

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Abstract

Purpose

The forging industry in India, largely comprising MSMEs, is highly unorganized, leading to substantial wastes in the processes. These units are now in direct competition with similar units across the world. In order for these units to have a sustainable competitive advantage, these units need to leverage the potential of their employees, establish a continuous improvement culture, improve their processes and leverage on their knowledge to make their operations highly efficient and eliminate their wastes. Lean methodology has the power to address all these issues.

This paper provides a step wise process of lean implementation in a MSME in forging industry, right from diagnostic stage to project implementation. Entrepreneurs in MSME sector who find LEAN intimidating could get motivated with this case study and embark on adopting lean techniques to make their operations world class.

Design & Methodology

The case study methodology has been adopted in this paper to explain in detail the step wise process of lean implementation in a forging MSME.

Findings

Lean implementation in MSMEs has resulted in vast improvements in labor productivity, throughput, customer delivery, quality and changeover time. These are detailed in the paper,

Practical implications

The findings of this paper are based on this case study of lean implementation in a forging MSME. Similar implementation, in other industries could result in a different set of findings, based on the environment and culture existing in those units.

Originality value

This case study bridges the gap between knowledge of lean and skills of implementing lean, especially in a forging industry. It can guide lean practitioners in similar implementation.

Keywords

Lean, MSME, Deskillling, 5S, SOP, Visual management, MSME

1. INTRODUCTION

1.1. Objective

The Make in India initiative launched by Prime Minister of India in September 2014 aims to transform India into a manufacturing hub of the world. With more than 36 million MSMEs forming the lowest denominator of the supply chain, the effectiveness of this initiative is directly dependent on the competitiveness of the MSMEs. With 'Make in India' and startup initiatives, the MSME sector will significantly emerge contributing to the economic development in the next few years. 'Productivity' in this sector is vital for their efficient operations, as higher operating margins can ensure sustenance and supply the capital required for growth.

According to a study (Seyed M.Z., 2011) the current scenario of lean implementation in India shows that only 31.6% of Indian manufacturing companies have adopted lean practices and tools, whereas 68.4% of the companies are yet to begin implementation.

This paper provides details of one cycle of successful lean implementation in a MSME. This will enable the readers to understand the power of lean and how it can be leveraged even by MSMEs to make them competitive. This paper would hopefully facilitate wider implementation of lean in MSMEs.

1.2. Contents

The various tools and techniques of Lean like 5S, *Poka Yoke*, Visual management, JIT, *Kanban*, Load levelling (*heijunka*), TPM, Autonomous maintenance, SMED are explained. Step wise methodology of lean implementation comprising diagnostic study, identification of projects under the Lean Paradigms of Zero waste and Zero defects, preparation of VSM and roadmap, implementation of projects and the financial and non-financial benefits accrued out of the implementation are detailed.

1.3. Background

This is an era of globalization. Geographical boundaries are becoming blurred in economic sphere of activity. With global corporates willing to source its raw material from different parts of the globe, companies are now looking at two factors – cost of sourcing and quality of the products sourced. India and China are now emerging as the manufacturing hubs of the world.

After World War II, Japan was in shambles, with its entire economy devastated. During that period, Toyota Production System evolved its own manufacturing strategy, developed by Taiichi Ohno at the Toyota Motor Company in 1950s (Ohno, 1988). This system was later popularized as “Lean” manufacturing by the publication of the famous book “The machine that changed the world” (Womack, et al., 1990). It involves improving processes while delivering quality products to the customer at the lowest cost (Motwani, 2003; Seth and Gupta, 2005) (Prashar A. 2013) Lean manufacturing is centered on preserving value with less work. It aims to maximize customer value and minimize the effort to realize the customer value, by eliminating the different wastes (*muda*), strain (*muri*) and inconsistency (*mura*) in the manufacturing processes.

Womack and Jones (1996) summarized the concept of lean thinking in five steps:

1. Specify customer value
2. Identify value stream of product

3. Make the value stream flow
4. Create pull
5. Pursue perfection

Adoption of the lean techniques leads to a culture in an organization wherein the worker/operator is guided by the system itself in his/her work and systems are so developed that the probability of mistakes by the worker is drastically reduced. In other words, effective lean implementation facilitates deskilling of the manufacturing operations to a great extent.

The Indian manufacturing is in similar state as that of Japan in 1950s. If India is to be competitive and become the manufacturing hub of the world as envisaged by the “Make in India” initiative of Government of India, the role of MSMEs (Micro, Small and Medium Enterprises), which form the foundation of Indian manufacturing industry, gains greater significance.

1.3.1. MSME sector in India

MSME or **Micro Small and Medium Enterprises** play a crucial role in the socio-economic development of the country. They provide large employment opportunities at a comparatively lower capital cost than large industries and also help in industrialization and development of rural areas. MSMEs are often complementary to large industries as ancillary units. The sector, comprising of over 36 million units, as of today, provides employment to over 80 million persons. The MSME sector through more than 6,000 products, contributes about 8% of GDP besides 45% of the total manufacturing output and 40% of the exports from the country. The MSME sector has the potential to spread industrial growth across the country and can be a driving force in making the GOI’s “Make in India” campaign a resounding success.

(Source - <https://indiafellow.wordpress.com/2016/09/24/msme-the-current-scenario/>)

1.3.2. Necessity to adopt lean by MSMEs

With large corporates sourcing their raw material from across the globe, geographical boundaries are no more a constraint. In such a scenario, MSMEs are now competing with the industries across the globe. They have to necessarily be competitive both in costs and quality. With limited capital available at the disposal of the MSMEs, they necessarily have to look at innovative ways to remain competitive.

Manufacturing units have to be nimble in delivering quality products at competitive rates and shorter lead times. LEAN methodology which organizations to achieve all these and much more at minimal investment levels. This recipe suits a MSME perfectly as they are not very capital intensive.

Adoption of lean methodology enables an organization to evolve a culture of continuous improvement, which is a necessity in this era of cut throat competition. Thus adoption of lean by MSMEs is no more a luxury but a necessity, to make their operations world class.

1.3.3. Sustenance of improvements in a MSME

In a MSME, the entrepreneur is the person who is multi-tasking right from marketing his products to procurement. Most of the MSMEs are structured such that all the employees below the entrepreneur possess skills and capabilities to follow instructions rather than take initiatives

to think and make changes. This necessitates that specific actions needs to be taken to enable the sustenance of lean by the MSME. Simplification of lean implementation, considering the skill set of the supervisors in a MSME, with more emphasis on visual management systems thereby deskilling the supervision is the way out in such a scenario.

