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Effect of Machining Parameters on MRR and Surface Roughness in Internal Grinding using EN8, EN31 Steel

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Abstract

Internal Grinding is an approach to produce desired outcome with greater surface finish in metal cutting process. Unfortunately, external machining parameters play a vital role in research areas with numerous investigations. Considering this, present work focuses on the machining parameters on internal grinding process with necessary coolant oil as has been experimentally observed in our research laboratories. The literature survey predominantly states that the frequently used engineering material in automobile sectors to be EN range of steel and here we have chosen EN8 and EN31. The experimental work was carried out using these two materials in internal grinding machine. The various machining parameters such as cutting force, cutting speed, depth of cut were monitored to analyze the characteristics of outcome such as material removal rate (MRR), surface roughness and tool life. In addition to this, coolant lubrication also constitutes as a main part in improving surface quality and MRR. Surface roughness was measured using SE-1200 surface roughness tester and cutting force was measured using kistler cutting force dynamometer. Comparatively, it could be concluded that the EN31material produces minimum surface roughness 0.628µm in presence of synthetic oil used as cutting oil and also increases the tool life 669.7x10^6 seconds.

Keywords: Internal Grinding; EN8; EN31; Coolant Oil; MRR; Surface Roughness; Tool Life

INTRODUCTION

Grinding is one of the most important metal finishing processes. The abrasive grinding wheel rotates at a high speed to remove the material from the work piece. The materials of the grinding wheels are tempered hardened steel, silicon carbide, aluminum oxide [1, 2]. It is used to improve surface finish and produce close tolerance on flat and cylindrical surfaces by removing a small amount of material [3]. Mostly an abrasive material rubs against the metal part and removes tiny pieces of material. The removal of metal from the work piece is much faster than the one which was earlier done with single edge tools such as chisels. It is also used to sharpen the various cutting edges of cutting tools and sharp objects such as knives etc [4]. The surface roughness and material removal rate were identified as quality attributes and assumed to be directly related to performance of mechanical pieces, productivity and production cost for obtaining a desired machinability. The present article deals with the various input process parameters such as cutting force, Cutting speed and depth of cut, cutting oil [5, 6]. Study on the effect of dissolving a low concentration of TiO_2 nanoparticles in the mineral oil based lubricant, as well as on the overall performance of a window type air-conditioning system using R22 as working fluid was carried out [7, 8]. The nanoparticles that were used to produce nanofluid in the different earlier reviewed articles were Al_2O_3, Cu, copper oxide, gold, silver, silicon and particles and carbon nano tube [9, 10].

Internal grinding is a finishing process used to finish the previously drilled, reamed, or bored hole using small grinding wheels at high RPM. The various elements of an internal grinding machine are the work head used to hold the work and has its own drive and the wheel head, which is the internal grinding spindle. By using internal grinding, several different internal contours can be produced within a work piece [11]. In Internal grinding process, the CBN wheels are used which enables a high material removal rate along with a high surface quality [12]. The shape and dimension errors of the finished part are the main drawbacks due to high thermal load on the work piece [13, 14]. Internal grinding process has precise and narrow tolerance areas in both its size and form-shaping aspects [15]. Usually the specimen surface is offered in the shape of straight, tapered, grooved or profiled. The main objective of this paper is to show how our knowledge on grinding process can be utilized to predict the grinding behavior and achieve optimal operating processes parameters. Predictions from these experimental values were analyzed and calibrated with actual data. It mainly involves several variables such as cutting force, depth of cut, cutting speed etc. The main objective in any machining process is to maximize the metal removal rate and to minimize the surface roughness.

EXPERIMENTAL SECTION

A. Specimen used

In concern with numerous applications in automobile sector and literature survey experiment was carried against EN range of steel such as EN8 and EN31. The schematic picture, Figure 1 shows, the dimensions of machined component which was considered for internal grinding process and the composition of each one are depicted in Table 1.

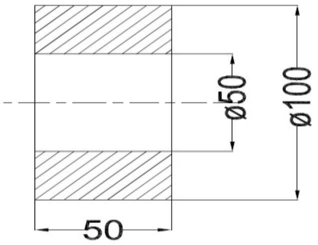

Figure 1. Dimensions and shape of specimen

Table I. Chemical Composition Of En8 And En31 Steel

Elements	EN8	EN31
Carbon	0.45%	1.30%
Silicon	0.35%	0.30%
Manganese	1.00%	0.50%
Sulphur	0.06%Max	0.025%

