

Introducing lean, not mean, to improve the productivity in a cutting tool manufacturing company

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ABSTRACT

Owing to global competition, manufacturing industries are constantly facing the challenges of reducing product cost, customer lead-time, manufacturing cycle time etc. Lean manufacturing principles are widely used in a variety of industries to meet these challenges through the reduction of waste. Lean principles are not only being applied in manufacturing industries, but also in other areas and service providing organisations such as healthcare, office, construction, government, software & IT etc. First, focusing on theory and wider industry literature, the paper attempts to demonstrate what “lean” is and how and why it should be applied. Then it highlights why manufacturing is important for the UK and argues the justification of adopting lean principles in UK industries. The principal objective of the current work is to assess the implementation of lean manufacturing methods in a major cutting tool (Bandsaw) manufacturing industry with the help of case studies. Reviewing the case study in question, the paper then discusses the benefits of lean implementation in action towards improving productivity. It then puts forward a series of recommendations for improving the current implementation process and for becoming a successful lean organisation.

1. INTRODUCTION

In today's globalised economy, companies are increasingly forced to compete for the share of world market. Irrespective of manufacturing environments, there is a constant pressure on the companies in developed countries to increase productivity responsiveness and to decrease lead times and manufacturing costs, while maintaining and improving the quality level. This places companies based in the developed world in a precarious position. As a result, companies are being forced to search and adopt new manufacturing methods to ensure competitiveness. In the traditional business models, products could be manufactured and sold in a stable marketplace using strategic production and marketing plans. However, in today's volatile and ever-changing marketplace, companies must be able to rapidly sense what customers want and respond to their needs quickly. Recently, lean manufacturing philosophy has caught the attention of both academia and manufacturing industries around the world to meet the challenges of improving manufacturing performance and to gain a competitive advantage in the marketplace. Although the lean concept has been developed for automotive manufacturing industries, over time it has been established that the lean concept is transferable to a variety of other industries and organisations such as administration, construction, software & IT, service industries, logistics, military etc. [1-5]. The purpose of this investigation is to examine the lean implementation process in a cutting tool manufacturing industry and to assess the benefits by reviewing its application across the factory shop floor through a case-based approach. Owing to confidentiality, the manufacturing plant in question will be referred to as “Company” throughout the paper.

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2. INVESTIGATION METHODOLOGY

First the study was focused on the theoretical principles of lean manufacturing and the necessary tools and techniques for successful implementation. This was particularly useful in developing a foundation for conducting further studies. The study then examined the current status of manufacturing industries in the UK and the reasons for moving towards lean manufacturing. Primary data from official sources were used to demonstrate the justification for adopting lean principles in UK manufacturing. Empirical evidences (collected from various important websites on Lean Manufacturing) in the form of case studies were studied. Each stage of manufacturing process was closely studied to gain in depth knowledge of the Company. The lean manufacturing tools and techniques applied in the milling section of the Company were investigated to gather the results of practical benefits and sustainability of lean. The senior managers, who were directly involved in the lean programme, were also interviewed to have their comments on the beneficial outcomes of lean events. The findings of which were intended to form the basis of the recommendations for lean implementation.

3. LEAN MANUFACTURING CONCEPT, TOOLS AND TECHNIQUES

‘Lean manufacturing’ has evolved from the widely adopted Japanese manufacturing concepts such as “Just-in-

Time” or “Toyota Production System”. Lean manufacturing differs from the traditional mass manufacturing concept in a way that products should be produced at the rate of customer demand, not keeping the workers or machines busy. The term “Lean” was popularized by James Womack’s revolutionary book “The machine that changed the world” published in 1990 [6]. According to Womack and Jones, “Lean thinking is a way to do more and more with less and less – less effort, less time and less space” [7]. Targeted and accurate analysis of existing operations, prioritisation of areas for improvement and working in a smarter way are key to the development of an efficient lean manufacturing operation. The essence of the lean process is to continuously identify and eliminate any waste, which consumes resources, but creates no value to the product and to provide what costumers actually want. The lean process typically focuses on eliminating seven forms of waste as shown in Figure 1. More recently, failure to utilise untapped human potential is also recognised as an eighth form of waste.

