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Appraisal of Equipments for Lean Manufacturing Environment- A MCDA Approach

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***Abstract*: Nowadays, Lean manufacturing tools become a key strategy for global competition. In a lean manufacturing environment, the selection of process equipments is a complex multi criteria problem. To solve such types of problems we use the VIKOR method . By using the VIKOR method decision makers can take the decision which is closer to the ideal solutions. In this paper linguistic fuzzy data is used to find out the ranking. It explains the procedure of VIKOR model in selecting a machine with a numerical example.**

***Index Terms*: Equipment selection, Fuzzy VIKOR, Lean manufacturing,.**

I. INTRODUCTION

In manufacturing plants across the world, lean manufacturing techniques are used to meet increasing demands and withstand in the global market .Lean manufacturing techniques have facilitated them to dramatically increase their competitive edge, The journey starts from Henry Ford's continuous assembly lines for the Ford Model. The combination of this concept as well as a successful industrial practice of many others has come as one to create what we know now as lean manufacturing.

The main idea behind lean manufacturing is maximizing customer value while minimizing the seven deadly wastes. Waste is defined as an activity that does not add value to the product. Through the elimination of waste along the entire manufacturing process the company can produce quality products at low-cost. Many companies have implemented lean manufacturing techniques to create more efficient workflows. In a lean manufacturing environment the role of equipment selection is vital because they play the major role on the process line.

II. MCDA

Multi-criteria decision-making (MCDM) relegates to screening, prioritizing, ranking, or selecting a set of options under usually independent, unequal or inconsistent attributes. Over some phases, the Multi-criteria decision-making methods have been marked. The methods differ in many areas—theoretical environment, type of questions asked and the type of results known (Hobbs &Meier, 1994). Some methods have been expertly particularly for one specific problem, and are not useful for other problems.

Other methods are more general, and many of them have attained reputation in various areas. The most significant idea for all the methods is to make a more formalized and better-informed decision-making process. There are many possible ways to classify the existing MCDM methods.

[1]Thomas L. Saaty invented AHP technique in 1970,This makes the decision making problem in various hierarchies as a goal, criteria, sub-criteria and decision alternatives (Saaty, 1990, Saaty and Vargas, 2001). AHP method assists decision makers to pact with complex decision problems, set priorities and to make the best decision particularly when subjectivity exists. AHP is extremely suitable to solve problems where the evaluation criteria can be organized in a hierarchical way into sub-criteria. Due to its mathematical simplicity and flexibility, AHP has been a favorite decision tool for research in many fields. In mid 1960s ELECTRE originated in Europe. ELECTRE stands for ELimination Et ChoixTraduisant la REalité (ELimination and Choice Expressing REality. The modified version of this outranking method is ELECTRE I ,ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE IS and ELECTRE TRI.

Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE) method have been introduced in 1982 by Professor Jean-Pierre Brans. This method allows the decision maker to visualize the main features of a decision problem. PROMETHEE has successfully been used in many decision making problems.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was developed by kwang sunyoon and Hwang ching-lai in 1980.In TOPSIS the selected alternative should be as close to the ideal solution as possible and as far from the negative-ideal solution as possible.

III. THE VIKOR METHOD

[2]VIKOR method developed by Opricovic (1998), Opricovic and Tzeng (2002),the Serbian name: VlseKriterijumskaOptimizacija I KompromisnoResenje, denote multi-criteria optimization and compromise solution(Chu, Shyu, Tzeng, &Khosla, 2007). The VIKOR method was developed for multi-criteria optimization of complex systems (Opricovic&Tzeng, 2004). This method centered on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal,

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It establishes the multi-criteria ranking index based on the particular measure of ''closeness" to the ''ideal" solution (Opricovic, 1998).According to (Opricovic&Tzeng, 2004) the multi-criteria measure for compromise ranking is developed from the PLp-metric used as an aggregating function in a compromise programming method (Yu, 1973).