2. LITERATURE REVIEW

The literature review touches upon definition of Make in India, followed by origin of lean, characteristics of lean, principles of lean, outcomes of lean from different published articles of international journals of repute such as Emerald Publishers, International Journal on Lean Six Sigma etc.

2.1. Make in India

During 2014, Government of India has taken a bold step by focusing on “Make in India” concept. The idea is to strengthen the manufacturing base. The share of the manufacturing sector in the GDP is currently 16% and the aim of “Make in India” initiative is to enhance this to 25%. Make in India program aims to ease the process of doing business, ensure high quality manufacturing and facilitate exploring untapped zones.

Within a year of announcement of “Make in India” initiative, the global community has got a confidence in the Indian Government and has pumped in 44% additional Foreign Direct Investment (FDI) into India.

2.2. Origin of Lean

Taiichi Ohno and Shigeo Shingo are credited with the introduction of Lean production system at Toyota Motor Company (TMC). Lean production or Just-in-time production is typically described as a manufacturing system striving for continuous improvement and systematically eliminating waste (Crawford & Cox 1990 et al). Western world were truly interested in the philosophy of Toyota Production System (TPS) through the book “The Machine that changed the world” (Womack & Jones 1990). TPS has introduced the concept of training within industries (TWI) (Robinson & Schroeder 1993). The key behind the movement was “learning by doing” rather than telling or showing.

After World War II, during 1950s, Japan was facing challenges to meet the quality levels of USA. During this period, Japan embraced lean culture to improve Quality, Cost and Delivery – the three primary requirements of any customer. The top management commitment to lean implementation is very unique in Toyota (Thirumani & Goutam 2016)

2.3. Characteristics of Lean

Elimination of non-value add (NVA) activities in production & delivering the goods just-in-time (JIT) are the primary objectives of lean (Sanchez and Perez 2001). Lean is a function of flexible motivated team members continually seeking better ways of doing (Dennis 2002).

According to Masaaki Imai (the father of Kaizen), internal systems need to be established to sustain lean initiative in any industry, failing which, workers would revert to earlier methods of doing work (Shredian 1997). Masaaki Imai's (1986) principle was "The Kaizen strategy is that not a day should go by without some kind of improvement being made"

Basic tools used in lean are *Muda*, *Muri* and *Mura*. These are Japanese words meaning waste, strain and inconsistencies or variation (Khadri and Khan 2003).

Ibrahim (2005) describes seven waste addressed traditionally in lean, but subsequent researchers added another two wastes, totaling nine. They are Waiting, Over-production, Rework/Rejection, Motion, Transportation, Inventory, Over-processing, Intellect and Energy

Detailed explanation of the above nine wastes are given below

- a. **Overproduction** – happens when product is made too early or too much, resulting in waiting in the system. This in turn results in locked up cash or inventory. According to Sensui Masaaki Imai, overproduction is the mother of all wastes, as it leads to creation of all the other *muda* described below. JIT (just-in-time) production is the solution to avoid this *muda*.
- b. **Waiting** – Waiting occurs in any process both in manufacturing and service industry. Some examples of waiting are waiting for email from head office, waiting for maintenance technician, waiting for quality inspector to approve, machine waiting for operator, machine waiting because of breakdown, waiting for raw material to be supplied etc.
Waiting is of three types – machine waiting, men waiting and material waiting. Under the lean principle, the order of priority in which the *muda* of waiting is eliminated is 'material waiting', 'machine waiting' and finally 'men waiting'. 'Material waiting' represents the customer in the factory. If the material moves fast across the factory and is delivered to the customer, value is realized by the customer and material will get converted to cash. Hence 'material waiting' elimination is accorded top priority followed by elimination of 'machine waiting' as investment has already been made in machines and aim should be to maximize its utilization. The last waiting addressed is 'men waiting' as this resource is a flexible resource and could be utilized elsewhere as well.
- c. **Transport** – Any movement of materials or components in a manner that does not add value to the customer is considered as *muda* of transport
- d. **Over-processing** – happens when components are processed more than necessary (for example, heating steel ingots more than required temperature, curing castings longer than required, inspection, looking for parts, counting parts etc.). This can lead to increase in cycle time
- e. **Inventory** – Stored finished goods at warehouse or work in progress or raw material adds to the financial cost of the manufacturer (in the form of additional working capital) which many times cannot be passed on to the buyer. This additional inventory in storage can also lead to the other *muda* of rework/reject due to obsolescence, damage in storage etc.
- f. **Motion** - Any extra movement on the part of the operator while producing such as walking, picking, carrying, placing, just watching, stretching, lifting, bending and even searching of tools or spares results in *muda* of motion
- g. **Rework/Rejection** – Producing defective parts leads to addition in costs and reworking costs, leading to additional labor, space and cost of inventory. Calling back defective

goods from the customer owing to rejection can cause huge damage to the business both in terms of money and reputation.

- h. **Intellect** – Underutilization of talent of the employees could be a form of waste. For example a skilled person in analytical chemistry not engaged in the laboratory
- i. **Energy** – Any loss of any form of energy is a waste. Primary sources of energy such as gas, oil, coal etc. apart from secondary sources of energy such as steam, electricity, compressed air leaks etc. wasted in the industry. Insulation loss, transmission loss, leaks in pipelines, spillage etc. are examples under this head.

2.4. Principles of lean

“Doing more with less” is the key principle of lean. In the process, we eliminate waste from the process (Womack et al 1990, Womack and Jones 1996). For example, whether it is an automobile manufacturing process or a pizza delivery process, time between receipt of order and realization of cash after delivery is critical for both types of business, or for that matter any business.

Kusar et al (2005) has described lean manufacturing methods as primarily consisting of a set of important tools. They are SMED (Single Minute Exchange of Dies), TPM (Total Productive Maintenance), Poka Yoke (Mistake proofing), 5S, VSM (Value Stream Map), Visual control, Andon, Pull/Kanban system, 5W and cell production. These tools provide adequate knowledge to identify non value added activity in any process.

Lean thinking converts knowledgeable workers to independent goal seekers and encourages them to apply their problem solving skills and critical thinking capabilities to serve customers. It enables them to standardize their processes and make daily production schedules visible to encourage ownership and to continue their improvement efforts (Laraice et al 1999).

2.4 1. Case Studies on Lean from MSMEs

A review of some of the case studies on lean implementation in MSMEs shows that they are based on data collection through interviews, questionnaires and direct observation. They focus on the results obtained and thereby comment on the effectiveness of implementation of some of the lean tools. There is hardly any published literature which depicts any live case studies in Forging Industry.

