Investigate the Effect of Turning Parameters on Tool Wear on Various Cutting Tool Inserts Using Response Surface Methodology

C. Ramesh Kannan, P. Padmanabhan and A. Lawrance Paul

Abstract--- *The work aims to investigate the effect of turning parameter on tool wear of various cutting tool insert using response methodology. The AISI4340 steel is machined with different cutting tool insert of High Speed Steel (HSS), Carbide, and Cermet by turning process. Speed, feed, depth of cut are selected parameters. The results were encouraging to minimize the flank and crater wear and Material Removal Rate (MRR) in selected inserts. The results revealed that comparison between three inserts are in increasing trend. The carbide cutting tool insert have superior wear resistance due to high hardness.*

Keywords--- *Tool Wear, Different Inserts, MRR, Chip Morphology.*

I. INTRODUCTION

THE manufacturing industries are trying to decrease cutting cost and machining with different material. Tool wear is one of the major issues in metal cutting and significantly influenced by the tool life. The three most common cutting tool materials currently in used for production machining operations are (HSS), carbide, cermet and diamond also widely employed. The harder tool material, the better it can be resist wear at faster cutting speed, high cutting temperature and shorter tool life [1]. In general AISI4340 steel is used to make components subject with high stress namely gears, stud, bolt and general engineering applications. The CVD coated cutting tool insert has been used to machining the steel to obtain the wear percentage of 49.1% and 50.2% respectively [2]. The tool wear resistance improve the hardness by decreasing the retained austenite. The amount of various secondary carbide has been spread over the cutting tool insert results increase in wear resistance [3].

The work study about the economic feasibility, volume of chip removal, tool life, surface roughness and flank wear. Tin coated carbide is better tool life compare than uncoated carbide. The coated carbide 30 times higher than the machining cost per part for uncoated carbide. The coated carbides are 90.5% of cost saving. [4]. The investigation on the steels are confirmed in the domain of enhancing mechanical properties using heat treatment EN24 grade of

steels exhibits higher hardness, better corrosion resistance compare to en8 steel [5]. Experimental determination of the high strength temperature strength of cemented carbide PVD, CVD-coated correct carbide insert tested in continuous turning of quenched and tempered steel the predicted deformation and the experimental result was acceptable. The difference between the simulated and flank width on deformed cutting edge was approximately 15% using secondary condition based on experimental data on acceptable agreement between simulated and measured edge profile of deformed tools was obtained for both cemented carbides in the TNMA insert style. The machining of AISI4140 steel with selected parameter with performance measurement of tool wear is the minimization of wear due to increase of hardness [6]. The carbide cutting tool compression cermet insert to attain the better wear resistance of work material has great potential application in matching [7]. The study bout the nanostructure alumina and FeCu-based cermet coatings APS Technique is used on stainless steel substrates. Thermal spraying induces the creative of hard and soft phase due to high reactivity of nanostructured powders. The predominant failure mechanism in nanostructured coatings is micro-fracturing followed by a subsequent pull out of wear particles within the quasi-plastic zone [8]. The performance the machining of medium hardness HSS. TiN coated polycrystalline ceramic mixed alumina and coated tungsten carbide. This paper focused on the tribological complexity of the wear mechanism of the different tool material used in machining of medium hardness [9]. AISI T15 HSS. Cutting test of the HSS were carried out with four different cutting tools. The chip compared from high speeds a decrease in the ratio are calculated. [10]. under try turning Inconel 718 is machined using ceramic cutting tool. The notch wear boundary and the hardened layer depth beneath the machining surface are measured, and a notch wear depth prediction model based on the hardened layer is proposed. The proposed notch wear model is based on the depth of hardening and the notch wear geometry [11]. The hardened AISI4340 steel using uncoated and coated tungsten carbide insert ISO grade k. Tool life and wear mechanisms were assessed and the acoustic emission signal was collected during the trials and further processed using the PSD and auto covariance techniques. The presence of coating result in longer tool life [12]. The wear rate rake face are characterized to represent all possible cases of wear and chipping edge. In this process using material AISI 1014 material machining by tungsten carbide insert. [13]. The ball depression method to estimate the difference in mechanical assets due to heat management on as traditional EN8 Steels [14]. The agonizing wear performance

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of as conventional hardened-tempered and nitride structural steel, EN31 and bearings steel, EN24. The load at which the transition to stick-slip nature depends on the surface and not on the hardness [15].

Cermet beats the show of carbides for flank wear surface temperature, work piece and cutting forces. Cutting speed affected work piece surface temperature and the flank wear of carbide is most. Coated cermet experienced a lower work piece surface temperature but higher feed force higher radial force compared to uncoated carbide[16]. The study deals with experimental investigation for effect of different cooling techniques on tool wear when machining EN24 steel by using uncoated tungsten carbide inserts. Mathematical model for crater and flank wear are found to statically significant [17]. WC-6Co polycrystalline diamond tool wear and work are also discussed. Micro structural analysis of the both theof four cutting tool in unreformed work material and the chip using electron-backscatter diffraction provided evidence to support the phase transformation [18]. The signal to noise ratio and performance characteristic is analysing in turning operation. The result of the analysis shows that none of the factors was found to be significant. The signal noise ratio is depent on machining condition and hardness value of the inserts. [19]. The carbide insert are using this turning machining operation to carbide is a good harness material compare than the other two insert. The hardness value are increasing the rate of wear are decreasing that the hardness and the wear resistance are inversely proportional [20].

