# Selection of LEAN Facilitator and Machine for Implementing LEAN Manufacturing System in a Discrete Manufacturing

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***Abstract: In present competitive business environment, Lean manufacturing becomes a key strategy for global competition. Lean manufacturing is a combination of best techno social practices which consists of the social aspects (people and society) and technical aspects (machine and technology).Most of the lean practices are shop floor techniques that concentrate in eliminating non value added activity in the production floor. The purpose of lean manufacturing is to attain higher quality, productivity, Yield and less down times of machines. For successful implementation of LEAN manufacturing system in any organization-selection of facilitator and system of evaluating the degree of applied lean tools for selected process plays a vital role. To solve this type multi criteria decision making problems, a detailed study and investigation done using VIKOR method. By using the VIKOR method the decision makers can take the decision which is closer to the ideal solutions. In this paper linguistic fuzzy data is used to find the ratings and weights. A numerical example is proposed to demonstrate with an application of the proposed technique. Finally under fuzzy environment using this VIKOR method, with multi criterion decision makers and with their weightage best LEAN facilitator was selected to implement lean manufacturing system .At the same time to adopt appropriate lean tools and get desired results best fitted lean process line and machine was selected and identified***

**Keywords - Lean manufacturing, facilitator selection, fuzzy, VIKOR.**

## I. Introduction

Lean manufacturing system is a comprehensive set of techniques that, when combined and applied, reduce and then eliminate the seven wastes. This system uses set of tools that assist in identification and elimination of wastes. It can also be termed as “A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection”. The fundamental philosophy behind Lean Manufacturing system is to provide superior quality products for more Customers at a significantly lower price and to contribute to a more prosperous society. Lean Manufacturing has endeavoured to rationalize production by

Completely eliminating waste in the production process

- To build quality into the process
- To reduce costs - productivity improvements
- To develop its own unique approach toward corporate management

To create and develop integrated techniques that will contribute to corporate operation. Establishment and mastering of a lean production system would allow you to achieve the following benefits:

- Waste reduction or Elimination
- Production cost reduction
- Decrease in manufacturing cycle times
- Labour reduction while maintaining or increasing throughput
- Inventory reduction while increasing customer service levels
- Higher quality
- Higher profits
- Higher system flexibility in reacting to changes in requirements improved
- More strategic focus

Improved cash flow through increasing shipping and billing frequencies. Recently, lean techniques have moved from manufacturing plants to operations of all kinds, everywhere: insurance companies, hospitals, government agencies, airline maintenance organizations, high-tech product-development units, oil production facilities, IT operations, retail buying groups, and publishing companies, to name just a few. In each case the goal is to improve the organization’s performance on the operating metrics that make a competitive difference, by drawing employees into the hunt to eliminate unneeded activities and other forms of operational waste

## II. Multi Criteria Decision Making (Mcdm) Methods

Multiple criteria decision making (MCDM) refers to making decisions in the presence of multiple, usually conflicting, criteria. It is the most well known branch of decision making. It is a branch of a general class of Operations Research (or OR) models which deal with decision problems under the presence of a number of decision criteria. The Multi criterion Decision-Making (MCDM) are gaining importance as potential tools for analyzing complex real problems due to their inherent ability to judge different alternatives (Choice, strategy, policy, scenario can also be used synonymously) on various criteria for possible selection of the best/suitable alternative (s). In general, there exist two distinctive types of MCDM problems due to the different problems settings: one type having a finite number of alternative solutions and the other an infinite number of solutions. Normally in problems associated with selection and assessment, the number of alternative solutions is limited. In problems related to design, an attribute may take any value in a range. Therefore the potential alternative solutions could be infinite. If this is the case, the problem is referred to as multiple objective optimisation problems instead of multiple attribute decision problems. This white paper focus will be on the problems with a finite number of alternatives. There are two types of MCDM methods. One is compensatory and the other is non compensatory

**Non-compensatory Methods**

Non-compensatory methods do not permit tradeoffs between attributes. An unfavourable value in one attribute cannot be offset by a favourable value in other attributes. Each attribute must stand on its own. Hence comparisons are made on an attribute-by-attribute basis. The MCDM methods in this category are credited for their simplicity.

