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Application of Topsis: A Multiple Criteria Decision Making Approach in Tool insert Selection

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Abstract— *In modern decision science the Multiple attribute decision making (MADM) is playing an important role for selection of best from number of alternative. It is used in various areas such as society, economics, military, management, manufacturing, etc. To date, most research has focused on single-period multi-attribute decision-making in which all the original decision information is given at the same period, and a number of methods have been proposed to solve this kind of problems. In this paper I have discussed a unique advent for ideal cutting tool insert selection method. In this method, a well-known Multiple Attribute Decision- Making (MADM) methods such as Technique for order preference by similarity to ideal solution (TOPSIS) use for a case study of tool insert selection for best surface finish in CNC (Computer Numerical Control) turning operation. In these methods their relative performance are compared with respect to ranking of alternative and from ranking we have selected best tool insert for better surface quality during turning operation on alloy steel using CNC turning centre .*

Keywords— Multiple attribute decision making, Technique for order preference by similarity to ideal solution (TOPSIS).

I. INTRODUCTION

Multiple-criteria decision-making or multiple-criteria decision analysis (MCDA) is a sub-branch of operations research that accurtely considers multiple criteria in decision-making encompassment. Whether in our daily life or in professional lives, there are commonly uesd multiple contrary criteria that need to be check out in making decisions. Cost or price is generally one of the main criteria [1, 2, 3]. Some measure of quality is typically another criterion that is in conflict with the cost. In purchasing a car, cost, comfort, safety, and fuel economy may be some of the main criteria we consider. It is unusual that the cheapest car is the most comfortable and the safest one. In management, we are interested in getting high returns but at the same time reducing our risks [4]. Again, the stocks that have the potential of bringing high returns typically also carry high risks of losing money. In a service industry, customer satisfaction and the cost of providing service are two adversing criteria that could be useful to consider [5, 6]. In making the decision of whether to build a thermal power plant or not, and where to build it, there are not only very difficult issues involving multiple criteria, but there are also multiple parties who are deeply affected from the consequences

MCDM method is broadly classified into two categories: multiple attribute decision making and multiple objective decision making, depending on whether the problem is a selection problem or a design problem.

Out of the many MADM methods five methods are commonly used:

- Simple Additive Weighting (SAW) method
- Weighted product method(WPM),
- Analytic hierarchy process(AHP),
- Revised Analytic hierarchy process(RAHP),
- Technique for order preference by similarity to ideal solution (TOPSIS).

Each decision matrix in MADM methods has four main parts, namely: (a) alternatives (b) attributes, (c) weight or relative importance of each attribute and (d) measure of performance of alternatives with respect to the attributes. The decision matrix is shown in table 1.1. The decision matrix shows alternatives, Ai (for I =1,2,.....,N), attributes, Bj (for j=1,2,....,M), weights of attributes, Wj (for j =1,2,.....,M) and the measure of performance of alternatives, mij (for i=1,2,.....,N; j=1,2,.....,M). Given the decision matrix information and a decision making method, the task of the decision maker is to find the best alternative and/or to

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rank the entire set of alternatives. It may be added here that all the elements in the decision matrix must be normalized to the same units, so that all the elements in the decision problem can be considered.

Table 1
Decision matrix in MADM methods

Alternative	Attribute			
	B1(W1)	B2(W2)	B3(W3)	Bm(Wm)
A1	m11	m12	m13	m1m
A2	m21	m22	m23	m2m
An	mn1	mn2	mn3	m nm

II. METHODOLOGY

2.1 The Methodology of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method [09].

This method is based on the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution, and the farthest from the negative ideal solution. The ideal solution is a hypothetical solution for which all attribute values correspond to the maximum attribute values in the database comprising the satisfying solutions; the negative ideal solution is the hypothetical solution for which all attribute values correspond to the minimum attribute values in the database. TOPSIS thus gives a solution that is not only closest to the hypothetically best, that is also the farthest from the hypothetically worst. The main procedure of the TOPSIS method for the selection of the best alternative from among those available is described below:

Step 1: The first step is to determine the objective, and to identify the pertinent evaluation attributes.

Step 2: This step represents a matrix based on all the information available on attributes. This matrix is nothing but the decision table. Each row of this matrix is allocated to one alternative, and each column to one attribute. Therefore, an element mij of the decision table 'D' gives the value of the j-th attribute in original real values, that is, non-normalized form and units, for the i-th alternative. In the case of a subjective attribute (i.e., objective value is not available), a ranked value judgment on a scale is adopted. Once a subjective attribute is represented on a scale, then the normalized values of the attribute assigned for different alternatives are calculated in the same manner as that for objective attributes.

Step 3: Obtain the normalized decision matrix, Rij .This can be represented as

$$Rij = mij/[\Sigma m2ij]_{Mj=1}\ ½ \qquad \ldots\ldots 1$$

Step 4: Decide on the relative importance (i.e., weights) of different attributes with respect to the objective. A set of weights wj (for j=1, 2 ,…. M) such that ∑ Wj =1 may be decided upon.