The various J alternatives are denoted as a_1; a_2; . . a_J . For alternative a_j, the rating of the i^{th} aspect is denoted by f_{ij} , i.e. f_{ij} is the value of i^{th} criterion function for the alternative a_j; n is the number of criteria. Development of the VIKOR method started with the following form of Lp-metric:

$$Lp;j = \left\{ \sum_{i=1}^{n} [w_i(f_1^* - f_{ij})/(f^* - f_1^-)^p]^{1/p} \right\}$$

$1 \le p \le \infty$; j=1,2,3,.....j.

Within the VIKOR method Lpj is used to formulate ranking measure. Also TOPSIS, another MCDM method, is based on aggregating function representing ''closeness to ideal". In TOPSIS the chosen alternative should have the ''shortest distance" from the ideal solution and the ''farthest distance" from the ''negative-ideal". The TOPSIS method introduces two reference points, but it does not consider the relative importance of the distances from these points. These two MCDM methods use different kinds of normalization to eliminate the units of the criterion functions, whereas the VIKOR method uses linear normalization, the TOPSIS method uses vector normalization. The normalized value of the VIKOR method does not depend on the evaluation unit of criterion function, whereas the normalized values by vector normalization in the TOPSIS method may depend on the evaluation unit (Chuet al., 2007).

IV. FUZZY APPROACH

Which decision making process, the decision maker is frequently faced uncertainties and problems. In other words usual language to express observation or judgment is always subjective, uncertain or unclear. To resolve the ambiguity, uncertainty and prejudice of human judgment, fuzzy set theory (Zadeh, 1965) was initiated to express the linguistic terms in decision making (DM) process.

Bellman and Zadeh developed fuzzy multicriteria decision making (FMCDM) methodology in 1970 to determine the lack of accuracy in assigning importance weights of criteria and the ratings of alternatives regarding evaluation criteria. The logical tools that people can rely on generally measure the outcome of a bivalent judgment (yes/no, true/false), but the problems posed by the real-life condition and human thought processes and approaches to problem-solving are by no means bivalent (Tong &Bonissone, 1980). Just as conventional, bivalent logic is based on classic sets, fuzzy logic is based on fuzzy sets. A fuzzy set is a set of objects in which there is no clear-cut or predefined he boundary between the objects that are or are not members of the set.

The key thought behind this definition is that of ''relationship": any object may be a member of a set ''to some degree"; and a logical proposition may hold true"to some degree". Each element in a set is associated with a value indicating to what degree the element is a member of the set. This value comes within the range [0, 1], where 0 indicate the minimum and 1 indicate the maximum degree of membership, while all the middle values indicate degrees of ''partial" membership (Bevilacqua, Ciarapica, &Giacchetta, 2006). This approach helps decision makers solve complex decision making problems in a systematic, consistent and productive way .

V. CHEN AND HWANG 5 POINT SCALE

The method proposed by[5] Chen and Hwang (1992) first converts linguistic terms into fuzzy numbers and then the fuzzy numbers into crisp scores.. The conversion scales were proposed by synthesizing and modifying the works of Wenstop (1976), Bass and Kwakernaak (1977), Efstathiou and Rajkovic (1979), Bonissone (1982), Efstathiou and Tong (1982), Kerre (1982), and Chen (1988),. These linguistic terms can be equated in terms like

1. Low,
2. Below Average
3. Average,
4. Above Average
5. High.

The method uses a fuzzy scoring approach that is a modification of the fuzzy ranking approaches proposed by Jain and Chen The crisp score of fuzzy number is obtained as follows:

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

VI. PROPOSED METHOD FOR EQUIPMENT SELECTION

In this section a methodical approach of the VIKOR being applied to solve the equipment 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 maker.

Equipment selection in the lean manufacturing system is a group multiple criteria decision making (GMCDM) problem. This is illustrated by the following sets.

1. [3]A set of decision makers called D= {D1,D2,D3}
2. A set of possible equipment called F= {E1,E2.E3,E4}
3. A set of criteria, C={C1,C2,C3,C4,C5}

The main steps of the work are:

The proposed model has been applied to a lean equipment selection in the following steps:

Step 1: The Company desires to select a good machine.After preliminary screening, four equipments (F1, F2, F3, F4), 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-Capacity
C2-Usability
C3-Technology
C4-Efficiency
C5-Precise

Step 3: Three decision makers use the linguistic weighting variables shown in Fig to assess the importance of the criteria.