**Compensatory Methods**

Compensatory methods permit trade-offs between attributes. A slight decline in one attribute is acceptable if it is compensated by some enhancement in one or more other attributes. Compensatory methods can be classified into the following 4 subgroups

**Scoring Methods**

The scoring method selects or evaluates an alternative according to its score (or utility). **Utility** or score is used to express the decision maker's preference. It transforms attribute values into a common preference scale such as [0,1] so that comparisons between different attributes becomes possible. A very popular method in this category is the Simple Additive Weighting method. This method calculates the overall score of an alternative as the weighted sum of the attribute scores or utilities. The Analytical Hierarchy Process (AHP) is another popular method in this category. This method calculates the scores for each alternative based on pairwise comparisons

**Compromising Methods**

The compromising method selects an alternative that is closest to the ideal solution. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method belongs to this category. This method first normalises the decision matrix of a MCDM problem. Then based on the normalised decision matrix, it calculates the weighted distances of each alternative from an ideal solution and a nadir solution. A solution relatively close to the ideal solution and far from the nadir solution is evaluated to be the best

**Concordance Methods**

The concordance method generates a preference ranking which best satisfies a given concordance measure. The Linear Assignment Method is one of the examples in this family. In this method it is believed that an alternative having many highly ranked attributes should be ranked high.

**Evidential Reasoning Approach**

The evidential Reasoning (ER) approach is the latest development in the MCDM area It is different from the above 3 conventional methods. Instead of describing a MCDM problem with a decision matrix, the ER approach uses a extended decision matrix, in which each attribute of an alternative is described by a distributed assessment using a belief structure.

**VIKOR Method**

The VIKOR method, developed by Opricovic & Tzeng (2002), is based on the compromise programming of multi-criteria decision making (MCDM). We assume that each alternative is evaluated according to a separate criterion function; the compromise ranking could be utilized by comparing the measure of closeness to the ideal alternative. It was developed as a multicriteria decision making method to solve a discrete decision problem with no commensurable and conflicting criteria. This method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria. The VIKOR method is an effective tool in multicriteria decision analysis, particularly in situations where the decision maker does not know to express his/her preference at the beginning of system design to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions.

**TOPSIS Method**

TOPSIS (technique for order preference by similarity to an ideal solution) method is a popular approach to MADM and has been widely used in the literature. TOPSIS was first developed by Hwang and Yoon for solving a MADM problem.

TOPSIS simultaneously considers the distances to the ideal solution and negative ideal solution regarding each alternative and selects the most relative closeness to the ideal solution as the best alternative.

The best alternative is the nearest one to the ideal solution and the farthest one from the negative ideal solution and the relative advantage of TOPSIS is the ability to identify the best alternative quickly

**Fuzzy Approach**

The goal of multi-criteria decision analysis (MCDA) is to structure and simplify the task of making hard decisions to the extent that as well and as easily as the nature of the decision permits (Belton, 1990). MCDA works on the assumption that the appeal of an alternative depends on the likelihood of the possible consequences of the alternative, and the preferences concerning the possible consequences.

What makes MCDA unique is the way in which these factors are quantified and formally incorporated into the problem analysis. Existing information, collected data, models and professional judgments are used to quantify the likelihoods of ranges of consequences, whereas utility theory is used to quantify preferences. The usual or traditional approach to MCDA calls for single or precise values for the different model inputs, i.e., for the weights as well as for the performances of the alternatives in terms of the identified criteria. However, we adopt a less demanding approach for the decision maker (DM), who is able to provide fuzzy numbers instead of single values.

## III Proposed Methodology for Selecting Lean Facilitator And Machine-Case Study

The case study company is a Steel manufacturing firm located in Hyderabad. Now the management wants to implement lean principles to their process line.For find the initial leanness of the process and select the better lean process line two MCDA methods are used. In this study the following five KPIs is considered as criteria and four process lines as alternatives.

1. Manufacturing cycle time(MCT)
2. Idle time (IT)
3. Yield (Yd)
4. Rework/Rejection (Re)
5. Amount of scraps (AS)

The methods use a fuzzy scoring approach that is a modification of the fuzzy ranking approaches proposed by Jain (1976, 1977), and Chen (1985)to find the weights of the criteria . The crisp score of fuzzy number 'M' is obtained are tabulated in **table 1** .In Table 2 the weights of each criteria derived from the plant managers linguistic term.

Table 1 Chen Fuzzy scale

| Linguistic term | Fuzzy number |
|---|---|
| Low | M1=0.115 |
| Below average | M2=0.295 |
| Average | M3=0.495 |
| Above average | M4=0.695 |
| High | M5=0.895 |

Table2 Wright Calculation

| Criteria | Score | Fuzzy number | Weight |
|---|---|---|---|
| MCT | High | 0.895 | 0.25 |
| IT | Above average | 0.695 | 0.19 |
| Yd | Average | 0.495 | 0.12 |
| Re | High | 0.895 | 0.25 |
| As | Above average | 0.695 | 0.19 |

As mentioned above the 5 KPIs are kept as criteria .In this MCT, IT, Re, AS are negative that means the minimum is best P/L is positive.

