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Study on Influence of Process Parameters and Insert Nose Radius on Surface Roughness in Turning Operation

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Abstract

In engineering manufacturing, contribution of machine tools is a vital deciding factor in fulfilling the dynamic requirements of an industry. In this context, an effort has been made to determine the most significant factor on surface roughness on mild steel material in plane turning operation. In the current study, an experimental work is carried out to determine the effect on surface roughness while machining under various machining factors, cutting tool insert nose radius and process parameters. The experimental trials were designed with Taguchi L9 orthogonal array and carried out for each insert nose radius with different levels of process parameters, spindle speed, depth of cut and feed rate. The surface roughness of the machined part was measured for each trial. The effect and significance of process parameters and insert tool nose radius on surface roughness was analysed using Analysis of variance (ANOVA). The investigation reveals that the spindle speed is the most significant factor on surface finish during plane turning operation.

Keywords: *Surface roughness, Taguchi, ANOVA, process parameters, insert nose radius*

1.0 Introduction

Manufacturing process in an engineering industry has an important role in executing the process to complete the customer needs in time. Any discrepancy in the process of achieving the set goals either by issue in the machinery or in the process leads to huge setback in the business. As the machinery and process are interrelated to each other, it is an at most responsibility of the personnel to maintain the appropriate correlation between these two. In the present study an effort has been made to establish the relation between one such engineering manufacturing activities. In this approach, it becomes a mandate to understand the related resent developments in this particular area, which are explored in the following discussions. In an analysis during turning of AL 7075 based hybrid composites, it is concluded that the greatest impact on the surface roughness is from feed rate. On three composites, the lowest feed rate provided the least amount of surface roughness [1]. An experimental study on En24 and HCHCr alloy steels materials with carbide inserts cutting tool reveals that the surface roughness of HCHCr alloy steel is better than the surface roughness of En24 alloy steel. Increase of feed rate and cutting speed results in increase of surface roughness and decrease in surface roughness, respectively [2]. Hard turning of oil hardening non-shrinking steel to investigate and compare the effect of wiper inserts and conventional inserts and cutting parameters on surface roughness reveals that wiper inserts gives good machined surface than conventional

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inserts and cutting parameter. The most influencing parameter on surface roughness is feed rate [3]. An experimental study on mild steel with the carbide insert cutting tool on surface roughness monitoring in plane turning results that, the feed rate has the greatest impact on surface roughness, whereas tool wear is influenced the most by cutting speed. Cutting fluid also had a considerable impact on surface roughness and tool wear [4]. In turning operation of an Aluminum-Magnesium (AM) alloy, it is resulted that the superior surface polish can be achieved by turning at greater speeds with lower feeds and DOC [5]. To predict an experimental study, the surface roughness in the hard turning revealed that the cutting speed and feed rate have the highest effect on surface roughness, according to an analysis of variance (ANOVA) [6]. In machining of AISI304 steel, under two lubrication methods, MQCL and flood cutting and 3 levels of process factors, feed, speed and depth of cut. The results indicated that under MQCL conditions, surface roughness and vibrations decreased and feed rate was most influencing process factor on both surface roughness and vibrations [7]. An investigation on influence of process parameters on surface roughness in hot turning of Monel400 shows that, as feed rate and cutting speed increased, there is a decrease in surface roughness and increase in depth of cut and temperature, surface roughness increases [8]. AISID2 steel was hard turned with cubic boron nitride tools to analysis of surface roughness under cutting parameters, cutting speed, feed rate, nose radius with keeping depth of cut constant, that exhibits, surface roughness was most influenced by feed rate and then by tool nose radius and cutting speed and it also indicates that increase in nose radius tool lowers surface roughness value [9]. An investigation on the influence of nose radius, machining parameters, feed rate, and tool geometry on surface roughness analyzed based on the method response surface, in cold rolled steel C62D dry turning with cutting tool inserts coated with tungsten carbide shows that, most influencing parameter on surface roughness is feed rate [10]. An investigation on machining of an iron based Nickel alloy with materials of uncoated and PVD coated tool during dry machining, results that in comparison with the uncoated tool, at intermediate machining circumstances, the PVD coated tool had a reduced tool wear rate and less surface roughness than the uncoated tool [11]. An investigation on influence of process parameters and edge tool geometries during hard turning of AISID2 steel on surface roughness discloses that, surface roughness appears to be dependent on feed rate [12]. An experimental investigation on EN19 Steel during turning operations with carbide coated tool to determine the optimized process parameters, coolant (MQL) 2 levels, speed 3 levels and depth of cut 3 levels resulted that, the most influencing parameter on both vibrations and surface roughness and optimized combination of both surface roughness and vibrations was found with MQL condition [13]. A hardened AISIH13 steel with TiCN ceramic tool turned under the dry machining condition discloses that the most influencing process parameter on surface roughness is feed rate. With the increase in cutting speed with decreasing feed, surface roughness decreased [14]. An investigation, on annealed AISI1020 steel turned using carbide insert tools under cutting parameters, depth of cut feed rate and cutting speed reveals that, surface roughness increases with the increased feed rate and decreased cutting speed. It also resulted that, cutting speed is the most important process parameter for surface roughness, following by feed rate and depth of cut. [15]. In consideration with the recent developments related to manufacturing using machines tools, it is proposed to conduct an experimental investigation on influence of tool geometry and surface roughness in plane turning of mild steel material is affected by process factors.