Forging industry by itself is in the unorganized sector and is labor intensive. This exposes this industry to severe threats in terms of competition from the developed economy. In this scenario, a live case study on lean implementation in the forging industry explaining the end to end process of lean implementation, with tangible outcomes, is fully justified. This will facilitate acceleration of the progress and development of process improvement initiatives in the industry, in an Indian context.

2.5. Outcomes of Lean

The main goals of lean implementation are Operational efficiency, Customer satisfaction, Quality, Competitive strategic advantage and Management worker relations

Association of Manufacturing Excellence (AME) indicated outcomes normally associated with lean implementation could be

- a. 70-90% reduction in setup time
- b. 20-60% improvement in productivity
- c. 40-80% reduction in process time
- d. 30-70% reduction in inventory
- e. 40-90% reduction in walking time (distance travelled)

There are a number of case studies on the outcomes of lean initiatives in different manufacturing and service industries. Some of the published data are summarized below.

In the period 1992-1998 through lean initiatives Nippon Steel Corporation (NSC) has improved the quality of the products by bringing down defect levels from 15.2% to 10.8% and energy consumption had reduced from 4.2% to 4.6% level. Cost of maintenance was brought down at NSC from 29.1% to 24.3% (Adam Paul Brunet and Steve New 2003).

In a small and medium enterprise (SME), a machine vice manufacturing industry processing time has been reduced after a Kaizen event by 44% and an amount of Rs. 64000 has been saved by recovering a total of 80 square feet working area. Improvement in the form of workflow has also been achieved (Amit Kumar Arya and Sanjeev Kumar Jain 2013)

A pharmaceutical product manufacturer's quality of operations improved resulting in lead time to manufacture reduction from 25 to 16 days, on time delivery performance improved from 67% to 87%, analyst productivity improved by 20%

(www.tefen.com/uploads/inisights/1449921513-74dYYQKV.pdf)

In a North American automotive industry from January 1992 to December 1993, lean initiative led to an increase in productivity by 50% (Roderick Bockmiller 1994).

Similarly in a case study in a SME, inventory access time reduced by 87% and total travel time reduced by 44% and total throughput time of product reduced by 46% (Amit Kumar Arya and Suraj Choudhary 2015)

3. METHODOLOGIES

The purpose of this case study is to bring forth the empirical studies applying Lean tools and techniques. Accordingly the Lean tools deployed are Value stream map, Muda, Muri, Root cause analysis. Live examples in the case study section prove the connection between theory and practice of Lean.

This section broadly covers two divisions. The first one deals on the theory on case study design and the second one on how the case study adopted the application of lean tools to achieve the required objectives of the paper. This paper under presentation is a case study of explanatory type.

3.1. Case study research

Case study as defined by Yin Robert (1994) in his book “Case study research design and methods” covers the following aspects

A case study paper shall reflect on two basic questions – How & Why? Case study method, either explanatory or descriptive type, aims to provide a first-hand experience of the people and the events associated. It helps to answer the question of whether scientific theories and models actually work in the real world. Thus the ability of the case study is to examine the depth of the case in a real life context.

3.2. Lean tools methodology

In order to achieve deskilling of workforce in low technology areas, the process has to be robust. Workforce with very little training / experience can be employed when the process is robust. A robust process will eliminate the possibility of producing defective goods and also ensure safety of the work force. This is possible by introduction of lean methodology tools in the system. This is a proactive tool essential to ensure that mistakes are prevented in the product or service process.

The following tools which are relevant for this paper are covered

- a. TPM (Total Productive Maintenance)
- b. SMED (Single Minute Exchange of Dies)
- c. Visual management
- d. JIT (Just in Time)

3.2.1 TPM (Total Productive Maintenance)

TPM is one of the powerful tools aimed to attain zero-breakdown, zero-accidents and zero-rejections. The principle of this are supported by 8 pillars which are Autonomous maintenance, Planned maintenance, Focused improvement, Quality maintenance, Safety, Health & Environment, Office TPM, Development maintenance and Education & Training

These eight pillars help to address the 16 different losses in any industry and thereby achieve the goals of TPM

3.2.2. SMED (Single Minute Exchange of Dies)

The primary aim of this tool is to reduce the non-value added activities in a setup or changeover process, thereby drastically reducing the change-over time. Taiichi Ohno (1988), President of Toyota Motor Corporation, during 1950, reduced the change over time for a sheet metal stamping die (Automobile manufacturing) from 1 day to 3 minutes using SMED (Venkatesan T M, 2016).

The underlying theory of SMED is the changeover time is split into internal and external set-up time

Internal set-up time: Activities that take place in a changeover process after the equipment is shut down for changeover

External set-up time: Activities that take place in a changeover process before the equipment is shut down for changeover or after the equipment is started after a changeover

The first iteration of changeover time reduction is achieved by shifting as much of the activities of changeover in internal setup time to external setup time. Once this is achieved, the focus shifts to reduction in internal set-up time.

3.2.3. Visual management

“A picture can speak better than a 1000 words” is a well-known proverb. The spirit of this proverb in shop floor implementation is what we term as “Visual management”. A picture can give a clear understanding to an employee irrespective of his level in an organization.

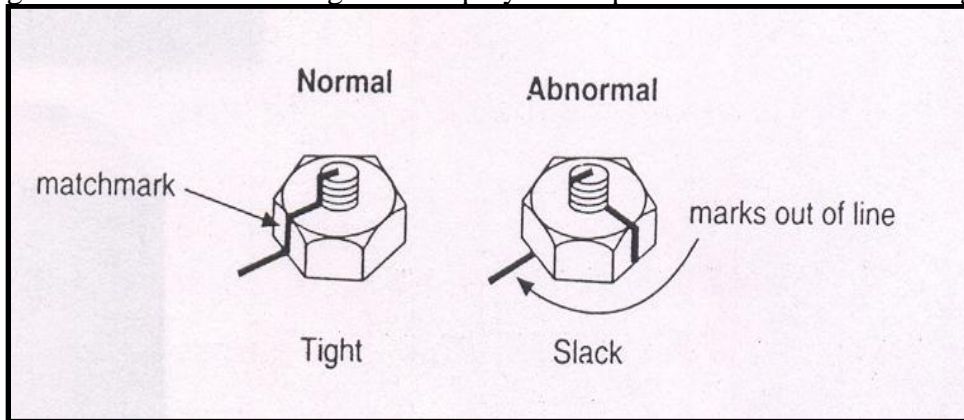


Figure 3.1 Example of visual management

3.2.4. JIT (Just-in-Time)

This system ensures that the vendors supply to the production line just before the demand for the raw material is felt. This helps in saving valuable space, inventory cost, deterioration in storage, obsolescence in storage etc. Automotive industries follow this system meticulously with close to zero inventory levels. Parts from vendors are received in evening for the next day morning production schedules.

