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Influence of Machining Parameters on the Surface Finish during Surface Grinding

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ABSTRACT: Surface grinding is one of the complex processes to obtain a good surface finish. The objective of this work is to study the effect of the machining parameters on the quality of surface finish obtained during a surface grinding process. The machining parameters considered are the grinding wheel type, hardness of the workpiece and the depth of cut which influence the quality of surface finish. The material chosen for this work is Hardening Non Shrinking (OHNS) Die Steel. Experiments were conducted by varying the machining parameters and measuring the corresponding outputs i.e., Vibrations of the spindle bearing along 3 axes, surface roughness of the specimen and the temperature at the tool work piece interface. Using ANOVA, the influence of the grinding wheel type, material hardness and the depth of cut on the surface roughness was analysed. The analysis showed that the material hardness has the most significant influence on the surface finish. The surface roughness showed increase in values at 30 HRC and 40 HRC and from 40 HRC to 50 HRC, the surface roughness decreased. The justification for the above behaviour requires further in depth analysis of the process.

KEYWORDS: Surface Grinding, Surface Roughness, OHNS Steel, Depth of Cut, ANOVA, Hardness, Grinding wheel grit size

I. INTRODUCTION

Grinding is one of the most common machining processes that currently runs in the industry and surface grinding is the preferred method for producing flat surfaces of good finish. Obtaining the best possible surface finish is of utmost importance in the industry as it decides the final quality of the work piece and in turn leads to customer satisfaction. The degree of surface finish obtained depends on a host of factors or input parameters that need to be controlled in order to produce required surface finish. These factors include feed, speed, depth of cut, material type, grinding wheel type and grinding wheel material. These factors can be controlled based on the surface finish required for the finished component. A rough surface requirement might require cutting conditions varying from that of a smooth finished surface. There have been several studies conducted to study the effect of such vibrations by changing input parameters.

II. LITERATURE SURVEY

Experimentation in the field have concluded that for three parameters such as speed, depth of cut and grit size, the most significant factor is the wheel speed, followed by grit size and depth of cut for grinding of Stainless Steel. [1]. Work has also been carried out experiments with the input parameters such as speed, depth of cut, wheel grit size and table speed to come to a conclusion that speed has the most significant effect on the surface roughness of the work piece. [2]. Another similar experiment carried out which suggested that the depth of cut contributes most to the surface roughness at 50% while the speed and the feed contribute 40 % and 10 % respectively. [3]. In the present work the statistical method of analysing the data, has been based on Design of Experiments as suggested by one of the research papers. [4]. The process parameters that were taken up for another study were grinding wheel (cutting tool) abrasive grit size, depth of cut by the machine tool and feed rate. Thirteen experiments were conducted in order to obtain the sufficient data post

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Vol. 6, Issue 6, June 2017

which the surface roughness values were entered into the Design Expert Software to obtain the optimal solution. The concluded optimal values were grit size of 60 mesh, depth of cut of 0.05mm, and feed rate of 0.5mm from Taguchi while a grain size of mesh 54, depth of cut of 0.05 and feed of 0.45mm by using response surface methodology. This study also showed that RSM is better than Taguchi when the input parameters are varied within the selected levels. [5]. Experiments were carried out similar to that of the work done previously wherein optimization of the surface grinding parameters for optimal surface roughness in AISI 1080 steel was carried out. The surface roughness was determined by the use of a Surface roughness tester. This results shows that the depth of cut has a significant effect on surface quality whereas the feed has a mediocre effect on surface quality. While the dressing depth of cut has a very low effect on surface quality. The optimum grinding parameter combination for the AISI 1080 steel from the calculations that carried out were, depth of cut per pass of 0.10 mm, feed rate of 0.20 mm and dressing depth of cut of 0.01 mm. [6]. The effect of abrasive tools on the surface of EN24 steel was studied through experimentation by using three input parameters namely the speed of the grinding wheel, speed of the table and the depth of cut. Post experimentation, it was concluded that the error between experimental and theoretical values at the optimal parameter condition for Material Removal Rate and Surface Roughness (Ra) lie within roughly 4.96% and 4.30%, respectively. Also, it was determined that, the optimal parameter conditions for wheel speed was 850RPM, Table speed was 15m/min and Depth of cut was 11.94 μ m for maximum Material Removal Rate and minimal surface roughness. [7].