Units
MCT -Minutes
IT -Minutes
Yd -Percentage
Re -Number of units
As -Kg

Table 3 Indicates the data for same model Steels. Table 3 to 7 illustrates the steps involve in COPRAS method

Table 3: Decision matrix

| Process line | MCT | IT | P/L | Re | AS |
|---|---|---|---|---|---|
| Wt | 0.25 | 0.19 | 0.12 | 0.25 | 0.19 |
| L1 | 168 | 46 | 15 | 12 | 1.6 |
| L2 | 152 | 39 | 15.65 | 12 | 1.4 |
| L3 | 170 | 32 | 15 | 11 | 2 |
| L4 | 164 | 40 | 16.36 | 13 | 2.2 |

Table 4 Normalized decision matrix

| Process Line | MCT | IT | P/L | Re | AS |
|---|---|---|---|---|---|
| Wt. | 0.25 | 0.19 | 0.12 | 0.25 | 0.19 |
| L1 | 0.256 | 0.29 | 0.24 | 0.25 | 0.22 |
| L2 | 0.232 | 0.25 | 0.25 | 0.25 | 0.19 |
| L3 | 0.26 | 0.2 | 0.242 | 0.23 | 0.28 |
| L4 | 0.25 | 0.255 | 0.264 | 0.27 | 0.305 |

Table 5 Weighted Normalized matrix

| Process Line | MCT | IT | P/L | Re | AS |
|---|---|---|---|---|---|
| Wt. | 0.25 | 0.19 | 0.12 | 0.25 | 0.19 |
| L1 | 0.064 | 0.055 | 0.0288 | 0.0625 | 0.0418 |
| L2 | 0.058 | 0.0475 | 0.03 | 0.0625 | 0.0361 |
| L3 | 0.065 | 0.038 | 0.029 | 0.0575 | 0.0532 |
| L4 | 0.0625 | 0.04845 | 0.0316 | 0.675 | 0.0579 |

Table 6 Sum Values

| Process Line | Sj+ | SJ- |
|---|---|---|
| L1 | 0.0288 | 0.2233 |
| L2 | 0.03 | 0.2041 |
| L3 | 0.029 | 0.2137 |
| L4 | 0.0316 | 0.236 |

Table 7. Relative weights

| Process Line | Z value | Rank |
|---|---|---|
| L1 | 0.2436 | 3 |
| L2 | 0.264 | 1 |
| L3 | 0.253 | 2 |
| L4 | 0.234 | 4 |

Table 8 and table 9 explains the SAW method Table 8 Normalize Table

| Process Line | MCT | IT | Yd | Re | AS |
|---|---|---|---|---|---|
| Wt | **0.25** | **0.19** | **0.12** | **0.25** | **0.19** |
| L1 | 0.9047 | 0.6956 | 0.92 | 0.92 | 0.875 |
| L2 | 1 | 0.82 | 0.96 | 0.92 | 1 |
| L3 | 0.8837 | 1 | 0.92 | 1 | 0.7 |
| L4 | 0.9263 | 0.8 | 1 | 0.846 | 0.64 |

Table 9 Rank Table

| Process Line | A value | Rank |
|---|---|---|
| L1 | 0.864 | 3 |
| L2 | 0.941 | 1 |
| L3 | 0.904 | 2 |
| L4 | 0.728 | 4 |

**Lean facilitator selection**
**Proposed Method-Case Study in Pennar Industries**

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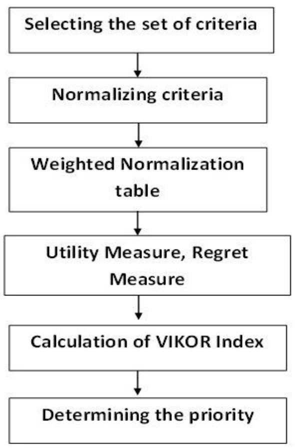
A Systematic approach to extend the VIKOR is proposed to solve the facilitator selection problem under a fuzzy environment in this section(Forghani,Mohammad Ali;Izadi,Leyla,(2013).The basic steps of the proposed method consists of the following items, as shown in figure




