International Journal of Engineering Research and General Science Volume 3, Issue 6, November-December, 2015
ISSN 2091-2730

Effect of Varying Surface Grinding Parameters on the Surface Roughness of Stainless Steel

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Abstract— Surface grinding is a very complex process to control yet it has very significant role in controlling the performance of the equipments and machine tools. Thus it is very important to analyse the process parameters by performing experiments. This is the purpose my research work in which I have tried to analyse the effect of varying surface grinding parameters on the surface roughness of Stainless Steel using white aluminium oxide grinding wheels. The main input parameters taken into consideration in this study are depth of cut, wheel speed and wheel grain size. Results are tabulated and plotted in form of comparison graphs for ease of analysis.

Keywords— Surface grinding, Surface roughness, Stainless steel, Grinding parameters, Grain size, Depth of cut, Wheel speed.

INTRODUCTION

Surface grinding is a material removal process that involves the interaction of abrasive grits with the workpiece at high cutting speeds and shallow penetration depths. The properties and grain size of these abrasive particles determine the performance of grinding operation. Each individual and irregularly shaped grain acts as a cutting element (single point cutting tool) in every grinding process. It is a mixture of cutting, plowing, and rubbing, with the percentage of each being highly dependent on the geometry of the grit. Surface grinding machines are used primarily to grind flat surfaces as in our analysis. It is a complex process to control because of a number of input parameters required to achieve the desired output of the operation. Most significant desired output parameter in surface grinding is the surface finish followed by other parameters like material removal rate, surface hardness, etc. Many input parameters like abrasive type, grain size, infeed, depth of cut, work speed, coolant used, etc control the surface finish of workpiece. Therefore a analysis is required to study the effect of input parameters on surface finish of various materials in surface grinding operation.

A number of studies have already been done to study the effects of input parameter in grinding process. Vishal Francis et. al. [1], stated that if feed and depth of cut were varied and spindle speed was kept constant to observe their effect on surface roughness then feed rate was found to be the most significant factor in case of cast iron and none of the factor was found be significant for mild steel and stainless steel. H. Adibi et. al. [2], stated that the amount of loading over the wheel surface increases sturdily with increasing depth of cut but is less affected by changes of table speed. Kirankumar R. Jagtap et. al. [3], Stated that the most influencing parameter to surface roughness for AISI 1040 is work speed (Nw) in rpm followed by depth of cut, grinding wheel speed and number of passes. Shih et. al. [6] proposed that, increasing the grinding wheel speed reduces the average chip thickness and increase the effective hardness of the wheel, resulting in more efficient workpiece material removal rates when the workpiece material is ceramic or steel. Hassui et. al. [8], proposed that, the wear of a grinding wheel has a direct effect on the workpiece vibration and both have effect on the workpiece quality. Nathan et al [9], proposed that, in the grinding process, a proper estimate of the life of the grinding wheel is very useful. When this life expires, redressing is necessary. Hardened C60 steel (Rc 40) specimens were ground with an A463–K5–V10 wheel in a cylindrical grinding machine. The results revealed that the surface quality and in service behaviour of a ground component is affected seriously by the occurrence of grinding burn.

METHODOLOGY

This research takes into account the effect of mainly three process parameters of Surface grinding process i.e. Wheel Speed (rpm), Wheel Grain size and Depth of cut on Surface Roughness with reference to Mild Steel, Die Steel and Stainless Steel as workpiece material. All other process parameters of surface grinding operation are kept constant. Stainless steel is widely used in industry machinery, precision tools, automobiles and household products and these applications require different part surface finish values in order to achieve maximum performance and working life period. Therefore this analysis is done to study the effect of input parameters on surface finish of stainless steel in surface grinding operation. A horizontal spindle and reciprocating table type Surface grinder, White Aluminium Oxide grinding wheels and an average table speed (up grinding) of 0.15 m/s is used throughout the experiment. Synthetic soluble oil (oil to water ratio of 1:25) is used as cutting oil. Material plates are cut into required number of small specimens using Power hacksaw and Chop saw. A Variable frequency drive is used to vary the rpm (wheel speed) of the grinding wheel to three different values. A total of 27 experiments are done on each material by varying wheel grain size, wheel speed (rpm) and depth of cut. Separate mild steel plates of thickness thinner than workpiece specimen are used to hold small workpiece specimen tightly, for stainless steel because of its non ferrous nature. Later surface roughness of each specimen is checked using Mitutoyo Surface roughness tester with cut-off length as 0.25cm. Stainless steel specimen approx. size taken for experiment is 30 x 20 x 6 mm (Length x