III. EXPERIMENTAL DETAILS

The study takes into account 3 parameters that are considered significant in the process of surface grinding i.e. grinding wheel grit size, the hardness of the work piece and the depth of cut per pass. Oil Hardening Non Shrinking (OHNS) Steel is one of the most widely used steels for making dies and in similar applications. Die manufacturing is a field of multiple requirements where in different types of dies require different surface finishes. This work has been carried out to study the effect of machining parameters on the surface finish of the specimen. A total of 27 experiments have been carried out with varying grinding wheel type, depth of cut and material hardness. A constant speed surface grinder from Perfect Union has been used for this project. Surface roughness was measured using a Talysurf of Mitutoyo make on each of these specimens. The process variables, levels and the number of experiments have been decided by the Design of Experiments and the N- Factorial Method.



Fig 1. The surface grinding process

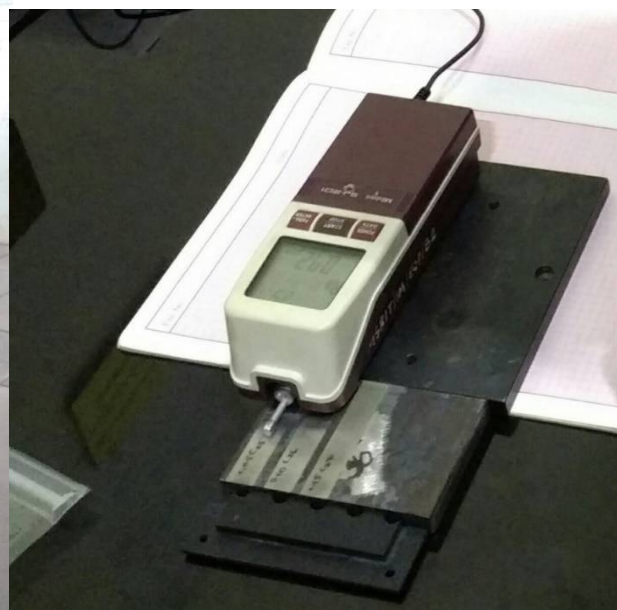


Fig 2. The Mitutoyo Surface roughness tester

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

The experiments are carried out using a surface grinder from Perfect Union shown in Fig 1. It consists of an accelerometer mounted on the spindle bearing connected to a Fast Fourier Transform (FFT) analyser and a computer with the corresponding analysis software installed. The vibrations are picked up by the accelerometer and are converted to human readable signals by the software. The specimens are then subjected to the surface roughness test using the Talysurf shown in Fig 2. The results are then tabulated corresponding to their cutting condition.

In the present work, the following steps were undertaken:

- Selection of the material of the specimen and also the machine tool to be used for the experiments.
- Fabrication of the mounting stud for the accelerometer.
- Selection of machining parameters suitable of the machine chosen.
- Design of Experiments for conducting experiments.
- Equipment set up for measuring and the experiments are carried out in the predetermined order post which each of the specimens are subjected to the surface roughness test. The test is carried out on 3 points for each specimen and the average of the surface roughness is considered for each. The Talysurf used in this case is the Mitutoyo J 201 Model. The values of the average surface roughness are tabulated along with the process parameters and are subjected to ANOVA to determine the most significant parameter.

The tables 1-3 give the details of the Grinding Machine used, chemical composition of the material used in the study and the type of grinding wheel used.

