SUSTAINABLE DEVELOPMENT OF PRODUCTIVITY THROUGH LEAN MANUFACTURING IN MEDIUM ENTERPRISES

Abhijit Chakraborty, Supriya Naha Biswas and Sweta Sarkar

[1]Department of Mechanical Engineering, Global Institute of Management and Technology, Nadia, West Bengal, India
{chakrabortyabhijit100, snaha.me, swetamech13}@gmail.com

ABSTRACT

Lean is the buzzword in today's world of competition. It has been applied to various areas of the industry but in our country it is new and not so much applied to the small and medium scale enterprises. The medium enterprises are facing tough competition from different sectors where lean is going to be a solution for all such problems. By minimising the waste and applying the concept of lean with different tools such as kaizen, kanban, TPM and 5S concept, productivity can be increased and the waste in various dimensions such as overproduction, inventory, waiting time and defects can be reduced to a large extent. This paper has tried to focus on the improvement of productivity by the application of lean concept so that the medium enterprises can increase its profit by putting more emphasis on value added activities and discarding non-value added activities.

KEYWORDS

Productivity, lean, waste, quality, technique

1. INTRODUCTION

Lean manufacturing may be viewed as a systematic approach to identify and eliminate the waste (non-value added activities) through continuous improvement and synchronizing the production process to such an extent that flow of the product can be possible at the pull of the customer with emphasised focus on perfection (quality) in the pursuit of manufacturing excellence. Therefore, Lean has a basic goal of satisfying the customer through on time delivery of high quality products by simply eliminating waste. Elimination of variable aids for reducing the overall cycle time is a core objective of Lean. Consequently, this helps to reap the benefits that Lean proponents advocate; namely shorter cycle time, shorter lead time, lower WIP, faster response time, lower cost, greater production flexibility, higher quality, better customer service, higher revenue, higher throughput and increased profit. Lean as a philosophy illuminates and eliminates non-value adding steps; it is also essential to successful product development processes.

Table 1. Eight wastes of manufacturing

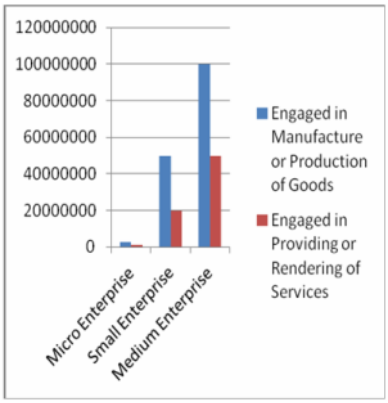
Types of Wastes	Causes
Overproduction	Producing more products than needed
Inventory	Any supply in excess to produce product
Waiting	Idle operator and machine time
Motion	Movement of people or machine which does not add value
Transportation	Any material movement which does not directly support value added operation
Defects	Making defective parts

Extra processing	Any process which does not add value to product
Peoples' talent and motivation	Related people unfit to fulfil job requirement/unable to perform up to the mark

When applied properly, Lean methods will make any shortcomings in the system appear quickly and they will have a profound impact. Clearly, the ultimate goal is the elimination of waste, as it can account for between 55% and 95% of the manufacturing process.
In this occasion we must have a clear concept about the scale of enterprises. According to the newly enacted Micro, Small and Medium Enterprises Development Act 2006, which has come into effect from October 2, 2006, enterprises are classified into Micro, Small and Medium according to the following criteria:

Table 2. Scaling criteria for enterprises

Type of Enterprise	**Engaged in Manufacture or Production of Goods**	**Engaged in Providing or Rendering of Services**
Micro	Does not exceed 25 Lakh rupees	Does not exceed 10 Lakh rupees
Small	More than 25 Lakh rupees, but does not exceed 5 Crore rupees	More than 10 Lakh rupees, but does not exceed 2 Crore rupees
Medium	More than 5 Crore rupees, but does not exceed 10 Crore rupees	More than 2 Crore rupees, but does not exceed 5 Crore rupees



This paper is concerned to medium scale enterprises only.

