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An Analysis of Surface Roughness and Material Removal Rate in Cylindrical Grinding of Hardened OHNS using Response Suface Method

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***Abstract* - Cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. Surface finish is the important output responses in the production with respect to quantity and quality respectively.**

The aim of this analysis was to study the effect of the cylindrical grinding parameters: work speed, feed and number of passes on surface roughness and material removal rate during the grinding of hardened OHNS material. The depth of cut and work speed was kept constant. The experiment was carried out on Schleif SA 5/2 U. OHNS is an important material mainly used for making wear resistant products such as dies, punches, measuring tools and spline gauges.

Keywords - Cylindrical grinding, MRR, Surface finish, ANOVA, Response surface methodology (RSM).

1. INTRODUCTION

With the rapidly growing trends in developing and deploying advanced processing technologies, manufactured components / products are expected to demonstrate superior quality and enhanced functional performance. Material removal processes continue to dominate among all manufacturing processes. The functional performance of components from material removal processes is heavily influenced by the quality and reliability of the surfaces produced. [1]

In modern industry the goal is to manufacture low cost, high quality products in short lime. Automated and flexible manufacturing systems are employed for that purpose along with computerized numerical control (CNC) machines that are capable of achieving high accuracy and very low processing lime. Surface roughness is a measure of the technological quality of a product that greatly influences the manufacturing cost. It describes the geometry of the machined surfaces and combined with the surface texture. The mechanism behind the formation of surface roughness is very complicated and process dependent. [2]

In machining operations, the quality of surface finish is an important factor in evaluating the productivity of machined parts. Grinding processes are used to smooth or improve surface finish quality. Cylindrical grinding is a complex, material removal process with a great number of influencing factors, which are non-linear, interdependent and difficult to quantify. To maximize the surface quality, the selection of grinding parameters is vital, surface roughness is chiefly affected by the selection of grinding parameters. [3]

A lot of attempts have been made to describe more effectively and adequately the grinding process. This is dissimilar to other machining processes, as the cutting edges of the grinding wheel don't have uniformity and act differently on the workpiece at each grinding. In spite of these attempts describing the grinding action between the grinding wheel and the workpiece has not been made clear. So statistical models and computer simulations that could deal with the variety of the cutting edges were introduced. These complexities and difficulties of illustrating the grinding process also raise obstacles to the optimization of the grinding process and to the verification of the interrelationship between grinding parameters and outcomes of the process. [4]

In the present work, the work speed, feed, and number of passes were selected as the input parameters. Wheel speed and depth of cut was kept constant. The effect of these parameters on surface roughness (Ra) and material removal rate (MRR) was analyzed to reach an optimum level.

2. EXPERIMENTAL PROCEDURE

A. Workpiece material

The experiment was carried out on OHNS rounds of 25 mm diameter and 120 mm length. The OHNS material was selected keeping in mind the application of this material for manufacturing of slpine gauges which are largely used by the automotive industries. Thus after the cylindrical grinding the surface finish required is of much importance.

The raw OHNS bar was of 28 mm diameter which was turned hardened to 60 Rc. The chemical composition of OHNS is shown in table 1.

Sr. No.	Chemical composition in Percentage	
1	C	0.94
2	Mn	1.30
3	Cr	0.41
4	Ni	0.23
5	Mo	0.03
6	W	0.42
7	S	0.055
8	P	0.045
9	Si	0.38

Table 1

The figure 1 shows the work pieces before grinding was carried out.

Figure 1

B. *Machine specifications*

The experiment was carried out on Schleif SA 5/2 U cylindrical grinding machine as shown in the figure 2. The grinding wheel specifications are 300 mm X 127 mm X 40 mm Al_2O_3.

Figure 2

C. *Measurements*

The surface roughness value was measured on Taylor Hobson surtronic 3 for 0.8 mm of cut off length over a length of 4 mm normal to grinding surface as shown in figure 3.

MRR is calculated by taking the difference in the weights of the work piece, before and after grinding, and dividing by the time required for machining the work piece.

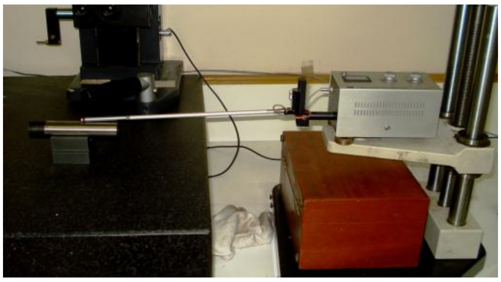


Figure 3

3. EXPERIMENTAL CONDITIONS

The values of the parameters for carrying the analysis are as shown in table 2.

