EXPERIMENTAL INVESTIGATION AND PREDICTION OF SURFACE ROUGHNESS IN SURFACE GRINDING OPERATION USING FACTORIAL METHOD AND REGRESSION ANALYSIS

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ABSTRACT

This study deals with the investigation and prediction of the surface roughness in surface grinding operation. The experiments have been conducted using factorial design on a surface grinding machine with silicon oxide as an abrasive wheel. Feed and depth of cut were varied to observe their effect on surface roughness. Analysis of variance was used to find the significant factor and regression equation was developed to predict the surface roughness. Three different materials were used in this investigation (cast iron, mild steel and stainless steel). Feed rate was found to be the most significant factor in case of cast iron and for mild steel and stainless steel none of the factor was found be significant.

Keyword: Surface Roughness, Surface Grinding, Regression Analysis, Factorial Method.

INTRODUCTION

Surface roughness often shortened to roughness, is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Surface grinding is the most common of the grinding operations. It is a finishing process that uses a rotating abrasive wheel to smooth the flat surface of metallic or non-metallic materials to give them a more refined look or to
attain a desired surface for a functional purpose. It is an expendable wheel that is composed of an abrasive compound used for various grinding (abrasive cutting) and abrasive machining operations. In the experiment, common manufacturing metals i.e. Cast Iron, Mild Steel and Stainless Steel were used. Cast Iron is used in track wheel, automotive crankshaft, bearing surface etc. Mild Steel is used in Armour pipes, magnets etc. Stainless Steel is used in architecture, bridges etc. therefore it is worthwhile to study surface roughness property of these materials for surface grinding operation.

METHODOLOGY

Factorial design is an important method to determine the effects of multiple variables on a response. Factorial design can reduce the number of experiments one has to perform by studying multiple factors simultaneously. Additionally, it can be used to find both main effects (from each independent factor) and interaction effects (when both factors must be used to explain the outcome). Factorial design is best used for a small number of variables with few states (1 to 3).

Regression analysis is a statistical process for estimating the relationships among variables. Regression analysis helps one understand how the typical value of the dependent variable (or 'criterion variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed.

MATERIALS AND METHOD

The material used for the experiments were cast iron, mild steel and stainless steel. Dimensions and chemical composition for each material are given below:-

**Cast iron:** Length-80mm and Width-55mm and thickness-50mm. And its chemical composition iron- 3%, carbon-5.55, silicon alloy-1-3%, sulphur-0.5, magnesium-0.5%, and potassium-0.55.

**Mild steel:** Length-65mm and Width-37mm and thickness-5mm. And its chemical composition Carbon- 0.16-0.18%, Silicon- 0.40%max, Manganese- 0.70-0.90%. Sulphur-0.040%max, Phosphorus-0.040%max.

**Stainless steel:** Length-67mm and Width-50mm and thickness-10mm. And its chemical composition carbon- 0.12%, Manganese- 7.5-10%, Silicone-0.9%, Chromium-14-16%, Nickel-0.5-2.0%, Molybdenum-0.2%, Phosphorus-0.06%.

Nine experimental runs were carried out for all the three material in student’s workshop of SHIATS Allahabad (U.P.) INDIA. Correspondingly surface roughness was measured for each experiment. The two process parameters, viz. depth of cut and feed rate were varied and spindle speed was kept constant.

<table>
<thead>
<tr>
<th>Process parameters</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of cut (mm)</td>
<td>0.1</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Feed (mm/rev)</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Table 2 shows the values of the responses obtained from the experimental runs for all the three materials.

<table>
<thead>
<tr>
<th>EXP NO</th>
<th>FEED (mm/min)</th>
<th>DOC (mm)</th>
<th>Surface roughness (µm)</th>
<th>Surface roughness (µm)</th>
<th>Surface roughness (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(cast iron)</td>
<td>(mild steel)</td>
<td>(stainless steel)</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>0.1</td>
<td>12.5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>0.3</td>
<td>12.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>0.5</td>
<td>7.5</td>
<td>1.25</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>0.1</td>
<td>7.5</td>
<td>7.5</td>
<td>2.5</td>
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<tr>
<td>5</td>
<td>40</td>
<td>0.3</td>
<td>2.5</td>
<td>1.25</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>0.5</td>
<td>2.5</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
<td>0.1</td>
<td>5</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>0.3</td>
<td>5</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>9</td>
<td>50</td>
<td>0.5</td>
<td>1.25</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(1) Effect of variation of process parameters on response

Figure 1 (a, b & c) shows Pareto charts for all the three materials demonstrating the effect of parameters on surface roughness. It is clear from the chart that feed rate crosses the reference line in case of cast iron (fig. 1 a) i.e. it is potentially important factor. Contour plots for surface roughness vs. feed rate and depth of cut are shown in figure 2.
Figure 2 (a) shows that best surface roughness is obtained as we increase feed rate from 30 to 50 (mm/min) and on simultaneously increasing depth of cut from 0.1 mm to 0.5 mm in case of cast iron. For mild steel the best surface roughness is obtained as we keep depth of cut between 0.3 mm to 0.5 mm and feed rate should be kept between 30 to 45 mm/min, on further increasing the feed surface roughness deteriorates. In case of stainless steel there are three regions where we can get best surface roughness; first combination is when depth of cut is 0.1 mm and feed rate is kept around 45 mm/min, second when feed rate is 30 mm/min and depth of cut is around 0.3 mm and thirdly when depth of cut is kept 0.5 mm and feed rate is kept between 35 to 45 mm/min.

Figure 2 (a): Contour plots for Cast iron

Figure 2 (b): Contour plots for Mild steel
Equation 1 shows the regression equation obtained for response (surface roughness) in terms of feed and depth of cut for Cast iron, similarly for Mild steel and Stainless steel regression equations are shown in equation 2 and 3 respectively.

Surface roughness (microns) = 23.9 - 0.354 feed (mm/min) - 11.5 Depth of cut (mm) \[1\]

Surface roughness (microns) = 6.46 + 0.062 feed (mm/min) - 14.6 depth of cut (mm) \[2\]

Surface roughness (microns) = 10.7 - 0.125 feed (mm/min) - 7.29 depth of cut (mm) \[3\]

Time series graph for all the three materials were plotted showing the response values obtained from experiments and regression equation. Figure 3 (a, b & c) shows times series plot for Cast iron, Mild steel and Stainless steel respectively. The predicted values seems to be in close agreement with the experimental values.
CONCLUSION

The study deals with the investigation of effect of process parameters on surface roughness, factorial method and regression analysis were used for this study.

From the analysis of result, following conclusion can be drawn:

- Most important parameter for surface roughness was found to be feed rate in case of cast iron.
- Predicted values are in close agreement with the experimental values therefore the developed model can be adequately used for prediction of surface roughness in surface grinding operation.

REFERENCE


