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Selection of Levels of Dressing Process Parameters by Using TOPSIS Technique for Surface Roughness of En-31 Work piece in CNC Cylindrical Grinding Machine

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Abstract: Grinding is metal cutting process used for mainly finishing the automobile components. The grinding wheel performance becomes dull by using it most of times. So it should be reshaping for consistent performance. It is necessary to remove dull grains of grinding wheel which is known as dressing process. The surface finish produced on the work piece is dependent on the dressing parameters in sub-sequent grinding operation. Multi-point diamond dresser has four important parameters such as the dressing cross feed rate, dressing depth of cut, width of the diamond dresser and drag angle of the dresser. The range of cross feed rate level is from 80-100 mm/min, depth of cut varies from 10 – 30 micron, width of diamond dresser is from 0.8 – 1.10mm and drag angle is from $40^o – 50^0$, The relative closeness to ideal levels of dressing parameters are found for surface finish produced on the En-31 work piece during sub-sequent grinding operation by using Technique of Order Preference by Similarity to Ideal Solution (TOPSIS).In the present work, closeness to ideal solution i.e. levels of dressing parameters are found for Computer Numerical Control (CNC) cylindrical angular grinding machine. After the TOPSIS technique, it is found that the value of Level I is 0.9738 which gives better surface finish on the En-31 work piece in sub-sequent grinding operation which helps the user to select the correct levels (combinations) of dressing parameters.

1. Introduction

Demand for high quality surface finish, less lead time, low cost and higher productivity are need of the hour in industries. Grinding is a metal cutting process which is used for finishing of hard stage parts. Grinding operation has numerous parameters which will decide it affect on the surface roughness of the work piece. Grinding wheel, work piece material characteristics, grinding wheel– work piece kinematics, dressing process and truing are parameters of grinding operations.

Xun Chen,.Brian Rowe established the relation for grinding performance by changing the dressing conditions for surface grinding using simulation. However it will be interesting to see the results for the same if operation is carried out in CNC cylindrical grinding machine. V.P.Darji and R.V. Rao (2014) used Multi Criteria Decision Making method for selection of material in sugar industries. Rajnish Kumar, Jagadish, and Amitava Ray (2014) presented TOPSIS method for selection of material for optimal design. R. Kumar, C. Bhomik and A. Ray (2013) demonstrated TOPSIS method for selection of cutting tool material. En-31 (13, 14) is more commonly used in manufacturing industries. Surface finish is an important parameter in manufacturing engineering and it can influence the performance of mechanical parts and the production cost.

The objective of the grinding process is to generate parts with high surface finish, with minimum tolerance. Dressing (5, 7) is the process of removing dull grains of grinding wheel in order to make it sharp. Topography of wheel is important aspect which has an effect on the surface finish produced of the work piece. Topography (12) of wheel is generated by dressing process. Selection of appropriate process parameters for producing good quality of surface finish on the specific material plays important role in manufacturing. Selection of correct process parameter reduces manufacturing time, increase in productivity, increase efficiency of process, less cost and it makes less confusion for the selecting the range of parameters. So it is necessary to select correct values (level) of dressing parameters for generating better surface finish of work piece. Improper selection of dressing parameters (level) causes poor surface finish on the En-31 work piece, high power loss and it is uneconomical.

2. Literature Review, Conclusion from Reviewed Literature and Need of Present Research Work

A. Fritsche and F. Bleicher (2015) focused on evaluating and influencing dressing results by changing the grain size distribution based on statistical and experimental investigation. They developed “Active Grain Stack” (AGS) model which give information of a structure of grinding wheel and how different layers interact with each other. Fritz K Locke et al. (2016) developed a method to simulate a detailed 3- D model of the grinding wheel structure. They used volumetric composition which includes no. of grins, their orientation; their distribution in grinding wheel. The 3D model has been developed to measure and transfer the shape of Cubic Boron Nitride (CBN) grains. In addition, a method has been created numerically for realistic CBN grains

After reviewing the literature and industrial survey, it is found that, dressing parameters are highly effective in producing good quality of surface finish on the work piece in CNC cylindrical angular grinding machine. Very few researchers have worked on EN31 material. Therefore there is a need to find out a solution which will be nearly equal to the ideal levels of these parameters to have a good surface finish of En31 work piece which would help the user to select the correct levels of dressing parameters which is the main objective of grinding process.