II. EXPERIMENTAL DETAILS

A. The Preparation of Work Material and Tool Material

EN24 is selected as work material the shape of 32mm diameter, 150mm long. After sizing the work material polished by emery paper. The chemical composition of EN24 steel as known as table1.

The inserts are purchased by Chennai tools Chennai. The HSS are mostly high alloyed tool steel with contained 18% tungsten, 4% chromium and 5% vanadium. HSS tools good hardness value insert. This insert are tough and suitable disturbed cutting and are used to manufacture tools of complex profiles. The most industries used carbide, cermet and high speed steel. This paper about at the high speed steel. The difficult cutting speed are 10 to 100m/min. Because of the brittleness we choose the carbide insert to better high speed tools. It is the better surface finish because of high hardness and high alloyed steel. The difficult cutting speed is 50 to 500m/min. Cermet contains 70% of aluminium oxide and 30% of Tungsten carbide with performance ceramics with coating with best benefits. The difficult cutting speed is 50 to 350m/min.

The tool maker's microscope is used to measure the wear. Experimental and measuring instruments are available in CIPET, Madurai.

Specification of tool maker's microscope is optical head mm200, XYZ stroke is 50x50x110mm, scale resolution is 001/0.1 (default) 1/10 μ m, magnification accuracy 0.1%, objective lenses (WD) is 3x(75.5mm) optical 1x(79mm),

5x(6mm), 10x(48mm), light source is white LED 8 segmented and the input voltage is 100-240V, (max 1.8A). The 40mm machining distance is maintained every work material. The tool wear is measured in single cutting of tool material and measure the flank and crater wear. The schematic diagram of work material and tool material as shown in figure 1.

Figure 1: The schematic Diagram of Prepared (a) Work Material Sample and (b) Insert

III. MORPHOLOGICAL ANALYSIS OF INSERT

The hardness value on the cutting tool inserts like carbide, HSS and cermet are 630HV, 518HV and 523HV respectively. The hardness measured using vickers hardness variation between the inserts as shown in figure 2. It reveals that the carbide cutting tool insert significantly improves that hardness.

Figure 2: Hardness Value of Different Cutting tool Inserts

The EN24 steel examples were turned at length of 100mm for particular limits at their levels. New set of inserts and specimens were used in each experiment and each experimentation was repeated at three times for their accuracy. The photo image of machining setup is shown in figure.3

Figure 3: Machining with Arrangements

A. Chip Morphology

When EN24steel was turned using HSS, a discontinuous chip was formed as shown in figure.4.

Figure 4: Chip from HSS Tool

When EN24 was turned using cermet, a build-up of chip was formed which resembled like a continuous chip but with little discontinuous structure in between as shown in figure.5

Figure 5: Chip from Cermet Tool

IV. MACHINING DETAILS

A galaxy Midas Computer Numerical Control universal turning machine was working to machining the EN24 steel examples for the length of 140 mm. CNMG120408SMRH13A inserts. The explanation of machine is allowable diameter of turned shaft is 240mm, length is 365mm, the chuck diameter is 169mm, spindle speed range is 40 to 400RPM and spindle power is 7.5KW. The inserts were mounted on the tool holder. ECLNL-2525M12 tool holder was applied to support the inserts.

V. RESULTS AND DISCUSSIONS

The Flank and Crater wear of Cermet, HSS and Carbide are analysed. The input Parameters are Speed, Feed and Depth of Cut. The flank and crater wear are optimised using the Orthogonal Array and the output discussed using Surface plot. The investigation result is tabulated Below. From the Table.1 deals the experimental investigation result of flank and crater wear of High Speed Steel (HSS), cermet, and

carbide insert. When EN24 Steel was turned using Carbide we observed formation of continues chip as shown in figure.6

Figure 6: Chip from Carbide Tool

From microscopic image shown in figure 7. The tool speed and depth of cut of cermet, carbide and HSS are 1500RPM and 0.5 mm respectively, as shown in figure 6. Also the feed rate varies as 0.1 mm, 0.2 mm, and 0.3 mm for HSS, cermet and carbide respectively.