Parameter	Low	High	Unit
Feed	2	5	m/min
Speed	250	350	RPM
No. of passes	4	8	---

Table 2

The work speed was kept constant to 1430 RPM and the depth of cut was 12.5 µm. Table 3 shows the experimental design matrix obtained by response surface methodology by using Minitab 14 software.

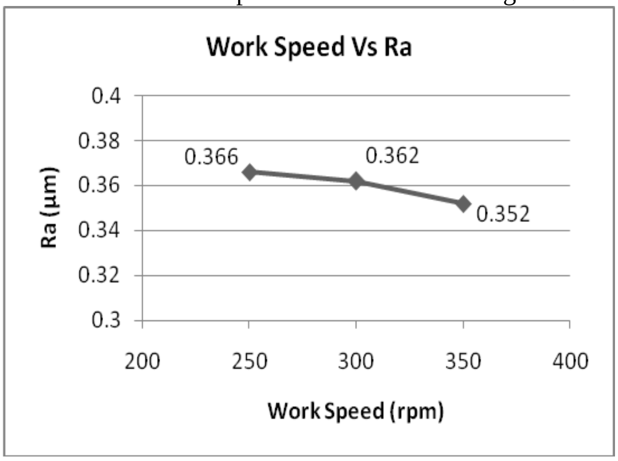
Run Order	Work Speed	Feed	No of Pass	Ra	MRR
1	300	3.5	4	0.38	0.23
2	350	3.5	6	0.35	0.40
3	300	2	6	0.33	0.22
4	300	3.5	6	0.35	0.35
5	300	3.5	6	0.37	0.33
6	250	5	8	0.37	0.37
7	250	3.5	6	0.35	0.33
8	300	3.5	6	0.35	0.37
9	350	2	4	0.33	0.17
10	350	5	8	0.36	0.37
11	250	2	8	0.35	0.20
12	250	5	4	0.41	0.22
13	350	5	4	0.39	0.33
14	300	3.5	8	0.37	0.46
15	300	3.5	6	0.35	0.30
16	300	3.5	6	0.35	0.33
17	250	2	4	0.35	0.10
18	300	3.5	6	0.35	0.31
19	350	2	8	0.33	0.26
20	300	5	6	0.35	0.33

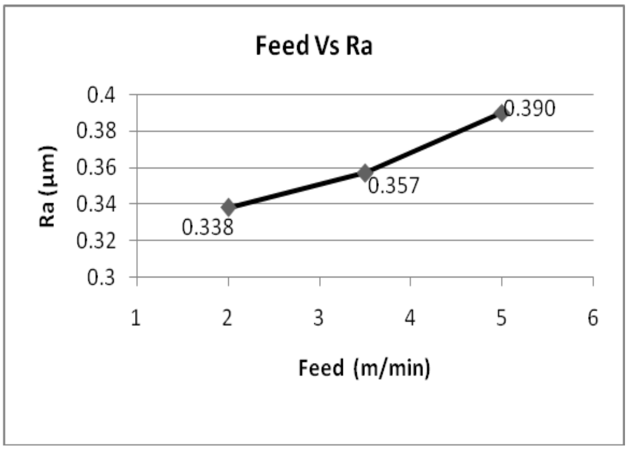
TABLE 3

Figure 4. Grinding of OHNS material

4. RESULTS

The main effects plot for Ra is shown in figure 5.





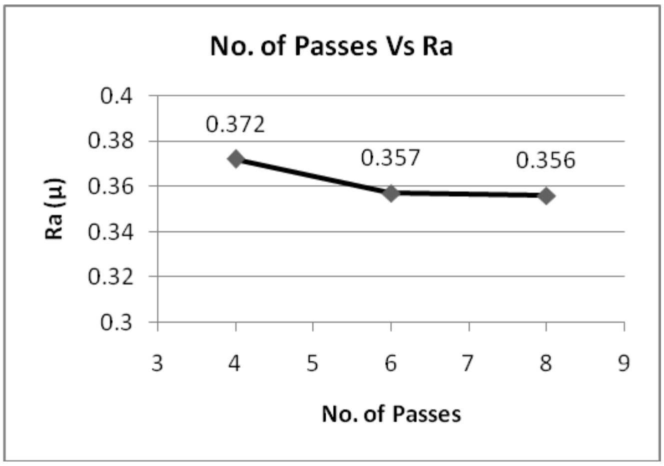
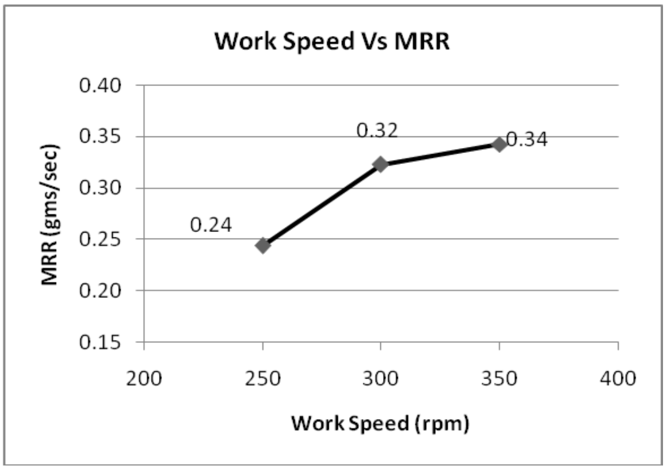