Table 1. Description of Grinding Machine

Sl. No.	Description	Specification
1.	Working area	460x200mm
2.	Vertical Feed Least Count	0.005mm
3.	Cross Feed Least Count	0.03mm
4.	Spindle Speed	2800 rpm (Single speed)
5.	Grinding wheel (mm)	150mm
6.	Electric Motor	1 HP
8.	Chuck	Magnetic

Table 2. Material Composition of OHNS Steel

Sl. No.	Chemical Composition (%)	OHNS Steel 01
1.	0.95	Carbon, C
2.	1.0	Manganese, Mn
3.	0.5	Chromium, Cr
4.	0.5	Tungsten, W
5.	0.10	Vanadium, V
6.	Remaining	Iron, Fe

Table 3. Wheel Parameters

Sl. No.	Detail	Description	Specification
1.	Material	Aluminium Oxide	A
2.	Dimensions	Diameter x Width x Bore (mm)	150x13x31.75mm
3.	Bond	V8	Vitrified
4.	Shape	1	Straight
5.	Grade Size	K	Medium
6.	Structure	5	Dense

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 6, June 2017

Table 4 below lists the details of the combinations of input parameters which are grinding wheel type, hardness of the material and depth of cut.

Table 4. Input parameters and its variations

Level	Grinding wheel type	OHNS Material Hardness (HRC)	Depth of Cut (mm)
1.	46	30	0.05
2.	60	40	0.10
3.	120	50	0.15

IV. RESULTS AND DISCUSSION

A total of 27 experiments were carried out in the order based on the Full Factorial Design of Experiments as shown in Table 6 and the average surface roughness values of each of the specimens were determined using the Talysurf corresponding to their respective cutting condition. Graphs were generated for the variation of this surface roughness for each condition based on the Analysis of Variance carried out and were discussed. From the ANOVA Table shown in Table 5, it is observed that the value of maximum “F” Value and minimum “p” value corresponds to the most significant parameter. In this case, it corresponds to the Hardness of the specimen. The next most significant parameter is the depth of cut per pass followed by the grinding wheel grit size.

Table 5. ANOVA Table for the process

Factor	ANOVA 3 3-level factors, 1 Blocks, 27 Runs; SR				
	SS	df	MS	F	p
(1)GW L+Q	0.207767	2	0.103883	1.006009	0.386435
(2)HRC L+Q	0.286223	2	0.143111	1.385893	0.276966
(3)DOC L+Q	0.255613	2	0.127806	1.237679	0.314912
1*2	0.000000	1	0.000000	0.000003	0.998682
1*3	0.035339	1	0.035339	0.342223	0.566233
2*3	0.074026	1	0.074026	0.716864	0.408936
Error	1.755470	17	0.103263		
Total SS	2.647499	26			

Table 6. Full Factorial Design of Experiment

Sl. No.	Grinding Wheel (Grade)	Material Hardness (HRC)	Depth of Cut (mm)
1	46	30	0.05
2	46	30	0.10
3	46	30	0.15
4	46	40	0.05
5	46	40	0.10

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

6	46	40	0.15
7	46	50	0.05
8	46	50	0.10
9	46	50	0.15
10	60	30	0.05
11	60	30	0.10
12	60	30	0.15
13	60	40	0.05
14	60	40	0.10
15	60	40	0.15
16	60	50	0.05
17	60	50	0.10
18	60	50	0.15
19	120	30	0.05
20	120	30	0.10
21	120	30	0.15
22	120	40	0.05
23	120	40	0.10
24	120	40	0.15
25	120	50	0.05
26	120	50	0.10
27	120	50	0.15

Surface plots were generated to study the variation of the surface roughness of the specimen with respect to the change in hardness as well as the other two input parameters. A total of 6 surface plots were generated and were studied as shown below.

