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Implementation of Lean Manufacturing Technique in Indian Manufacturing Industries

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ABSTRACT: Lean manufacturing is a management philosophy derived from Toyota Production System (TPS) which aims to increase the overall values of the product or service provided to the customer through elimination of non-value added activities. In the era of globalisation, to remain competitive in the global market, many medium and small sized Indian industries adopt lean manufacturing. This paper focuses on implementation of lean manufacturing in Indian MSMEs. To examine the implementation, attributes which influence lean manufacturing are obtained and industries' performances on these criteria are rated. In this paper, the methodology selected from many of the multi criteria models is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). In the actual real world situation, because of the unreliable nature of the information gathered, the attributes are often not absolute and are imprecise. These data can be considered as fuzzy and the aim of this paper is to adopt TOPSIS decision making method to problems with fuzzy data. The rating and weights of each data are expressed as triangular fuzzy numbers. These attributes are then normalized and the TOPSIS methodology is carried out to determine the effect of implementing lean manufacturing technique in an industry. The best industry is identified by fuzzy TOPSIS on the basis of performance towards the considered attributes is consistent with results identified by TOPSIS.

KEYWORDS: Lean manufacturing, Indian MSMEs, MADM, fuzzy TOPSIS

I. INTRODUCTION

Manufacturing operations are continually striving to increase productivity and output of their operations. Their goal is to satisfy the customer with the exact product, quality, quantity, and price in the shortest amount of time. The growing competitive environment and the shrinking globe have lead to the expansion of the market. It has become imperative for the firms to device the new ways and management techniques to hold and consolidate their market position. Staying competitive requires looking for new ways of reducing costs, increase the quality of the products and ensuring the on-time delivery of the products and services by eliminating the waste. An efficient lean manufacturing concept plays a very major role in achieving the above mentioned objectives. It has become imperative for the organizations to realize the importance of an effective and efficient lean manufacturing implementation for the survival in the global competitive market to sustain the constant increasing pressure. The lean approach is necessary to build an organizational culture of continuous improvement. Research in lean manufacturing has highlighted it ability to increase efficiency and customer response time, reduce costs and improve quality and profitability. The need of delivering the products and services at the right time and at diminished cost has increased manifold in current scenario. Thus it is not surprising to know that the organisations which have given considerable importance and have concentrated on lean implementation have performed well than their counterparts as is illustrated by various studies.

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II. LITERATURE REVIEW

2.1 Lean manufacturing

Extensive research on conceptualisation, implementation and evaluation of lean manufacturing has been carried out. Abdulmalek and Rajgopal illustrated implementation of several techniques of lean manufacturing in a steel industry. They also demonstrated a simulation model to analyse systems and to evaluate of the basic performance measures (Abdulmalek & Rajgopal, 2007). Melton studied the application of lean principles in chemicals and pharmaceuticals sector and its effects. He observed that implementation of lean principles increases the supply chain speed and hence increase in supply chain and business performance (Melton, 2005). Rachna Shah and Peter T. Ward identified the influence of plant size, plant age and unionization status on implementation of twenty two key practices of lean manufacturing (Rachna & Peter, 2003). Yang et al examined the relationship between lean manufacturing practices, environmental management and business performance by analysing data from 309 international manufacturing firms. The results implied that lean manufacturing is positively related to environmental management practices (Yang et al, 2011). Mabry and Morrison studied the implementation of lean practices in auto component manufacturing industry (Mabry & Morrison, 1996).

2.2 Implementation and evaluation of lean manufacturing in Indian industries

Lately, implementation and evaluation of lean manufacturing in Indian industries is of growing concern. Lean principles aim to reduce cost through elimination of non-value added activities and help the industries to face global competition. Despite the awareness and efforts, Indian industries are facing challenges in implementing and realising lean principles in their systems. Bhim Singh et al, determined the scope of implementation of lean principles in Indian industries considering 26 lean issues and 127 industries. The 26 lean issues were further classified into 5 groups such as customer issues, organisational issues, supplier issues, market issues and top management issues by factor analysis. They identified the potential issues in implementing lean principles (Bhim Singh et al, 2010). Achanga et al proposed that leadership and management; skills and expertise; finance and supportive organizational culture, are the critical factors for the successful of lean manufacturing transformation (Achanga et al, 2006). Devarani Devi et al studied the various obstacles in implementing the lean principles in Indian electronics industries. They also identified the various motivational factors and scope for implementation of lean manufacturing (Devarani Devi et al, 2013). Gurumurthy and Kodali evaluated the various alternatives of production systems like computer integrated manufacturing, manufacturing and lean manufacturing through Performance Value Analysis (PVA), a Multi Attribute Decision Making model (Gurumurthy & Kodali, 2008).

