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Optimization of Cylindrical Grinding Process Parameters of Hardened Material using Response Surface Methodology

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Abstract
Cylindrical grinding is a metal cutting processes. It comes under finishing process. For that purpose Metal removal rate and Surface Roughness are the major output parameters in the production to maintain quantity and quality respectively. CNC cylindrical grinding machine is used for performing the experiments with Response Surface Methodology with input machining parameters as work speed, feed rate and depth of cut. The Surface Roughness will be studied in mathematical model by using response surface methodology (RSM). To check the validity of the model Analysis of variance (ANOVA) will used. The influences of all decided input parameters on Surface Roughness can be studied based on the developed mathematical model. Accuracy of the model can be checked with the testing data. The new model can be used in the different manufacturing firms by selecting right combination of machining parameters to achieve an optimal metal removal rate (MRR) and Surface Roughness (Ra). The results will show that the effect of work speed, feed rate and depth of cut are influencing parameters on the output responses metal removal rate (MRR) and surface roughness (Ra). The results would be further confirmed by conducting confirmation experiments.

Keywords: *Material Removal Rate (MRR), Response Surface Methodology (RSM), Surface Roughness (Ra)*

1. Introduction

In modern manufacturing industry, the main objective is to manufacture low cost, high quality parts within short time. Machining is a major manufacturing process of nearly every product of the modern civilization. Main machining operations are turning, drilling, thread cutting, milling, grinding etc. among them grinding has been employed in manufacturing for more than 100 years. It is a manufacturing process involved with material removal rate and the last operation performed on a work-piece. The applications of grinding are mainly for making products requiring a high degree of accuracy and precision. Final shape and finish of the part depends on this operation; so it is a very important process in order to meet stringent specifications and tolerances for the output job. Cylindrical grinders are used on the work pieces that are symmetrical about an axis of rotation. The grinding of an outer surface of a work piece around an axis of rotation with the part held between centres is performed in external cylindrical grinding operation and it is an efficient and effective method of achieving exceptional roundness and good Surface Roughness. Optimization analysis of machining process are usually based on either minimizing production cost, maximizing production rate or obtaining the fitness possible surface quality by using empirical relationships between the tool life and the operating parameters.

Surface Roughness is a measure of the technological quality of a product and a factor that greatly influences manufacturing cost. Excessive Surface Roughness may degrade the performance of the output work and work-piece quality suffers. To achieve this goal, understandings relating to the effects of machining conditions and machining parameters on surface quality have to be precise and clear. Study in this regard is still being continued. In so far the effects of process parameters on Surface Roughness are concerned, there has been a bit of experimental study, but more extensive research is necessary.

Good Surface Roughness values and high MRR may obtain through process optimization, which needs a deep knowledge of the phenomena, mainly concerning the relationship between the process parameters and output characteristics. The aim of the work is to study the effects of processes parameters on Surface Roughness and MRR by using response surface methodology (RSM) with OHNS material. The present work is planned to identify the effect of cutting conditions on Surface Roughness and MRR of the job through experiments and using MINITAB 14 experimental design and response surface methodologies have been used to find out the optimal cutting conditions to get high quality Surface Roughness.

2. Experimental Setup

In the present work experiments have been conducted on cylindrical grinding machine for studying the effect of process parameters on Surface Roughness and MRR in traverse cut cylindrical grinding machine on OHNS material. The process parameters considers for present work are: work speed, Feed rate and depth of cut. Three levels of parameters have been used during traverse cut grinding. So that response surface methodology (RSM) can be utilize for analyses of the observed data.

The experimental set up used in the present work is shown in Fig. 1. The experimental set consists of several systems, such as grinding wheel, tail stock, head stock, work table and cooling system. Grinding wheel specifications are 300 X 127 X 40mm (Al_2O_3).

