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Optimization of Machining Parameters of Titanium Alloy Steel using : TOPSIS Method

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ABSTRACT

The surface roughness varies with the change of machining parameter. In this paper presents an approach to the determination of the optimal cutting parameters with the help of MCDM method to create high surface finish in the face milling of Titanium alloy. In present study TOPSIS method used to optimize the process parameter in face milling of Titanium alloy steel (Ti-6Al-4V) with PVD coated Cemented carbide face mill inserts.
Keywords: SDI TOOL,TOPSIS.

I. INTRODUCTION

Milling is the process for removing excess material from a work piece with a rotating cutting tool. Milling process is used for producing flat, contoured or helical surface, for cutting threads and toothed gears and for making helical grooves. Due to highly competitive global market, the organizations are now forced to focus more on increasing productivity while decreasing cost by right selection of machine tools. Proper selection of machine tool justifies labor saving, improved product quality and increased production rate with enhanced overall productivity. Vijay Manikrao Athawale[1] presents a paper on logical and systematic procedure to evaluate the computer numerical control (CNC) machines in terms of system specifications and cost by using TOPSIS method. Decision making plays a vital role especially in purchase department for reducing material costs, minimizing production time as well as improving the quality of product or service. A TOPSIS and VIKOR approaches to machine tool selection carried by jitendra kumar et al.[2].gives an idea about proper machine tool selection. TOPSIS 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. Effect of Machining Parameters on Surface Roughness for Titanium Alloy is carried by ganga sagar singh et al.[3]. A study on Multi-attribute optimization of machining process parameters in powder mixed electro-discharge machining using TOPSIS and grey relational analysis is given by S. Tripathy , D.K. Tripathy [4]. Y.B Gaidhani, V.S.Kalamani [5] presented a paper which focus on selection of various process parameters like-angle of impact, abrasive material type, Stand-off distance, abrasive mass flow rate and target material properties for getting the required output like-depth of cut and cut quality. Zeki Ayag et al.[6] proposed a TOPSIS and alpha cut based fuzzy AHP to proper machine tool selection. One of the most popular techniques for complex decision-making problems is the analytic hierarchy process (AHP) developed by Saaty, which decomposes a decision making problem into a system of hierarchies of objectives, attributes (or criteria), and alternatives.

II. METHODS AND MATERIAL

Topsis Method

TOPSIS method was firstly developed by Hwang and Yoon in 1981. The basic approach of this method is choosing an alternative that should have the shortest distance from the positive ideal solution and the farthest distance from negative ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes conflicting criteria, whereas the negative ideal solution maximizes the conflicting criteria and minimizes the benefit criteria. For the calculation of TOPSIS values, we have to go through the following steps.

Step 1:- We have find the objective and to identify the attribute values for each alternative.

Step 2:- In this step involves we developed a matrix. The row of this matrix is allocated to one alternative and each column to one attribute. The decision making matrix can be expressed as:

$$D = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix}$$

Step 3:- After step 2 using the decision matrix to develop the normalized decision matrix with the help of the formula given below:

$$X_{ij}{*}=Xij/\sqrt{\textstyle\sum_{i=1}^{n}(Xij^2)}$$

Step 4:- weight for each attributes using the formula given below is calculate and the sum of the weights should be 1. Importance of different attributes can be measured with the weights.

$$W_j=V_j/\textstyle\sum_{i=1}^{m} Vj \,\&\, \sum_{j=1}^{m} Wj= 1$$

Where V_j is the variance of each attribute which can be calculated by the formula given a below.

$$V_j=(1/n)\textstyle\sum_{i=1}^{n}(X_{ij}^{*} - X_{ijmean}^{*})^2$$

Step 5:- Then obtain the weighted normalized matrix V_{ij} by multiplying W_j with all the values X_{ij}^{*} such as

$$V_{ij}= W_j\, X^{*}_{ij}$$

Step 6:- In this step determines the positive ideal (best) and negative ideal (worst) solutions. The positive ideal and negative ideal solution given as:

a) The Ideal Positive (Best) solution

$$A^{+} = \{V_1^{+}\ldots\ldots\ldots\ldots\ldots\ldots\ldots,V_m^{+}\}=\{(\max v_{ij}|j\in I'),(\min v_{ij}|j\in I'')\}$$

b) The ideal negative (Worst) solution

$$A^{-}= \{V_1^{-}\ldots\ldots\ldots\ldots\ldots\ldots\ldots V_m^{-}\} =\{(\min v_{ij}|j\in I'),(\max v_{ij}|j\in I'')\}$$

Here,

I' = {j=1, 2 ....n|j }: Associated with the beneficial attributes .

I" = {j=1, 2 ....n|j }: Associated with non-beneficial adverse attributes.