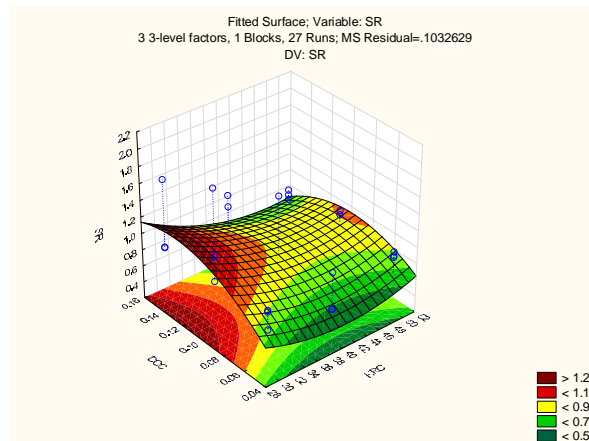


Fig. 3 Variation of surface roughness with change in depth of cut and hardness of the specimen with wheel grit size 46

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 6, June 2017

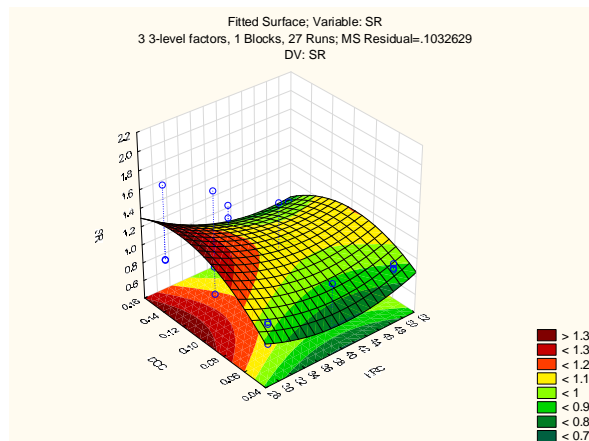


Fig. 4 Variation of surface roughness with change in depth of cut and hardness of the specimen with wheel grit size 60

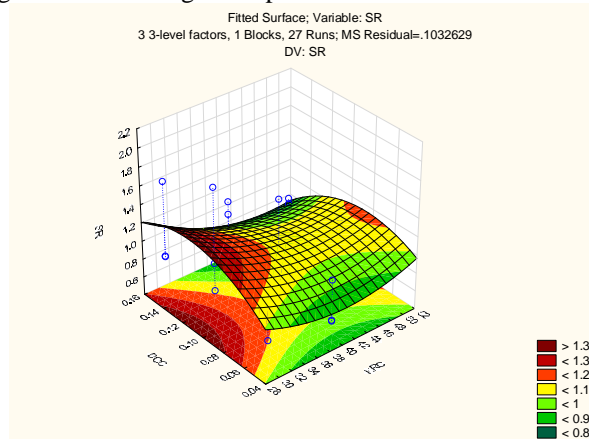


Fig. 5 Variation of surface roughness with change in depth of cut and hardness of the specimen with wheel grit size 120

It is observed from the above plots that as the hardness increases, the surface roughness shows an initial decrease up till a hardness of 40 HRC post which it tends to show a gradual increase. The region of maximum surface roughness is at the condition of lower hardness but maximum depth of cut. This may be due to the fact that an increased depth of cut can result in more friction and cutting forces which can reduce the surface quality. The region of least surface roughness is in the region of hardness 40 HRC and least depth of cut at 0.05mm. This is due to the proper cutting taking place at optimal depth of cut that prevents unwanted cutting forces or friction. The surface plots generated below show the variation of surface roughness with change in hardness and grit size.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

