GREEN CUTTING FLUID SELECTION USING MOOSRA METHOD

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Abstract

In every manufacturing process, cutting fluid is the key source of environmental pollution, with most favourable selection of cutting fluid for the green manufacturing(GM) being an essential for reducing the environmental pollution. The objective factors considered for the traditional selection are of two: cost(C) and quality (Q) but green factors also to be considered from the GM point of view. The aim of this research is to select the finest cutting fluid that minimize the environmental impact (E), cost(C) and maximize the quality (Q). This paper presents a new method, namely, multi-objective optimisation on the basis of simple ratio analysis (MOOSRA). A case study of cutting fluid selection for gear hobbing process was presented to validate the proposed model. The obtained result using MOOSRA has been compared with Analytical Hierarchical Process (AHP) and Decision Making Framework (DMF). The result shows that Syntilo 9930c is optimal in comparison with other.

Keywords: *Green manufacturing (GM), MOOSRA, Green cutting fluid, AHP, MCDM.*

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1. INTRODUCTION

Present scenario the environmental issues are very important in all the manufacturing industries because it creates the serious problem during the manufacturing process. After the ISO900 quality management system standards, the ISO 1400 environmental management system standards and the OHSAS18001 occupational health and safety assessment series published for entire manufacturing industries because cutting fluid used during the manufacturing process itself is main contributor for source of health and environmental risks. Therefore, how to minimize the environmental issues of the manufacturing industry becomes an important focus for the entire manufacturer. Due to this present condition, an advanced manufacturing system need to be done to reduces the environmental factors –green manufacturing (GM) is presented [1-3].

Even in the machining process, cutting fluids are generally used as a coolant to ensure a smooth machining operation, but in actual practice cutting fluid is major source of environmental pollution. Several researcher developed many techniques for cutting fluid selection considering the green aspects such as comprehensive model on cutting fluid mist information in machining, including mechanism of atomization, vaporization and liquefaction method was proposed in [4]. Manufacturing modelling for environmentally impact assessment [5], Explored the overview of environmentally conscious machining [6], Discuss on environmental planning for machining process [7-8], Cutting fluids evaluation based on occupational health and environmental hazards [9], Selection of cutting fluids in machining processes [10], Characterised the ecological factors of cutting fluids and showed its impact on nature, and wild life [11], Framed a decision making frame work model for green manufacturing [12]. Tuhin. et al [13] employed AHP model for selection of cutting fluid for green manufacturing and compare the result with decision making frame work model.

From the above survey, selection of cutting fluid task found to be a multi criteria decision (MCDM) problem. Hence, a need of proper MCDM method to achieve GM. Many researchers have developed many techniques for solving the MCDM problem such as LINMAP(Linear Programming Techniques for Multidimensional Analysis of Preference[14], Analytic Hierarchic Process (AHP)[15], ELECTRE (Elimination and Choice Translating Reality[16], Technique for Order Preference by Simulation of Ideal Solution (TOPSIS) [17], VIKOR [18], MOORA (Multi-Objective Optimization on basis of Ratio Analysis) is the process of simultaneously optimizing two or more conflicting criteria subject to certain constraints. This method can used in any of the filed like product design selection, facility layout selection, process selection, personal selection, decision on salvage of resources etc and this method works on the principles of multi objective optimization problems This method considers both beneficial and non-beneficial criteria for ranking one or more alternatives from a set of available options. The detailed explanation of MOORA illustrated in literature [19].

From the literature review it reveals that, even though the past researchers have applied various MCDM methods to solve several selection problems, it is observed that none of the author found in the area of cutting fluid selection for green manufacturing. It is also observed that, all these above methods are complex in nature, quite difficult to understand and require extensive mathematical knowledge to implement. Thus, a systematic and efficient approach to cutting fluid selection is necessary in order to select the best alternative for a given application, this not only minimizing the environmental factors also improve the efficiency of the selection process.

In this paper, the applications of MOOSRA methods are illustrated. To some extent MOOSRA method is parallel to MOORA method but it is more robust compare to MOORA. The detailed descriptions of MOORA method has been explored in literature [20]. However the basic assumptions of the MOORA method [21] hold good for MOOSRA method also. The definite rewards of MOORA method is (like-less computational time, very simple and stable, minimum mathematical calculations involved, etc.) over other MCDM methods are also available with MOOSRA method. Compare to MOORA, this method has two unique advantages:

1. Negative performance score that may appear in MOORA never appears in this method
2. This method is less sensitive to large variation in the rationalised values of the attributes.

