Selection of Lean Manufacturing Principle using AHP- A Case Study

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Abstract— Small scale sector occupies a position of prominence in Indian economy. It contributes more than 50% of the industrial production in value addition terms. Small scale sector accounts for one third of the exports revenue and employs the largest manpower next to agriculture. In India, the survival and growth of small scale industry largely depends on its ability to innovate, improve operational efficiency and increase productivity. Many businesses have been trying to adopt new business initiative in order to stay alive in the new competitive market place. Lean manufacturing is one of these initiatives that focus on the cost reduction by eliminating non-value added activities (wastes). Analytic Hierarchy Process (AHP) is used as Multi Criteria Decision Making (MCDM) technique to select best Lean manufacturing principle in small scale industry.

Key words: Analytic Hierarchy Process (AHP)

I. INTRODUCTION

To stay close to the customers is essential for sustainable growth and continuity of business. This forces all organizations to continue to evaluate customer needs and problems and take the best possible course of action to satisfy them. The need of the organization is to deliver high quality products through continuous improvement [1]. Manufacturing organization throughout the world is under great pressure to reduce the cost and meet the global quality standards [2]. Lean manufacturing is the hymn of survival and success for any organization through minimizing the wastage of resources and moving towards implementation of lean manufacturing have become key strategies to achieve cost cutting. The goal of lean manufacturing is to minimize all types of waste(non-value added activity) through incorporating less human effort, less inventory, less time to develop product and less space to become highly responsive to customer demand, while at the same time producing top quality products in the most efficient and economical manner.

The aim of this paper is to select best lean manufacturing principle using AHP a MCDM technique by considering suitable criteria in small flange coupling manufacturing industry. Analytic Hierarchy Process (AHP) is developed by Dr. Thomas L. Satty in 1970. It is a problem solving framework base on the innate human ability to make sound judgment about small problems. It is a quantitative technique use to facilitate decision that involves multiple competing criteria [3, 4, 5].

II. PROBLEM STATEMENT

Small scale sector occupies a position of prominence in Indian economy, contributing to more than 50% of the industrial production in value addition terms. Small sector account for one third of the export revenue and employs the largest manpower next to agriculture. In India, the survival and growth of small-scale industry largely depends on its ability to innovate, improve operational efficiency and increase productivity [6]. Many businesses have been trying to adopt new business initiative in order to stay alive in the new competitive market place. Lean manufacturing is one of these initiatives that focus on the cost reduction by eliminating non-value added activities (wastes).

Research at Lean Enterprise Research centre (LERC) U.K. indicated that for a typical manufacturing company the ratio of activity could be broken down as in table1.

Types of Activities	%Share
Value-added activity	5
Non Value-added activity(wastes)	60
Necessary non value-added activity	35
Total activities in % share	100

Table 1

This implies that up to 60% of the activity at a typical manufacturing company could potentially be eliminated. All Lean manufacturing principles are not possible to implement in small scale industry because of limited resources i.e. finance, infrastructure, work force available etc. The best Lean manufacturing principle is to be select using MCDM technique considering different effective criteria of small scale industry.

III. LITERATURE REVIEW

1) Mehmat and Jason (2008) gave the brief history of Lean manufacturing and discussed the different facets that are components of a lean culture and programs. Author examined the specific impact of each of the lean manufacturing principle on the bottom line and performance of a company. In this paper different principle of lean manufacturing has been discussed in order to improve quality and efficiency of the manufacturing organization.
2) Ihezie and Hargrove (2010) evaluated and performed an assessment of the current status of manufacturing organization. An assessment tool is used to evaluate current Lean manufacturing state in terms of actual manufacturing practice related to inventory cycles, production processes, maintenance procedure and operation, facility layout, quality control and other key metrics used to improve manufacturing facilities. In this paper, Lean assessment procedure and selection lean manufacturing tool considering different criteria has been discussed.
3) Miller et. al. (2010) A small furniture production company has integrated lean tools and sustainability concepts with discrete event simulation modelling and analysis as well as mathematical optimization to make a positive impact on the environment, society and its own financial success. The background of lean and green

manufacturing has been discussed. Eight typed of wastes identified by Toyota have been discussed in this paper. Nine forms of wastes identified by green manufacturing have also been discussed in this paper. A case study of chair manufacturing company has been taken in this paper.