2. LITERATURE REVIEW

Bicheno et al. (2009) insist that most successful organizations integrate systematic changes to match the needs of the customer, strategy and people in the business. Lean needs to look beyond manufacturing. Bicheno et al. (2009) dwell on the concept of a total Lean enterprise and suggest that it is a new product development where leading Lean organizations are becoming increasingly competitive. The most efficient organizations are those that can simplify and smooth the flow from the raw material input to the final product (Johnston, 2009). The Boston-based analyst firm Aberdeen Group in 2004 undertook a survey of 275 organizations, "The Lean Strategies Benchmark report" (Bartels, 2005) revealed important factors concerning competitiveness. The study concluded that when a manufacturing operation is successfully applied to a Lean strategy across the entire organization, it is as much as three times more likely to be an industry best-in-class performer than the laggards. Equally, it is between 2.5 - 6 times less likely to be as severely affected by customer pricing and service demands and the related squeeze on profits. The best-in-Class performers were 2.5 times more likely (25% as opposed to 10%) to indicate that customers demanding reduced prices were not important or only somewhat important to their organization. Moreover, the same organizations were three times as likely (18% versus 6%) to indicate that customers demanding shorter cycle times were not important or only somewhat important to their organizations than other classes of performers.

Shah et al. (2003) in their study of the four bundles; namely JIT, TQM, TPM and HRM found a positive correlation with operational performance. As a group they accounted for 23% of the variations in operational performance even after accounting for the effects of industry and organizational context. The Manufacturing Foundation findings (2004) were attained from 153 companies in the UK and from a range of sectors. In summary 62% of the 153 overall organizations reported a benefit from their Lean implementation. Ransom (2008), President of the "Ransom Research Institute," an independent equity investment research firm serving major investment organizations suggests that Lean gives organizations a competitive edge. It improves financial performance, which ultimately enhances valuations.

3. OBJECTIVES OF THE STUDY

The objectives of the present study are:

a) To determine the main problems in productivity sector in a medium scale enterprise.
b) To find out the solution of the problems applying Lean tools.
c) To sustain and increase the quality of the production.
d) Finally focusing on the enhancement of productivity.

4. METHODOLOGY

The study has been carried out in a medium scale plastic product manufacturing industry, located at Bonhooghly Industrial Belt, West Bengal, India. The study and analysis were made considering the production section of the industry. The types of machine tools studied consist of all types of machine tools namely, General Purpose Machine tools, Single Purpose Machine tools, Special Purpose Machine tools and CNC Machine tools.

The General Purpose Machine (GPM) tools are those which are designed to perform a great variety of work pieces by using number of attachments. Examples of this type of machine tools are Engine Lathe, Universal Radial drilling machine, Universal Milling Machine etc.
On the contrary, Single purpose machine (SPM) tools are those machine tools, which are designed to perform a single definite machining operation in machining number of identical work pieces. Examples of this type of machine tools are for turning the cam counters on camshafts, finishing operation of barrel, plastic extruder etc.

Special Purpose Machine tools and CNC Machine tools are manufactured individually and intended for performing a certain specified operations in machining a large number of identical work pieces. Applications of these machines are in large lots and mass production.
The tools used in Lean manufacturing in any enterprise are listed in a form of a table with their corresponding actions.

Table 3: Tools of Lean Manufacturing

Tools	Remarks
Standardised work	Jobs are broken down into elements and examined to determine best and safest method for each.
Workplace organisation (5s concept)	Sort (Seiri), Set-in-Order (Seiton), Shine (Seisco), Standardise (Shitsuke), Sustain (Seiketsu).
Quality at source	Error proofing devices are used, for example Pokayoke.
Teams	Departmental barriers are eliminated and replaced with cross functional teams.
Kaizen	Japanese word for continuous improvement.
Kanban	An information system that controls (Pulls) required parts in required quantities at the required time.