Waste of untapped

human potential

Under-utilised

people

Doing more work than

is necessary

Any wasted motion to pick up

parts or stack parts

Any non-work time waiting for

tools, supplies, parts, etc.

Maintaining excess

inventory of raw

materials, parts in

process, or finished

goods

Producing more

than is needed

before it is needed Wasted effort to

transport materials,

parts, or finished goods

into or out of storage, or

between processes

Repair or rework

WASTE

Correction

Waiting

Inventory

Motion

Transportation

Overprocessing

Over

production

Figure 1: The common forms of waste from lean manufacturing point of view

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Over the years a number of lean manufacturing tools and techniques have been developed to implement the lean philosophy with the goal of reducing process cycle times, improving delivery performance and reducing cost of operations. The most commonly used lean tools and techniques are Value Stream mapping, 6S, Kaizen, One piece flow, Cellular production, Pull production, Poka Yoke, Quick changeover or Single Minute Exchange of Die (SMED), Total Productive Maintenance (TPM), Supply Chain Management, Visual management, Work standardization, Factory layout etc. Lean delivers what companies really need in today's highly competitive world: shorter lead time, improved productivity, reduced work-in-process (WIP), effective saving of floor space, better customer service, improved quality, increased profit etc. The main challenges of lean manufacturing are process incapability and instability, fluctuation in demand and people issues such as cultivating lean through the quick attitude change of management. There is no defined end point in lean manufacturing, but it points to the direction of pursuing continuous perfection through endless improvement.

4. MANUFACTURING IN UK AND LEAN PRACTICE

UK manufacturing employs 3.6 million people, accounts for approximately 17% of national GDP, and contributes to half of all UK exports, but when financial, supply-chain and manufacturing-related services are taken into account, many more UK jobs depend on it. Manufacturing is also a key driver of innovation and technology advancement as it accounts for 80% of research and development [8]. Manufacturing is, therefore, important for UK both in terms of its impact on productivity and competitive advantage. However, it is recognised that there is a substantial productivity gap between UK manufacturers and their overseas competitors particularly France, Germany and USA [9-10]. Furthermore, UK continues to face relentless competitive pressures to reduce the manufacturing cost from around the globe, particularly from the emerging economies of China and India. In addressing this productivity gap and higher product cost, there is a clear rationale to support the UK manufacturing sector for improving the competitive position of the national economy.

The UK's main weakness in terms of manufacturing can be contributed to a number of factors such as lack of investment in capital equipment, spending less on research and development, ineffectiveness of business in utilising capital and lower skills levels compared to its close competitors. In order to address these weaknesses, the UK Government launched a Manufacturing Strategy in 2002 [11], which set out seven 'pillars' necessary to help in building a successful knowledge-intensive manufacturing sector. Amongst the priorities for action the government established the Manufacturing Advisory Service (MAS) aimed at raising productivity and competitiveness through best practice methods particularly through the application of lean manufacturing tools and techniques to the manufacturing processes. Obviously the relatively high wage rates in UK will not allow it to compete effectively in many sectors particularly in sectors that rely on mass manufacturing and labour intensive manufacturing. Therefore, in order to win in the face of low cost competitions the companies in UK will have to introduce new methods that will allow them to focus on more knowledge intensive and quality products and services at a relatively low cost. Adopting a lean manufacturing strategy is clearly the step forward to revitalise UK's declining productivity. While lean is now a way of life for many large manufacturers such as automotive and aerospace industries in UK, it is much less well practiced in the smaller companies than across Europe.