The weights of different attributes with respect to the objective, Wj (for j=1, 2… M), are decided by the decision maker rather arbitrarily, only few systematic methods can be used. The systematic method of deciding the weights of attributes Entropy Method is explained below. The entropy concept for deciding the objective weights of attributes. Entropy is a measure of uncertainty in the information formulated using probability theory. It indicates that a broad distribution represents more uncertainty than does a sharply peaked one. To determine weights by the entropy measure, the normalized decision matrix Rijis considered. The amount of decision information contained in and associated with each attribute can be measured by the entropy value ej as:

$$ej=-k\Sigma Rij\ lnRijNj=1 \qquad \ldots\ldots 2$$

Where, k = 1/ln N is a constant that guarantees 0≤ ej≤1. The degree of divergence (dj) of the average information contained by each attribute can be calculated as:

$$dj= 1 - ej \qquad \ldots\ldots 3$$

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The more divergent the performance ratings (for i = 1, 2…N) for the attribute Bj, the higher its corresponding dj and the more important the attribute d for the decision- making problem under consideration.

The objective weight for each attributes Wj (for j = 1, 2… M) is thus given by:

wj=dj /Σ dj Mk=1 ……………………………………………………………………………4

Step 5: Obtain the weighted normalized matrix Vij. This is done by the multiplication of each element of the column of the matrix Rij with its associated weight wj. Hence, the elements of the weighted normalized matrix Vij are expressed as:

Vij = Wj Rij ………………………………………………………………………………5

Step 6: Obtain the ideal (best) and negative ideal (worst) solutions in this step. The ideal (best) and negative ideal (worst) solutions can be expressed as:

$V+ = \{(\Sigma Vij/j\in J)\ ,maxi\ (\Sigma Vij/j\in J)/\ i=1,2,\ldots,N\}mini$ ……………………………………6

$V- = \{(\Sigma Vij/j\in J)\ ,mini\ (\Sigma Vij/j\in J)/\ i=1,2,\ldots,N\}maxi$ …………………………………… 7

Where, J = (j = 1, 2,…., M) /j is associated with beneficial attributes, and J = (j = 1, 2,…..,M) /j is associated with non-beneficial attributes. VI+ indicates the ideal (best) value of the considered attribute among the values of the attribute for different alternatives. In the case of beneficial attributes (i.e. those of which higher values are desirable for the given application) VI+ indicates the higher value of the attribute. In the case of non-beneficial attributes (i.e., those of which lower values are desired for the given application), VI + indicates the lower value of the attribute. Vj- indicates the negative ideal (worst) value of the considered attribute among the values of the attribute for different alternatives. In the case of beneficial attributes (i.e., those of which higher values are desirable for the given application), Vj- indicates the lower value of the attribute. In the case of non beneficial attributes (i.e., those of which lower values are desired for the given application), Vj- indicates the higher value of the attribute.

Step 7: Obtain the separation measures. The separation of each alternative from the ideal one is given by the Euclidean distance in the following equations.

$SI+ = \{\Sigma(Vij-VjMj=1+)2\ \}0.5$ i=1,2,………..N ………………………………………………8

$SI- = \{\Sigma(Vij-VjMj=1-)2\ \}0.5$ i=1,2,………..N ………………………………………………9

Step 8: The relative closeness of a particular alternative to the ideal solution Pi, can be expressed in this step as follows.

Pi = $Si-\ /\ (Si+\ +Si-)$ ……………………………………………………………………….10

Step 9: A set of alternatives is generated in the descending order in this step, according to the value of Pi indicating the most preferred and least preferred feasible solutions. Pi may also be called the overall or composite performance score of alternative Ai .

III. IMPLEMENTATION OF TOPSIS METHOD

K.G.Nikam, S.S.Kadam [10] studied Simple additive Weighted (SAW) and Weighted Product Method (WPM) methods of MADM applied for selection of a suitable tool insert from number of alternatives. The workpiece material was EN 8 steel. The Tool insert selection problem considers five alternative material and five attributes. The five alternative tool inserts were suggested by tool dealer such as TNMG160408FG, CCMT09T304FG,CNMG120412FC, SCMT09T308FG and CPMT 09T304 FG. All the five inserts were CVD coated carbide inserts manufactured by TaeguTec. Five attributes are selected as nose radius, approach angle, rake angle, clearance angle and angle of inclination. Surface roughness has affected by these attributes The ranking of tool insert based on its performance score (i.e. tool insert selection index) for all two methods is 3-1-4-5-2 which is same for two methods. So, from the ranking of the MADM methods it can be found that tool insert 3 i.e. CNMG 12 04 12 FC is the best tool insert for better surface roughness in turning of EN 8 steel. The Second choice is TNMG 16 04 08 FG.

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For this data I have used TOPSIS method which is explain as follow:

Step 1: The first step is to determine the objective, and to identify the pertinent evaluation attributes.