Width x Thickness) and material composition is given in Table 3. Process variables and their levels and number of experiments required is formed using N-factorial method as shown in Table 4.

Table 1: Machine Description

Sr. No.	Type	Specification
1.	Working area of grinder	225 x 400 mm
2.	Maximum height under wheel	250mm
3.	Vertical feed graduation	0.01 mm
4.	Cross feed graduation	0.05 mm
5.	Maximum spindle speed	2800 rpm
6.	Grinding wheel size (dia x bore x width) (mm)	178 x 31.75 x 13
7.	Electric Motor	1HP 3 Phase (2800rpm)
8.	Magnetic chuck	200 x 300 mm
9.	Dresser with holder	1 CR

Table 2: Wheel Parameters

Sr. No.	Type	Specification	Description
1.	Wheel Material	A	Aluminium Oxide (White)
2.	Grade	K	Medium
3.	Structure	5	Dense
4.	Binder	V8	Vitrified
5.	Shape	1	Straight
6.	Dimensions	Dia x Bore x Width (mm)	150 x 31.75 x 13

Table 3: Material Composition

Chemical Composition (%)	Stainless Steel T304
Carbon, C	0.08
Silicon, Si	1 Max.
Manganese, Mn	2 Max.
Phosphorus, P	0.045 Max.
Nickel, Ni	8 – 10.5
Sulphur, S	0.03 Max.
Chromium, Cr	18 – 20
Iron, Fe	Remaining

Table 4: Process variables and their Levels

Levels	Grinding Wheel Grain Size	Grinding Wheel Speed (rpm)	Depth Of Cut (mm)
1	46	1300	0.01
2	60	2000	0.02
3	120	2700	0.03

RESULTS AND CONCLUSION

3.1 Experimental results: Surface roughness of all 27 specimens is measured using the Mitutoyo Surface Roughness tester and given in Table 5 below.

Table 5: Experimental results for Stainless steel

Exp. No.	Material	Grain Size	Wheel Speed	Depth Of Cut	Surface Roughness, Ra
			rpm	mm	µm
1	Stainless Steel	46	1300	0.01	0.177
2	Stainless Steel	46	1300	0.02	0.185
3	Stainless Steel	46	1300	0.03	0.219
4	Stainless Steel	46	2000	0.01	0.140
5	Stainless Steel	46	2000	0.02	0.142
6	Stainless Steel	46	2000	0.03	0.155
7	Stainless Steel	46	2700	0.01	0.128
8	Stainless Steel	46	2700	0.02	0.134
9	Stainless Steel	46	2700	0.03	0.144
10	Stainless Steel	60	1300	0.01	0.138
11	Stainless Steel	60	1300	0.02	0.107
12	Stainless Steel	60	1300	0.03	0.109
13	Stainless Steel	60	2000	0.01	0.099
14	Stainless Steel	60	2000	0.02	0.096
15	Stainless Steel	60	2000	0.03	0.103
16	Stainless Steel	60	2700	0.01	0.111
17	Stainless Steel	60	2700	0.02	0.092
18	Stainless Steel	60	2700	0.03	0.095
19	Stainless Steel	120	1300	0.01	0.147
20	Stainless Steel	120	1300	0.02	0.134
21	Stainless Steel	120	1300	0.03	0.100
22	Stainless Steel	120	2000	0.01	0.185
23	Stainless Steel	120	2000	0.02	0.175
24	Stainless Steel	120	2000	0.03	0.169
25	Stainless Steel	120	2700	0.01	0.206
26	Stainless Steel	120	2700	0.02	0.202
27	Stainless Steel	120	2700	0.03	0.153

