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Optimal Selection of Cutting Fluid Using AHP and VIKOR

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ABSTRACT: Cutting fluids are important elements of manufacturing industries and are used in large quantity. But its use poses a serious health issue to the surrounding people working in its atmosphere. Hence, the disposal should be only after neutralization thereby protecting worker and aquatic life. This leads to select an optimal alternative which is not only environment friendly but also safe for human beings and aquatic life. Further it should also perform at par with the mineral oil based cutting fluid. In the present research a frame work has been proposed to assist the decision makers in selection and evaluation of lubricant by Analytical hierarchical process (AHP) and VIKOR method. In the proposed research three cutting fluids i.e. Neem oil with 5% emulsifier, Neem oil with 10% emulsifier and a conventional mineral oil based cutting fluid have been considered as an alternatives. These have been evaluated on the basis of different significant parameters like temperature at tool tip, surface roughness and tool wear. The basic aim of this paper is to present the logical selection process of a cutting fluid as well as to show that ranking or choice of cutting fluid may also change if the priority of the parameter is changed.

Keywords: Cutting Fluid*, AHP, VIKOR*

I INTRODUCTON

Cutting fluid is generally selected on the basis of its performance cost and quality But, due to the strict government norms related to environment and safety. Industries are bound to use cutting fluid which is not only environment friendly but also perform satisfactorily.

The purpose of this paper writing is to select best cutting fluid out of three alternatives viz conventional cutting fluid ie mineral oil based fluid, biodegradable fluid of neem with 5% emulsifier and neem with 10% emulsifier. These cutting fluids are judged on three parameters namely temperature at tool tip, surface roughness and tool wear.

In the past selection is based on the basis of experiments. But my purpose is to use the existing data and make a decision-making problem. It is to be mentioned here that these parameters greatly affect the turning operation. Hence, selection of optimal cutting fluid is desirable for any manufacturing unit. So, we can say selection of cutting fluid is a MCDM problem. In this paper, I have used an integrated approach using AHP and VIKOR techiques. In fact, MCDM technique is use to select the best alternative on the the basis of different criteria.

Cutting fluids are essential for manufacturing operations [1,2]. A cutting fluids help in increasing the productivity in three ways ie increasing the cutting speed, provide lubrication and cooling effect and thereby decreasing the adverse effect of high temperatures during machining operations.

Cutting fluids is classified in four ways viz straight oil, soluble oil, synthetic oil and semi-synthetic oils [3]. This classification is done on the basis of requirement For example for machining operations we use soluble cutting fluid is used whereas for drilling operations we use straight oils .

Experiments shows that bio- degradable cutting fluid helps in reducing tool and flank wear. [4]. Not only this its performance is better than the conventional cutting fluids [5-8].Though its difficult to develop soluble cutting fluids but once prepared it will retain its stability for a longer duration of time depending upon selection of a correct emulsifier. Due to the biodegradibility and non toxiicity these are safe for workers.

Cutting fluid acts as a lubricant for reducing friction to reduce generation of heat. it also act as a coolant to carry away heat and lastly it act as an anti- weld to prevent work piece under heat and pressure.

As a lubricant , cutting fluid must maintain a strong protective film between the the tool face and the metal . Such a film helps in sliding readily over the tool. proper lubrication helps in lowering power consumption and rate of tool To act as an effective coolant , a cutting fluid should have high thermal conductivity for the absorbtion of heat and its removal .

In industries due to the growing demand for high productivity which is related to high cutting speed , feed and depth of cut . This result in generation of heat and rise in temperature at the cutting zone. . A good surface finish is desirable for aesthetic look It also enhances b the tribological properties, fatigue strength, and corrosion resistance

Different Types of Cutting Fluids

 Soluble Oils

 Synthetic Oils

 Semi-Synthetic Oils

Straight Cutting Oils

Soluble oil

Oil does not dissolve in water. Oil is suspended in water in the form of tiny globules. Breaking of the oils into tiny particles is done by a chemical known as "Emulsifier". This medium of oil in water is known as an "Emulsion".

