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Selective Machinability Analysis for Effective Machining of En31 Alloy Steel During Dry and Wet Turning

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Abstract: In this research work the wear behavior of different set of experiment are carried out on HMT lathe. Cutting tool flank wears are measured using tool maker's microscope of resolutionof 0.01mm. The experimental tests are carried out with variation of different machining parameters speed,feed,depth of cut. The effect of cutting speed feed depth of cut on the selected machinability criteria such as tool wear and surface finish are analyzedgraphically. This research investigation also highlightsthe merits and demerits of the utilization of coated carbide inserts i.e.CCMT09T308PM4225andDNMX150608WM1525during machining of E0300 alloy steel during dry and wet conditions. This research work will be more helpful to the future researchers, modern manufacturing engineersand allied industries.
Key Words: E0300 alloy steel, Tool wear, Tool life, HMT lathe

1. Introduction

Metal cutting process is widely used to remove the unwanted materials. Turning is widely used manufacturing process. The surface finish is an important criteria, which indicate the basic quality of manufacturing product. The problem of tool wear monitoring in marching operation has been an active area of the research as it contributes about 7% of downtime of the machining centers. Moreover tool wear is the important factor assuring the quality of the machine product. In particular finish turning requires close attention to the cutting conditions. A worn cutting tool produces poor surface finish if the detoration of the cutting tool is not properly monitored, the work piece surface is significantly degraded with the subsequently loss of work piece surface quality and loss of manufacturing time. Hence it is important to study and analyze the cutting tool performance during marching for generation of better product in practice.

Aggarwal Amanet al. [1] reviewed the literature on optimization of machining parameters in turning processes. Arrazola P. J. et al.[2] studied micro-scale temperature fields in the cutting of two AISI 4140 steels using machinability ratings. Astakhov Viktor P. et al. [3] studied the influence of a cutting speed on the flank wear of carbide P10 insert during turning of AISI 52100 steel. Author concluded that tool wear is minimum at optimum cutting speed. Childs T. H. C. et al. [4] studied on surface finishes during turning and facing by round nosed tools. Author concluded that the minimum roughness can be achieved by cemented carbide but also with single crystal diamond round nosed tools. Choudhury I. A. et al.[5] carried out a series of turning tests on Inconel 718 using coated and uncoated carbide tools. Author described the effects of cutting variables (speed, feed and depth of cut) on cutting forces and tool life. Author concluded that an uncoated carbide tool gives better results as compared to that of the coated tools. Choudhury S. K. et al. [6] investigated on the flank wear of HSS tool during turning of C45 carbon steel. David W. Smthey et al.[7] studied on the region of a worn cutting tool where plastic flow of the work piece materials occurs. Diniz Anselmo Eduardo et al.[8] observed the cutting conditions during finish turning of 1045 steel for better tool life. Dragos, A. Gindy et al. [9] studied the process monitoring to assess the work piece surface quality in machining. Husnu Dirikolu M. et al. Jackson M. J. et al. [10] experimentally investigated on the variety of coated tool during machining of M42 tool steel. Kaye J. E. et al. [11] developed a mathematical model for on line prediction of tool wear during turning using the surface response methodology. Kevin Y. et al. [12] observed the performance of CBN tool during interrupted turning of hardened M50 steel. Kopac J. et al. [13] presented a reviewed result from available published work of some recently used cutting tool materials and coatings in machining. Authors concluded that Tool life is depending on certain technological parameters such as cutting tool material, tool materials etc. Kwon Yongjinet al. [14] proposed a simulated model to predict the tool wear index during turning of 4340 steel using uncoated tungsten carbide tools. Lim C. Y. H. et al. [15] investigated the wear of coated cemented carbide inserts during dry turning of hot rolled medium carbon steel work-piece. Author concluded that TiC coatings on carbide tool could increase the wear resistance during cutting. Manna A, Bhattacharyya B. [16] studied on the different tooling system during turning of AL/SiC MMC for optimal selection of tool and tooling system for effective machining of the above MMC. Manna A. et al. [17] studied on machinability of Al/SiC MMC. The influence of machining parameters e.g. cutting speed, feed and depth of cut on the cutting force and surface finish criteria were investigated during the experimentation. Manna A. et al. [18] experimental investigated the influence of cutting conditions on surface finish during turning of AL/SiC-MMC.Mustafizur Rahman et al. [19] reviewed of the research worked on the machining of titanium alloys and analyzed the drawback of the research. Penalva M. L. et al. [20] studied on CBN tool wear during turning of hardened steels. Author concluded that roughness profile could helpful to estimate the tool wear.