4. CASE STUDY

4.1. Background & Context

Lean Manufacturing Competitiveness Scheme (LMCS) is a scheme of the Ministry of MSME. The main objective of the Lean Manufacturing Competitiveness Scheme (LMCS) is to improve the manufacturing competitiveness in the MSME Sector. Lean Manufacturing involves applying Lean Techniques (e.g. Total Productive Maintenance (TPM), 5S, Visual control, Standard Operation Procedures, Just in Time, Kanban System, Cellular Layout, Poka Yoke, TPM, etc.) to identify and eliminate waste and streamline a system. The focus is on making the entire process flow, not improving only a few operations. Worker empowerment is also emphasized throughout the effort. (Source: <http://www.dcmsme.gov.in/schemes/lean-manufact.htm>). The larger enterprises in India have been adopting LMCS to remain competitive, but MSMEs have generally stayed away from such programs as they are not fully aware of the benefits.

This case study is based on lean implementation at one of the forging units in South India under the above scheme. This forging unit is a manufacturer of ferrous, non-ferrous and alloy forged components for flanges, pipe fittings, automotive components, valves etc. Due to growing demand, the managing partner of this MSME felt the need to enhance the operational efficiencies of the unit and thus joined a cluster of units who were interested in getting lean manufacturing implemented in their respective units. The total duration of this project was 18 months.

4.2 Projects identified and the reasons for the selection of projects

The journey commenced with a diagnostic exercise during which the processes at the forging unit were observed and studied under Lean paradigms of Zero Waste and Zero Defects. Following observations at the *gemba*, the overall process flow was initially mapped through a **Value Stream Map (VSM)**.

As can be seen from the value stream map the **value adding ratio (VAR) is only 3.30%** (Value adding ratio is the ratio of sum of cycle time of all the processes divided by the total time taken for a product to be manufactured) . The key reason for such a low value adding ratio is the high WIP between processes leading to a high throughput time. Further, the *gemba* walk provided several observations of *Muda* (waste) and *Muri* (strain) which are detailed below:

Inventory

- Observed WIP inventory of 8 MT at cutting, 4 MT post forging, 4 MT post Heat Treatment, 4.6 MT at machining, totaling to about 22 MT which is roughly 6 days production.
- 155 MT of non-moving and scrap material observed all over the plant and stored in a very haphazard manner (see pictures above). Some of the material has been lying in the plant for more than six months.

Material Transportation & handling

- Each of the operations - cutting, forging, heat treatment, shot blasting is located in a different shed and material has to be transported in trolleys between these stages. The product is handled multiple times in between processes each time being dropped to the ground and then picked up again.
- The cut blanks from the cutting section have to be transported about 50 metres to the forging section.
- Uneven flooring further aggravates the movement of trolleys increasing the strain on the workers.

Equipment / Process Waiting

- After the furnace is heated up, there were instances of the furnace waiting for the billets from cutting section which means loss in output as well as increased energy costs
- Heat treatment was waiting for parts to be loaded, the unloading and loading time is about 2 hours or approx. 20% of the total cycle