5. BACKGROUND OF THE COMPANY AND MANUFACTURING PROCESSES

The Company in question is one of the world's largest bandsaw manufacturers expanding its business in every corner of the world. Bandsaw is a multipoint cutting tool used for cutting off raw materials into customer ordered pieces preferably used by steel industries and steel stockholders. Analysis of information obtained from official sources (The Company, Department of Business, Enterprise and Regulatory Reform, UK and National Statistics, UK), it has been found that in terms of performance, the Company profitability and manufacturing added value per production employee are well above the average UK companies [8, 12]. Despite these obvious strengths in performance, the Company still needs to improve its relatively low stock turns and slightly higher scrap rate compared to the average UK companies. While the Company profitability outpaces that of the UK, in comparison to the European average its profitability is about average. Therefore, there remains room for improvement across many areas of the manufacturing processes in the Company.

The focus of this study is on bimetal (HSS tooth tip and spring steel backing material) bandsaw manufacturing through milling process. Specialist milling machines are employed to manufacture over 30 different bandsaw tooth forms. The manufacturing of bandsaws is a batch and queue process, which involves sharp tooth formation in bimetal band strips by milling operation, bandsaw tooth setting, heat treatment, tempering and shot blasting (Figure 510

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2). More than 85% of all bandsaws are manufactured through milling process both for production cutting and general-purpose cutting and the Company needs to increase its productivity for coping with the increased demand. Therefore, it is the prime importance to improve the operating performance of the milling process.

**Band strip Heat
treatment Tempering Shot
blasting
Tooth
Setting
Tooth
formation**

Left set

Right set

Figure 2: Bimetal bandsaw manufacturing cycle by milling process

6. IMPLEMENTATION OF LEAN TOOLS AND TECHNIQUES-CASE STUDIES

The Company initiated lean manufacturing programme in 2003 by mapping out manufacturing processes of bandsaws and implementing lean tools and techniques in the manufacturing operations through “Lean Event”. A team consisting of machine operators, maintenance technician, team leader, engineer and manager took part in the lean events. In this paper, the main focus is on Value Stream Mapping (VSM), Set-up reduction, 6S, Layout modification, Total Productive Maintenance (TPM) and Material & Information flow.

6.1. VALUE STREAM MAPPING (VSM)

Current value stream map was drawn for the bandsaw manufacturing through milling operation by analysing all the activities from raw material (bimetal band strip) to finished bandsaw. From the current value stream map, value adding and non-value adding activities (waste) were identified and wastes were eliminated where possible to draw the future and ideal state maps. The value stream map also helped to further analyse the material and information flow. Owing to the Company confidentiality, the maps are not presented here.

6.2. 6S

6S is a shop floor exercise designed to create an efficient workplace by securing safety, sorting, simplifying, sweeping, standardizing and sustaining. A neat and clean factory has higher productivity, fewer defects, more machine uptime, and is a better and safer place to work. Being a bandsaw manufacturer the shop floor of the Company was generally surrounded by sharp cutting edges, therefore it was the utmost importance to organise the working areas around the milling machine for safety of the employees. In addition, the operating condition around the milling machine was poor with dirt, sludge, improperly stacked materials, slippery floors, blocked vision, no labeling in the shop floor, insufficient labeling in the machine etc.

The 6S exercise started with the preparation of a standard checklist for the activities in the milling machine. Managers, team leaders and machine operators were interviewed on the 6S checklist to get the 6S score before and after the lean event. To implement 6S tools, walkways and work areas were clearly defined, neat and safe storage areas were defined, floor around the machine was cleaned and labeled highlighting the danger zone, unnecessary tools were removed and the location of each tool was clearly marked on the tool board and the tool board was positioned for easy access. After the lean event 6S score was improved by 81%, which was higher than the initial target (75%) as shown in Figure 3. 6S made subsequent set-up reduction event more effective. The 6S activities were concentrated around one of the milling machines and other milling machines will follow the same procedure. The 6S philosophy has been an ongoing activity in the Company.