The paper analyses the wear behavior of the different tools during. The different set of experiment is carried out on HMT lathe. Cutting tool averageflank wear are measured using toolmakers microscope of resolution 0.01mm. The experimental test are carried out with the variation of different machining parameters e.g. range of cutting speed 100 m/min to 225m/min, range of depth of cut 0.25mm to 1.5mm/rev and feed range from 0.2mm to 0.8mm /rev.

The effect of cutting speed, feed and depth of cut on the selected machinability criteria such as tool wear and surface roughness are analyzed graphically usingCCMT09T308PM4225andDNMX15 0608WM1525 coated inserts. This research investigation also highlights the merits and demerits of the utilization of coated carbide inserts during machining of E0300 alloy steel. The research work will definitely help to the future researchers, modern manufacturing engineers and allied industry

2. Planning for experimentation

A set of turning experiments are carried out on E0300 alloy steel of 65mm diameter and 550 mm long bar using HMT –LB 20 lathe. The chemical composition of the work piece is obtained using Spectrometer (IJA,USA). The detail chemical composition of the work piece is shown below in table 1

Table1. Chemical composition of E0300 alloy steel

Specification	%C	%Mn	%P	%S	%Ni	%Cr	%V	%Mo	%Co	%Ti	%W
E0300 alloy steel	0.87	0.76	0.46	0.82	0.028	1.34	0.01	0.03	0.01	0.01	0.25

Table 2. Details of cutting tool used and environment for turning experiments

Cutting tool used	Cutting tool specification	Rake angle	Clear- ance angle	Nose radius	Cutt- ing edge ngle	Environment
T-Max-P Positive insert	CCMT09T308 PM4225	0^0	7^0	0.8 mm	80^0	Wet and dry
T-Max-P Négative insert	DNMX150608 WM1525	$- 6^0$	0^0	0.8 mm	55^0	Wet and dry

Prior to the experiments, the sample was rough turned with a depth of cut 0.5mm in order to remove the outer layer which might have been hardened by rolling process in the production stage. The coated inserts of CCMT09T308PM4225 and DNMX150608WM1525 and tool holder PCLNR2020 M12 is used for experiments. The built up edge (BUE) were measured using a Mitutoyo shop microscope with 30X magnification and 1 um resolution.

Table 3. Cutting parameters and their levels

Sl. No.	Machining parameters	Level		
		1	2	3
1	A: Cutting speed, m/min.	40	100	160
2	B: Feed, mm/rev.	0.16	0.33	0.48
3	C: Depth of cut, mm.	0.50	0.75	1.25

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3. Effect of Continuous Machining Time on Average Flank Wear Width

The variation in cutting tool average flank wear with machining time, tool configuration and environment i.e. during dry and wet turning of E0300 alloy steel by DNMX150608WM1525insert is shown in figure 1 (a)and by DNMX150608WM1525 inserts is shown in figure 1 (b).

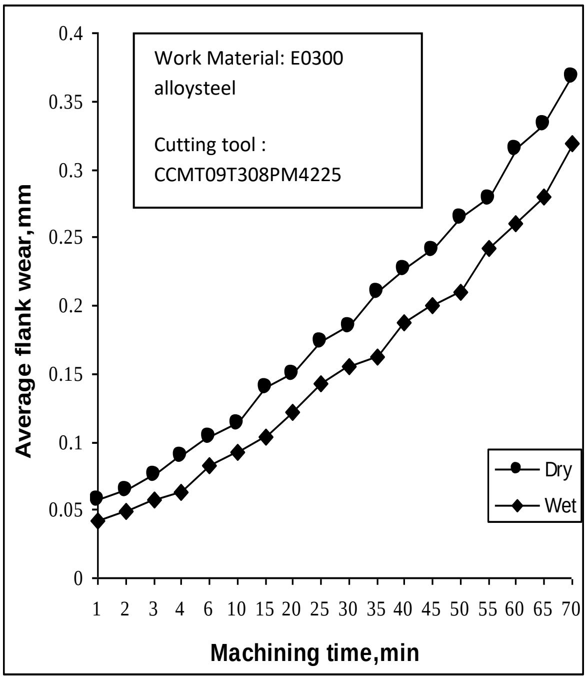

Fig (1a)