Fig. 1. Photographic view of the grinding machine

2.1 Work material

Work piece Material: OHNS φ25X 120mm (Hardened to 60 HRc)

Grinding length of each sample: 50 mm

Table 1. Chemical Composition of OHNS

Element	C	Mn	Cr	W	V
% Contribution	0.95	1.15	0.5	0.5	0.2

Table 2. Mechanical properties of OHNS

Maximum Stress (N/mm^2)	Yield Stress (N/mm^2)	Elongation (%)	Impact Strength (Nm)	Hardness (BHN)
950	465	10	25	288

2.2 Process Variables

The process parameters chosen for the present study are cutting speed (rpm), feed rate (m/min) and depth of cut (mm). The selection of the values of the variables is limited by the capacity of the machine used in the experimentation as well as recommended combinations defending on work piece and tool material. The parameters that were kept constant during this study are grinding wheel specifications, wheel type, number of passes in grinding, diameter of work piece, and diameter of wheel. Their levels are as follows:

Table 3. Levels of Experiments

Parameter	-1	0	1	Unit
Feed	2	3.5	5	m/min
Spindle Speed	250	300	350	rpm
Depth of Cut	0.005	0.010	0.015	mm

3. Result and Discussions

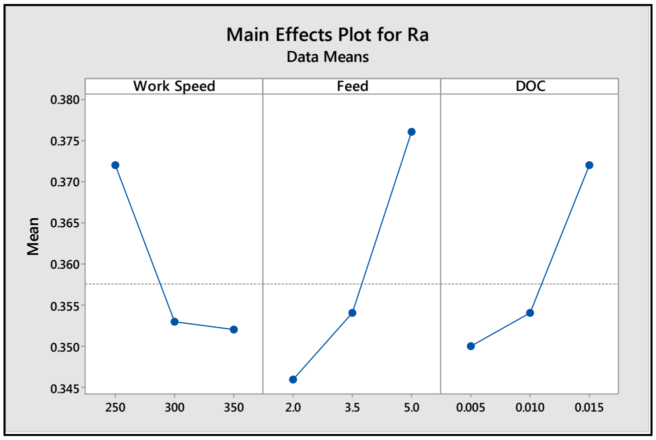
3.1. Experimental Result

In this chapter, result through experimental work is recorded, as shown in table 4. Experimental data obtained for Surface Roughness and Material Removal Rate (MRR) is analysed and mathematical modelling is done for both responses.

Table 4. Experimental Results

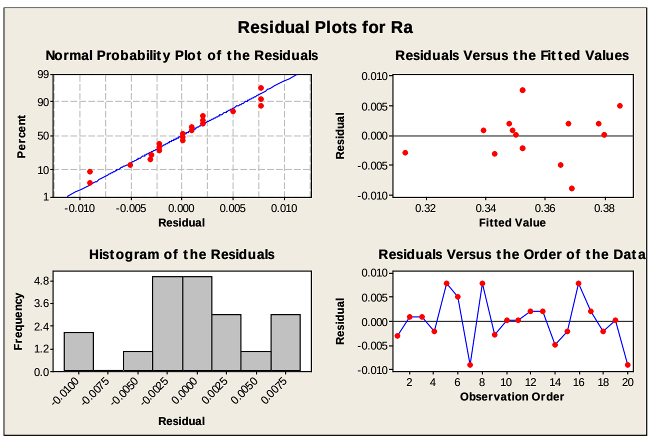
Run Order	Work Speed	Feed	DOC	MRR	Ra
	RPM	m/min	mm	gm/sec	µm
1	300	3.5	0.005	0.23	0.34
2	350	3.5	0.010	0.37	0.35
3	300	2.0	0.010	0.22	0.33
4	300	3.5	0.010	0.35	0.35
5	300	3.5	0.010	0.33	0.36
6	250	5.0	0.015	0.37	0.37
7	250	3.5	0.010	0.33	0.35
8	300	3.5	0.010	0.37	0.35
9	350	2.0	0.005	0.17	0.33
10	350	5.0	0.015	0.37	0.36
11	250	2.0	0.015	0.20	0.35
12	250	5.0	0.005	0.22	0.38
13	350	5.0	0.005	0.33	0.39
14	300	3.5	0.015	0.39	0.37
15	300	3.5	0.010	0.30	0.35
16	300	3.5	0.010	0.33	0.35
17	250	2.0	0.005	0.16	0.35
18	300	3.5	0.010	0.31	0.35
19	350	2.0	0.015	0.26	0.33
20	300	5.0	0.010	0.33	0.39

Comparing the p-value to a commonly used α-level = 0.05, it is found that if the p-value is less than or equal to α, it can be concluded that the effect is significant. This clearly indicates that the feed has greatest influence on Ra and MRR followed by DOC and work speed.