2.0 Experimental Set up

The experimental work on plane turning operation was carried on engine lathe under dry cutting conditions with different combinations of machining parameters as listed in the Table 1.

Table 1: Details of Machining Parameters

Parameters	Description
Process Parameters	
Spindle speed (S) in rpm	250, 420, 710
Depth of cut (D) in mm	0.3, 0.6, 0.8
Feed rate (F) in mm/rev.	0.05, 0.11, 0.22
Cutting tool Insert	
Nose radius (R) in mm	0.2, 0.4, 0.8
Insert code	CCMT09T304PA120
Insert material	Carbide
Work piece material and cutting condition	
Work piece Material	Mild Steel
Cutting Condition	Dry

Table 2: Experimental Data

Trails	S	D	F	Surface Roughness in microns		
				Nose Radius		
				0.2	0.4	0.8
1	250	0.3	0.05	6.803	5.212	6.645
2	250	0.6	0.11	3.398	4.340	6.840
3	250	0.8	0.22	5.958	7.419	9.441
4	420	0.3	0.11	3.746	4.387	6.243
5	420	0.6	0.22	5.395	5.001	7.428
6	420	0.8	0.05	3.535	4.415	6.470
7	710	0.3	0.22	5.059	3.237	5.098
8	710	0.6	0.05	4.288	3.300	4.159
9	710	0.8	0.11	3.552	2.457	4.592

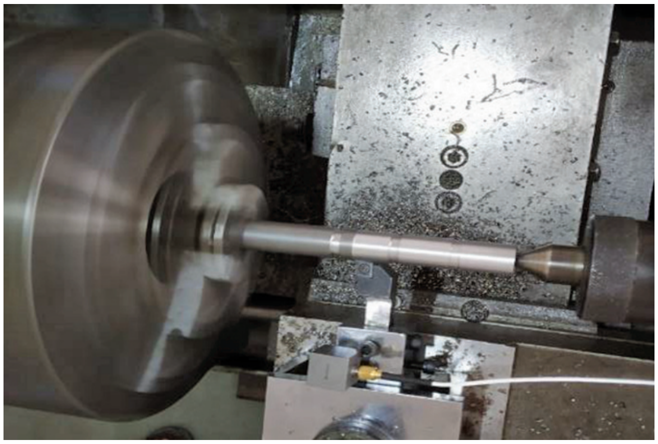

Figure 1: Experimental Set up

Figure 2: Surface Roughness Measurement

Optimum experimental trials were planned by L9 Taguchi orthogonal array principle. The experimental trials were carried out by using the experimental set up, showed in the Figure 1. The surface roughness for each trial was measured using Talysurf instrument, shown in Figure 2 and tabulated in the Table 2.