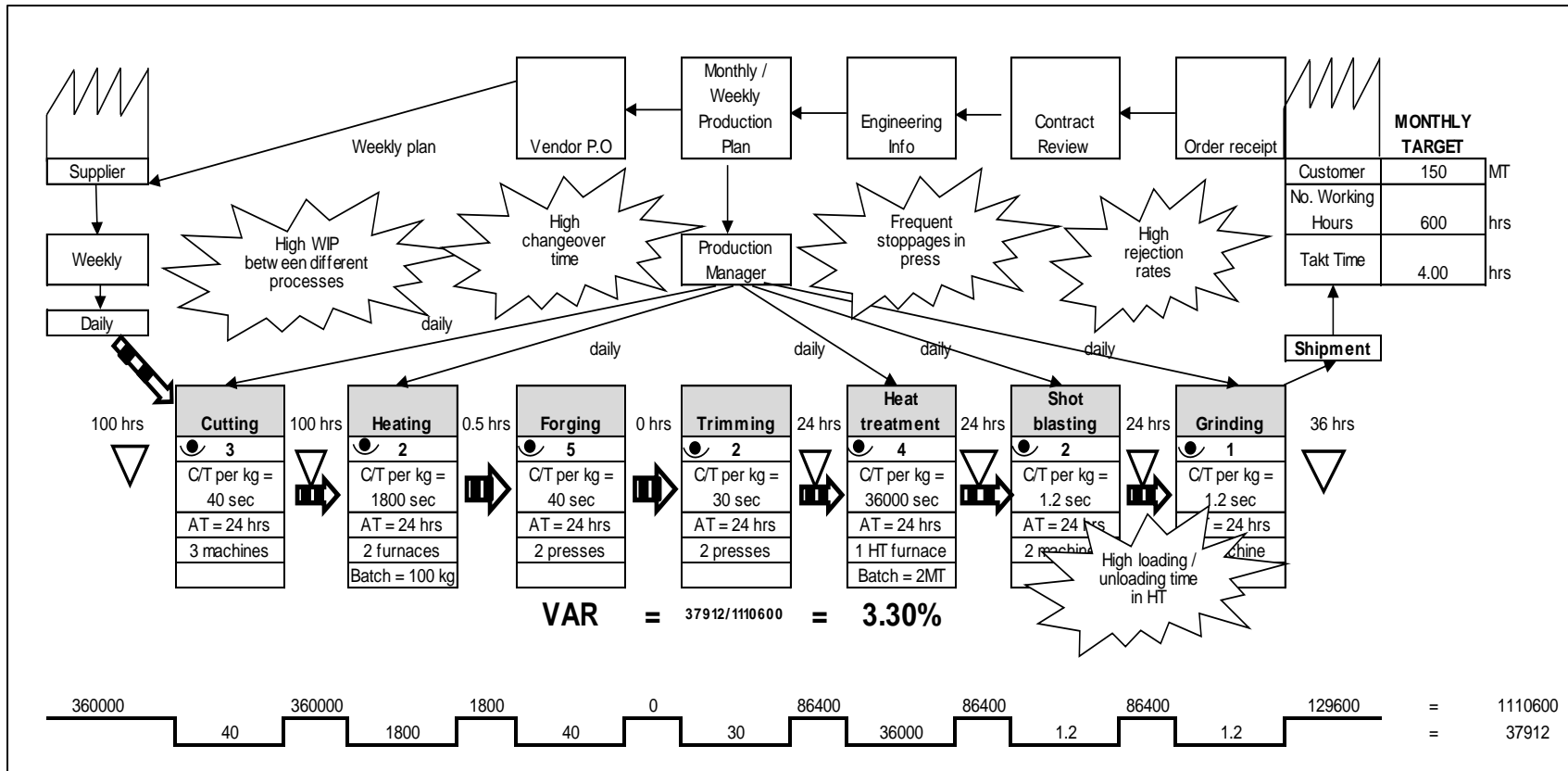


Figure 4.1 Value Stream Map of the forging unit before lean implementation

Changeover time

- A complete die changeover takes about 2 hours while it takes 45 minutes to change only the die in cases where billet size remains the same.

Rejects & Rework - The last four months data shows total rejection of 2% internally and another 1.7% from the customer while internal reworks are approximately 14.5%.

Delivery lead time – A sample data analysis of purchase orders indicated a wide variation in the total lead time ranging from 14 days to 49 days.

The above observations taken together with the VSM analysis provided the rationale for prioritizing the following areas for focused improvement.

1. **Increasing the throughput of forging press and increasing labor productivity** – Forging is the heart of the entire process and any increase in throughput of this process will directly increase the throughput of the entire plant. Further this being a labor intensive process, increase in throughput will also increase the labor productivity.
2. **Reduction in loading and unloading time for heat treatment** – With 20% of the heat treatment cycle being used for loading and unloading time, any reduction would result in the capacity of the heat treatment getting enhanced.
3. **Reduction in changeover time in press** – On average one or two changeovers are carried out in each of the presses on a daily basis. With changeover time ranging from minimum of 45 min. to more than 2 hours, reduction in changeover time will directly increase the throughput of the plant
4. **Reduction in Rejections** – Current rejection levels of 3.5% and rework levels of 14% leads to unnecessary expense of poor quality, delays in delivery and hence customer dissatisfaction. Improvement in the quality at the point of generation of the defect will directly result in cost savings and an improved delivery performance.
5. **Improvement in OTIF (On time in full)**– The sum of cycle times across entire value stream is less than 2 days but the actual delivery lead time vary varies from 14 to 49 days Computed OTIF is below 50% and improvement in this will enhance customer satisfaction.

The improvement projects were taken up first for executing in Stages II, III and IV of the implementation journey. Standardization of processes was then taken up in the last stage – this was mainly done through production planning, 5S and SOP adherence.

4.3. Project Team

The core project team comprised of the Proprietor, Production Head and Quality Head. In addition Quality supervisor, Cutting and heat treatment supervisor, Production supervisor and Tooling supervisor were formed into teams for projects in their respective areas

4.4. Project Schedule: month / phase-wise activities

The project commenced in February 2016. In discussion with the managing partner the following road map was planned and executed phase wise

Table 4.1 Road map of lean implementation

| Improvement Project | Activity / Milestone Completion Date | Mar-16 | Jul-16 | Oct-16 | Feb-17 | Jul-17 |
|--|---|--------|--------|--------|--------|--------|
| Awareness and Roadmap for Improvement | Familiarization Seminar of Lean Concepts and Tools | | | | | |
| | Identification of base line & focus areas, roadmap for lean implementation | | | | | |
| Increase the throughput of the line (MT/month) | Improve the furnace utilization to ensure that the forging press is continuously loaded with material | 45.0 | 45.0 | 60.0 | 80.0 | 100.0 |
| Labor productivity in above line (kg/man hour) | Eliminate multiple handling and improve productivity (Current level 7.95) | 8.00 | 8.00 | 10.00 | 15.00 | 20.00 |
| Improve OTIF (On time in full) to customers | Implement pull based system to trigger manufacturing | | 40% | 55% | 65% | 70% |
| Quality Monitoring & Reduction | Put in place a system for tracking customer complaints and root cause analysis | | | 4.00% | 1.00% | 0.00% |
| | Process parameter monitoring in forging and heat treatment to ensure consistency | | | 6.00% | 2.00% | 1.00% |

4.5. Improvement projects

4.5.1. Project 1: Increasing throughput in forging and improving labor productivity

Process description

Billets are cut from raw material (in the form of rods) and are supplied to the forging section. These billets are then heated in the furnace to the required temperature before they are forged in the forging press. After forging the components are immediately trimmed in the trimming press and then sent for heat treatment

Current State Observations & Measurement Plan

A detailed observation of the forging cycle threw up the following issues related to loss in capacity of the forging press.

1. Frequent stoppages of the forging press were observed due to want of raw material (heated billets). After every 30-40 minutes of forging, the press was stopped for heating the next batch of billets in the furnace
2. During some of the changeovers, it was observed that the inserts of the die were not producing the correct quality components due to which the inserts had to be reworked. This caused the forging press to be stopped. In some of these instances the plan had to be changed after discovering that the die insert could not be reworked resulting in another changeover.
3. The forging team was working in dusty and hot conditions due to the nature of the process and was forced to take breaks to alleviate their strain.
4. Cutting section production was carried out independent of consumption of cut pieces in forging leading to huge WIP of cut pieces between cutting and forging section. At the same time, there were instances of shortage of the raw material planned for forging.

Root Cause Analysis & Countermeasures

The main root causes for all the above *muda* was the lack of constant feeding of right material to the forging press and insufficient preparation of the dies before starting forging.

Improvement Plan

1. Various trials were carried out to ensure continuous feeding of billets to the forging press. Based on the trials the following system was established
 - a. For 1 MT forging press “zig-zag” loading system was established. In this system the first lot of billets is heated to the required temperature in parallel with the die changeover process. Once forging process has started, a continuous flow of hot billets is ensured by loading 5 new billets into the furnace on consumption of every 5 heated billets by the press. In this way, all billets reach the required minimum temperature while ensuring continuous feeding of hot billets to the forging press.
 - b. For 1.5 MT forging press, since the components are heavier, two furnace feeding system was established wherein as the material is being consumed from one furnace the other furnace heats the next lot of billets to the required temperature.
2. A system was established wherein the tools needed for forging are inspected and made ready in advance so that there is no loss of capacity due to defective tools / dies.
3. Since continuous feeding of billets was established, the forging team would not be getting breaks due to waiting for hot billets as had been happening earlier. To take care of fatigue, the forging team was therefore given a scheduled break of a 2-3 minutes after every 30-40 min. of continuous running of forging press.