B. Method of Work

The experiment was carried out in an internal grinding machine. This set up was specifically done for conducting this research work which enables with change of cutting speed, depth of cut, measurement of cutting force etc. After comparing with various research works, synthetic oil was selected as cutting oil which enhances material removal rate and surface quality by reducing the friction and heat. It accelerates the heat transfer rate and provides feasibility to the operation during grinding. Each and every moment of machining process was observed carefully by providing input parameters in sequential manner. Figure 2 shows the grinding of a specimen when it is fitted on chuck subjected to high speed grinding wheel which is assisted with coolant system to meet better accuracy and finish. The raw work piece was purchased and it was turned as per the dimensions shown in Figure 1. It was also drilled with 50mm diameter which ensures that, it was greater than the diameter of the grinding wheel. Finally, the inner side of the work piece was grinded using internal grinding machine as shown in Figure 2 [16-18]. The present paper follows the various input process parameters of an internal grinding machine that includes depth of cut, cutting speed, cutting force. The surface roughness, material removal rate, Tool life was chosen as output parameters. The experiments were conducted as per the full factorial method [19-21]. To improve the quality of the surface finish and the appearance of the work piece, internal grinding process was mostly used [22-25]. During the grinding operation, a large amount of heat was produced and to reduce the heat a proper coolant was used.

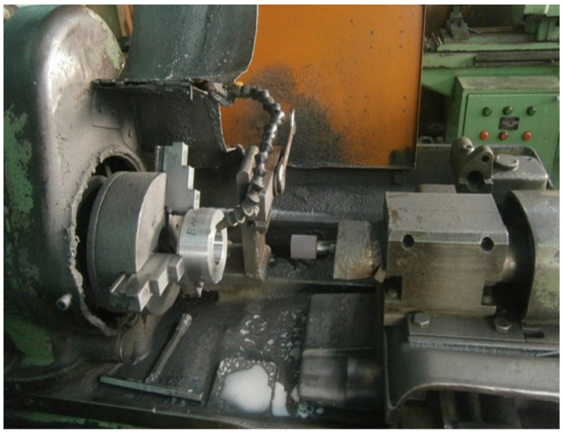

Figure 2. Experimental setup

Figure 3 shows, the instrument used to measure the cutting force during the machining which is familiarly known as kistler cutting force dynamometer. Similarly, Figure 4 that, the instrument widely used in research activities to measure surface roughness value, namely surface roughness tester. The three readings were recorded on each face of the four samples of EN8 and EN31 steel material respectively for the checking of the surface roughness to record the output response.

Figure 3. Cutting force dynamometer

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Figure 4. SE-1200 surface roughness tester

Table III. Output Parameters in Machining

Materials	Sample	Surface Roughness (µm)	Material Removal Rate (gm/sec)	Tool Life (Sec)
EN8	A	0.669	0.000104	555.2x10^6
		0.700	0.000144	555.2x10^6
		0.666	0.000134	555.2x10^6
	B	0.661	0.0000612	176.2x10^6
		0.669	0.000148	627.2x10^6
		0.694	0.000418	396.6x10^6
EN31	A	0.637	0.000384	629.2x10^6
		0.633	0.000265	629.2x10^6
		0.681	0.0000531	629.2x10^6
	B	0.628	0.000149	669.7x10^6
		0.656	0.000276	429.1x10^6
		0.682	0.000452	258.7x10^6

ANALYSIS AND OBSERVATION

During machining, possible observations were made for input parameters and output parameters and are given in Table 2 and Table 3 respectively. Here cutting force, cutting speed, depth of cut are considered as prime input factors and it was possibly changed by keeping any one as constant. Probably for sample A, cutting speed was maintained as constant and for sample B, depth of cut was maintained as constant. For all the specimens cutting oil was maintained as same to provide better heat resistance and surface quality.

Table II. Input Parameters in Machining

Materials	Sample	Cutting Force (N)	Cutting Speed (m/min)	Depth of Cut (mm)
EN8	A	44.33	0.017	0.13
		78.20	0.017	0.17
		114.1	0.017	0.2
	B	42.21	0.0085	0.1
		69.31	0.0158	0.1
		90.14	0.0208	0.1
EN31	A	35.18	0.01577	0.1
		69.54	0.01577	0.2
		109.3	0.01577	0.3
	B	47.04	0.01519	0.1
		88.31	0.01984	0.1
		117.6	0.02688	0.1

RESULTS AND DISCUSSION

It is a common fact that, optimizing machining parameters will produce specified outcomes as per requirements. Previous studies elaborately state that, technical relationship with every parameter involved in that machining process and it resembles the ensured optimization techniques. Keeping this as a part, some essential parameters have been discussed here which could be a possible solution to get the betterment of outcome products.

