APPLICATION OF PREFERENCE SELECTION INDEX (PSI) METHOD FOR THE OPTIMIZATION OF TURNING PROCESS PARAMETERS

R. Vara Prasad¹, Ch. Maheswara Rao² and B. Naga Raju³

¹²Assistant Professor, Mechanical Department, ANITS, Visakhapatnam-531162, Andhra Pradesh, India
³Professor, Mechanical Department, ANITS, Visakhapatnam-531162, Andhra Pradesh, India

Abstract- The present work illustrates the impact of the process parameters on the various performance characteristics. AA7075 work pieces are machined using taguchi’s L9 orthogonal array. The responses of material removal rate (MRR) and surface roughness (Rₐ and Rₗ) at different combinations of speed, feed depth of cut are optimized using preference selection index (PSI) method. The results of PSI concluded that the speed at 2000 rpm, feed at 0.4 mm/rev and depth of cut at 0.75 mm are the optimal combination for achieving the higher material removal rate and lower surface roughness concurrently.

Keywords- Material Removal Rate (MRR), Surface Roughness (Rₐ and Rₗ), Preference Selection Index (PSI) method.

I. INTRODUCTION

Surface roughness is most commonly refers to the variation in the height of the surface relative to the reference plane. It is generally characterized by two the parameters known as arithmetic average roughness (Rₐ) or centre line average (CLA) and ten point average height (Rₗ). Arithmetic average is defined as the average values of ordinates from the mean line and ten point heights is the average difference between the five highest peaks and five lowest valleys of the surface texture within the sampling length, measured from a line parallel to the mean line.

In present days, the manufacturers are struggling for making the decisions when multiple performances are to be achieved at a time. For solving such cases, there are many multi-objective optimization methods are available. Preference selection method is one of that and it was developed by Maniya and Bhatt for solving the multi-attribute decision making problems. This method is useful when there is conflict in deciding the relative importance of attributes. The advantage of this method over other is that, it considers the weights/contributions of the individual performance characteristics in measuring the combined preference index values and the ranking of alternatives can be given in the descending order of obtained PSI.

II. EXPERIMENTAL CONDITIONS

In the present work aluminium based alloy (AA7075) is taken as the work piece in cylindrical form for machining. The chemical composition and mechanical properties of AA7075 are given in the tables 1 and 2. Machining was carried out on CNC Turret lathe (DX-200, SEIMENS make, input power: 20KW, spindle speed: 50-3500 rpm) by considering speed, feed and depth of cut as the cutting parameters at three different levels as shown in the table 3. Nine experiments were planned for covering the entire parametric space of the selected parameters as given in the table 4.
Table 1. Chemical composition of AA7075

| Element | Composition |
|---------|-------------|
| Al      | 87.1-91.4   |
| Zn      | 5.1-6.1     |
| Cu      | 1.2-2.0     |
| Cr      | 0.18-0.28   |
| Fe      | 0.5 max     |
| Mg      | 2.1-2.9     |
| Mn      | 0.3 max     |

Table 2. Mechanical properties of AA7075

| Property          | Value         |
|-------------------|---------------|
| Density (gm/cm³)  | 2.8           |
| Ultimate tensile strength (Psi) | 83000         |
| Yield strength (Psi) | 73000         |
| BHN               | 150           |
| Rockwell          | 1387          |

Table 3. Parameters with their levels

| Parameter     | Level-1 | Level-2 | Level-3 |
|---------------|---------|---------|---------|
| Speed, rpm    | 1000    | 1500    | 2000    |
| Feed, mm/rev  | 0.2     | 0.3     | 0.4     |
| DOC, mm       | 0.5     | 0.75    | 1       |

Table 4. L9 OA

| S.No. | v     | f    | d    |
|-------|-------|------|------|
| 1     | 1000  | 0.2  | 0.5  |
| 2     | 1000  | 0.3  | 0.75 |
| 3     | 1000  | 0.4  | 1    |
| 4     | 1500  | 0.2  | 0.75 |
| 5     | 1500  | 0.3  | 1    |
| 6     | 1500  | 0.4  | 0.5  |
| 7     | 2000  | 0.2  | 1    |
| 8     | 2000  | 0.3  | 0.5  |
| 9     | 2000  | 0.4  | 0.75 |

III. METHODOLOGY

Preference selection method was developed by Maniya and Bhatt for solving the multi-attribute decision making problems. This method is useful when there is conflict in deciding the relative importance of attributes. The steps involved in are