4. System of trolleys was introduced between cutting and forging to eliminate multiple handling. The number of trolleys limits the WIP between cutting and forging section. This also ensured that the cut pieces were consumed within 24 hours in forging, thereby reducing the WIP.

Outcomes

The above improvements resulted in increased output from the forging press as well as enhancement in the labor productivity. The following chart of labor productivity from Jan 2017 to July 2017 shows the trend of labor productivity (the slight dip in March and April 2017 is due to induction of new operators on account of festival holidays).

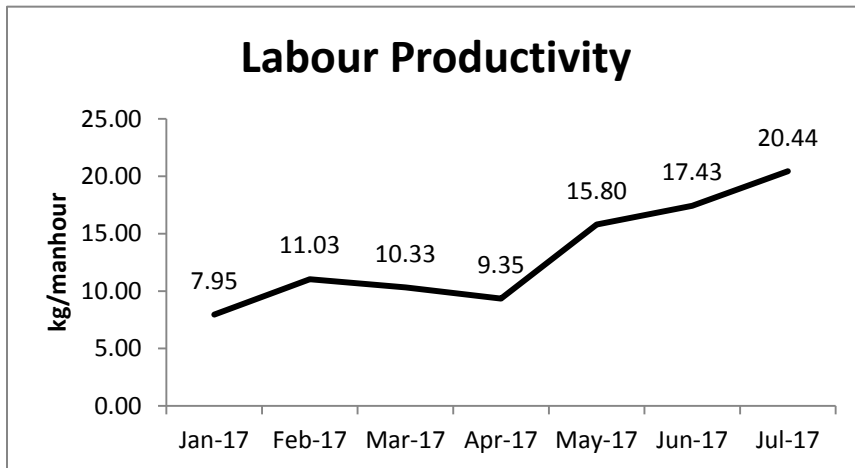


Figure 4.2 Labor Productivity

4.5.2. Project 2: Reduction in loading and unloading time in heat treatment

Process description

After forging and trimming, the components are accumulated to form a 2 MT batch for heat treatment. These components are then stacked on the heat treatment bed manually (this takes approximately 1 hour). The bed is then inserted into the furnace and heat treatment cycle commences. After the heat treatment cycle, the bed is brought out of the heating chamber and allowed to cool using fans (approx. 45 min.) After cooling the components are then unloaded from the bed and the next batch is loaded (approx. 15 min.). The total loading and unloading time of a batch is approximately 2 hours while the actual cycle time of heat treatment is a maximum of 10 hours.

Current State Observations & Measurement Plan

The various observations pertaining to the heat treatment process are:

1. Heat treated components are pushed out of the bed in hot condition, onto the floor around the bed manually using spades.

2. Multiple handling of components – they are dropped on the floor after trimming and allowed to cool. They are then loaded on to a trolley and then transported to heat treatment and dropped again on the ground. These components are then manually picked up and loaded on the heat treatment bed.



Figure 4.3 Loading of components on heat treatment bed

3. Since the flooring between trimming and heat treatment is uneven, movement of the components in trolleys was very strenuous.
4. The area around the heat treatment bed was getting blocked with hot components of previous batch and this was delaying the start of loading of the next batch, resulting in longer waiting time between batches.
5. Unloading of heat treatment bed was done manually due to which the workers had to wait for components to cool down before commencing unloading.

Root Cause Analysis

Multiple manual handling of individual components is the root cause for strain and a non-value adding time of almost 20% for loading a batch.

Improvement Plan

1. Output from trimming directly collected in trolleys through a chute made to enable easy sliding of components onto trolleys.



Figure 4.4 Direct collection of trimmed components in trolley

2. A ramp was made which allowed the heat treated components to be pushed away from the bed in hot condition itself, thereby creating space around the bed which enables loading of the next batch, without waiting for the previous batch to be cooled.



Figure 4.5 Ramp to unload hot components from bed

3. To avoid the piece by piece loading onto the bed, a trial was taken with the trimmed components being loaded onto a MS bin offline and this bin was then placed on the heat treatment bed. The components underwent heat treatment as per specifications.

Outcomes

Since MS bin could not withstand the heat treatment cycle, it was decided to replace with SS bin. This will reduce the loading and unloading time from 2 hours to apporx. 15 min. (which is time taken to unload and load the bins). The unit has planned to invest in SS bins and crane for loading and unloading the bins at a later date.

4.5.3. Project 3: Reduction in changeover time in press

Process description

Die changeover is done whenever the product being run is changed as per production plan. There are two types of changeover:

1. Partial changeover – change in component design/shape but same input billet size. This takes about 45-60 minutes
2. Full changeover – change in both component design and in input billet size, both die and die holder need to be changed in this case and this takes 2-2.5 hours.

Changeover time is defined as the time interval between completion of the last good piece of the running lot to the finishing of the first good (approved) piece of the next lot.

Current State Observations

Following are the key contributors to high changeover time

1. The next die and insert to be set on the press was brought there after the press was stopped
2. During changeover, there were instances of the die being ready but billets were not available at required temperature to start the forging operation
3. Significant time was spent in adjusting and aligning the top and bottom die

4. No standard temperature set for heating of dies/inserts before changeover
5. The burner set up used for preheating die was brought to the press after die setting was completed. Five minutes were lost in adjusting the flame as needed
6. Even for components which are regularly produced, the heating of the first lot of billets was started only after approval of the first component.

Root Cause Analysis

The main causes for increased changeover time were

- External activities being done after forging hammer has been stopped
- Lack of standards for preheating, setting

Countermeasures

1. A video of the changeover process was shot and activity wise analysis done by the team. The activities were re-categorized as external and internal.
2. Specific responsibilities was assigned to each of the member of the changeover team
3. A proper procedure was developed for alignment of top and bottom die thereby ensuring that the first component produced after changeover is a good component.
4. Components loaded in furnace at appropriate time so that they are ready for forging just in time as the die is preheated and ready
5. Die is heated to temperature of 150 deg. C and measured using a temperature gun. This ensures that there is uniformity in die heating
6. For regular components, since instances of first piece rejection was negligible, entire batch of billets were heated at the outset without waiting for first component clearance

Outcomes

Average changeover time reduced from 90 min. to < 50 min.

