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EMPLOYING TOPSIS TECHNIQUE TO SELECT OPTIMAL PERFORMANCE OF TURNING PROCESSES

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A B S T R A C T

Optimization performance of cutting turning parameters considers significant approach to manage metal parts economically throughout machining processes which have a main role in obtaining value added. This research aims to identify the best optimization performance of machining turning parameters, where they achieve lower surface roughness and ultimate rate of removal metal. Three parameters were used in turning operations which are First parameter, the speed of cut, Second parameter, the rate of feeding and Third Parameter, the deepness of cut out. Each parameter has three levels. Technicality for Order Priority by Symmetry to Ideality Solution (TOPSIS) adopted of optimizing multi-objectives simultaneously. Results showed that the best factors of operating were (1500 m/min, 0.5mm/rev, 0.5 mm) because they produced two an optimal attributes were First Attribute, the roughness of surface (1.74 µm) and Second Attribute, the rate of removal metal (375.00 cm3/min).

1. INTRODUCTION

Operations are common procedure through the cutting of metal procedures. It is as well the most widespread operations conduct aerospace, automotive parts, medical, and different manufactures (Mohanavel et al., 2021). This research is identify the roughness of surface and rate of removal metal throughout optimization of three operation parameters (Mazarbhuiya et al., 2018). The effect of operations are mirror on the two attributes the roughness of surface metal and rate of removal metal. These Parameters are utilized to estimate the quality of a product (Nalbant et al., 2007). Lower roughness of surface metal and ultimate rate of removal metal rate are significant because of increasing customer requests into yield quality and less cost manufacture (Fayazfar et al., 2023). They are attributes which impact on performance of mechanical accessories and manufacturing costs (Asiltürk & Neşeli, 2012). On the knowledge, operation factors are select through labors experience in addition to standard references. The chosen cutting parameters may not an optimal solution that results maximum product cost (Thakur et al., 2009). Ideal performance of operation parameters is achieving by choosing the optimal cutting factors (Yang & Tarng, 1998). Utilizing of statistical technique supports selecting the optimum integration of cutting parameters (Zuperl et al., 2005). The literature survey throughout optimization of cutting parameters have been widely utilized in turning operations as following.

2. LITERATURE REVIEW

Balasubramaniyan and Selvaraj (2017) determined optimum cutting parameters in turning operations. They utilized two statistical techniques to reduce three attributes were the micro-hardness, roughness of surface and increase material removal rate (MRR) (Altuğ, 2016). Their results illustrated the efficiency of this method.

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3. METHODOLOGY

Research framework includes the goal of experimental work which is selection the best cutting parameters contribute to produce multi objectives that are minimum first attribute and maximum second attribute, where each one of that attributes is output to impact three alternatives throughout operations (Yan & Li, 2013). One statistical technique of multi-criteria methods is employed in this research to analysis two objectives simultaneously, as shown in figure 1.

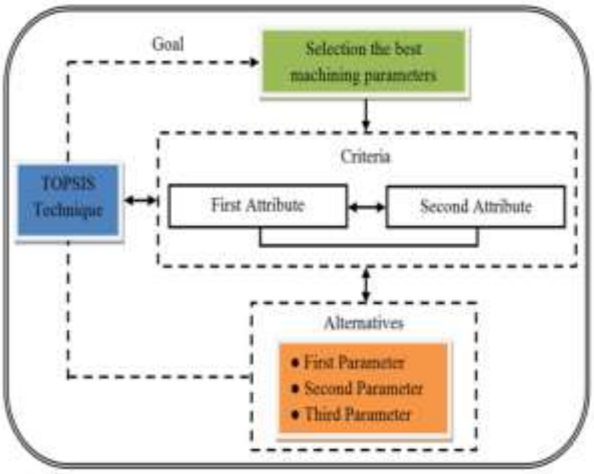

Figure 1. Framework of optimization cutting parameters

4. WORKPIECE ATTRIBUTES

First attribute (the roughness of surface) that produces from operation the metal workpiece is significant criteria of manufacturing applications. This attribute obtains by applying mathematical average approach to the ultimate value of an attribute altitudes of average measurements. Output of any machining process relies second attribute (The Rate of Removal Metal-RRM) which was determined using three factors as following in eq. (1) .

$$RRM = v \cdot f \cdot a \qquad (1)$$

3- the matrix of normalized weighting

$$v_{ij} = r_{ij} \times w_j \qquad (4)$$

4- the passive and affirmative ideality solutions of non-useful and useful attributes.

$$A^- = \{(\min_i V_{ij} \mid j \in J), (\max V_{ij} \mid j \in J) i = 1,2, \ldots \ldots m\} = \{v_1^-, v_2^-, \ldots v_j^-, \ldots v_n^-\} \qquad (5)$$

$$A^+ = \{(\max_i V_{ij} \mid j \in J), (\min V_{ij} \mid j \in J) i = 1,2 \ldots m\} = \{v_1^+, v_2^+, \ldots v_j^+, \ldots v_n^+\} \qquad (6)$$

Gunantara (2018) studied an impact of machining parameters onto responses which were mathematical mean of Roughness, and rate of Removal metal. They employed two statistical techniques from multi-criteria methods. Their results illustrated the best alternative of cutting parameters were deepness of cut at 0.4 mm, rate of feed at 0.15 mm/rev, and speed at 225 m/min.