Cells	Proper placement of machines.
Total productive maintenance (TPM)	Consists of a companywide equipment maintenance program that covers the equipment life cycle and requires participation by every employee.
Value stream mapping	A method of visually mapping a product's production path, including material and information flow, from dock to stock. It takes a holistic look at the activity required (both value added and non-value added) to move a product from raw material to customer.
TAKT time	It is the rate at which customer requires the product and is computed as – TAKT time = (Available work time/Customer demand) per day

The detailed outlines of the activities related to the study and analysis are given below:

- The brief overview and salient information are being gathered from the Production Manager and sampling plan was discussed in consultation with the unit in-charge and other associates of the concerned area.
- After Sampling of the plant facilities, the basic principles of the process were studied and the value stream mapping was done.
- Then, records related to production were reported and first hand information was examined. This exercise was necessary in order to understand and compare the past and current levels of plant status, so that proper lean tools could be suggested in the present situation to enhance production. The main aim was to understand driving forces behind the decision to go for lean.
- Observations were analyzed and required steps were taken.
- The Lean Manufacturing tools and techniques were also introduced in the Machine shop.
- The detailed study and analysis were brought into the open session for discussion with the employees, so that any new idea may come up and secondly, all the employees may know as to how to implement the lean tools. This had also helped in giving a message to them that the area, which was not selected during sampling, also requires improvement like others.

5. OBSERVATIONS AND ANALYSIS

By observing the first hand information we determined the following problems for the industry

a) Absence of appropriate methodology to assure quality.
b) Less compatibility of the individual protection of equipment.
c) Old machines and machine tools.
d) Unorganized workplace.
e) Inadequate and insufficient number of measuring instruments.
f) Lack of training.
g) Insufficient illumination.
h) Absence of application of new technology.

It has been observed during the study and analysis that maintenance department is the worst resourced area and there is no adequate manpower available to manage the machines. Quite often

the machines have to wait for repairs for long time, resulting to the loss of production. Only two persons were deployed for the repair and maintenance. A simulation model has been developed to assess the actual requirement of the manpower for the purpose of repair and maintenance.
The data on vital problems determined above are given in a form of tables:

Table 4: Details about the old machines and loss

Sl. No.	Type of Machine	No. Of Machines	No. Of Old Machines need Replacement	% of Lagging in Productivity
1.	GPM	10	3	30%
2.	SPM	7	2	29%
3.	CNC	4	0	0
Total		21	5	23.81%

Table 5: Details about maintenance (repairing related) delay

Sl. No.	Type of Machine	No. Of Machine	Avg. No. Of Repairs Required per month	Avg. Delay time in Repair per Machine per month (in days)
1.	GPM	10	4	2
2.	SPM	7	2	2
3.	CNC	4	1	3
Total		21	7	7

6. APPLICATION OF LEAN MANUFACTURING TOOLS

From the detailed analysis of the observations it is evident that immediate attention is required to reduce or eliminate the determined problems with suitable tools and techniques. Though many tools and techniques are available, lean tools in today's context come handy with scientific approach. As a result the tools like 5-S, TPM, SMED, KAIZEN, Quality at source and POUS were suggested to take up on need-basis.

The maintenance department needs further special and immediate attention as observed by the analysis of past records. A team was formed to examine the machine conditions and to do area demarcations within 5-S principles and basic TPM like lubrication, tightening and cleaning.
It was also suggested that the workers need sufficient training about improvement in production, maintenance of machine tools, understanding Lean concept and handling the jobs.

7. PRODUCTIVITY IMPROVEMENT DUE TO APPLICATION OF LEAN CONCEPT

The effectiveness of Lean Manufacturing on productivity has been tested in Plastic Extruder. The productivity related data before and after the application of lean tools are tabulated in Tab. 6.

Table 6: Productivity related data for 8 days before and after application of lean tools

Days	1	2	3	4	5	6	7	8	Total
Before (x)	47	53	52	51	49	52	50	53	407
After (y)	53	54	53	54	50	54	51	54	423

The student's t test (one tail t-test) has been carried out with the help of tabulated data (Tab. 6). The following assumptions were considered

- The parent production from which the sample has been drawn is normal.