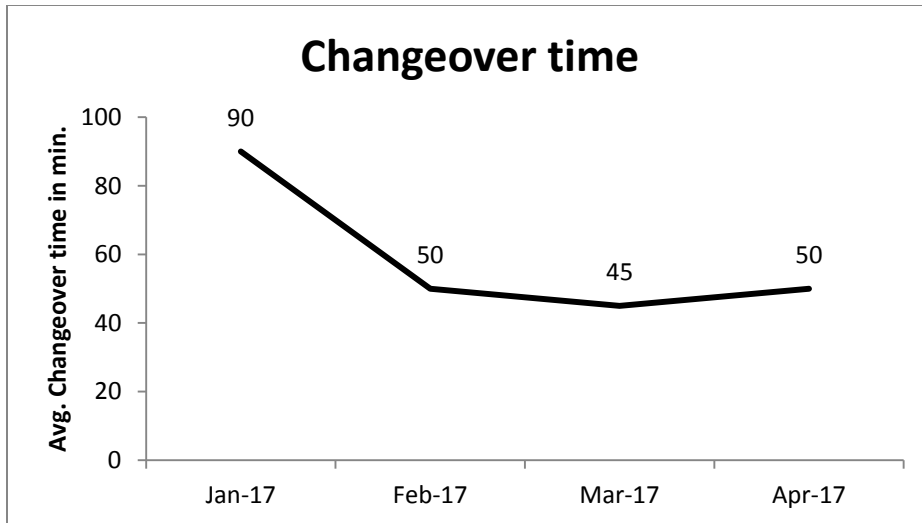


Figure 4.6 Reduction in changeover time

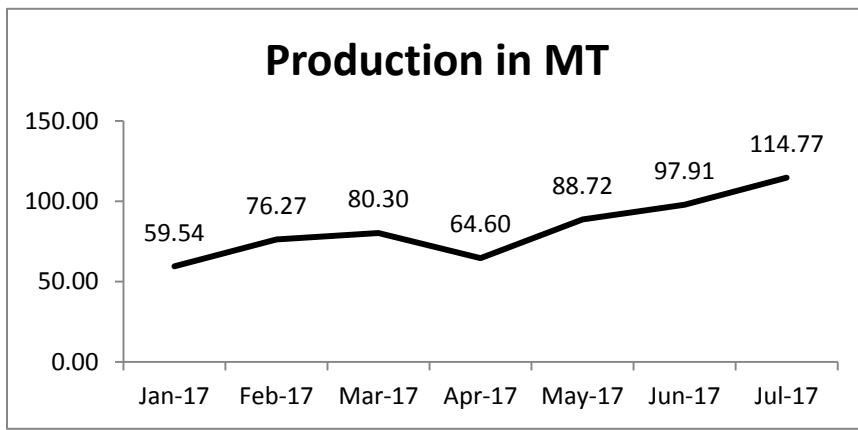


Figure 4.7 Increase in Output due to reduced changeover and improved throughput

4.5.4. Project 4: Reduction in rejection levels

Current State Observations

The rejection levels of the components were very high with rejection levels of 4% including 2% from the customer while reworks were to the tune of 14%.

Components with high rejection levels were taken up for root cause analysis and the observations were as follows

- i. The weight of the cut billets was observed to be not consistent, with variations as high as 200 grams as against the process specification tolerance of 50 grams.
- ii. Flash generated during the upsetting stroke falling on the die inserts and sticking to them
- iii. Un-filling problem observed in a particular component AA.



Figure 4.8 Unfilling problem

Root Cause Analysis

For Weight Variation - Specifications of cut weight range not provided to cutting section and lack of process control to maintain the cut weight within a range of 50 gms

For un-filling - Improper cross-section of the billets for the affected component

For flash - Lack of cleaning of the die insert after the upsetting stroke resulted in flash being present at the time of the profile stroke in forging press leading to pitmarks



Figure 4.9 Pitmark problem

Improvements made

- The specified range of weight for the planned component is now given in the work order to cutting section
- The cut piece weight was controlled within a range of 50 gms. by introducing online weight checking in cutting section. In case of any deviations, the length setting on cutting machine is appropriately reset to get required weight.
- For component AA, the profile of the billet was changed from a circular cross-section to a semicircular cross-section thereby minimizing the unfilling problem in the component.



Figure 4.10 Change in billet cross-section

- Air cleaning was introduced after upsetting which ensured that the flash generated in upsetting is blown away thereby eliminating the root cause for pit marks

Outcomes

After institutionalising the above countermeasures, the rejection levels (both internal and customer returns) reduced substantially. The team was now trained in the methodology of root cause analysis and used the same for improving the quality levels in other components as well.

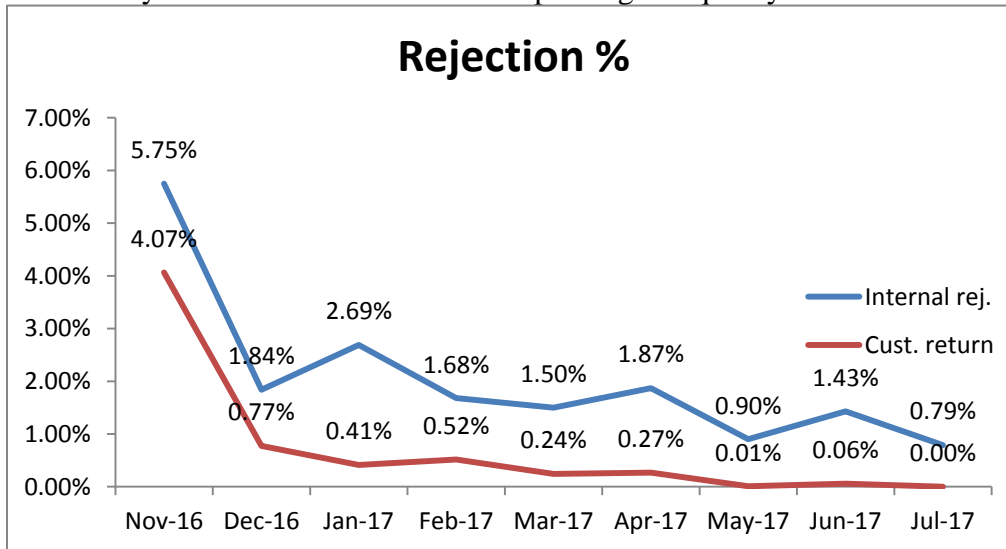


Figure 4.11 Reduction in rejection percentage

4.5.5. Project 5: Improvement in customer delivery performance (OTIF - On time in full) of the plant

Current State Observations & root cause analysis

- Delivery orders were not tracked on the shop floor
- Production planning was done for the forging section only which did not take into consideration the committed dates to the customers. The cutting section and the heat treatment section did not have any plans linked to this plan and operated independently.