6.3. SET-UP REDUCTION

Set-up time is defined as the time between the last good piece off the current run and the first good piece off the next run. At a first glance, reducing set-up time does not appear to provide a significant payback as set-up time might represent only few percentage of total processing time. Capacity and flexibility are indeed the important

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Introducing lean, not mean, to improve the productivity in a cutting tool manufacturing company reasons for improving set-up time. However, reducing set-up times gives the opportunity for lead-time reduction, better use of resources (e.g., people, equipments etc.) and increased responsiveness to customers. The most significant payback of a set-up reduction programme enables to set a platform for effectively implementing other lean tools and techniques such as batch size reduction, work-in-process (WIP) reduction, JIT, Kanban, total quality management, pull systems, waste elimination etc.

0

10

20

30

40

50

60

70

80

90

Target Before After
6S score (%)

81% Improvement

Figure 3: 6S scores before and after applying the 6S tools

Owing to the increasing demand of milled bandsaw products every year, the Company needed more

manufacturing capacity and more flexibility in the range of products. The milling operation, being a batch operation, has a long set-up time, which needs to be shortened both for improving the manufacturing capacity and accommodating product variation. Prior to commencing the set-up reduction programme, the video of a standard set-up procedure was analysed to identify the scope of potential time saving. The activities performed to reduce the set-up time were rearranging of raw material for easy loading, increasing manpower, reduction of manual operation, design of smarter tools and equipments for easy changeover, tool standardization etc. Standard work procedure was established after taking set-up reduction measures. Achieving substantial reduction in set-up times of milling operation in the Company seemed like a daunting task when the initiative began with an ambitious target of 80% reduction. However, it was realised that no target was impossible when the set-up time was reduced by 88% through coordinated team effort and innovative ideas (Figure 4).

6.4. LAYOUT MODIFICATION

The layout modification of the milling section was carried out to generate more floor space for future manufacturing lines. Three different layout modifications were proposed in the milling section: First level layout, Intermediate layout and Ideal or Dream layout. First level layout was carried out with the modifications, which could be performed with minimum effort and cost while the Intermediate layout was designed to carry out major rearrangement

of the milling machines and associated equipments. Rearrangement of the machines and equipments will facilitate more space between machines, will ensure easy access to the machines and will create a safe working environment.

The proposed Ideal layout was designed to establish the continuous one-piece flow of material from milling to setting and from setting to heat treatment sections avoiding the current queuing process. The one piece flow of material could be facilitated by using a simple, compact, easy to set-up machines for tooth formation (e.g., laser machining) instead of heavy and complicated milling machines. This continuous flow of operation was aimed to decrease the work-in-process (WIP), lead-time, manual handling time between processes and to improve ergonomics. Some modifications according to the First level layout have been completed already, which created some extra floor space and a safer working environment and others modifications will be followed in the time to

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come. An estimation of floor space savings could be made by revisiting the Company in near future when all the layout modifications will be completed.

0

10

20

30

40

50

60

70

80

90

100

**Target Before After
Set-up time (mins)**

88% Reduction

Figure 4: Set-up time before and after applying the set-up reduction approach

6.5. TOTAL PRODUCTIVE MAINTENANCE (TPM)

Increasing demand of bandsaw products forced the Company to reduce machine downtime and to improve Overall Equipment Effectiveness (OEE). One of the milling machines was targeted for total productive maintenance work and similar work will be performed subsequently in other milling machines. Before the lean event, there were no structured TPM system, no accurate OEE calculation, very little space around the milling machines, dirty machines, poor swarf disposal system etc. The work started with cleaning of the machine and surrounding areas, replacement of steel guard with light guard, moving ancillary equipments to a separate location, devising a new swarf collection bin etc., which created a clean and easy to access machine. Detail analysis of past manufacturing