- The sample observations are independent i.e. the sample is random.
- The population standard deviation is unknown.

Let the productivity before and after the application of lean tools be x and y respectively as tabulated in Tab. 6.

Then according to hypothesis,

H_0: $\mu x = \mu y$; there is no significant difference in productivity.

H_1: $\mu x \neq \mu y$; there is significant difference in productivity.

Alternate Hypothesis H_0: $\mu x < \mu y$ (Left tailed),

If the samples of productivity were assumed to be independent then t test for difference of means will be applied to test H_0:

Test Statistic $t = \frac{(\bar{x}-\bar{y})}{\sqrt{S^2\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} \sim t n_1 + n_2 - 2$

Where,

Mean value of x = $\bar{x}$;

Mean value of y = $\bar{y}$;

No. of data of mean values of x = n1;

No. of data of mean values of y = n2;

$$S^2 = \frac{1}{n_1 + n_2 \quad 2}\left[\sum(x-\bar{x})^2 + \sum(y-\bar{y})^2\right]$$

Where, S represents an unbiased estimate of the common population Variance σ^2.

The statistical calculations are tabulated in Tab. 7.

Table 7: Statistical Calculations of Productivity (x and y) before and after the application of Lean tools

Productivity X			**Productivity Y**		
x	$\delta_1 = x - 50$	δ_1^2	y	$\delta_2 = y - 52$	δ_2^2
47	-3	9	53	1	1
53	3	9	54	2	4
52	2	4	53	1	1
51	1	1	54	2	4
49	-1	1	50	-2	4
52	2	4	54	2	4
50	0	0	51	-1	1
53	3	9	54	2	4
Total	7	37	Total	7	23

$\bar{x}$ = 50+7/8 = 50.875 and $\bar{y}$ = 52+7/8 = 52.875

n_1 = 8 and n2 = 8;

Now,

$$\sum(x-\bar{x})^2 = \left[\sum \delta_1^2 - \frac{(\sum \delta_1)^2}{n_1}\right] = 30.875$$

$$\sum (y - \bar{y})^2 = \left[\sum \delta_2^2 - \frac{(\sum \delta_2)^2}{n_2}\right] = 16.875$$

$$S^2 = \frac{1}{n_1 + n_2 - 2}\left[\sum (x - \bar{x})^2 + \sum (y - \bar{y})^2\right] = 3.41$$

Therefore,

$$t = \frac{(\bar{x} - \bar{y})}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \sim t n_1 + n_2 - 2 = -2.17$$

Tabulated $t_{0.05}$; for (8 + 8 – 2) = 14 degree of freedom, for one tail test is 1.76. The critical region for the left tail test is t < - 1.76. Since calculated t is less than – 1.76; H_0 is rejected at 5% level of significance. It is concluded that the productivity X and productivity Y differ significantly as regards to their effect on increase in productivity.
Further, since $\bar{y} > \bar{x}$; productivity Y is superior to productivity X.

8. BARRIERS TO LEAN

Revealingly, the overall analysis made from the study of questionnaires has discovered how the enterprise reflected a very strong and negative association with the following potential Lean barriers:

a) Insufficient understanding of the potential benefits.
b) Insufficient external funding.
c) Lack of internal funding.
d) Insufficient senior management skill to implement Lean.
e) Insufficient supervisory skill to implement Lean.
f) Insufficient workforce skill to implement Lean.
g) The cost of the investment.

This proved that in the medium scale enterprise the Lean barriers are either not permitted to cultivate and/or do not prevent the enterprise from advancing on its Lean journey.