Figure 5 shows, the absolute relationship between the depths of cut and cutting force, meanwhile it ensures that whenever the depth of cut is more, it quietly increases the cutting force because more amount of force is applied to have increased volume of material. Here EN8 and EN31 provide the same phenomena during grinding. From Figure 6, it could be clearly understood that increasing depth of cut leads to poor surface finish which indicates increased surface roughness value. Expected surface quality is not achieved in case of more depth of cut.

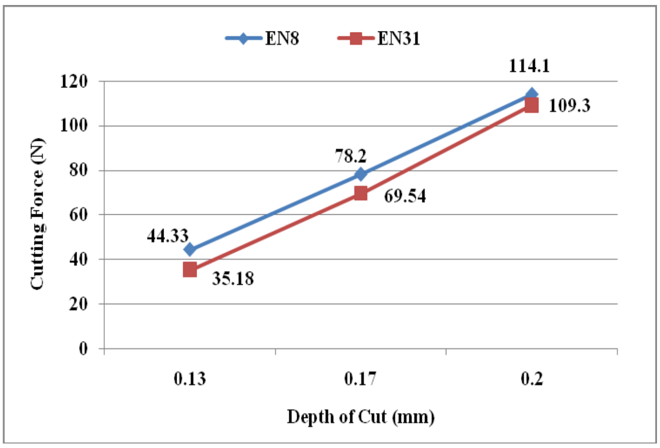

Figure 5. Depth of cut Vs cutting force

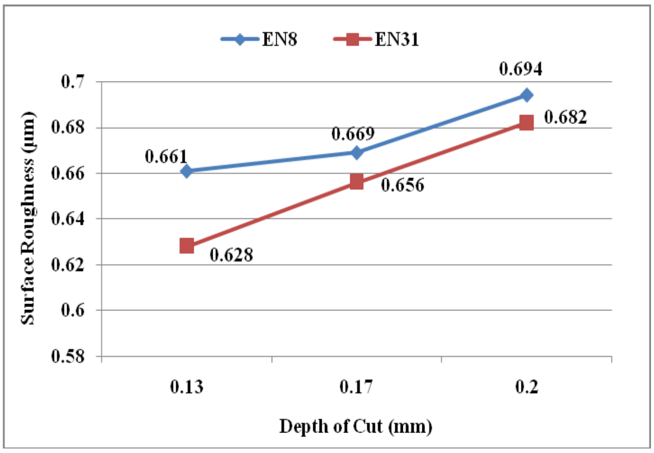

Figure 6. Depth of cut Vs surface roughness

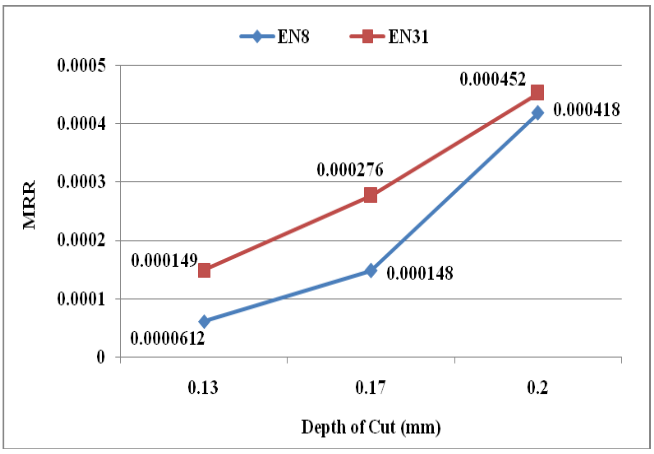

Figure 7. Depth of cut Vs MRR

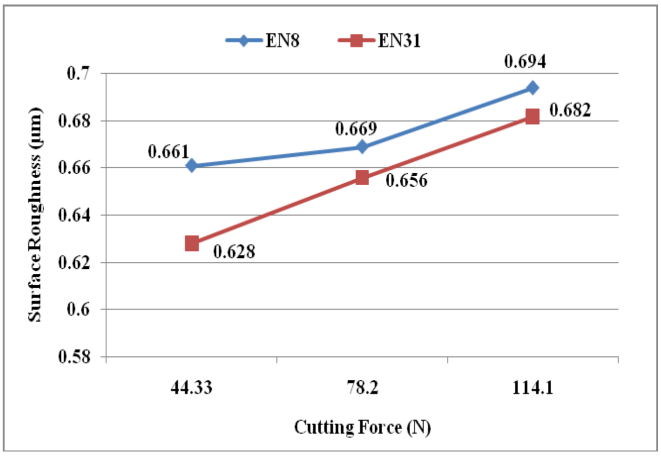

Figure 8. Cutting force Vs surface roughness

When depth of cut is more, tool contact area with work piece material increases, meanwhile volume of material removed is more. Figure 7 indicates the relation of increasing depth of cut with material removal rate. Cutting force is the force required to cut the material from the work piece during machining which reduces the surface quality when it increases, which is shown in Figure 8. Here surface roughness increases, because cutting force generated is more due to the fast advancement of the tool and vibrations occur which deteriorates the surface finish improvement.