2.3 Fuzzy TOPSIS

TOPSIS is one of the popular methods applied to multiple criteria decision-making. TOPSIS is a deterministic model and is characterised by an independence axiom. It is assumed that the attributes or preferences are independent and the aggregation operation is based on linear addition. To the contrary, real world problems may pose inter-dependence or interactive characteristics between preferences. Fuzzy measure or the non-additive measure was introduced by Sugeno in 1974 to overcome this problem and hence the prototype fuzzy TOPSIS was established. The fuzzy measure makes monotonicity instead of additive property. Fuzzy TOPSIS is the most effective tool to model inter-dependent criteria and deal with decision problem (Chunqiao Tan, 2011). Fuzzy TOPSIS is an improvement in the TOPSIS method which enables us to incorporate weights with values over a range and hence effectively model real world problems as uncertainty is inevitable. Rouhani et al applied fuzzy topsis to evaluate the enterprise systems with respect to 34 aspects on business intelligence (Rouhani et al, 2012). Jia-Wen Wang et al asserted that fuzzy TOPSIS provides more accurate and meaningful results that are consistent with other methods. They also proposed that this method is more reasonable than other methods through analysing LI-BPIC supplier selection problem (Jia-Wen Wang et al, 2009). Krohling et al illustrated a case study to identify the best management alternative to prevent accidents with oil spills applying fuzzy TOPSIS. They used 10 alternatives and two criteria for this MCDM problem (Krohling et al, 2011). Fu Yuan-guang investigated MCDM problem with fuzzy TOPSIS through an illustrative case study and indicated that this method can be implemented with less information and provide objective and reasonable results (Fu Yuan-guang, 2009).

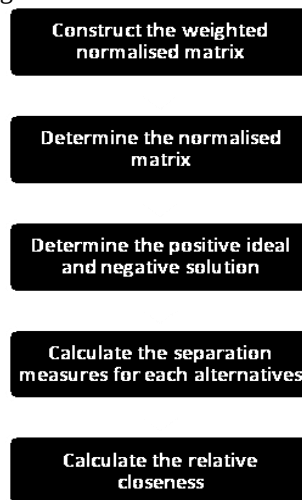
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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Fuzzy TOPSIS methodology

The basic concept of TOPSIS method is that the chosen alternative (optimal alternative) should have the shortest distance from the positive ideal solution and the farthest distance from negative ideal solution. Positive ideal solution is a solution that maximizes the benefit criteria and minimizes adverse criteria, whereas the negative ideal solution maximizes the adverse criteria and minimizes the benefit criteria. In this study fuzzy weights are employed using triangular fuzzy numbers to eliminate ambiguity in determining the weights. The procedure to be followed when triangular fuzzy numbers are incorporated is given below:



III. PROBLEM DESCRIPTION

Manufacturing sector plays a crucial role in the Indian economy. It contributes more than 75% in Indian exports. However, Indian manufacturing industries are facing tremendous challenges due to liberalization and globalisation. Imports and MNCs and especially china are becoming major threats to Indian industries. To combat these challenges Indian industries try to adopt recent trends and practices to improve productivity. Lean manufacturing is already widespread in many industries abroad. Lean practices are still in the early stage in Indian industries. Large scale industries have started implementing lean principles. On the other hand, only a few small and medium scale industries have implemented them. It is clear from the literature review that Indian industries are still struggling to realise lean way of life. In general, the success of implementation of any particular management practice frequently depends upon organizational characteristics, and not all organizations can or should implement the same set of practices. This study deals with the identification of critical factors that affect the implementation of lean manufacturing in Indian MSMEs and evaluating the performance of MSMEs with respect to these criteria.

4.1 Identification of factors

The response collected through the survey was tabulated as given in the following table.

	MSME's(6 industries)					
Success Factors	A	B	C	D	E	F
Organisational structure	5	5	5	5	5	5
Resources optimization	4	4	4	4	4	3
Knowledge management	1	1	1	1	2	1

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

Employee status	3	2	3	3	2	2
Team working	3	1	1	2	3	2
Manufacturing setups	3	4	3	3	3	4
Design improvement	1	1	1	1	1	1
Manufacturing planning	2	2	1	1	2	2
Advances in design	1	2	2	1	2	1
Status of productivity	2	1	1	2	1	2
Time management	2	2	1	2	1	1

The performance of industries with respect to the 11 critical factors were analysed using Multi Attribute Decision Making. This study includes fuzzy TOPSIS for evaluation. TOPSIS is a deterministic technique used to identify the best among the given industries with respect to implementation of lean manufacturing. TOPSIS involves the comparison of the distances of the alternatives from the positive ideal solution and the negative ideal solution. The alternative closest to the positive ideal solution and farthest from the negative ideal is ranked the best. Fuzzy TOPSIS is an extension of TOPSIS and takes into account the uncertainties involved in real time situation and gives more accurate results.

4.2 Evaluation using fuzzy TOPSIS

Since the weights and performance ratings of the criteria are given as crisp values in TOPSIS, it is not ideal in modeling real world conditions. The criteria used are inter-dependent. For instance strong management and leadership influences employee trust and Training and education have signification effect on skills and expertise of employees. Similarly, effect of factors on implementation of lean practices also varies with respect to the type of industry. All these variations cannot be incorporated in TOPSIS. Hence fuzzy TOPSIS is used to for accurate evaluation including all the uncertainties.