**Arrangement of decision making group**

In lean implementation, as a change initiative, it is vital to involve several people and experts from different functional areas within the company in facilitator selection process. Efficient communication between experts is essential because the better the parties are informed about the process. In this part the objectives of the selection process as well as its scope and possible alternatives are defined. Thereby at the end of this step we have a set of possible facilitators called

$$F = \{ F1, F2, F3, F4, F5 \}$$

And a set of decision makers called

$$D=\{ DM1, DM2, DM3 \}$$

**Definition and description of a finite set of relevant attributes**

Facilitator selection first requires the identification of decision attributes (Criteria).For this purpose we must consider all decision-making group opinion. There are a number of “group based” research techniques available to determine the views or perceptions of individuals in relation to specific topics. The purpose of such work is to increase the depth and scope of discussion, ensure wide coverage of ideas, and involve grope members in selecting priorities and to seek agreement or consensus on the topic in question. After reviews a set of 5 criteria

$$C=\{ C1, C2, C3, C4, C5 \}$$

**Definition and description of a finite set of relevant attributes**

This selection problem expressed in the matrix format for Kth decision maker as linguist term like Low, Average, Average, Above average and High.The following tables indicate the scores given by three decision makers for five facilitators

**Proposed Method for Facilitator Selection**

In this section a methodical approach of the VIKOR being applied to solve the facilitator selection problem under a fuzzy environment. The magnitude weights of various criteria and the ratings of qualitative criteria measured as linguistic variables. Because linguistic assessments merely about the slanted judgment of decision makers. Facilitator selection in the lean manufacturing system is a group multiple criteria decision making (GMCDM) problem. This is illustrated by the following sets.

1. A set of decision makers called D= {D1, D2, D3}
2. A set of possible facilitator called F= {F1, F2, F3, F4, F5}
3. A set of criteria, C= {C1, C2, C3, C4, C5}

The main steps of the wok are:

The proposed model has been applied to a lean facilitator selection process of a firm working in the field of automobile part manufacturing in the following steps:

Step 1: The Company desires to select a good lean facilitator. After preliminary screening, five candidate facilitator (F1, F2, F3, F4, and F5) remains for further evaluation.

Step 2: A committee of three decision makers(DM), D1; D2 and D3, has been formed to select the most suitable facilitator. The following criteria have been defined:

C1-Education Qualification
C2-Knowledge of the Process
C3-Coaching skill

Table 10,11 , and 12 shows ratings given by decision makers 1,2 & 3

**Table 10: Ratings of five facilitators by decision maker 1**

| | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| F1 | BA | AA | L | H | H |
| F2 | H | H | H | H | L |
| F3 | L | H | L | H | BA |
| F4 | H | A | AA | H | H |
| F5 | AA | H | BA | L | BA |

**Table 11: Ratings of five facilitators by decision maker 2**

| | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| F1 | AA | A | A | AA | AA |
| F2 | AA | AA | AA | AA | A |
| F3 | A | H | A | AA | AA |
| F4 | H | L | BA | AA | AA |
| F5 | BA | A | AA | A | AA |

**Table 12: Ratings of five facilitators by decision maker 3**

| | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| F1 | A | H | L | A | A |
| F2 | H | A | A | A | L |
| F3 | L | H | L | H | A |
| F4 | AA | A | A | H | H |
| F5 | A | H | A | L | A |

Step 3: Three decision makers use the linguistic weighting

variables to assess the importance of the criteria. The importance weights of the criteria determined by these three decision makers are shown in **Table 13**. Also the decision makers use the linguistic rating variables to evaluate the ratings of candidates with respect to each criterion. The ratings of the five facilitators by the decision makers under the various criteria are shown in **Table 13**

**Table 13 Importance weight of criteria.**

| | DM1 | DM2 | DM3 | Weights |
|---|---|---|---|---|
| C1 | A | A | AA | 0.17 |
| C2 | H | AA | H | 0.25 |
| C3 | H | AA | AA | 0.23 |
| C4 | A | BA | A | 0.14 |
| C5 | A | AA | H | 0.21 |

Table 14: Rating of facilitators

| | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DM1 | DM2 | DM3 | DM1 | DM2 | DM3 | DM1 | DM2 | DM3 | DM1 | DM2 | DM3 | DM1 | DM2 | DM3 |
| F1 | BA | A | AA | AA | H | A | L | L | A | H | A | AA | H | A | AA |
| F2 | H | H | AA | H | A | AA | H | A | AA | H | A | AA | L | L | A |
| F3 | L | L | A | H | H | H | L | L | A | H | H | AA | BA | A | AA |
| F4 | H | AA | H | A | A | L | AA | A | BA | H | H | AA | H | H | AA |
| F5 | AA | A | BA | H | H | A | BA | A | AA | L | L | A | BA | A | AA |