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The importance weights of the criteria determined by these three decision makers are shown in Table 1. Also the decision makers use the linguistic rating variables shown in Fig to evaluate the ratings of candidates with respect to each criterion. The ratings of the four equipments by the decision makers under the various criteria are shown in Table.

Table 1 Importance of criteria in fuzzy format

	DM1	DM2	DM3
C1	A	AA	A
C2	A	A	BA
C3	H	H	H
C4	H	H	AA
C5	AA	A	AA

Table 2 Importance of criteria in Chen and Hwang Scale

	DM1	DM2	DM3
C1	0.495	0.695	0.495
C2	0.495	0.495	0.295
C3	0.895	0.895	0.895
C4	0.895	0.895	0.695
C5	0.695	0.495	0.695

Table 3 Importance weight of criteria

	Score	Weights
C1	1.685	0.168
C2	1.285	0.128
C3	2.685	0.267
C4	2.485	0.248
C5	1.885	0.189

Table 4.1 The linguistic evaluations of criteria 1

	C1		
	DM1	DM2	DM3
E1	BA	A	AA
E2	H	H	AA
E3	L	L	A
E4	H	AA	H

Table 4.2 The linguistic evaluations of criteria 2

	C2		
	DM1	DM2	DM3
E1	AA	H	A
E2	H	A	AA
E3	H	H	H
E4	A	A	L

Table 4.3 The linguistic evaluations of criteria 3

	C3		
	DM1	DM2	DM3
E1	L	L	A
E2	H	A	AA
E3	L	L	A
E4	AA	A	BA

Table 4.4 The linguistic evaluations of criteria 4

	C4		
	DM1	DM2	DM3
E1	H	A	AA
E2	H	A	AA
E3	H	H	AA
E4	H	H	AA

Table 4.5 The linguistic evaluations of criteria 5

	C5		
	DM1	DM2	DM3
E1	H	A	AA
E2	L	L	A
E3	BA	A	AA
E4	H	H	AA

Table 5.Evaluation in Numbers.

	C1	C2	C3	C4	C5
Weight	**0.168**	**0.128**	**0.267**	**0.248**	**0.189**
E1	0.50	0.70	0.241	0.70	0.70
E2	0.90	0.70	0.70	0.69	0.3
E3	0.30	0.90	0.30	0.90	0.50
E4	0.70	0.30	0.50	0.90	0.90

Table 6 .E value

	C1	C2	C3	C4	C5
E1	0.11	0.04	0.27	0.24	0.06
E2	0	0.04	0	0.25	0.19
E3	0.17	0	0.23	0	0.13
E4	0.06	0.13	0.12	0	0

Step 5: The values of E,F and ``P are calculated by using the equations

$E_i=\sum_n^m wj[(m_{ij})_{max}-(m_{ij})]/[(m_{ij})_{max}-(m_{ij})_{min}]$

$Fi=Max\ of \sum_n^m wj\ [(m_{ij})_{max}-(m_{ij})]/[(m_{ij})_{max}-(m_{ij})_{min}]$

Pi = v ((Ei - Ei.min) / (Ei.max - Ei.min)) + (1 - v) ((Fi - Fi.min) / (Fi.max - Fi.min))

for all the facilitators

E1=0.72 F1=0.27 P1=1

E2=0.48 F2=0.25 P2=0.636

E3=0.53 F3=0.23 P3=0.0.625

E4=0.31 F4=0.13 P4=0

Step 6: The ranking of the Lean facilitator by E, F and P in decreasing order is shown in Table

Table 7 The ranking of the equipment by E, F and P in decreasing order.

	Ranking of equipment			
By E	E4	E2	E3	E1
By F	E4	E3	E2	E1
By P	E4	E3	E2	E1

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As we see in Table 7 the equipment E4 is the best ranked. Hence E4 is the best choice.

VII. CONCLUSION AND FUTURE RESEARCH

Many industries have stressed the advantages of lean manufacturing system to increase the competitive advantage. The equipment 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 an the VIKOR, a MCDM method, in fuzzy environment is used to select the suitable equipment effectively. 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.

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