The following sections are organized as follows: section: 2 detailed explanation methods used for this case study. Validation of the proposed theory with a case study discussed in section: 3, section: 4 discuss the results and discussion. Final conclusion and, references have been listed at last section

2. MOOSRA

First MOOSRA method has been developed by Das et al. [21]. Generally, the MOOSRA methodology starts with the formulation of decision matrix which has in general four parameters, namely: alternatives, criteria or attributes, individual weights or significance coefficients of each criteria and measure of performance of alternatives with respect to the criteria. The detail explanation of MOOSRA explained below.

2.1 Step I: Formation of the Decision Matrix

This methodology starts with the definition of decision matrix in which number of criteria's and alternatives are listed. The performance of each alternative with respect to each critiea is carried out using following equation.

$$X_{ij} = \begin{bmatrix} X_{11} & X_{12} & \dots\dots\dots\dots & X_{1n} \\ X_{21} & X_{22} & \dots\dots\dots\dots & X_{2n} \\ \dots\dots & \dots\dots & \dots\dots\dots\dots & \dots\dots \\ X_{m1} & X_{m2} & \dots\dots\dots\dots & X_{mn} \end{bmatrix} \tag{1}$$

Where, the criteria's are denoted by, $X_1, X_2, \dots X_n$.

2.2 Step II: Normalization of the Fuzzy Decision Matrix

The process of transforming attributes value into a range of 0–1 is called normalization and it is required in multi attribute decision- making methods to transform performance rating with different data measurement unit in a decision matrix into a compatible unit. In MOOSRA method normalized elements of the fuzzy decision matrix using following equation.

$$X_{ij}^{*} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^{2}}} \tag{2}$$

Where, the value X_{ij}^{*} represents the normalized performance of i^{th} alternative on j^{th} objective for $i = 1,2,3,\dots n$ and $j = 1,2,3,\dots m$.

2.3 Step III: Determination of Performance of the Alternatives

The performance score Y_i of all the alternatives are computed as the simple ratio of weighted sum of beneficial criteria to the weighted sum of non-beneficial criteria using following equation.

$$Y_i = \frac{\sum_{j=1}^{g} w_j X_{ij}^{*}}{\sum_{j=g+1}^{n} w_j X_{ij}^{*}} \tag{3}$$

Where, g is the number of attributes to be maximized, $(n-g)$ is the number of attributes to be minimized. w_j is an associated weight of the j^{th} attributes.

In some cases, if we consider that the attributes are equally importance then the optimization formula becomes,

$$Y_i = \frac{\sum_{j=1}^{g} X_{ij}^{*}}{\sum_{j=g+1}^{n} X_{ij}^{*}} \tag{4}$$

2.4 Step VI: Ranking of the Alternatives

In this step, ranking of the alternatives was carried out, When sorted in descending order, the best alternative is that which has the highest assessment value. It is recommended to have an ordinal ranking of Y_i values to derive the final preference of the candidate alternatives.

3. A CASE STUDY

Based on the above model, a case study is selected to discuss the working and significance of the proposed model. The case study is on the how to select the optimum cutting fluid for a gear hobbing process among three types of cutting fluid in the Chongqing Machine Tool Works, China[12]. The three cutting fluids are, Traditional Cutting fluid (A1), Syntilo 9930c (A2) and Syntilo R Plus cutting oil (A3).

3.1 Step I: Formation of the Decision Matrix

In this step, formulation of decision matrix and its relative importance weights has been taken from the published literature [13]. They were shown in Table-3, Table-4. The detailed explanation of calculation procedure has been described in the literature [13].In this study, three main criteria's of GM are quality (Q), environmental impact (E) and cost(C) are shown in Fig-1, ten sub-criteria's were tabulated in Table-1 and corresponding three alternatives are A1: Traditional Cutting fluid, A2: Syntilo 9930c and A3: Syntilo R Plus cutting oil have been identified has been presented in Table-2.

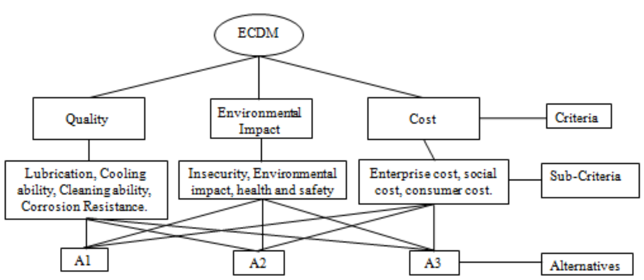

Fig -1: Hierarchy Model for GM [13]

Table-1: List of Criteria [13]

Criteria	
Lubricating Ability	C1
Cooling Ability	C2
Cleaning Ability	C3
Corrosion Resistance	C4
Toxicity	C5
Security	C6
Environmental Pollution	C7
Enterprise Cost	C8
Consumer Cost	C9
social Cost	C10

Table-2: List of Alternative fluids [13]

Alternatives	
A1	Traditional Cutting fluid
A2	Syntilo 9930c
A3	Syntilo R Plus cutting oil.