Step 4: The linguistic evaluations shown in Tables 13 and 14 are converted into fuzzy numbers. Then the aggregated weight of criteria and aggregated fuzzy rating of alternatives is calculated to construct the fuzzy decision matrix and determine the fuzzy weight of each criterion, as in Tables 15

**Table 15 Decision Matrix in crisp score for facilitators**

| | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| WEIGHT | 0.17 | 0.25 | 0.23 | 0.14 | 0.21 |
| F1 | 0.5 | 0.7 | 0.241 | 0.7 | 0.7 |
| F2 | 0.9 | 0.7 | 0.7 | 0.69 | 0.3 |
| F3 | 0.3 | 0.9 | 0.3 | 0.9 | 0.5 |
| F4 | 0.7 | 0.3 | 0.5 | 0.9 | 0.9 |
| F5 | 0.5 | 0.7 | 0.5 | 0.3 | 0.5 |

**Weight evaluation of selection criteria**

| | DM1 | DM2 | DM3 | WEIGHTS |
|---|---|---|---|---|
| C1 | 0.495 | 0.495 | 0.695 | 0.17 |
| C2 | 0.895 | 0.695 | 0.895 | 0.25 |
| C3 | 0.895 | 0.695 | 0.695 | 0.23 |
| C4 | 0.495 | 0.295 | 0.495 | 0.14 |
| C5 | 0.495 | 0.695 | 0.695 | 0.21 |

Step-5:Calculation of utility measure, Regret measure and VIKOR index

The values of E(Utility Measure),F(Regret Measure) and P(VIKOR INDEX) are calculated
by using the equations

$$Ei=\sum mij)max-(mij)]/[(mij)max-(mij)min]$$

$$Fi=\sum mij)max-(mij)]/[(mij)max-(mij)min]$$

$$Pi = v ((Ei - Ei\text{-}min) / (Ei\text{-}max - Ei\text{-}min)) + (1 -v)$$
$$((Fi -Fi\text{-}min) / (Fi\text{-}max - Fi\text{-}min))$$

| Utility Measure (E) Value of Facilitator | | | | |
|---|---|---|---|---|
| E1 | E2 | E3 | E4 | E5 |
| 0.26 | 0.08 | 0.14 | 0.30 | 0.26 |
| | | | | |
| **Regret Measure (F) Values of Facilitator** | | | | |
| F1 | F2 | F3 | F4 | F5 |
| 0.10 | 0.08 | 0.07 | 0.13 | 0.13 |
| | | | | |
| **VIKOR Index (P) Values of Facilitator** | | | | |
| P1 | P2 | P3 | P4 | P5 |
| 0.70 | 0.05 | 0.14 | 1.00 | 0.91 |

The ranking of the Lean facilitator by E, F and P in decreasing order is shown in Table 16.

**Table 16 :The ranking of the facilitators by E, F and P in decreasing order.**

| Ranking of Lean Facilitator | | | | | |
|---|---|---|---|---|---|
| By E | F2 | F3 | F1 | F5 | F4 |
| By F | F3 | F2 | F1 | F5 | F4 |
| By P | F2 | F3 | F1 | F5 | F4 |

Step 6:As we see in Table 16 the facilitator F2 is the best ranked. Hence F2 is the best choice

## IV. CONCLUSION

Many industries have stressed the advantages of lean manufacturing system to increase the competitive advantage. The facilitator selection problem becomes the most important issue to implement a successful system. The selection problem is often controlled by uncertainty in practice, and in such situation fuzzy set theory is an appropriate tool to deal with this kind of problems. In actual factory system, the decision maker is not able to express his rating precisely in numerical values and the evaluations are very often expressed in linguistic terms. In this work the VIKOR, a newly introduced MCDM method, in fuzzy environment is proposed to deal with the both qualitative and quantitative criteria and select the suitable facilitator effectively. The proposed method is very flexible. Using this method not only enables us to determine the outranking order, but also assess and rate..Also the proposed method in fuzzy environment provides a systematic approach which can be easily extended to deal with other lean manufacturing decision making problems

Practitioners and academics have emphasized the advantages of lean manufacturing . In order to increase the competitive advantage, many companies consider that a well designed and implemented lean system is an important tool. In this study, the application of the COPRAS and SAW is presented for the analysis leanness of process lines in the Steel industry. Four process lines are considered to illustrate the application capability of this method. It is clear that the top-ranked alternatives exactly match with methods.This paper not only built MCDA model to evaluation process lines, but also calculates the degree of leanness. This study reduces the risk involved in the omission of parameters. This work may be extended by using the other MCDA methods like TOPSIS, SMART,VIKOR.

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