record sheets and discussions with milling operators and managers it was identified that quality checking, batch setup, cutter grinding, machine breakdown and uncategorized non-production times were the main cause of the machine down time. Manufacturing data were also used to calculate Overall Equipment Effectiveness (OEE). As the machine breakdown time and uncategorized non-production time were responsible for major share of the total machine downtime, therefore efforts were primarily focused on reducing them. Regular maintenance (daily, weekly and monthly) was scheduled for the machine to be carried out by the maintenance department and this would reduce the chance of unexpected machine breakdown. Since operators were closest to the machines, they were also included in maintenance and monitoring activities in order to prevent and provide warning of malfunctions. One operator was assigned to the milling machine for the daily preventative maintenance work and this would give the operator a sense of responsibility to the machine. New operators were also appointed in the milling section to reduce the level of uncategorized non-productive time. Computerised production monitoring system was implemented in the milling machine for accurate calculation of OEE and the causes of machine downtime could be analysed for further improvement in the OEE. In addition, the new set-up procedure established after the set-up reduction event would be helpful in reducing machine downtime. After the lean event OEE was improved by 21% as shown in Figure 5. It was suggested to conduct a sustainable TPM program across the whole factory by measuring OEE regularly and taking necessary actions.

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Before After

OEE (arb. unit)

21% Improvement

Figure 5: Overall Equipment Effectiveness (OEE) before and after the lean event

6.6. MATERIAL AND INFORMATION FLOW

With the increased demand and product mix variation both the materials as well as the information flow in the Company needed to be improved to reduce lead times and service level requirements. After going through the value stream map, a number of areas were identified where improvement in material and information flow was required. Extra handling of raw material boxes due to irregular arrangement during shipment to the company caused waste of time and effort. Raw material supplier was directed to arrange the boxes in a certain order to avoid unnecessary handling. Unnecessary movements of raw materials from stores to material preparation area and from there to milling machines were minimised by relocating material preparation area closer to the materials store. Difficult to find packing notes attached with raw material boxes were put in bright coloured envelope to avoid wasting time in searching for them. Labels were also attached at each end of raw material box (printed on white paper) to read them easily. Production planning control board was redesigned to accommodate detail information about the production in milling. Introduction of a Kanban card system was proposed to order the raw material according to the requirement. The raw material supplier will also be involved to give them a better understanding of any changing requirements as and when required. Computer controlled production monitoring system was integrated with all milling machines to display real time production status (machine running or machine stopped for a certain period of time). This visual information alerts employees and delivers actionable information from plant floor to the top floor. Methods or procedures have been established for better material and information flow and work are in progress.

7. CONCLUDING REMARKS AND RECOMENDATIONS

The paper reviewed the lean implementation process in a major cutting tool manufacturing industry. It was demonstrated that several lean techniques such as 6S, Set-up reduction, Floor layout, Total Preventative Maintenance (TPM), Visual control etc. could be implemented with great success. The core benefits achieved from the lean implementation were significant reduction of set-up time, increased manufacturing capacity, increased overall equipment effectiveness, easy-to-work and safer working environment and, improved material & information flow. All these activities contributed to direct and indirect improvements in the productivity of the Company. Some of the lean implementation processes required a much longer-term analysis. Revisiting the Company some time in the future could draw a more conclusive picture. Lean implementation in the Company is a continuous process, and the years to come will be the true challenge to prove that results are sustainable. However, what is evident is that if the Company continues to implement the principles of lean manufacturing throughout the factory it can successfully improve the productivity.

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The Company should develop a strategic lean roadmap and continuously measure the improvements to sustain the lean culture, which does not happen over night. The Company should target for becoming as a lean organisation by implementing lean principles in all processes of bandsaw manufacturing, supply chain management etc. in the time to come. Training of shop floor operators and employees is essential to motivate them for working towards improvement. Since the shop floor worker making the product, so the work must begin with developing the people first. Despite having a well-organised quality management system in the Company, integration of *Six Sigma* approach into the *Lean* approach would ensure further reliability in the manufacturing processes and product quality.

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