"Oil" provides lubricity and "water" ensures cooling. Operations where lubricity is equally important as cooling is, require "Richer emulsions" (higher oil concentration) e.g. Drilling, Milling, Turning. Operations where cooling is the primary role of the coolant permit "higher dilutions" e.g. Grinding.

Soluble oil is capable of forming stable emulsions upto a hardness of 400 ppm. If the water is harder beyond this, "separation" would take place

Semi-Synthetic coolants

Semi-Synthetic coolants contain partially mineral oil and synthetic chemicals. They combine the advantages of synthetic coolants and at the same time the disadvantages are not as in the case of hundred percent synthetics

Straight Cutting Oils or Neat Oils

Straight Cutting Oils or Neat Oils are pertroleum based mineral oils reinforced with "Extreme pressure" additives (EP additives). For applications where the speed of the tool is very low, depth of cut taken is high, cutting pressures are high, the primary role of coolant is to provide: Adequate lubricity so that friction is reduced

Synthetic oils

Synthetic oils do not contain mineral oil. Instead they contain some synthetic chemicals as substitutes.

 Synthetic coolants have a tendency to foam. If the rate of coolant flow for a particular requirement is very high, excessive foaming can be caused. This would result in poor surface finish and reduced tool life.

Literature Survey

Use of cutting fluid is remarkable . Approximately 40 million metric ton of lubricant is used world wide and is expected to enhance by 44 million metric ton by the year 2022.

With the advent of 4th industrial revolution new materials and productivity has increased a lot

Methodology

Due to the complexity of the task, decision making associated with them is equally complex. Hence, some efficient techniques are required which provide the best solution. For the best choice, this paper has summarized three major and useful techniques of Multiple Criteria Decision Making (MCDM), namely, AHP (Analytic Hierarchy Process) and VIKOR(Technique for Ordered Preference By Similarity to Ideal Solution).(16)

The most important advantage of the multiple criteria methods is their capability of addressing the problems that are marked by different conflicting interests(17)

In the present research a frame work has been proposed to assist the decision makers in selection and evaluation of lubricant by Analytical hierarchical process (AHP) and VIKOR method

A brief introduction for these two processes have been sumarized so that it assist the reader in understanding the concept of two proposed methods.

AHP Method

This technique developed by Satty is often use for solving complex decision problem. It breaks the problem into hierachy of objectives ie attributes (criteria) .Due to the ability to handle situations involving subjective judgments, multiple decision, and consistency of preference, it is most preferred technique

In AHP method, we allot weights to the relative importance of the attributes based on objective function. For this we construct a pair-wise comparison matrix with a scale of the relative importance. Values entered in the pair-wise comparison matrix should be based on Saaty's Nine Point scale. Comparison of an attribute with itself will always be alloted the value of 1. It impliesthe main diagonal entries of the matrix will always have 1. For the other cells the numbers 3, 5, 7, and 9 are allotedfor "moderate importance," "strong importance," "very strong importance," and "absolute importance" For n number of attributes, the pair-wise comparison matrix will be between the ith attributes and jth attributes which will be a square matrix .A nxn and aij will denote the comparative weightage of ith attribute with jth the attribute.

In this pair-wise comparison matrix, aij = 1 when i = j and aji = 1/aij. The eigenvector or priority weights vector w will be calculated by the summation of each column of the matrix and then divide each element of the matrix with the summation of its column. Then, averaging across the rows will give us the normalized eigen vector. A = ⎡⎢⎣ a11 ⋯ a1n . . . . an1 ⋯ ann⎤⎥⎦ We have to know the vector w = [w1,w2,.,wn] which represents the weight of the each criterion which is given in pair-wise comparison matrix A. To recover the vector w from the pair-wise comparison matrix A, it will go for a method of two-step procedure: For each of the A's columns divide each entry in column i of A by the sum of the entries in column i. This yields a new matrix, called Anorm (for normalized) in which the sum of the entries in each column is 1.