ISSN 2091-2730

3.2 Graphs depicting the comparative results of effect of varying wheel grain size for a specific value of wheel speed on surface roughness of Stainless steel:

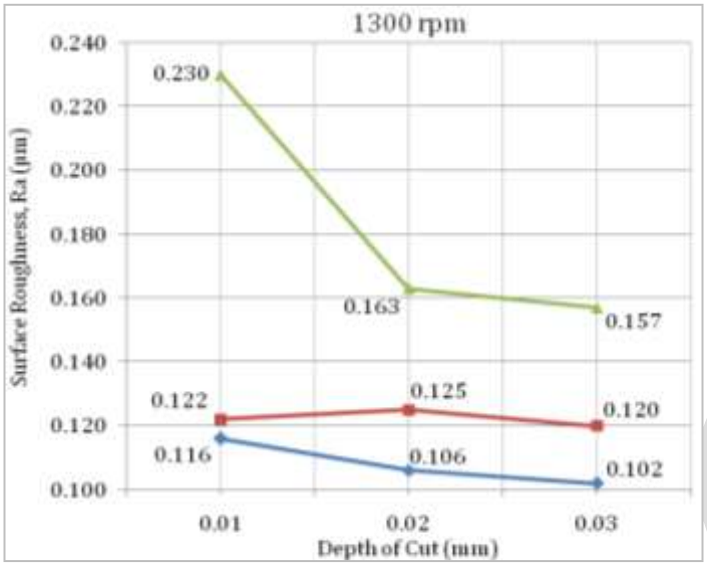


Fig 3.2(c)

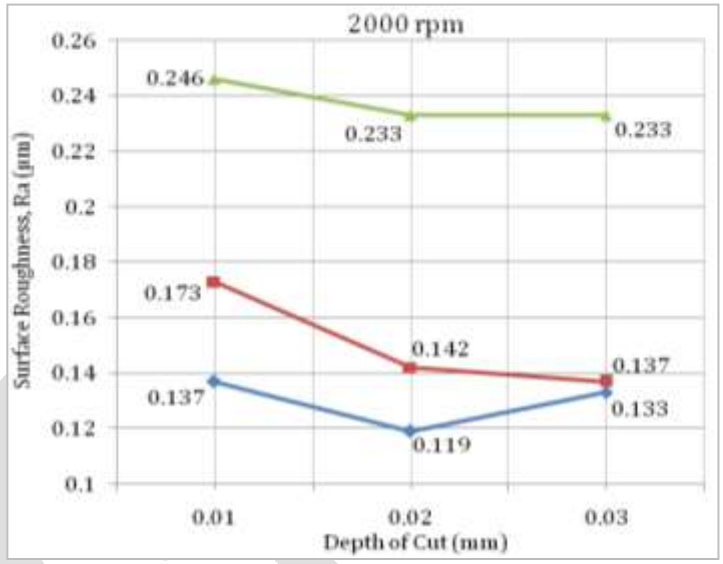
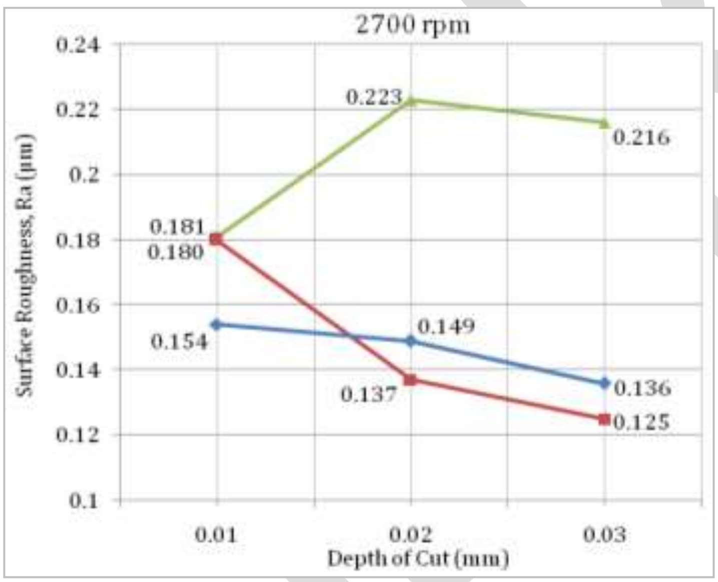
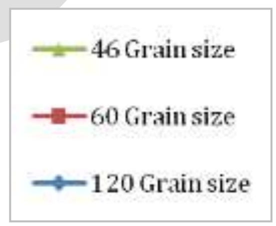