Step 1: Define the objective, attributes and alternatives.
Step 2: Formation of the decision matrix based on the available information.
Step 3: Normalization of attributes

\[ N_{ij} = \frac{x_{ij}}{x_{ij}^{\text{max}}}; \text{for beneficial type} \] \hspace{1cm} (1)

\[ N_{ij} = \frac{x_{ij}^{\text{min}}}{x_{ij}}; \text{for non-beneficial type} \] \hspace{1cm} (2)

Where, \( x_{ij} \) is the measured attribute for i=1,2,3,........n and j=1,2,........m.
Step 4: Calculation of mean value of the normalized data

\[ N = \frac{1}{n} \sum_{i=1}^{n} N_{ij} \] \hspace{1cm} (3)

Step 5: Finding of preference variation value from the mean value.

\[ \varphi_{j} = \left( \sum_{i=1}^{n} [N_{ij} - N]^{2} \right)^{\frac{1}{2}} \] \hspace{1cm} (4)

Step 6: Finding of deviation in the preference value.

\[ \Omega_{j} = \left[ 1 - \varphi_{j} \right] \] \hspace{1cm} (5)

Step 7: Finding the overall preference value for the attributes.
subjected to $\sum_{j=1}^{m} w_j = 1$

Step8: Preference selection index is calculated for each alternative by

$$\theta_j = \sum_{j=1}^{m} X_{ij} w_j$$

(7)

Step9: The value computed for the PSI i.e. $\theta$, should now used for giving the ranking. The best alternative is the one with maximum value of $\theta$.

IV. RESULTS AND DISCUSSIONS

The measured responses of the material removal rate and surface roughness characteristics were shown in the table 5. The objective is to setting of the optimal process parameters in order to optimize the multiple responses. The responses are normalized using beneficial and non-beneficial types for material removal rate and surface roughness characteristics by using Eq(1) and Eq(2) and the obtained values are shown in the table 6.

| S.No. | MRR  | Ra  | Rz   |
|-------|------|-----|------|
| 1     | 9.21 | 2.11| 9.04 |
| 2     | 24.85| 5.023| 22.68|
| 3     | 32.57| 9.17| 36.103|
| 4     | 20.57| 2.036| 8.546|
| 5     | 39   | 7.16| 26.94|
| 6     | 24.85| 11.59| 43.963|
| 7     | 41.14| 3.35| 13.263|
| 8     | 27   | 7.25| 26.086|
| 9     | 39.85| 11.75| 45.376|

| S.No. | MRR  | Ra  | Rz   |
|-------|------|-----|------|
| 1     | 0.2239| 0.9649| 0.9454|
| 2     | 0.6040| 0.4053| 0.3768|
| 3     | 0.7917| 0.2220| 0.2367|
| 4     | 0.5000| 1.0000| 1.0000|
| 5     | 0.9480| 0.2844| 0.3172|
| 6     | 0.6040| 0.1757| 0.1944|
| 7     | 1.0000| 0.6078| 0.6443|
| 8     | 0.6563| 0.2808| 0.3276|
| 9     | 0.9686| 0.1733| 0.1883|

The mean values of the normalized data of the attributes are obtained using Eq(3) and the values are $N_{MRR} = 0.6996$, $N_{Ra} = 0.4571$ and $N_{Rz} = 0.4701$. The preference variation values from the mean values obtained using Eq(4) are $\phi_{MRR} = 0.5191$, $\phi_{Ra} = 0.8539$ and $\phi_{Rz} = 0.7993$. The deviation in the preference value is obtained using Eq(5) are $\Omega_{MRR} = 0.4809$, $\Omega_{Ra} = 0.1461$ and $\Omega_{Rz} = 0.2007$. The overall preference values for the attributes are obtained as $w_{MRR} = 0.5810$, $w_{Ra} = 0.1764$ and $w_{Rz} = 0.2425$. Finally, the ranking is given in the descending order of PSI values obtained same is shown in the figure.