The objective of this work is to develop TOPSIS method for selection of closeness to the ideal dressing parameters for generating better surface finish on the work piece. A seven steps approach method can be used in finding closeness to ideal dressing parameters for generating better surface finish on the work piece.

3. TOPSIS Method

TOPSIS was first presented by Yoon (1980) and Hwang and Yoon (1981), for solving Multiple Criteria Decision Making (MCDM) problems based on the concept that the chosen alternative should have the shortest Euclidian distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal

Solution (NIS). For instance, PIS maximizes the benefit and minimizes the cost, whereas the NIS maximizes the cost and minimizes the benefit. It assumes that each criterion require to be maximized or minimized. TOPSIS is a simple and useful technique for ranking a number of possible alternatives according to closeness to the ideal solution. TOPSIS is one of the popular techniques so more discussion is not given.

4. TOPSIS Method for present research work

Referring the steps of the TOPSIS method, the following steps have been applied for the present research work.

Step 1- There are four input parameters namely dressing cross feed rate, dressing depth of cut, width of the diamond dresser and drag angle of the dresser. Levels of these parameters are given in table 1. Level I includes cross feed rate of 80 mm/minute, dressing depth of cut of 10 micron, width of dresser 0.8 mm and drag angle of dresser of 40^0. Similarly Level II and Level III are designed as shown in table 1. Decision matrix is given in the table I.

Table 1.Input parameters and levels

Name of parameters	Dressing cross feed rate (mm/min.)	Dressing depth of cut(micron)	Width of the diamond dresser(mm)	Drag angle of the dresser(degree)
Level I	80	10	0.8	40
Level II	90	20	0.9	45
Level III	100	30	1.1	50

Step 2- - Normalized decision matrix

Relative performance of normalized values of dressing process parameters namely dressing cross feed rate, dressing depth of cut, width of diamond dresser and drag angle of dresser are calculated and given in table 2.

Table 2. Normalized decision matrix

Name of parameters	Dressing cross feed rate (mm/min.)	Dressing depth of cut(micron)	Width of the diamond dresser(mm)	Drag angle of the dresser(degree)
Level I	0.511	0.267	0.490	0.5111
Level II	0.5750	0.5346	0.552	0.5750
Level III	0.6388	0.8019	0.6748	0.6516

Step 3- Weighted decision matrix

Each dressing process parameter is equally important after normalized dressing process parameters and Level I, Level II and Level III also. So Analytical Hierarchical Process (AHP) process is used for to quantify the relative importance of each dressing process parameters as shown in equation I. Dressing process parameters are critically assisted in term of surface finish produced on the EN-31 work piece in sub-sequent grinding operation. Order of ranking descends as follows.

1. Dressing cross feed rate.

2. Dressing depth of cut

3. Width of diamond dresser

4. Drag angle of dresser

Weighted decision matrix is formed by weight of parameter multiply by each element of column.

$$Wi = [0.6384 \quad 0.1866 \quad 0.1201 \quad 0.0544] \text{ --- I (Found by AHP method)}$$

Table 3. Weighted decision matrix

Name of parameters	Dressing cross feed rate (mm/min.)	Dressing depth of cut(micron)	Width of the diamond dresser(mm)	Drag angle of the dresser(degree)
Level I	0.3262	0.04982	0.0588	0.02780
Level II	0.3670	0.09975	0.0662	0.03128
Level III	0.4078	0.1496	0.0810	0.03544

Step 4-Identify positive and negative solutions

Positive ideal solution (V+) and negative ideal solution (V-) are determined and given in table 4

Table 4. Identify positive and negative solutions

V+	0.3262	0.04982	0.0588	0.03544
V-	0.4078	0.1496	0.0810	0.02780

Step 5- Separation measure for each alternative is calculated. The positive ideal solution and Negative ideal solution are defined as follows.

$$S+ = \{0.20358 \quad 0.10885 \quad 0.20385\}$$

$$S+ = \{0.20358 \quad 0.10885 \quad 0.00764\}$$

Step 6 - Relative closeness to each solution is given in step 6.

$$\text{Ci} = \{0.963829 \quad 0.515339 \quad 0.03617\}$$

If the values are less than one then it is acceptable. In step 6 all values are less than one hence solution as acceptable and maximum value is the best.