Figure 7: Microscopic Image

Table 1: Cutting Parameter with Wear

S.No.	Speed (m/min)	Feed rate (mm/rev)	Depth of cut(mm)	HSS (mm)		Cermet (mm)		Carbide (mm)	
				Flank Wear	Crater Wear	Flank Wear	Crater Wear	Flank Wear	Crater Wear
1.	50	0.1	0.1	0.065	0.005	0.095	0.010	0.065	0.005
2.	50	0.1	0.2	0.075	0.015	0.100	0.015	0.080	0.020
3.	50	0.1	0.3	0.080	0.020	0.125	0.020	0.085	0.025
4.	50	0.2	0.1	0.085	0.025	0.130	0.025	0.090	0.030
5.	50	0.2	0.2	0.095	0.030	0.135	0.030	0.095	0.035
6.	50	0.2	0.3	0.100	0.035	0.140	0.055	0.100	0.045
7.	50	0.3	0.1	0.120	0.045	0.145	0.065	0.120	0.050
8.	50	0.3	0.2	0.125	0.050	0.150	0.075	0.125	0.055
9.	50	0.3	0.3	0.130	0.055	0.155	0.085	0.140	0.065
10.	100	0.1	0.1	0.145	0.065	0.175	0.095	0.150	0.075
11.	100	0.1	0.2	0.155	0.075	0.20	0.10	0.155	0.080
12.	100	0.1	0.3	0.160	0.085	0.215	0.125	0.160	0.090
13.	100	0.2	0.1	0.17	0.090	0.250	0.130	0.170	0.120
14.	100	0.2	0.2	0.185	0.120	0.265	0.145	0.185	0.125
15.	100	0.2	0.3	0.195	0.125	0.285	0.155	0.195	0.135
16.	100	0.3	0.1	0.20	0.135	0.295	0.165	0.200	0.155
17.	100	0.3	0.2	0.205	0.155	0.300	0.175	0.205	0.160
18.	100	0.3	0.3	0.225	0.160	0.305	0.185	0.220	0.175
19.	150	0.1	0.1	0.230	0.180	0.315	0.195	0.210	0.195
20.	150	0.1	0.2	0.235	0.195	0.325	0.200	0.225	0.220
21.	150	0.1	0.3	0.24	0.220	0.330	0.225	0.235	0.230
22.	150	0.2	0.1	0.25	0.245	0.345	0.265	0.245	0.245
23.	150	0.2	0.2	0.265	0.275	0.355	0.285	0.255	0.255
24.	150	0.2	0.3	0.275	0.295	0.365	0.295	0.275	0.265
25.	150	0.3	0.1	0.295	0.305	0.370	0.325	0.290	0.275
26.	150	0.3	0.2	0.310	0.305	0.375	0.345	0.300	0.295
27.	150	0.3	0.3	0.325	0.320	0.385	0.375	0.320	0.320

A. Effects of Flank Wear

From figure 8, the cutting speed range from 50m/min to 150m/min, feed rate range from 0.1mm/rev to 0.5mm/rev and the depth of cut is 0.3mm. It deals with the flank wear increased with. Increase in cutting speed at selected insert. The percentage varies between the inserts of HSS (46%), carbide (33%) and cermet (45%).

Figure 8: The Direct Effect of Flank Wear

The carbide cutting tool insert dominate the flank wear with respect input parameter compare than other two inserts. The flanks wear increase with increase in selected parameters. There is a formation of linear curve against the cutting speed. Carbide tool insert is the lower wear resistance followed by the cermet and HSS.

Figure 9: Interaction of Flank Wear

From figure.9, the surface plot deals with the interaction between the selective parameters with flank wear. The cutting speed is increase with increase in wear followed by the feed rate and depth of cut.

B. Effect of Crater Wear

From figure 10, the cutting speed range from 50m/min to 150m/min, feed rate range from 0.1mm/rev to 0.5mm/rev and the depth of cut is 0.3mm. It deals with the crater wear increased with increase in cutting speed at selected insert. The percentage varies between the inserts of HSS (38%), carbide (22%) and cermet (31%).

Figure 10: The Direct effect of Crater Wear

The carbide cutting tool insert dominate the crater wear with respect input parameter compare than other two inserts.

Figure 11: Interaction of Crater Wear

Figure.11 defined the interaction effect of selective parameter with crater wear. The crater wear decrease with increase in material hardness.

Figure 12: The Selective Parameters with MRR

Material Removal Rate (MRR) is the linear trend against selective parameters. Higher material removal rate attain the carbide insert dominate the other inserts. From figure.12, deals with the material removal rate in the different insert in the percentage of 23%, 13%, and 17% respectively.

VI. CONCLUSION

This experimental work has discussed the possibility of production flank and crater wear on cutting parameters in turning of EN24. The observations from the test can be summarized as follows:

Based on the high hardness and toughness of influenced the flank and crater wear. The cutting speed and depth of cut is the most influenced factor for followed by the depth of the cut for the flank wear. The flank wear increased with increase of cutting speed and depth of cut. The crater wear is the dependent parameter of feed, speed and depth of cut.

As a result it is found that the carbide cutting tool insert improve the wear resistance. The material removal rate of cutting tool inserts are discussed with confirm the higher hardness carbide is more material removal rate compare than other inserts. This paper can be extending to exam in the tool wear of various turning tools. The investigation is applied industrial application in cutting tool design and automations.

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