4) Wong Cheng and Wong Yew (2011) attempted to understand and actual implementation of lean manufacturing in electrical and electrode manufacturing industry. A case study was conducted by asking relevant question through a structured interview approach with the key personal that are responsible for lean manufacturing implementation. Lean manufacturing has been implemented between 4 to 6 years in case companies. Lean Manufacturing tool grouped in focused areas improve performance of the case company. Total four companies have been taken for case study.
5) Amin and Karim (2011) developed a methodology to quantitatively measure the performance of manufacturing system in detecting causes of inefficiency and to select appropriate lean strategies to address problem identify. A systematic methodology has been developed to support lean manufacturers to effectively select lean strategy for their organization and evaluate process improvement.
6) Saaty T.L. (2208) presented analytic hierarchy process (AHP) a multi criteria decision making technique (MCDM). In this paper methodology of AHP has been discussed. Fundamental scale of absolute number has been discussed in this paper. Application of AHP in various fields has also been discussed.
7) Vinodh et al. (2012) used the analytic hierarchy process (AHP) for selecting best concept in lean environment. They also validated that AHP is an effective approach for enabling best concept selection, thereby improving the leanness of the organization.

IV. RESEARCH METHODOLOGY

A decision is a choice out of a number of alternatives in such a way that the preferred choice is the best option among the possible. Therefore the main objective of MCDM is the design of mathematical model tool to support the subjective evaluation of a finite number of decision alternatives under a finite number of criteria in order to find the best choice [7]. To make the decision, we should know the problem, purpose of decision, the criteria of decision. MCDM model can support the decision maker in choosing the control strategy that best meets all of the conflicting criteria that can formally incorporated into the management plans proven.

In this paper AHP is applied for selecting best lean manufacturing principle considering different related criteria and identify which is most favourable lean principle for small scale flange coupling manufacturing industry.

The analytical hierarchy process has been used while finding the lean manufacturing tool. Satty describes and elaborates the process. The criteria are compared with each other. Thus providing an opportunity for a pair-wise comparison for evolving the structure in to judgement matrix [8].

In the matrix, one begins with an element on the left and compares how much more important it is than a criteria on top. When compared with itself, the ratio is one. When compared with other criteria, if it is more important, an integer value as discussed below is used. If, however, it is less important, then reciprocal of the previous integer value is used. In either case reciprocal value is entered in the transpose position of the matrix. Thus only m (m-1) /2 judgments are considered where m is the total number. A scale of 1 to 9 (adapted from Saaty) is used for giving judgment value.

Intensity of importance	Definition
1	Equal importance
2	Weak or Slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very very strong
9	Extreme importance

The weight ages of the features are obtained by calculating the Eigen Vector weights for the judgement matrix. An index of consistency is calculated to provide information on how serious is violations of numerical and transitive consistency. The results could be used to seek additional information and re-examine the data used in constructing the scale in order to improve consistency.

It is necessary to check the consistency in the pair wise comparison matrix and validation of the AHP [9].

V. CASE STUDY

The industry considered for case study is Ghanshyam Steel a small scale flange coupling manufacturing company.

Industry characteristics	Detail about case organization
Industry type	Discrete
Industry sector	Manufacturing
Product	Flange coupling component.
Product type	Critical components
Product volume & variety	High volume low variety
Company vision	To be a star performer and market leader
Company mission	Continuous improvement of product, Process and people.

The organization is currently facing lot of problems in terms of quality, delivery, high cost of manufacturing etc. After long discussion with owner of company, engineers and technicians following lean tool is taken for AHP.

Following criteria are to be taken for best lean tool selection through AHP.

1) Time taken for implementation (TFI): More time taken in implementation of lean tool is not advisable in small scale industry.
2) Cost of the implementation (COI): Some of the lean tool requires large cost to implement because of requirement of automatic system component and software. Therefore low cost for implementation is advisable.