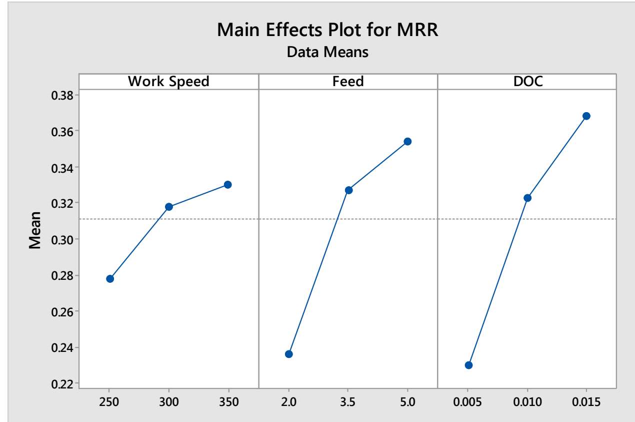
Graph 1.Main Effect Plot for Ra

It can be seen from Graph 1 that feed has a huge impact on roughness value Ra. Graph shows that Feed and depth of cut at low level yields low Ra value and Spindle speed at low level yields high roughness value. The graph shows that increase in Feed and Depth of cut results in increase of Ra value.



Graph 2. Residual Plots for Ra

Based on the plot for Ra (Graph 2) the residuals appear to be randomly scattered about zero. Therefore, constant variation is observed between residuals and fitted values and no evidence of non constant variance, missing terms, outliers or influential points exist. Constant variance means that the model developed is adequate.

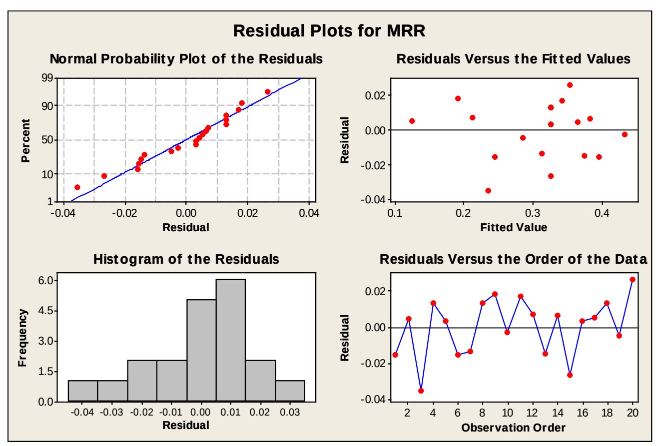


Graph 3. Main Effect Plot for MRR

It can be seen from Graph 3 that Feed has a huge impact on MRR value. Feed and depth of cut at high level yields high MRR value. The graph shows the specific trends for spindle speed i.e. increase in the values results in increase of MRR value. But the rate of increase of MRR for feed is higher than that for spindle speed.

For MRR data, the residuals generally appear to follow the straight line. Therefore, the given design is well balanced and no evidence of non-normality, skewness, outliers or unidentified variables exists.

Graph 4 reveals that the residuals generally fall on a straight line, implying that the errors are normally distributed. This implies that the models proposed for the MRR are adequate and there is no reason to suspect any violation of the independence or constant variance assumption.



Graph 4. Residual Plots for MRR

4. Conclusions

In present work, experimental investigation has been reported on Cylindrical Grinding process of OHNS φ25X 120mm (Hardened to 60 HRc). Response surface methodology (RSM) has been utilized to investigate the influence of three important parameters Work Speed, Depth of cut and Feed rate on two responses namely Surface Roughness (Ra)and Material Removal Rate (MRR). The analysis of experimental work is performed using MINITAB 14 statistical software. The important conclusions from the present research work are summarized as follows.