Improvements made

- Route card was introduced for every customer order which enabled tracking of the order on the shop floor. This also enabled measurement of lead time for delivery of that particular order

- A system was put in place to consider the customer committed date as the primary parameter for the weekly production planning of forging. The cutting plan was linked to forging plan to make the required billets one day before.
- Every customer order is now tracked to arrive at the customer delivery performance (OTIF) of the plant

Outcomes

After institutionalising the above countermeasures, there has been a steady improvement in the customer delivery performance (OTIF) of the plant

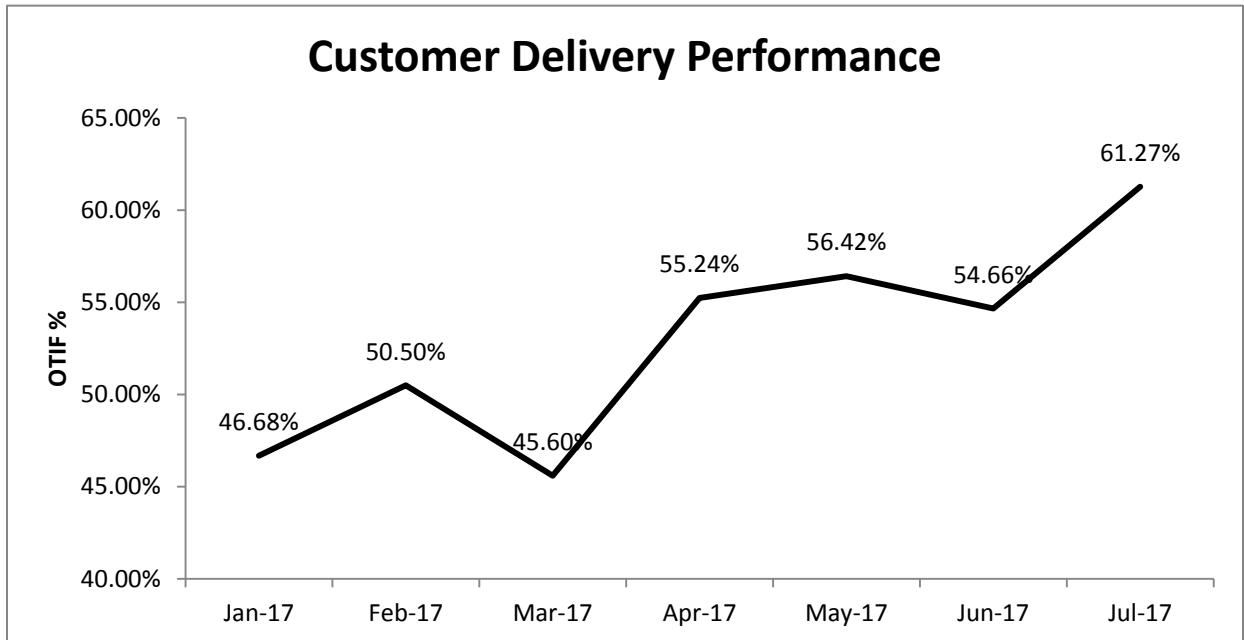


Figure 4.12 Improvement in customer delivery performance (OTIF)

4.6. Financial savings due to lean implementation:

The following are the details of the financial savings which accrued for the unit by virtue of lean implementation:

1. Increase in the output of the plant by at least 20 MT per month which translates to 240 MT per annum. Assuming selling price of Rs. 50 per kg, this translates to an increase in revenue of Rs. 1.2 Cr per annum. Assuming a profit of 5%, this translates to an **increase in profit of Rs. 6 lakhs per annum**
2. Manpower productivity increase – Increased from 8 kg per man-hour to 20 kg per man-hour. Assuming Rs. 45 per man-hour as labor cost, this translates to a reduction in labor cost per kg from Rs. 5.6 per kg to Rs. 2.25 per kg – a saving of Rs. 3.35 per kg. Assuming a monthly output of 100 Mt this translates to a savings of Rs. 3.35 lakhs per month → **Rs. 40 lakhs per annum reduction in labor cost**
3. Reduction in rejection percentage from 5.7% to 0.6% → 5% reduction in rejection which translates to 5 MT savings per month. Assuming 70% as cost of raw material, this results

in raw material cost savings of Rs. 1.75 lakhs per month. **Total raw material cost savings per annum is Rs. 21 lakhs per annum**

Thus the overall financial benefit per annum in terms of profitability would be **Rs. 67 lakhs per annum**

5. Findings

The following table summarizes the improvement in various parameters in the MSME after successful lean implementation within a period of 18 months

Table 5.1 Quantification of improvements

| S.No. | Parameter | Before Lean | After Lean | Improvement |
|-------|-----------------------------------|-------------|------------|---------------|
| 1 | Labor productivity in kg/man-hour | 7.950 | 20.440 | 157% increase |
| 2 | Changeover time in min. | 90 | 50 | 44% reduction |
| 3 | Production in MT per month | 59.54 | 114.77 | 93% increase |
| 4 | Internal rejection | 5.75% | 0.79% | 86% decrease |
| 5 | Customer return | 4.070% | 0.004% | 99% decrease |
| 6 | Customer delivery | 46.68% | 61.27% | 31% increase |

Overall the financial savings is to the tune of Rs. 67 lakhs per annum

6. CONCLUSION

Thus by using lean tools and techniques, the forging unit has been able to improve their productivity, quality and customer delivery leading to substantial financial benefits. All these have been achieved with the same infrastructure, minimal investment and same personnel. These results have been achieved in a very short period of 18 months.

This case study demonstrates the power of using lean tools and techniques with the objective of making the process robust, even in an environment of low technology and at the same time unskilled labor. Lean implementation is not something which is beyond the comprehension of the employees of MSMEs. It has enabled the MSME to leverage the potential of their employees, establish a continuous improvement culture, improve their processes and leverage on their knowledge to make their operations highly efficient and eliminate their wastes.

Thus MSMEs can ensure sustainable competitive advantage by implementing lean. They now can not only survive but thrive in the highly competitive markets of the world and facilitate India to become the manufacturing hub of the world. This case study could act as a catalyst in bringing about significant cultural change in the society of MSME entrepreneurs and provide them the necessary confidence to embrace LEAN wholeheartedly.

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