3) Workforce Available (WFA): Small scale industry hasfewer workforces. Therefore lean tool required large or more workforces to implement is not advisable.
4) Space Available (SA): Some of lean tool required large space for inventory, in process inventory etc. Therefore space availability is important criteria.
5) Availability of infrastructure facility (AIF): Small scale industry may not have all the facility required for all lean tool implementation.

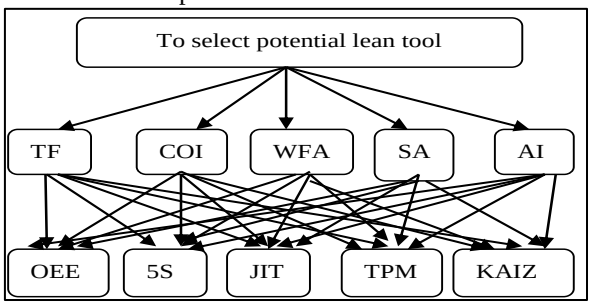

Fig. 1: Hierarchical Tree of AHP

Pair-wise decision matrix is prepared based on the feedback from the professionals. Weights for each criterion and its relationship were checked through decision makers having considerable experience of the industry. Initial decision making was carried out through series of long discussion with engineers, technicians and owner of the company. Based on the above process various pair-wise matrixes are prepared and checked for the consistency as per the formula given by Saaty.

TFI	Kaizen	OEE	JIT	5S	TPM	Priority vector
Kaizen	1	1/3	3	1/2	2	0.1680
OEE	3	1	2	2	5	0.3945
JIT	1/3	1/2	1	1/3	1/3	0.0841
5S	2	1/2	3	1	2	0.2327
TPM	1/2	1/5	3	1/2	1	0.1205

Table 4: shows the pair wise comparison for criteria Time taken for Implementation (TFI). Maximum Eigen value is $\lambda_{max.}$is5.4112 and Consistency Index is 0.1028.

+0	Kaizen	OEE	JIT	5S	TPM	Priority vector
Kaizen	1	1/2	4	1/3	2	0.1793
OEE	2	1	5	3	3	0.4030
JIT	1/4	1/5	1	1/2	1/2	0.0690
5S	3	1/3	2	1	2	0.2377
TPM	1/2	1/3	2	1/2	1	0.1108

Table 5: shows the pair wise comparison for criteria Cost of Implementation (COI). Maximum Eigen value is λmaxis5.3409and Consistency Index is 0.0852.

WFA	Kaizen	OEE	JIT	5S	TPM	Priority vector
Kaizen	1	1/3	1	1/3	1/2	0.0927
OEE	3	1	5	3	2	0.4235
JIT	1	1/5	1	1/2	1	0.1027
5S	3	1/3	2	1	3	0.2439
TPM	2	1/2	1	1/3	1	0.1369

Table 6: shows the pair wise comparison for criteria Work force available. Maximum Eigen value is λmax. = 5.2454and Consistency Index is 0.0613.

SA	Kaizen	OEE	JIT	5S	TPM	Priority vector
Kaizen	1	1/4	5	1/4	1/3	0.1152
OEE	4	1	6	2	3	0.4100
JIT	1/5	1/6	1	1/3	1/2	0.0584
5S	4	1/2	3	1	1	0.2302
TPM	3	1/3	2	1	1	0.1859

Table 7: Pair wise comparison for SA

Table 7 shows the pair wise comparison for criteria Space available. Maximum Eigen value is λmax. =5.4633and Consistency Index is 0.1033.

AIF	Kaizen	OEE	JIT	5S	TPM	Priority vector
Kaizen	1	1/4	1	1/3	1/3	0.0794
OEE	4	1	6	2	3	0.4388
JIT	1	1/6	1	1/3	1/2	0.0783
5S	3	1/2	3	1	1	0.2166
TPM	3	1/3	2	1	1	0.1867

Table 8: Pair wise comparison for AIF

Table 8 shows the pair wise comparison for criteria Availability of Infrastructure facility (AIF). Maximum Eigen value is λmax.is5.0597 and Consistency Index is 0.0149.

Final judgment matrix for the comparing the importance of five decision criteria is as in Table 9.