Majumder and Saha (2018), focused on the implementation of the hybrid multi-criteria decision making method as a necessary chosen work tool to typical. They used statistical approach from multi-objective criteria. Their results illustrated an optimum factors were integration of feed rate 0.08 mm/rev, deepness of cut 0.1 mm and spindle speed 160 rpm.

Reddy et al. (2019) determined an ideal operation factors. They utilized one statistical method from multi-criteria attributes that were two attributes, the rate of Removal metal and roughness of surface. Their results showed the best factors were (179 m/min, 0.26 mm/rev, 1.8 mm) that can achieve maximum MRR and minimum Ra.

5. STATISTICAL TECHNIQUE

This approach is a technique to make an ideal decision which contributes to select alternative solution has outmost measure of passive ideality solution and the shortest measure of affirmative ideality solution. This technique has seven procedures are as following (Prakash et al., 2016):

1- normalizad decision matrix is calculated as following:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}} \qquad (2)$$

Where rij represents normalized value with respect to attribute x_{ij}.

2- pair wise comparison matrix.

$$W_j = \begin{bmatrix} a_{11} & a_{12} & a_{13} & - & - & a_{1N} \\ a_{21} & a_{22} & a_{23} & - & - & a_{2N} \\ a_{31} & a_{32} & a_{33} & - & - & a_{3N} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ a_{N1} & a_{N2} & a_{N3} & - & - & a_{NN} \end{bmatrix} \qquad (3)$$

where, w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{k} w_j = 1$

5- the separation exeuctions of all alternatives for passive and affirmative ideality solutions are (S_i^-) and (S_i^*).

$$RP = \frac{S_i^-}{S_i^* + S_i^-} \qquad (9)$$

where, $i = 1, 2, \ldots \ldots m$

$$S_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2} \qquad (7)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2} \qquad (8)$$

where, $j = 1, 2, \ldots \ldots m$

6- the relationship of ralative proximity (RP) with ideality passive and affirmative of alternative solutions.

Table 1. Machine Turning Parameters and Their Loads

Levels	Parameters		
	First (m/min)	Second (mm/rev)	Third (mm)
1	380	0.5	0.2
2	715	0.4	0.3
3	1500	0.2	0.5

Table 2. Design of experiments and their results

Trial No.	Alternatives			Attributes				
	First (m/min)	Second (mm/rev)	Third (mm)	First (µm)			First (µm)	Second (cm^3/min)
1	380	0.5	0.2	2.103	2.200	2.090	2.13	38.00
2	380	0.4	0.3	1.93	1.920	1.915	1.92	45.60
3	380	0.2	0.5	1.65	1.890	1.870	1.80	38.00
4	715	0.5	0.3	1.750	1.781	1.770	1.77	107.25
5	715	0.4	0.5	1.931	1.950	1.980	1.95	143.00
6	715	0.2	0.2	1.540	1.550	1.570	1.55	28.60
7	1500	0.5	0.5	1.720	1.730	1.760	1.74	375.00
8	1500	0.4	0.2	1.630	1.610	1.700	1.65	120.00
9	1500	0.2	0.3	1.470	1.450	1.480	1.47	90.00

From table (3) Normalized value (r_{ij}) of each attribute (x_{ij}) was determined by utilizing the equation (2) that depends on an information that determined in table (2).
From table (4) an equation (4) was utilized to calculate of weighted normalized value of each attribute.

Table 3. Normalized results of attributes

Trial No.	Normalized Attributes	
	First (µm)	Second (cm^3/min)
1	0.397611	0.084787
2	0.35841	0.101745
3	0.336009	0.084787
4	0.330409	0.239301
5	0.36401	0.319068
6	0.289341	0.063814
7	0.324809	0.836717
8	0.308008	0.26775
9	0.274407	0.200812

Table 4. Weighted normalized values

Trial No.	Weighted Attributes	
	First (µm)	Second (cm^3/min)
1	0.318089	0.016957
2	0.286728	0.020349
3	0.268807	0.016957
4	0.264327	0.04786
5	0.291208	0.063814
6	0.231473	0.012763
7	0.259847	0.167343
8	0.246406	0.05355
9	0.219526	0.040162

The following Equations (5 and 6) were determined affirmative and passive ideality solutions (A+ and A-) of each attribute that associated with benefit and cost criteria. The figure (1) illustrates the criteria values of first and second attributes that can give value added and non-value added Figure (2).
The relative proximity was calculated depending on rates of affirmative and passive ideality solutions that resulted from equations (7 and 8).
From equation (9) relative proximity was obtained. From table (5) the rank of all relative proximity values is associated with cutting parameters that fulfill an optimization.
7- ordering the status values of all relative proximity that obtained it from last prcedure and organizing them according to operation factors that achieved an optimization of first and second attributes.