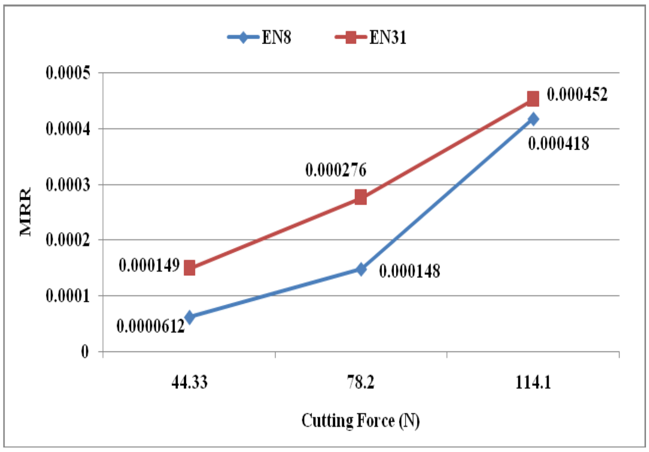

Figure 9. Cutting force Vs MRR

Figure 8 and Figure 9 ensure the increment of surface roughness and material removal rate during the gradual increment of cutting force. It may be due to the fast and high impingement of tool on work piece which affects the uneven travel of tool on work piece. This is quite common in both the material and EN 31, possibly produces a favorable outcome as compared to EN8.

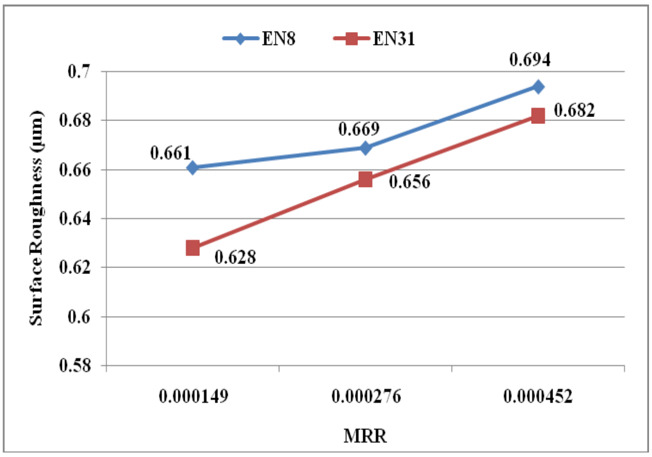

Figure 10. MRR Vs surface roughness

Figure10 indicates that, as material removal rate increases, surface roughness also increases because the amount of material being cut from the work piece surface increases in a single stroke of tool movement thus increases surface roughness and also material removal rate increases in the same order because the penetration of grinding tool abrasives into the work piece surface increases and thus removal of bigger chips of material takes place which causes scratching of work piece surface and results in lesser improvement in percentage surface finish. Here, the chemically mixed synthetic oil provides better machining quality when compared with normal cutting oils and is also verified with surface roughness tester. These parameters are discussed in the presence of synthetic oil only.

CONCLUSIONS

The present experimental work was completely done with keen observation by optimizing the input parameters as possible in internal grinding machine. Here, two different materials were subjected to machining operation and relation amongst them was studied. From this experimental work it could be concluded that,

- Internal grinding is a finest method to produce improved surface quality in machined components. Whenever the input parameters get deflected, it reflects on the outcome of the component. It may be cutting force, depth of cut, cutting speed.
- In both materials, increasing depth of cut reduces the surface finish of component; meanwhile it increases MRR because more volume of material gets eliminated. Hence, the surface finish depends upon the depth of cut which is to be optimized.
- Tool life is a major parameter which gradually falls on increasing the cutting force and depth of cut because of more contact and stress on work piece material.
- Cutting speed is a major impact on machining which determines the tool life and MRR. High cutting speed leads to more volume of material removed from work in a short time.
- Cutting fluid is an essential parameter in providing better surface quality which assists tool life and material removal rate without any thermal interruptions during grinding operation.
- Comparatively EN8 consumes less amount of cutting force with increased roughness. Material removal rate is high in EN31 Material and produces quality surface finish.

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