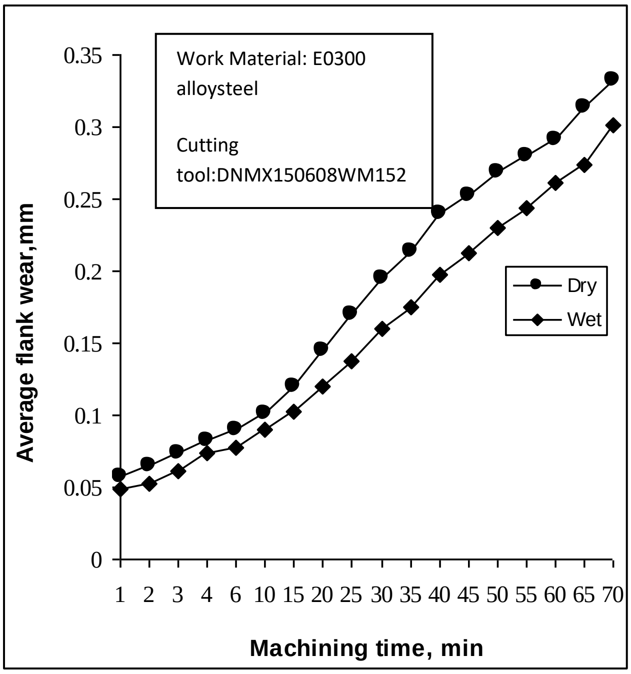

Fig (1b)

Figs. 1(a) and figure1(b) Growth of average flank wear in mm observed while turning E0300 alloy steel by CCMT09T308PM4225 and DNMX150608WM1525 respectively under dry and wet environments.

Test Result and discussion

Figure 1(a) shows the effect of continuous machining time (min) on the average flank wear (mm) during turning of E0300 alloy steel by CCMT09T308PM4225 insert under dry and wet conditions. From the figure 1(a), it is clear that average flank wear increases with increase in machining time. In dry turning, the average flank wear width is 0.30 mm after 59 minutes of continuous turning. Tool life is assumed to have ended before the maximum flank wear width reaches its limit of 0.30 mm [65]. Hence, life of CCMT09T308PM4225 insert under dry turning of E0300 alloy steel is 58 minutes only. It is also observed that flank wear gradually increases with increase of machining time and 0.368 mm flank wear width was measured after 70 minutes of continuous machining in dry environment and at 100 m/min cutting speed, 0.16 mm/rev feed rate, 1.25 mm depth of cut. The average flank wear width is 0.057 mm after only 1 min continuous machining with same parameter setting as mentioned above. In wet turning, the average flank wear widths are 0.30 mm,

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0.319 mm and 0.042 mm after 68 min, 70 min and 1 min of continuous machining respectively with same parameter setting as mentioned above against the dry turning. Hence, life of CCMT09T308PM4225 insert under wet turning of E0300 alloy steel is 68 minutes only.

Figure 1(b) shows the effect of continuous machining time (min) on the average flank wear (mm) during turning of E0300 alloy steel by DNMX150608WM1525 insert under dry and wet conditions. From the figure 1(b), it is clear that average flank wear increases with increase in machining time. In dry turning, the average flank wear width is 0.30 mm after 59 minutes of continuous turning. Tool life is assumed to have ended before the maximum flank wear width reaches its limit of 0.30 mm [65]. Hence, life of DNMX150608WM1525 insert under dry turning of E0300 alloy steel is 62 minutes only. It is also observed that flank wear gradually increases with increase of machining time and 0.333 mm flank wear width was measured after 70 minutes of continuous machining in dry environment and at 100 m/min cutting speed, 0.16 mm/rev feed rate, 1.25 mm depth of cut. The average flank wear width is 0.058 mm after only 1 min continuous machining with same parameter setting as mentioned above. In wet turning, the average flank wear widths are 0.301 mm, and 0.049 mm after 70 min and 1 min of continuous machining respectively with same parameter setting as mentioned above against the dry turning. Hence, life of DNMX150608WM1525 insert under wet turning of E0300 alloy steel is 68 minutes only.