6. EXPERIMENTAL METHOD

The turning processes were performed employing three cutting parameters with three levels of each parameter as shown in table (1). Work-pieces should have minimum roughness and ultimate rate of removal metal in order to use in flange coupling to transfer power from electric motor by easy motion inside two combined shafts. The integration between two attributes were optimized throughout employing an optimum cutting parameters utilizing one statistical technique
From table (2) Nine tests of work-pieces that produced from an operation parameters were executed. Three tests conducted for each work-piece, but second attribute was found it from theoretical equation (1).
The comparative significance matrix of performance attributes that resulted from cutting turning parameters was conducted rely on the equation (3). The goal of minimum first and maximum second attributes represent non-beneficial and beneficial values.

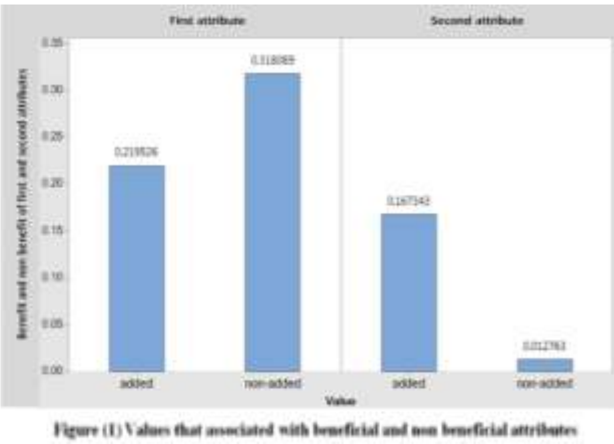

Figure 2. Values that associated with beneficial and non beneficial attributes

Table 5. Ranks of cutting parameters that achieve an optimization

Trial No.	Affirmative ideality solution	Passive ideality solution	$S^{+}+S^{-}$	Relative Proximity	Rank
1	0.179807	0.004194	0.184001	0.022793	9
2	0.161627	0.032265	0.193892	0.166407	8
3	0.158255	0.049460	0.207715	0.238115	7
4	0.127606	0.064204	0.19181	0.334727	6
5	0.112807	0.057696	0.170503	0.338387	5
6	0.155099	0.086616	0.241715	0.358339	4
7	0.040321	0.165188	0.205509	0.803799	1
8	0.116925	0.082474	0.199399	0.413613	3
9	0.127181	0.102300	0.229481	0.445789	2

Table 6. Optimization Parameters

Trial No	Alternative			Attribute	
	First (m/min)	Second (mm/rev)	Third (mm)	First (µm)	Second (cm^3/min)
7	**1500**	**0.5**	**0.5**	**1.74**	**375.00**

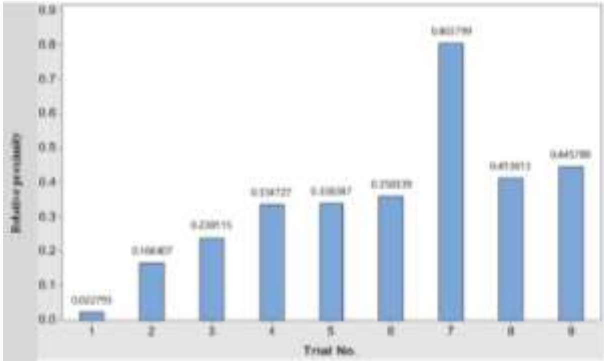

Figure 3. Comparison the best relative closeness of nine alternatives

The figure (3) and table(6) shown that alternative seven was the best alternative that can achieve an optimization of roughness and rate of removal metal attributes throughout turning operations.

Better alternative of operation parameters are selected according to bigger relative proximity as shown in figure (3).

7. CONCLUSIONS AND RECOMMENDATIONS

Statistical technique was effectively employed to identify relative closeness throughout negative and positive ideal solutions of each experiment. An optimum cutting parameters considers an essential goal of this research that integrates between two criteria were minimum roughness and ultimate rate of removal metal after using nine alternatives of machining turning parameters. An optimal Performance of machining turning parameters was determined utilizing bigger relative proximity (0.803799) that simultaneously fulfilled minimum first attribute (1.74 µm) and maximum second attribute (375.00 cm^3/min) throughout trial number (7) that represents an optimum alternative of cutting parameters were first (1500 m/min), second (0.5 m/rev), third (0.5). For future work, other techniques can be used such as integration between fuzzy logic and analytical hierarchy process in other services and industrial applications.

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