Table-3: Decision matrix [13]

Alternatives/ Criteria	A1	A2	A3
C1	0.0923	0.6155	0.292
C2	0.1001	0.3	0.5997
C3	0.1095	0.5813	0.309
C4	0.0926	0.615	0.2923
C5	0.0891	0.3234	0.5874
C6	0.0891	0.3234	0.5874
C7	0.0787	0.6584	0.2627
C8	0.6668	0.111	0.222
C9	0.648	0.1221	0.2297
C10	0.1693	0.4433	0.3873

Table-4: Criteria Weights [13]

Criteria	Weights (Wj)
C1	0.3
C2	0.3
C3	0.3
C4	0.0999
C5	0.1221
C6	0.2297
C7	0.6480
C8	0.5813
C9	0.1095
C10	0.3090

3.2 Step II: Normalization of the Decision Matrix

In this step normalization of the decision matrix using Eqs. (2). corresponding results shown in Table-5.

Table -5: Normalized Decision matrix

Alternatives/ Criteria	A1	A2	A3
C1	0.1343	0.8953	0.4247
C2	0.1476	0.4425	0.8845

C3	0.1641	0.8710	0.4630
C4	0.1348	0.8949	0.4254
C5	0.1317	0.4781	0.8684
C6	0.1317	0.4781	0.8684
C7	0.1103	0.9231	0.3683
C8	0.9372	0.1560	0.3120
C9	0.9280	0.1749	0.3290
C10	0.2764	0.7237	0.6323

3.3 Step III: Determination of Performance of the Alternatives

In this step, computation of preference selection index y_i for all he criteria using Eqs. (3). Ranking the alternatives based on preference selection index y_i.The best alternative is one with highest value of y_i.The final results were tabulated in Table-6.

Table-6: Rank the projects based on assessment value. y_i

Alternatives	y_i	Rank
A1	0.1718	3
A2	0.6758	1
A3	0.5957	2

4. RESULTS AND DISCUSSION

Optimum selection of cutting fluid for GM point of view helps for the entire manufacturing system to achieve the above mentioned objectives. This research has proposed a new decision making theory to show the effectiveness of the proposed model. The analysis result shows that Syntilo 9930c (SCF2) is optimal in comparison with other and their result has been compared with DMF model and AHP model. The results found to be same is shown in the Fig.2 and Table-7.

Table -7: Result comparison of MOOSRA with other Model.

Projects	Ranking		
	MOOSRA	DMF Model[12]	AHP[13]
A1	3	3	3
A2	1	1	1
A3	2	2	2

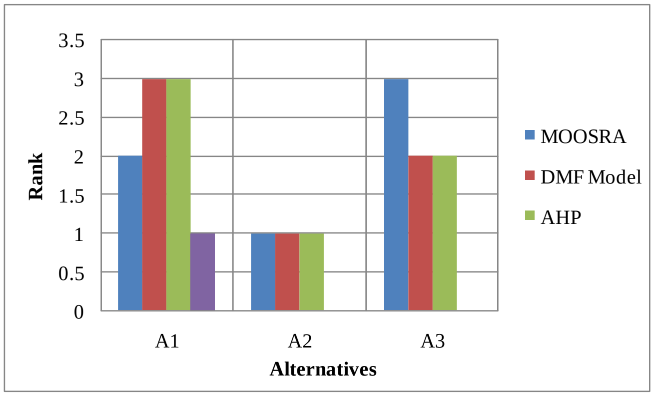

Fig -2: Comparison of results

5. CONCLUSIONS

GM is an approach to reduce the environmental impact in the product manufacturing system. Every cutting fluid has different environmental effect during the manufacturing system. The aim of this research to select the optimum cutting fluid that minimizes the environmental impact (E), cost(C) and maximizing the quality (Q), for GM. To satisfy this, a new decision making theory is farmed, which integrated the three factors combined in to the cutting fluid for GM. The result is compared with the DMF Model, AHP model and found to be same using proposed methodology

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