4. Variation in surface finish, Ra (µm) with that of cutting speed and feed in turning E0300 alloy steel by CCMT09T308PM4225 and DNMX150608WM1525 inserts under dry and wet environment.

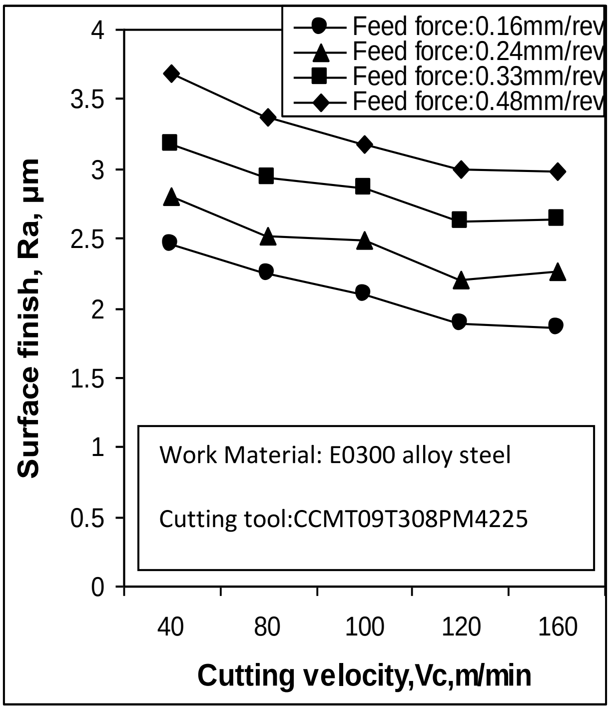

Fig.2(a)

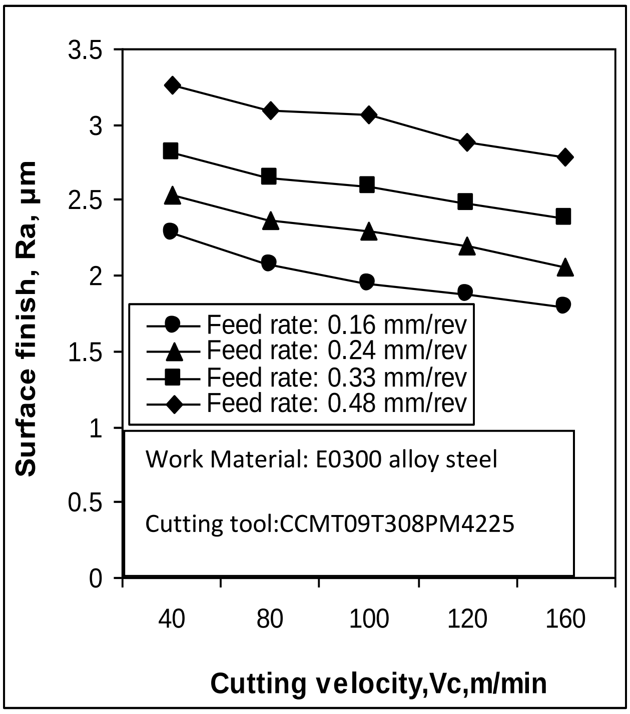

Fig.2 (b)

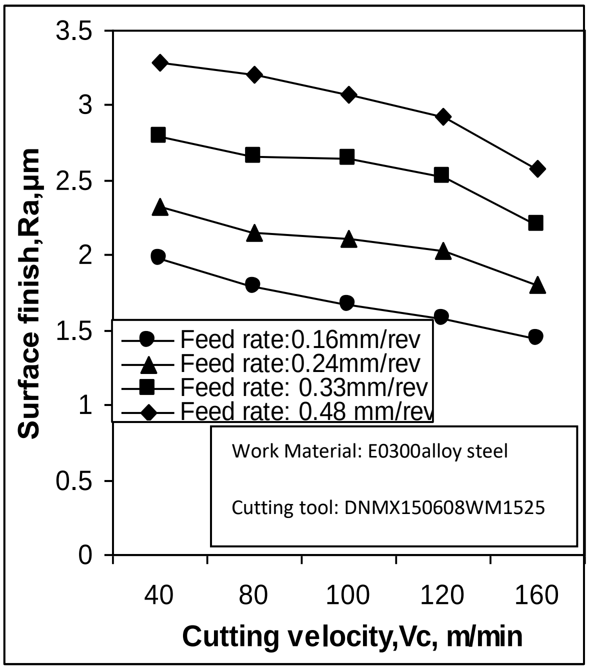

Fig.2(c)