3.0 Results and Analysis

The experiments trial were undertaken as per the design of experiments. For each trial, surface roughness was recorded and documented. The data was analyzed to understand the effect of process parameter and tool geometry. Further, the analyses was carried out to determine influence of most significant process parameter by using analysis of variance (ANOVA) tool on surface roughness.

3.1 Effect of Process Parameters and Insert Nose Radius on Surface Roughness

Influence of process parameters and insert tool nose radius on surface roughness was carried out. In context with this, graphs were plotted for the values of surface roughness recorded at constant speed 250 rpm, 420 rpm and 710 rpm with different combinations of other two process parameters. Figure 3 shows one such plot with hold value of spindle speed as 420 rpm.

From the graph, it is seen that, surface roughness increases as the insert nose radius increases. Similar trends were observed with spindle speed of 250 rpm and 710 rpm. But, at speed 710 rpm the surface roughness value was lowest in 0.4 mm nose radius tool than in 0.2 mm and 0.8 mm nose radius tool. Increased

Table 3: Analysis of Variance (ANOVA)

Process parameters	Sum of square	Dof	Meansquare	F value	p-valu
Insert Nose Radius : 0.2mm					
S	9.223	2	4.611	41.413	0.02
D	0.015	2	0.007	0.0691	0.93
F	2.569	2	1.284	11.538	0.07
Error	0.222	2	0.111		
Insert Nose Radius : 0.4mm					
S	6.61	2	3.31	0.92	0.52
D	0.53	2	0.26	0.074	0.93
F	2.16	2	1.08	0.3	0.76
Error	7.17	2	3.59		
Insert Nose Radius : 0.8mm					
S	7.37	2	3.68	6.83	0.12
D	6.06	2	3.03	5.62	0.15
F	6.02	2	3.01	5.59	0.15
Error	1.08	2	0.54		

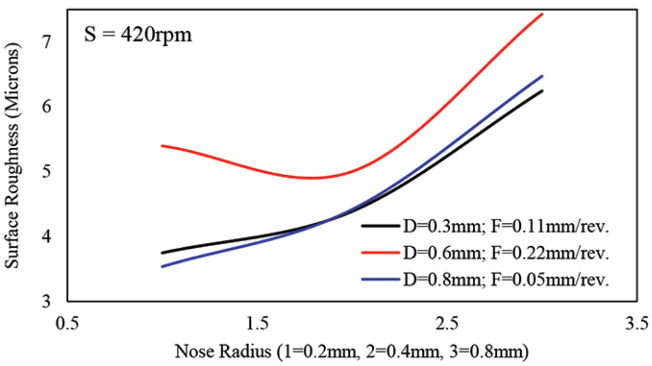

Figure 3: Nose radius v/s Surface Roughness

contact area of cutting tool edge with work piece at higher insert nose radius could be the reason for increase in surface roughness at higher insert nose radius.

3.2 Analysis of Variance (ANOVA)

The most significant process parameter of mild steel turned on surface roughnes under various machining conditions and insert tool nose radius was analysed by analysis of variance (ANOVA) method. analysis of variance (ANOVA) was analysed using Design Expert software. ANOVA results for three different insert nose radius is tabulated in the Table 3.

From ANOVA, it is observed that the most significant process parameter is spindle speed for different insert nose radius. However, the next significant parameter differs for each insert nose radius, which are, feed rate for 0.2mm and 0.4mm insert nose radius and depth of cut for 0.8mm insert nose radius.

4.0 Conclusion

An experimental work was carried out to study the influence of insert tool nose radius and process parameters on surface roughness during plane turning operation on mild steel material.

L9 Taguchi orthogonal arrays with 3 levels of process parameters was used to design the optimized number of experiments. The experimental data was analysed by Analysis of Variance (ANOVA) tool and graphs were plotted for insert nose radius v/s surface roughness at different cutting parameters. This study reveals that, the impact of spindle speed is much on the surface roughness. The study also reveals that the magnitude of the surface roughness is more at higher insert nose radius.

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