Fig 3.2(d)





Surface finish comparison:

Wheel Speed(rpm)	***Grain size***
1300	120 > 60 > 46
2000	120 > 60 > 46
2700	60 > 120 > 46

Surface finish of stainless steel decreases with increase in speed of Al_2O_3 wheels. On an average at every speed better surface finish is shown by grain size 120. Only at 2700 rpm, grain size 60 shows better finish as compared to 120 grain size. Surface finish varies largely with small grain size but less with large grain size wheel. Fig. 3.1d shows comparative results for surface finish.

3.3 Graphs depicting the comparative results of effect of varying wheel speed (rpm) for a specific value of wheel grain size on surface roughness of Stainless steel:

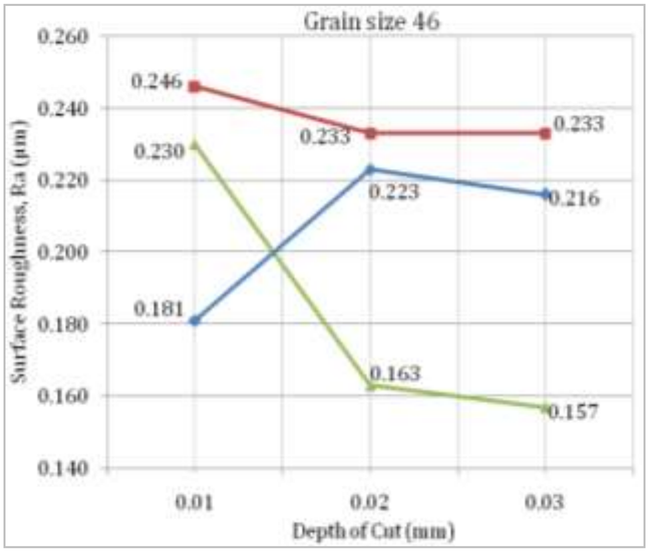


Fig. 3.3(c)