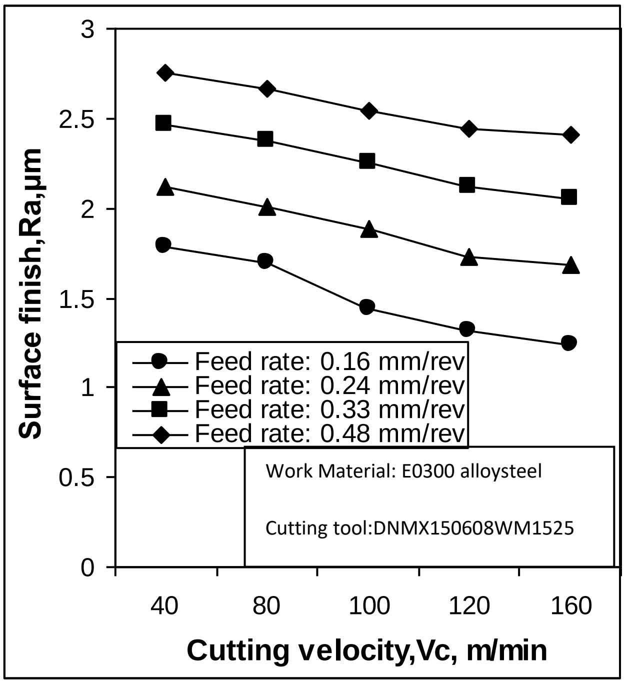

Fig.2(d)

Figure 2. Variation in surface finish, Ra (µm) with that ofcutting speed and feed in turning E0300 alloy steel by CCMT09T308PM4225 and DNMX150608WM1525 inserts under dry and wet environment

Test result and discussion

CCMT09I308PM4225 insert under dry and wet condition respectively. From the figures2 (a) and 2 (b), it is clear that surface roughness decreases with increase in cutting velocity and increase of feed rate. In dry turning, the magnitude of surface roughness is 3.68 µm at 40 m/min cutting velocity and 0.48 mm/rev. But surface finish, Ra (µm) is only 1.86 µm when machining is done with the parameters setting at 160 m/min cutting velocity, 0.16 mm/rev feed rate and 1.25 mm depth of cut. Similarly, in wet turning, the magnitudes of surface roughness are 3.26 µm and 1.79 µm respectively when machining undertaken at same parametric combination as mentioned above by CCMT09I308PM4225 insert. Figure 2 (c) and 2 (d) show the effect of cutting velocity, Vc (m/min) and feed rate,(mm/rev) on the surface finish, Ra (µm) during turning of E0300 alloy steel by DNMX150608WM1525 insert under dry and wet condition respectively. Here also observed similar trends in results i.e. surface roughness decreases with increase in cutting velocity and decrease of feed rate. The magnitudes of surface roughness are 3.28 µm and 1.44 µm in dry turning and 2.76 µm and 1.24 µm in wet turning at same parametric setting for both the cases i.e. 40 m/min cutting velocity, 0.48 mm/rev feed rate, and 160 m/min cutting speed, 0.16 mm/rev feed rate respectively.

5. Conclusions:

The conclusion relevant to this investigation is outline below:

1. The rate of cutting tool averageflank wear is gradually increased within the increase of machining time for dry and wet turning using CCMT09T308PM4225 and DNMX150608WM1525 inserts on E0300 alloy steel.
2. The surface finish improves with increase of cutting speed and at constant feed rate for both dry and wet turning using CCMT09T308PM4225 and DNMX150608WM1525 inserts on E0300 alloy steel.
3. The recommended high cutting speed for better surface finish during dry and wet turning.
4. The surface roughness of the work part is influenced by tool wear. In addition, dimensional deviation, tool wear rate is influenced by cutting velocity.

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