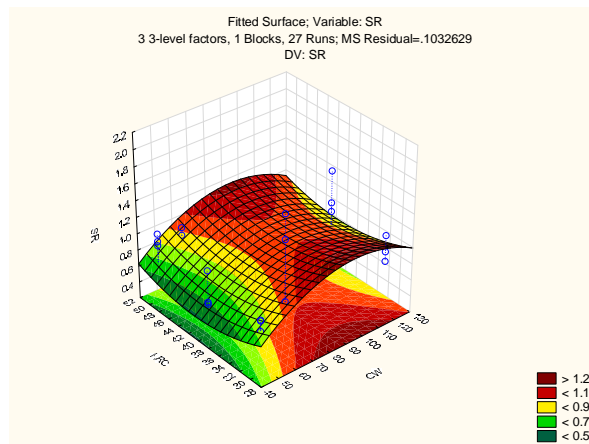


Fig. 6 Variation of surface roughness with change in grit size and specimen hardness with depth of cut at 0.05mm

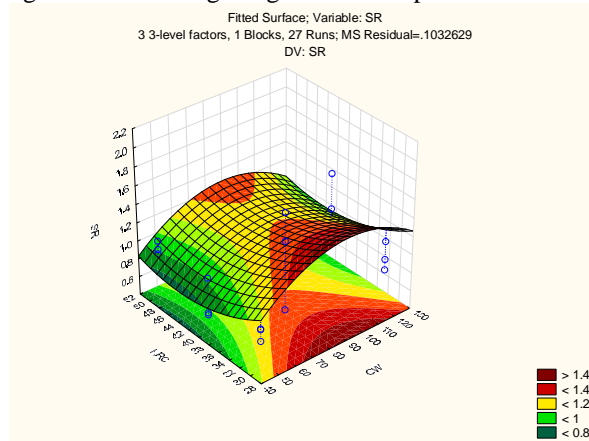


Fig. 7 Variation of surface roughness with change in grit size and specimen hardness with depth of cut at 0.10mm

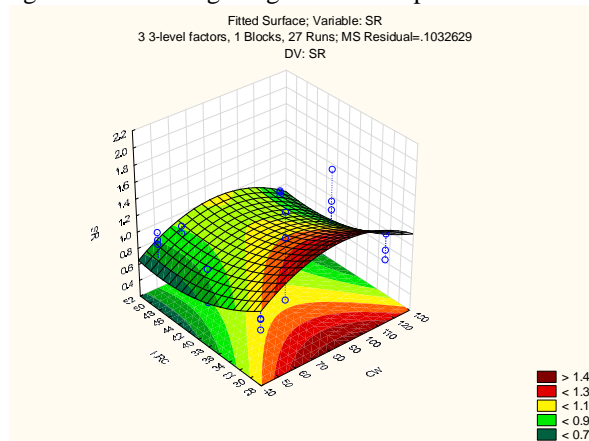


Fig. 8 Variation of surface roughness with change in grit size and specimen hardness with depth of cut at 0.15mm

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 6, June 2017

The surface roughness tends to show a dip as the hardness increases and then shows an increase. This variation is seen for a constant value of grit size. This may be due to the fact that the optimal hardness for the material to achieve minimal surface roughness must be in the region of 40 HRC where it dips. The region of highest surface roughness recorded in this surface plot is higher than the previous plot due to the increased depth of cut. The minimum is recorded at values of higher hardness.

V. CONCLUSION

The work was conducted considering the Design of Experiments where in 27 experiments were carried out. The input parameters considered were the depth of cut, grinding wheel grit size and the material hardness. From the analysis carried out using ANOVA it was concluded that the hardness of the material is the most significant parameter. The depth of cut forms the next parameter with most influence followed by the grinding wheel grit size. There are a lot of stresses produced when the grinding wheel comes in contact with the work piece. Harder materials result in greater stresses being built up. Depth of cuts also cause a fairly significant effect on the surface roughness. Very low depths of cut can result in ploughing and less of cutting action where as too high a depth of cut can lead to fracture and breakage of the grains. Such conditions are also not desirable. Studies such as the above and similar to them are very significant as they help in creating a solid relationship between the dependent and independent factors in the process of Surface Grinding. It is also helpful in increasing the efficiency of the process and can be implemented in semi automation, both of which help in increasing productivity in the shop floor.

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