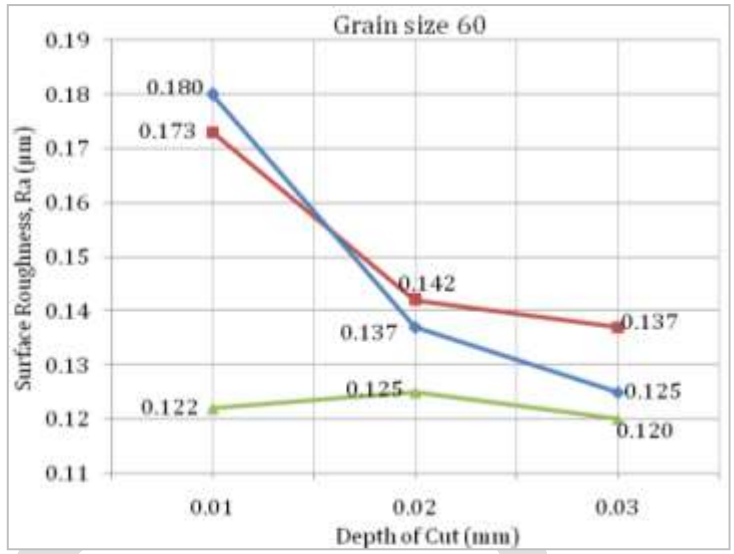
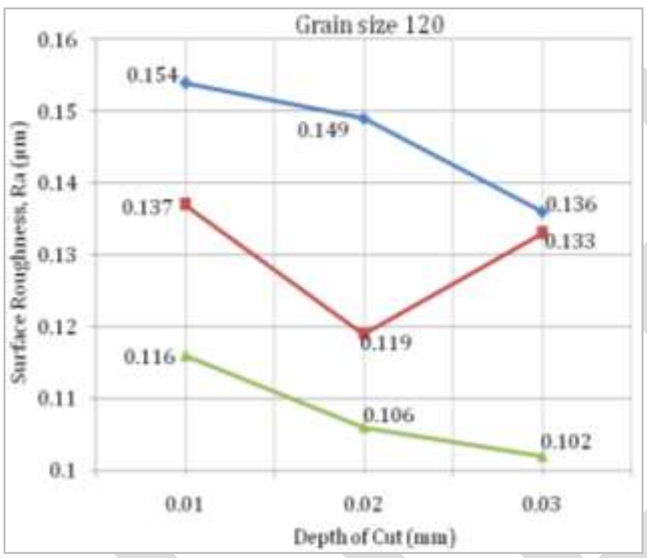


Fig. 3.3(d)



Surface finish comparison:

Grain size/ Depth of cut	***Wheel Speed(rpm)***
46 / 0.01	2700 > 1300 > 2000
46 / 0.02	1300 > 2700 > 2000
46 / 0.03	1300 > 2000 > 2700
60 / 0.01	1300 > 2000 > 2700
60 / 0.02	1300 > 2700 > 2000
60 / 0.03	1300 > 2700 > 2000
120/ 0.01	1300 > 2000 > 2700

Stainless Steel shows better surface finish at lower speeds of Al_2O_3 grinding wheels for almost every grain size at maximum depth of cut. The surface finish is increasing with increase in wheel grain size. Due to good surface toughness value of stainless steel, there is a lot of grain wear and fracture at high wheel speed. But at large depth of cut, the grains are able to shear the surface better thus allowing more cutting action. Fig. 3.1d shows comparative results for surface finish

CONCLUSION

Out of the three process parameters under study, most significant factor in surface grinding is wheel speed followed by grain size and depth of cut. Increasing wheel speed increases the tangential cutting force on material surface thus allowing more cutting and less of plowing and rubbing of grains. But this also increases stresses on Al_2O_3 wheel grains because of hardness and toughness of stainless steel, , thus leading to high grain wear and abnormal fracture. This reduces the cutting action and causes more of plowing and grain rubbing against the metal surface. As all grain size particles fail to provide better surface finish a high wheel speeds, it is clear that Al2O3 particles fail to grind stainless steel. Thus should not be used for grinding stainless steel.

With increase in depth of cut, there is a proportional increase in the normal pressure at the point of contact of wheel and workpiece. Very less depth of cut will lead to less cutting and more rubbing or plowing due to small shear pressure or good toughness value of material. Large depth of cut will also lead to less cutting and more rubbing or plowing due to more wear, abnormal fracture and completely break-off of wheel grains. Thus an optimum value needs to be determined depending upon material and machine/process parameters.

Considering all the results we can say that in order to achieve minimum surface roughness with Al_2O_3 wheel, we need to choose an optimum value of grain size and depth of cut and a higher wheel speed or lower wheel speed for a certain material. Materials with good machining ability show better surface finish with higher wheel speed and materials with high toughness show poor surface finish with increasing grain sizes.

Studies like these can help to create a relation between independent and dependent variables in surface grinding process thus reducing the errors in design and improving the overall efficiency of the process which can lead to increase in productivity.

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