Table 2
Attribute for CNC turning tool insert

Too insert no.	Nose radius (mm)	Approach angle (degree)	rake angle (degree)	Clearance angle (degree)	Angle of inclination (degree)
1	0.8	93	-7	0	-6
2	0.4	95	0	7	0
3	1.2	95	-6.5	0	-6
4	0.8	93	0	7	0
5	0.4	95	0	11	0

Tool insert1:TNMG 160408 FG, Tool insert 2:CCMT 09T304FG, Tool insert3:CNMG 120412FC, Tool insert 4:SCMT 09T308 FG, Tool insert 5:CPMT 09T304 FG

Step 2:

Table 3
Normalize data for tool insert selection attributes

Too insert no.	Nose radius (mm)	Approach angle (degree)	rake angle (degree)	Clearance angle (degree)	Angle of inclination (degree)
1	0.666	0.9786	1	0	1
2	0.333	1	0	0.6363	0
3	1	1	0.9285	0	1
4	0.666	0.9789	0	0.6363	0
5	0.333	1	0	1	0

Step 3: obtain the normalized decision matrix,Rij . this can be represented as

Rij = m ij / [Σ $mij2Mj$=1] 1/2 ……………………………………………………………11

$$\begin{vmatrix} 0.4586 & 0.4414 & 0.7328 & 0 & 0.7071 \\ 0.2293 & 0.4509 & 0 & 0.4730 & 0 \\ 0.6886 & 0.4509 & 0.6804 & 0 & 0.7071 \\ 0.4586 & 0.4414 & 0 & 0.4730 & 0 \\ 0.2293 & 0.4509 & 0 & 0.7433 & 0 \end{vmatrix}$$

Step 4: Relative importance of attributes can be assigned the values as explained in step 4 of TOPSIS method theory

ej = 1N ΣRij $lnRijNJ$=1 ………………………………………………………………….12

e1 = −15[0.666ln0.666+ 0.333ln0.333+ 1ln1+0.666ln0.666+ 0.333ln0.333]

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e1 = 0.2547

Similarly, e2 = 0.008350 , e3 = 0.0137761, e4 = 0.115064, e5 = 0

d1 =1-e1= 1- 0.2547=0.7453

Similaely, d2= 0.9917,d3=0.9863,d4=0.885,d5=1

Here the objective weight for each attribute Wj is given by:

W1= d1/ $\Sigma djMk$=1

W1= 0.7453/4.6083 = 0.1617

Similarly, weight of attribute is W2 = 0.2151,W3 = 0.2140,W4 = 0.1920,W5 = 0.1756

Step 5: The weighted normalized matrix, V9×5 is calculated.

$Vij=wjRij$ ……………………………………………………………………………13

0.1076	0.2105	0.2140	0	0.2169
0.0538	0.2151	0	0.1221	0
0.1617	0.2151	0.1986	0	0.2169
0.1076	0.2105	0	0.1221	0
0.0538	0.2151	0	0.1920	0

Step 6: The next step is to obtain the ideal (best) and negative ideal (worst) solution. These are calculated as:

V1+ = 0.1617 V1⁻ = 0.0538

V2+ = 0.2151 V2⁻ = 0.2105

V3+ = 0.2140 V3⁻ =0

V4+ = 0.1920 V4⁻ = 0

V5+ = 0.2196 V5⁻ = 0

Step 7: The next step is obtain the separation measures, and these are calculated.

S1+ = 0.1995 , S1⁻ = 0.3094

S2+ = 0.3324 S2⁻ = 0.1221

S3+ = 0.1926 S3⁻ = 0.3132

S4+ = 0.3191 S4⁻ = 0.1334

S5+ = 0.3250 S5¯ = 0.1920

Step 8: The relative closeness of a particular alternative to ideal solution calculated and these are

$$Pi = Si_i^- / (Si^+ + Si^-)$$

P1 = 0.607977, P2 = 0.268646, P3 = 0.619217, P4 = 0.294806 , P5 = 0.371373

Step 9: By arranging in descending order, the best tool insert is 3-1-5-4-2-4.Here TOPSIS suggests the best tool insert for EN8 work piece material is CNMG 12 04 18 FC as the right choice for the given problem of selection of a suitable tool insert. The second choice is TNMG 16 04 08 FG.

IV. CONCLUSION

The proposed MADM method, the Simple additive Weighted (SAW) and Weighted Product Method (WPM) applied for selection of a suitable tool insert from number of alternatives. The ranking of tool insert based on its performance score (i.e. tool insert selection index) for all two methods is 3-1-4-5-2 which is same all two methods. So, from the ranking of three MADM methods it can be found that tool insert 3 i.e. CNMG 12 04 12 FC is the best tool insert for better surface roughness in turning of EN 8 steel. The Second choice is TNMG 16 04 08 FG.

After implementing the TOPSIS method the ranking of tool insert based on its performance score (i.e. tool insert selection index) is 3-1-5-4-2 So, from the ranking of TOPSIS(MADM) methods it can be found that tool insert 3 i.e. CNMG 12 04 12 FC is the best tool insert for better surface roughness in turning of EN 8 steel. The Second choice is TNMG 16 04 08 FG.

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