From the results, it is clear that the values of speed, feed and depth of cut (i.e. 2000 rpm, 0.4 mm/rev, 0.75 mm) are corresponding for achieving the desired multiple performances.
Table 7. Weighted values of the responses and PSI

| S.No. | MRR   | $R_a$ | $R_z$ | PSI    | Rank |
|-------|-------|-------|-------|--------|------|
| 1     | 5.3510| 0.3722| 2.1922| 7.9154 | 9    |
| 2     | 14.4379| 0.8861| 5.4999| 20.8238| 7    |
| 3     | 18.9232| 1.6176| 8.7550| 29.2957| 3    |
| 4     | 11.9512| 0.3592| 2.0724| 14.3827| 8    |
| 5     | 22.6590| 1.2630| 6.5330| 30.4550| 2    |
| 6     | 14.4379| 2.0445| 10.6610| 27.1434| 5    |
| 7     | 23.9023| 0.5909| 3.2163| 27.7096| 4    |
| 8     | 15.6870| 1.2789| 6.3259| 23.2918| 6    |
| 9     | 23.1529| 2.0727| 11.0037| 36.2292| 1    |

Figure 1. PSI Vs Experiment number

V. CONCLUSIONS

- The results of PSI concluded that the speed of 2000 rpm, feed of 0.4 mm/rev and depth of cut of 0.75 mm are the optimal conditions for achieving the higher material removal rate and lower surface roughness concurrently.
- The PSI method is very simple in calculations and can be employed for multi criteria decision making problem conveniently.

REFERENCES

[1] Ch. Maheswara Rao, S. Srikanth and R. Vara Prasad, “Application of Taguchi Based Grey Relational Grade Method To Optimize The Multi Responses”, IJMTER, vol.4, issue.7, pp. 121-126, 2017.
[2] G. Karuna kumar, Ch.maheswara rao and V.V.S Kesava rao, “Investigation of Effect Of Speed, Feed And Depth of Cut on Multiple Responses Using Vikor Analysis”, IJMTER, vol.5, issue.2, pp. 164-168, 2018.
[3] Ch.Maheswara Rao, K. Jagadeeswara Rao and K.Suresh, “Optimization of Material Removal Rate and Surface Roughness Using Grey Analysis”, IJERD, vol.12, issue.3, pp.49-58, 2016.
[4] Ch. Maheswara Rao, K. Venkata Subbaiah and Ch. Suresh, “Prediction of Optimal Designs for Material Removal Rate and Surface Roughness Characteristics”, International Journal of Lean Thinking, Vol-7, Issue-2, 2016, pp.24-46.

[5] H. Kumar, M. Abbas, Aas Mohammad and H. Zakir Jafri, “Optimization of Cutting Parameters in CNC turning”, IJERA, ISSN: 2248-9622, vol. 3, no. 3, 2013, pp. 331-334.

[6] Ch. Maheswara Rao and K. Venkata Subbaiah, “Optimization of Surface Roughness in CNC Turning Using Taguchi method and ANOVA”, International Journal of Advanced Science and Technology, ISSN: 2005-4238, Vol-93, 2016, pp.1-14.

[7] Ch. Maheswara Rao, K. Venkata Subbaiah and K. Sowjanya, “Influence of Speed, Feed and Depth of cut on Multiple Responses in CNC Turning”, International Journal of Advanced Science and Technology, ISSN: 2005-4238, Vol-92, 2016, pp.59-76.

[8] Ch. Maheswara Rao and K. Venkata Subbaiah, “Effect and Optimization of EDM Process Parameters on Surface Roughness for EN41 Steel”, International Journal of Hybrid Information Technology, ISSN: 1738-9968, Vol-9, No.5, 2016, pp.343-358.

[9] Ch. Maheswara Rao and K. Venkata Subbaiah, “Application of WSM, WPM and TOPSIS Methods for the Optimization of Multiple Responses”, International Journal of Hybrid Information Technology, ISSN: 1738-9968, Vol-9, No.10, 2016, pp.59-72.

[10] Ch. Maheswara Rao and K. Venkata Subbaiah, “Application of MCDM Approach-TOPSIS for the Multi Objective Optimization Problem”, International Journal Of Grid And Distributed Computing, vol.9, No.10, pp.17-32, 2016.

[11] Ch. Maheswara Rao, S.Srikanth and R.Vara Prasad and G.Babji, “Simultaneous Optimization of Roughness Parameters Using TOPSIS”, IJETT, vol.49, No.3, pp.150-157, 2017.

[12] Ch. Maheswara Rao and R.Vara Prasad, “Effect of Milling Process Parameters on The Multiple Performance Characteristics, Journal of Industrial Mechanics, vol.3, issue.2, pp.1-9, 2018.

[13] Ch. Maheswara Rao and B.Naga Raju, “Effect of WEDM Process Parameters on The Multiple Responses Using VIKOR Analysis, Journal of Recent Activities In Production, vol.3, issue.2, pp. 1-7, 2018.