	TFI	COI	WFA	SA	AIF	Priority vector
TFI	1	2	5	5	3	0.4282
COI	1/2	1	4	3	3	0.2837
WFA	1/5	1/4	1	1	1/2	0.0745
SA	1/5	1/3	1	1	1/2	0.0792
AIF	1/3	1/3	2	2	1	0.1341

Table 9: Final judgment matrix

Max. Eigen value in final judgment matrix λmax.is5.0618 and Consistency Index is 0.0154.

The priority vector in Table 9 is used to form the entries of the decision matrix. The decision matrix and the resulted final priorities are shown in Table 10.

	TFI (0.4282)	COI (0.2837)	AIF (0.1341)	SA (0.0792)	WFA (0.1341)	Priority vector
Kaizen	0.1680	0.1793	0.0794	0.1152	0.0927	0.1269
OEE	0.3945	0.4030	0.4388	0.4100	0.4235	0.4140
JIT	0.0841	0.0690	0.0783	0.0584	0.1027	0.0785
5S	0.2327	0.2377	0.2166	0.2302	0.2439	0.2322
TPM	0.1205	0.1108	0.1867	0.1859	0.1369	0.1481

Table 10: Decision matrix

The priority vector of various lean tools is obtained which decides the final priority for the selection. Thus suitable tool for the case company becomes OEE>5S>TPM>KAIZEN>JIT as the respective priority weights obtained are 0.4140>0.2322>0.1481>0.1269>0.0785. Thus VSM lean tool is best suited to the present case company as it holds the highest priority.

VI. CONCLUSION

The present paper enlightens the importance of small scale industry and problems faced by small scale industry. Lean manufacturing is one of the options to reduce non value-added activity (wastes) and improve operational efficiently of the organization. The question of selecting potential lean manufacturing principle out of many lean principle commercially available pose lot of challenge to practicing managers. Management also remains in dilemma for its future policy for lean philosophy. In such situations AHP is proved to be a potential tool. AHP provides a convenient approach for solving complex MCDM problems in many fields.AHP is a useful technique for discriminating between competing options in the light of a range of objectives to be met. In this paper the result of AHP shows that the value in final priority vector is high for OEE compare to all other lean manufacturing principle. Therefore the industry may select OEE as lean manufacturing tool for reducing non-value added activity (wastes). However lean manufacturing tools discussed in this paper may also be implemented in future to get maximum benefits. Constrained resources may be used optimally in a phased out manner instead of implementing all the lean manufacturing tools at a time.

REFERENCES

[1] G. Chauhan, T.P.Singh and S.K.Sharma. "Measuring the status of lean manufacturing using AHP." Int. J. On Emerging Techonoligies,No.1, Vol.2, pp 115-120,2010
[2] G. Miller, J. Pawloski and C. Standridge, "A case study of Lean, sustainable Manufacturing." Journal f Industrial Engineering and Management Vol.3, pp.11-32, 2010.
[3] Satty L. "Decision making with the analytic hierarchy process." Int. J. Services Sciences Vol.1, No.1, pp.83-98, 2008.
[4] Satty T.L., "Axiomatic foundation of the analytic hierarchy process." Management Science, Vol.32, No. 7, pp. 841-855, 1986.
[5] Satty T.L. "How to make decision: the analytic hierarchy process." European Journal of Operation Research, Vol.48, pp.9-28, 1990.
[6] G. Sethi and P. Pal." Energy efficiency in small scale industry- An Indian perspective." Tata Energy Research Institute.
[7] Krishnan P.V. and B. Vijay ramnath, "Mathematical Model Using AHP to optimize the Organizational Financial Performance" 9th AIMS International conference on Management, 2012.
[8] Anvari et.al. "A group AHP-based tool to Evaluate effective factors towards Leanness in Automotive industries" Journal of Applied Science Vol.11 pp.3142-3151. 2011.
[9] Triantaphyllous et. al. "Using the analytic hierarchy process for decision making in engineering application: some challenges" Inj. J. Of Industrial engineering application and practice vol. 2 no. 1 pp.35-44, 1995.