Step 7 –Ranking of preference order.

Level 1 has value of 0.963827, Level II has value of 0.515339, Level III has value of 0.0361 and Level I has maximum value and i.e. the best. Level III is worst option for surface roughness on En-31 work piece. Level II is intermediate solution for surface finish on En-31 work piece. User will produce good quality surface finish on En-31 by selecting option level I. Histogram of different levels of dressing parameters are shown in figure. 1

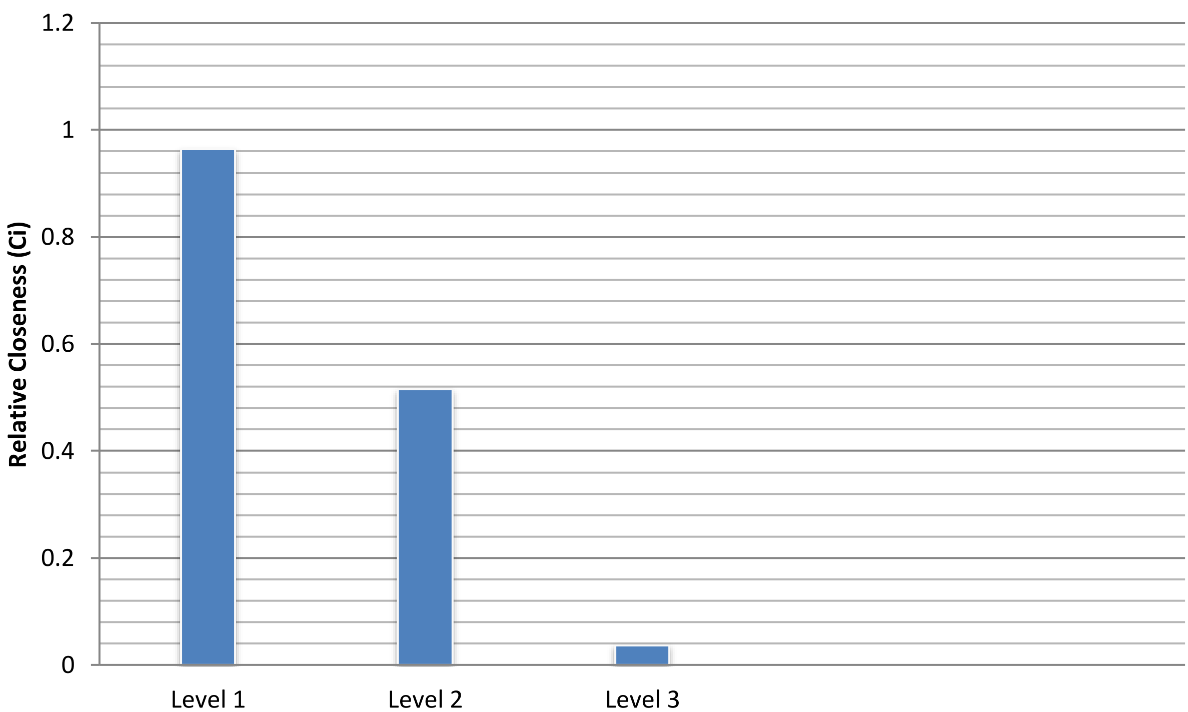

Figure 1. Histogram of different levels of dressing parameters.

5. Conclusions

TOPSIS method shows that closeness to the ideal solution of dressing parameters namely cross feed rate, depth of cut, width of diamond dresser and drag angle of multipoint diamond dresser is level I. The values of parameters are 80 mm/minute cross feed rate, 10micron depth of cut, 0.8mm width of diamond dresser and 40^0 drag angle of diamond dresser. These values are best for generating better surface finish on the En-31 work piece in sub-sequent grinding operation in CNC cylindrical angular grinding machine.

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expertise in the development of proposed selection of dressing process parameter for EN-31 using TOPSIS for CNC cylindrical grinding machine.

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