The main procedure of AHP is as follows:

Step 1: Construct a decision matrix usingSaaty's nine point scale by pairwise comparison technique

Intensity of Important Definition

1 Equal Importance

3 Moderate Importance

5 Strong Importance

7 Very Strong Importance

9 Extremely Important

2,4,6,8 For the intermediate values

Reciprocals For vice versa Comparison, if i to j is 3, then j to i is 1/3

Step 2: Construct a normalized matrix by dividing each number in a column of the pairwise comparison matrix by its column sum and average each row of the normalized matrix to get the priority vector of each alternative with respect to the particular criteria.

Step3: Calculate the consistency ratio using the formula

CR=CI/RI

CI is Consistency Index and

CI= λmax –n /n-1

Where n=No of criteria

RI= Random number index which depends on the no of criteria's are used in the present problem and taken as per the table 1

Step4: If the consistency ratio is <10% or 0.10 then the level of consistency is acceptable if not so then evaluation process is re- evaluated until its below 0.10.

Table 1: CRITERIA V/S CRITERIA

	Temperature	Surface Roughness	Tool Wear	NORMALISED VECTOR
Temperature	1	3	7	.6435
Surface Roughness	.333	1	5	.2828
Tool Wear	.142	.2	1	.07356
SUM	1.475	4.2	13	100

λmax=3.093

CI=(λmax- n)/(n-1)

CI=0.0465

CR=(CI/RI)*100

RI=0.58

CR=8.0172%

Table 2: TEMPERATURE

	5% Emulsifier	10%Emulsifietr	Straight Oil	PRIORITY VECTOR
5% Emulsifier	1	1	7	0.5107
10% Emulsifier	1	1	3	0.3895
Straight Oil	.14	.33	1	.0998
SUM	2.14	2.33	11	100

λmax=3.0927

CI= (λmax- n)/(n-1)

CI=0.04635

CR=(CI/RI)*100

RI=0.58

CR=7.93%

Table 3: SURFACE ROUGHNESS

	5% Emulsifier	10% Emulsifietr	Straight Oil	PRIORITY VECTOR
5% Emulsifier	1	3	7	0.64338
10% Emulsifier	.3333	1	5	0.2828
Straight Oil	.1428	.22	1	.07374
SUM	1.4761	4.2	13	100

λmax=3.0960

CI= (λmax- n)/(n-1)

CI=0.0480

CR=(CI/RI)*100

RI=0.58

CR=8.2%

Table 4: TOOL WEAR

	5% Emulsifier	10% Emulsifietr	Straight Oil	PRIORITY VECTOR
5% Emulsifier	1	3	5	0.6333
10% Emulsifier	0.3333	1	3	0.26049
Straight Oil	.2	.333	1	0.10613
SUM	2.14	2.33	11	100

λmax=3.0549

CI= (λmax- n)/(n-1)

CI=0.0774

CR=(CI/RI)*100

RI=0.58

CR=4%

VIKOR PROCEDURE:

Multi criteria decision making (MCDM) is one of the most prevalent methods for resolving conflict management issues (Deng & Chan, 2011). MCDM deals with decision and planning problems by consideration of multiple criteria and the importance of each (Haleh&Hamidi, 2011). Among the many MCDM methods, VIKOR is a compromise ranking method to optimize the multi-response process (Opricovic, 1998). It uses a multi criteria ranking index derived by comparing the closeness of each criterion to the ideal alternative. The core concept of VIKOR is the focus on ranking and selecting from a set of alternatives in the presence of conflicting criteria (Opricovic, 2011). In VIKOR, the ranking index is derived by considering both the maximum group utility and minimum individual regret of the opponent (Liou, Tsai, Lin, &Tzeng, 2011).

VIKOR denotes the various n alternatives as a1 , a2 ,. . ., an. For an alternative ai , the merit of the jth aspect is represented by fij; that is, fij is the value of the jth criterion function for the alternativeai , n being the number of criteria.