The fuzzy weights used for evaluation are given below.

Performance criteria	Fuzzy weights
Organisational structure	(1.85/11, 2.0/11, 2.1/11)
Resources optimization	(0.35/11, 0.37/11, 0.5/11)
Knowledge management	(0.75/11, 0.81/11, 0.83/11)
Employee status	(1.1/11, 1.22/11, 1.3/11)
Team working	(0.9/11, 1.0/11, 1.11/11)
Manufacturing setups	(0.48/11, 0.55/11, 0.68/11)
Design improvement	(0.65/11, 0.72/11, 0.75/11)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

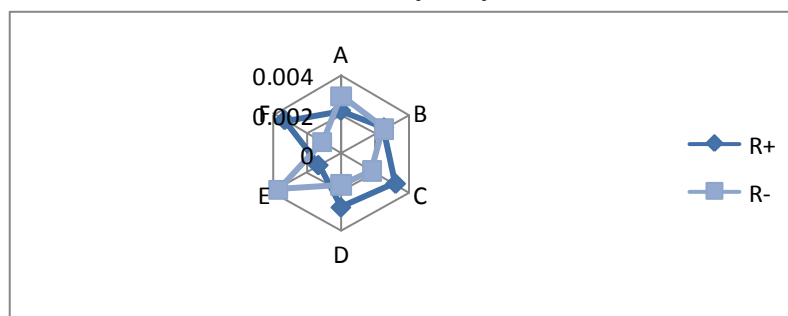
Vol. 4, Special Issue 6, May 2015

Manufacturing planning	(0.84/11, 0.85/11, 0.9/11)
Advances in design	(1.33/11, 1.7/11, 1.9/11)
Status of productivity	(0.85/11, 0.9/11, 0.93/11)
Time management	(0.95/11, 0.97/11, 1.08/11)

Industry	$S+(X10^3)$	$S-(X10^3)$	C
A	2.133	2.908	0.577
B	2.531	2.51	0.498
C	3.215	1.826	0.362
D	2.818	1.611	0.364
E	1.324	3.699	0.734
F	3.302	1.127	0.254

V. RESULTS AND DISCUSSIONS

The separation measures and relative closeness help to identify the best among the alternatives. The graph given below shows the separation measures for each alternative resulted by fuzzy TOPSIS method.



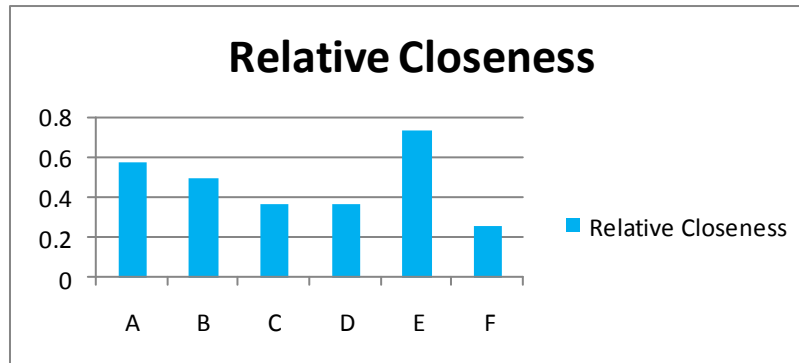
Separation measures obtained by fuzzy TOPSIS

The alternative which has the maximum separation from negative ideal (S^-) solution and minimum separation (S^+) from positive ideal solution is ranked first. It can be clearly observed from the graph alternative E has the minimum S^+ and maximum S^- and alternative F has maximum S^+ and minimum S^- . To quantify this separation relative closeness is determined. The alternative with maximum relative closeness is the most consistent with the performance measures. The relative closeness for each alternative was calculated and plotted. Relative closeness is used to estimate the alternative's distance from the solutions. Figure gives the relative closeness of each alternative. It can be observed that alternative E has the maximum relative closeness followed by A and alternative F has the minimum relative closeness.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Special Issue 6, May 2015



Relative closeness

The alternatives are ranked by comparing their relative closeness. The one with maximum relative closeness is ranked first. The ranks obtained by each alternative are given below.

Alternative	Rank
A	2
B	3
C	5
D	4
E	1
F	6

Alternative E is ranked first. This implies that E is the most consistent with the performance factors.

VI. CONCLUSION

Lean manufacturing reduces waste and increases productivity and hence facilitates industries to stay competitive in global market. Successful implementation of lean manufacturing is a major challenge faced by Indian industries. This study involves evaluation of lean manufacturing in Indian industries using multiple criteria decision making using fuzzy TOPSIS. Attributes which have due effect on implementation of lean manufacturing in MSMEs were collected. The extend of influence of each attribute was also identified. Industries were evaluated with respect to these attributes. The normalized fuzzy decision matrix was calculated and the distance from the positive ideal fuzzy solution and negative ideal fuzzy solution for each attribute was determined. Among the 6 alternatives evaluated, alternative E has the maximum relative closeness and hence is ranked first.

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International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Special Issue 6, May 2015

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