- From statistical analysis, it is clear that the feed rate and depth of cut have significant effects on Surface Roughness and MRR values.
- When Depth of cut and Spindle speed is increased the MRR is increased and the grits become dull. The dull grits led to raised grinding force and effect the geometry of work surface. Such conditions present excessive heating of surface, burn marks and may be small cracks.
- It is possible to predict the Surface Roughness and material removal rate before conducing grinding process.

References

[1] M. Melwin Jagadeesh Sridhar, M. Manickam and V. Kalaiyarasan, “Optimization of Cylindrical Grinding Process Parameters of OHNS Steel (AISI 0-1) Rounds Using Design of Experiments Concept”, International Journal of Engineering Trends and Technology, Volume 17, pp 109-114, Nov. 2014

[2] K Mekala, J Chandradas, K Chandrasekaran, T T M Kannan, E Ramesh and R NarasingBabu, “Optimization Of Cylindrical Grinding Parameters Of Austenitic Stainless Steel”, International Journal of Mechanical Engineering and Robotic Research(IJMERR), pp 208-215, 2014

[3] M. Ganesan, S. Karthikeyan& N. Karthikeyan, “Prediction and Optimization of Cylindrical Grinding Parameters for Surface Roughness Using Taguchi Method”, IOSR Journal of Mechanical and Civil Engineering, pp 39-46, 2014

[4] Taranveer Singh, KhushdeepGoyal, Parlad Kumar, “To Study the Effect of Process Parameters for Minimum Surface Roughness of Cylindrical Grinded AISI 1045 Steel”, Manufacturing Science and Technology, pp 56-61, 2014

[5] Suleyman Ne1eli,_Dlhan Asilturk and LeventCelik, “Determining the optimum process parameter for grinding operations using robust process”, Journal of Mechanical Science and Technology, pp 3587- 3595, 2012

[6] M.A. Kamely, S.M. Kamil, and C.W. Chong, “Mathematical Modeling of Surface Roughness in Surface Grinding Operation”, World Academy of Science, Engineering and Technology, pp 824- 827, 2011

[7] Lijohn P George, K Varughese Job and I M Chandran, “Study of Surface Roughness and its Prediction in Cylindrical Grinding Process based on Taguchi Method of Optimization”, International Journal of Scientific and Research Publications, pp 1-5, 2013

[8] Sandeep Kumar and Onkar Singh Bhatia, “Review of Analysis & Optimization of Cylindrical Grinding Process Parameters on Material Removal Rate of En15AM Steel”, PP 35-43, 2015

[9] Jae-SeobKwak, Sung-Bo Sim, Yeong-DeugJeong, “An analysis of grinding power and Surface Roughness in external cylindrical grinding of hardened SCM440 steel using the response surface method”, International Journal of Machine Tools & Manufacture, pp 304- 312, 2006

[10] G. F. Li, “Multi-parameter optimization and control of the cylindrical grinding process”, Journal of Mechanical Science and Technology, pp 232-236, 2002

[11] Jun Qian, Wei Li, Hitoshi Ohmori, “Cylindrical grinding of bearing steel with electrolytic in-process dressing”, Precision Engineering, pp 153–159, 2000

[12] Hemant S. Yadav and Shrivastav, “Effect of Process Parameters on Surface Roughness and Mrr in Cylindrical Grinding using Response Surface Method”, International Journal of Engineering Research & Technology, pp 1384-1388, 2014

[13] I.S. Jawahir, E. Brinksmeier, R. M. Saoubi, D.K. Aspinwall, J.C. Outeiro, D. Meyer, D. Umbrella, A.D. Jayal, “Surface integrity in material removal processes: Recent advances”, CIRP Annals - Manufacturing Technology, 60 (2011) 603–626

[14] T. Tawakoli, A. Rasifard, M. Rabiey, “High-efficiency internal cylindrical grinding with a new kinematic”, International Journal of Machine Tools & Manufacture, 47 (2007) 729–733

[15] M.Janardhan and Gopal Krishna, “Determination And Optimization Of Cylindrical Grinding Process Parameters Using Taguchi Method And Regression Analysis”, International Journal of Engineering Science and Technology, 2011

[16] H. Saglam, “An experimental investigation as to the effect of cutting parameters on roundness error and Surface Roughness in cylindrical grinding”, International Journal of Production Research, 2005