Figure 5

It is clear from the above graphs that as the speed increases from 300 to 350 RPM the value of Ra decreases from 0.362 to 0.352 µm. Though the increase in the feed increases the Ra value from 0.357 to 0.39 µm. The Ra value decreases from 0.357 to 0.356 as the number of passes increases from 6 to 8, but as from the trend of the graph it can be concluded that even if the number of passes is increased beyond 8 there should not be much changes seen in the Ra value. Thus with a low feed value and high work speed with 6 number of passes we can obtain a Ra value in the range of 0.35 to 0.36 µm.

The main effects plot for Ra is shown in figure 6.



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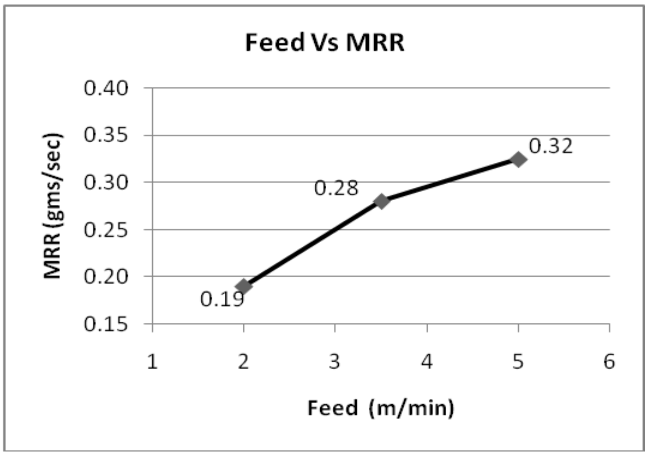

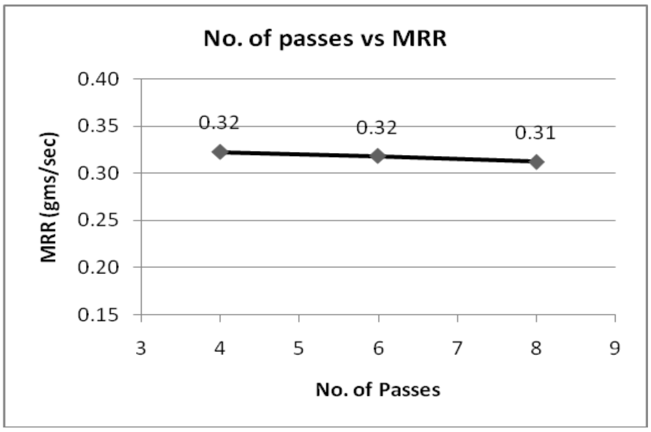

Figure 6

Thus from the figure 6 the increase in feed will give the higher value of MRR. As surface roughness is the most important response in cylindrical grinding to obtain the Ra between 0.35 to 0.36 the MRR we can get will be in the range of 0.2 to 0.3 gms/sec. Thus the increase in work speed results in better value of Ra with higher MRR rate of 0.34 gms/sec.

4. CONCLUSION

After conducting the experiment on OHNS rounds the following conclusions can be made:

1. Work speed and number of pass are the most effecting parameters for surface finish. Whereas feed plays an important role in deciding the MRR.
2. To obtain the surface finish of 0.35 to 0.36 µm the work speed can be kept in the range of 300 to 350 rpm with 6 numbers of passes and feed of 2 m/min.
3. For the above parameters the MRR can be obtained in the range of 0.3 to 0.32 gms/sec.
4. OHNS shows a good surface finish during cylindrical grinding with optimum process parameters.

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