Step 7:- Euclidean distance of each alternative from the ideal Positive solution and ideal negative solution which is given by the Euclidean distance given by the equations given below.

$$D_i^{+}=\sqrt{\textstyle\sum_{j=1}^{m}(V_{ij}\ -V_j^{+})2} \qquad i=1\ldots\ldots\ldots\ldots\ldots\ldots\ldots n.$$

$$D_i^{-}=\sqrt{\textstyle\sum_{j=1}^{m}\left(V_{ij} - V_j^{-}\right)^2} \qquad i=1\ldots\ldots\ldots\ldots\ldots\ldots\ldots n.$$

Step 8:- Calculate the relative closeness to the ideal solution of each alternative which is given by the formula:-

$$C_i^{*}=D_i^{-}/(D_i^{-} + D_i^{+}), \qquad i=1\ldots\ldots\ldots\ldots\ldots\ldots n.$$

Step 9:- A set of value is generated for each alternative. Choose the best alternative having largest closeness to ideal solution. Arrange the alternative as an increasing order of C_i^{*}.

Model Development

Titanium alloy (Ti-6Al-4V) is an alloy of high strength to the weight ratio. 16mm thick plate was used in this research work[3]. Mechanical properties of work piece have been shown in Table I. The work piece used for present study in the rectangular form with the dimensions as 97X 75X16mm^3

Table I : Mechanical Properties of Work Piece

Serial No	**Mechanical Property**	**Value**
1	Tensile strength (M Pa)	993
2	Yield Strength (M Pa)	830
3	Elongation	14
4	Modulus of Elasticity (G Pa)	114
5	Hardness (HRC)	36

Roughness of the work piece is depends on the speed, feed, depth of cut and coolant used. Eight no. of job have taken on different combination of the process parameters and find the set of roughness, A decision matrix is developed with the help of this as shown in the table II [3].

Eight no. of trial are considered as alternative and speed, Feed, D.O.C., Coolant, set-1 are considered as attribute for our model. Surface roughness given in SET-1 use in TOPSIS method to evaluate best alternative.

TABLE II

Quantitative Information of Process Parameter

Job no.	**Speed m/min**	**Feed mm/tooth**	**D.O.C mm**	**Coolant**	**(Set-1) R1 micron**
1	150	0.15	2.5	On	0.28
2	120	0.15	2.5	Off	0.32
3	150	0.10	2.5	Off	0.42
4	120	0.1	2.5	On	0.41
5	150	0.15	2.0	Off	0.36
6	120	0.15	2.0	On	0.40
7	150	0.10	2.0	On	0.44
8	120	0.10	2.0	Off	0.52

III. RESULTS AND DISCUSSION

This paper we used speed, feed, Depth of cut, Coolant used and roughness (roughness of machined surface has measured by piezoelectric type instrument) as attribute and find best job in which roughness is minimum. SDI-TOPSIS method is used to find best alternative solution. Result given in figure-1 shows that job 2 is the found closest to ideal solutions followed by job 5,job3, job8, job1, job6 job4, job7 in terms of minimum speed, maximum feed rate, maximum depth of cut, coolant off, minimum roughness.

					Options										
					1	**2**	**3**	**4**	**5**	**6**	**7**	**8**			
			Units	**Importance**	Job 1	job 2	job 3	job 4	job 5	job 6	job 7	job 8	**Goal**	**- Ideal**	**+ Ideal**
Criteria:	**1**	speed	m/min	1	150	120	150	120	150	120	150	120	minimize	150	120
	2	feed	mm/tooth	1	0.15	0.15	0.1	0.1	0.15	0.15	0.1	0.1	maximize	0.1	0.15
	3	depth of cut	mm	1	2.5	2.5	2.5	2.5	2	2	2	2	maximize	2	2.5
	4	coolant	on/off	1	1	0	0	1	0	1	1	0	minimize	1	0
	5	roughness	micron	1	0.28	0.32	0.42	0.41	0.36	0.4	0.44	0.5	minimize	0.5	0.28
				Score	**0.46**	**0.90**	**0.64**	**0.26**	**0.76**	**0.30**	**0.15**	**0.54**			

Figure 1. Result by SDI TOPSIS Tool

With the help of MINI-TAB a graph is plotted between roughness and other machining parameters as shown in figure 2. It is conclude that speed contribute highest effect on roughness followed by feed and depth of cut.

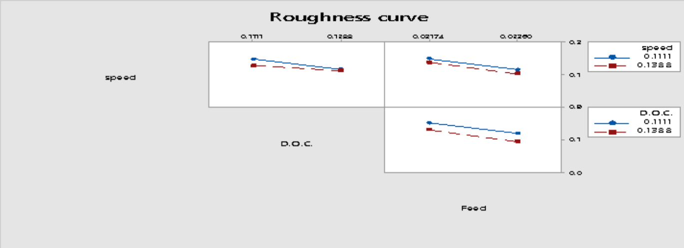

Figure 2. Variation in roughness with speed d.o.c. and feed

IV. CONCLUSION

Out of the five criteria we find that job 2 is the best followed by job 5, job3, job8, job1, job6 job4, job7 .In this analysis we gives equal importance to all the criteria and after that a relation is find between the process parameters and concluded that speed and feed are the main parameters that effects surface roughness of the job.

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