9. CONCLUSIONS

The medium enterprises can prosper in a much better way by the application of lean concept. This has been justified in the research work and validated by the statistical test and hypothesis. The waste i.e., overproduction, inventory, waiting, transportation, defects, etc. is to be reduced to the extent possible and value – added activities are to be encouraged as well. There are some constraints while applying lean concept which are to be addressed properly. The application of lean tools such as 5S concept, kaizen, TPM, etc. is going to give benefit to the medium enterprises and help the organisation to be competitive in the era of globalisation.

10. LIMITATIONS OF THE RESEARCH

Any potential issue surrounding validity, reliability and generalization was never relinquished. A superior extent of validity and reliability was secured than would have been the case with a single methodological approach as surveys were supplemented by single case study. Equally a cautionary observation is required with reference to the performing measures utilized. The survey respondents were informed that their responses should be taken into account and that the research was concentrated solely on the impact of Lean in their enterprise.

REFERENCES

[1] Annual Report 2011 – 2012, Ministry of Micro, Small and Medium Enterprises, Govt. of India.

[2] Bhasin. Sanjay (2011) "Improving performance through Lean", International Journal of Management Science and Engineering Management, 6(1), pp 23 – 36.

[3] Brunet. Adam Paul & New. Steve (2003) "Kaizen in Japan: an empirical study", International Journal of Operations & Production Management, Vol. 23, No. 12, pp 1426 – 1446.

[4] Mahapatra. S S & Mohanty. S R (2007) "Lean manufacturing in continuous process industry: An empirical study", Journal of Scientific & Industrial Research, Vol. 66, pp 19 – 27.

[5] Mahto. Dalgobind & Kumar. Anjani (2008) "Improvements in Product Quality and Productivity Through Pragmatic Analysis of Working Environment in Engineering Industries", Arab Research Institute in Sciences & Engineering, Vol. 4, No. 2, pp 77 – 97.

[6] Report of the working group on Science & Technology for Small & Medium Scale Enterprises (SMEs) for the eleventh five year plan (2007 – 2012).

[7] Singh. Jagdeep & Singh. Harwinder (2009) "Kaizen Philosophy: A Review of Literature", The Icfai University Journal of Operations Management, Vol. VIII, No. 2, pp 51 – 72.

Authors:

Dr. Abhijit Chakraborty has done his **PhD (Engg.)** from Jadavpur University, Kolkata – 32, West Bengal, India and also he has been working presently as **Asst. Prof. as well as HOD in the Department of Mechanical Engg.** of **Global Institute of Management & Technology**, Krishnanager, Dist-Nadia, West Bengal **(**affiliated to **West Bengal University of Technology and recognized by AICTE, New Delhi)** and having a teaching experience of total 11 years and industry experience of another 4 years. He acquired his B.Engg(Mechanical) degree from Utkal University, Bhubaneswar , Orissa ; PGDBM(equv. to M.B.A, recog. by AICTE, govt. of India) from IMM, kolkata and M.Sc(TQM) from Sikkim Manipal University. He is also associated with **MSME-DI**, **Under the Ministry of Small Scale Industries, Govt. of India** for last 7 years as a guest faculty and taking various MDP and ESDP classes. He is a member of the **Institute of Engineers (India)** as **MIE** and **All India Management Association** as **MIMA**. He has published ten research papers in the Journals and seven research papers in National and International Conference Proceedings. His area of research is Productivity and Quality, Industrial Engineering and Management, Materials Management etc.

Mr. Supriya Naha Biswas is a final year student of B.Tech in Mechanical Engineering under West Bengal University of Technology. He has the experience to work in 3 different projects under eminent guides. He also has presented papers in 4 national conferences. His current interests include Product Design & Development, Manufacturing Processes and Industrial Management. He is an active member of Institute of Physics and the Indian Science Congress Association.

Ms. Sweta Sarkar is a final year student of B.Tech in Mechanical Engineering, under West Bengal University of Technology. She has the experience to work in 2 different projects under eminent guides. She also has presented papers in 3 national conferences. Her current interests include Turbo machinery & Fluid Systems and Industrial Management. She is an active member of the Indian Science Congress Association.