The VIKOR procedure is divided into the following five steps:

STEP1: Identify the overall objective ,criteria , sub criteria and its different alternatives. Assign qualitative or quantitative value to each criteria and develop decision natrix

Step 2: Frame normalized decision matrix using equation

Step 3: Weights (Wi) for criteria are calculated using AHP

Step 4: Calculate the best (Xij)max and the worst (Xij)min values for all critera

Step5: Calculate the values for Ei and Fi and Pi using equation

Step6: On the basis of Pi arrange it in ascending order and find the minimum values of Pi

Criteria of Fluids

Temperature (C1), Surface Roughness(C2), Tool Wear (C3),

Table 5: List of alternative Fluids

SCF1	Neem with 5% emulsifier
SCF2	Neem with 10% emulsifier
SCF3	Traditional cutting fluid

Table 6: Criteria of Fluids with alternative Fluids

Alternative	C1	C2	C3
SCF1	0.5107	0.64338	0.6333
SCF2	0.3895	0.2828	0.26049
SCF3	0.0998	0.0737	0.10613
Weights	0.6435	0.2828	0.97356

Step-4: Determination of the best, i.e.$(X_{ij})_{Max}$and the worst, i.e.$(X_{ij})_{Min}$values for all criteria.

Table.7. $(X_{ij})_{Max}$and$(X_{ij})_{Min}$values for all the criteria

Criteria	C1	C2	C3
$(X_{ij})_{Max}$	0.5107	0.6433	0.6333
$(X_{ij})_{Min}$	0.0998	0.0998	0.1061

Step-5-6-7: Calculate the values of E_i, $F_i$and P_i (Performance Index value)

Table.8. *E* ,*F* and *P values*

Alternative	Ei	Fi	Pi
SCF1	-2.974	-0.4430	1.103
SCF2	-0.7965	0.1899	0.166
SCF3	-1.7051	-0.4057	0.142

Table.9. Performance index values (ascending order)

Alternatives	Pi	Rank
SCF1	1.103	1
SCF2	0.166	2
SCF3	0.142	3

CONCLUSIONS

A novel cutting fluid was developed from non edibleneem oil and a biodegradable emulsifier. This performs better than the conventional cutting fluid in all the parameters which have been studied viz. temperature rise at tip, tool wear and surface roughness.The same is proved by using the above two techniques

REFERENCES

1. Saaty TL (1990) How to make a decision: the analytic hierarchy process. Eur J Oper Res 48(1):9–26
2. Brinksmeier, E., Meyer, D., Huesmann-Cordes, A.G. and Herrmann, C., 2015. Metalworking fluids— Mechanisms and performance. CIRP AnnalsManufacturing Technology, 64(2), pp.605-628
3. Shaw, M.C. and Cookson, J.O., 2005. Metal cutting principles (Vol. 2). New York: Oxford university press
4. Hamdan, A., Sarhan, A.A. and Hamdi, M., 2012. An optimization method of the machining parameters in high-speed machining of stainless steel using coated carbide tool for best surface finish. The International Journal of Advanced Manufacturing Technology, 58(1), pp.81-91.
5. Khan, M.M.A., Mithu, M.A.H. and Dhar, N.R., 2009. Effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oilbased cutting fluid.Journal of materials processing Technology, 209(15), pp.5573-5583.
6. Rao, D.N. and Srikant, R.R., 2006. Influence of emulsifier content on cutting fluid properties. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 220(11), pp.1803-1806.
7. Shashidhara, Y.M.; Jayaram, S.R. Vegetable oils as a potential cutting fluid—an evolution. Tribology International 2010, 43 (5–6), 1073–1081
8. Lawal, S.A.; Abolarin, M.S.; Ugheoke, B.I.; Onche, E.O. Performance evaluation of cutting fluids developed from fixed oils. Leonardo Electronic Journal of Practices and Technologies 2007, 10, 137– 144.
9. Lawal, S.A.; Choudhury, I.A.; Nukman, Y. Application of vegetable oil-based metalworking fluids in machining ferrous metals—a review. International Journal of Machine Tools and Manufacture 2012, 52 (1), 1–12.
10. AarushiSingh1 , Sanjay Kumar Malik2 M. Tech. Student, Hindu College of Engineering, SonepatDeptt. of CSE, Hindu College of Engineering, Sonepat
11. Mardani A, Jusoh A, Nor K, Khalifah Z, Zakwan N, Valipour A. Multiple criteria decision-making techniques and their applications–a review of the literature from 2000 to 2014. Economic Research-EkonomskaIstraživanja. 2015 Dec 20;28(1):516-71.