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Analysis of Wear Behavior of Carbide Insert while Turning AISI D2 Tool Steel Material

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Abstract- **In this paper the effect of input parameters such as spindle rotation, feed rate and depth of cut on material removal rate and tool nose wear of machined components which were taken as the output parameters were analyzed during turning process. It is observed as the spindle rotation, feed rate and depth of cut increased material removal rate increases. When these parameters are varied the circumferential length of material encountering the tool work interface and cutting force increases that resulted in increased material removal rate. The effect of these process parameters on tool nose wear is also analyzed. Among the process parameters spindle rotation is having significant effect on tool nose wear compared to feed rate and depth of cut.**

Index Terms- Material removal rate, Tool nose wear, Turning, Difficult to machine material, Carbide tool

1. INTRODUCTION

Machining of difficult to machine materials is the emerging topic of today’s industry. Turning is a material removal process which employs a single point cutting tool for machining materials possesses different hardness. The flexibility and ability to manufacture complex shapes is one of the major advantage of turning compared to other machining processes. Tool wear caused by hardness of work piece material is the emerging areas of research in turning process. Several researchers have contributed to study the influence of process parameters on tool wear while machining different grades of steel materials. Authors studied the wear behavior of CBN tools and coated carbide tools while machining different grades of hardened steel and hardened AISI 4340 steel respectively [1]-[3]. An attempt has been made to study the influence of process parameters on tool wear using PCBN tool [4], patterned and non-patterned tool inserts [5] and using CVD coated carbide tools [6]. It is observed from literature not much work is carried out in analyzing tool wear of carbide inserts while turning difficult to machine materials.

In this work the effect of input parameters such as spindle rotation, feed rate and depth of cut on tool wear of the carbide inserts and machining characteristics are studied during turning of difficult to machine material.

2. EXPERIMENTAL DETAILS

Experiments were conducted on ESTEAM ETM 356 engine lathe with two controllable axes. The cutting tool used for turning is carbide CNMG 12 04 08 CQ insert. The Grade of the insert CJ255P, having a relief angle of 0^0 and nose radius of 0.8 mm. The experimental setup used for conducting experiments is given in Fig. 1. Round bars of AISI D2 tool steel with dimension 18 mm x 100 mm is used as the work piece material. The cutting variables such as spindle rotation, feed rate and depth of cut are varied at three levels and the machine setting parameters is given in Table 1. The length of machining is maintained constant at 50 mm throughout the experiments.

Fig 1 Experimental setup used for conducting experiments

TABLE 1 MACHINE SETTING PARAMETERS

Spindle Rotation (rpm)	Feed rate (mm/rev)	Depth of cut (mm)
600	0.05	0.40
1200	0.10	0.80
1800	0.15	1.20

TABLE 2 EFFECT OF PROCESS PARAMETERS ON MRR AND TOOL NOSE WEAR

S. No	Spindle rotation (rpm)	Feed (mm/rev)	Depth of cut (mm)	MRR (g/min)	Tool nose wear (mm)
1	600	0.05	0.40	3.447	0.103
2	600	0.05	0.80	5.598	0.095
3	600	0.05	1.20	6.735	0.093
4	600	0.10	0.40	6.714	0.098
5	600	0.10	0.80	10.668	0.099
6	600	0.10	1.20	11.580	0.100
7	600	0.15	0.40	12.924	0.108
8	600	0.15	0.80	15.165	0.109
9	600	0.15	1.20	21.402	0.110
10	1200	0.05	0.40	6.708	0.108
11	1200	0.05	0.80	16.008	0.100
12	1200	0.05	1.20	9.180	0.098
13	1200	0.10	0.40	15.672	0.099
14	1200	0.10	0.80	24.264	0.102
15	1200	0.10	1.20	24.000	0.106
16	1200	0.15	0.40	32.364	0.085
17	1200	0.15	0.80	57.960	0.086
18	1200	0.15	1.20	55.440	0.098
19	1800	0.05	0.40	21.168	0.086
20	1800	0.05	0.80	12.474	0.080
21	1800	0.05	1.20	40.068	0.075
22	1800	0.10	0.40	7.740	0.083
23	1800	0.10	0.80	46.044	0.085
24	1800	0.10	1.20	55.548	0.089
25	1800	0.15	0.40	25.272	0.073
26	1800	0.15	0.80	38.826	0.075
27	1800	0.15	1.20	89.208	0.086

In this work the effect of input parameters such as spindle rotation, feed rate and depth of cut are varied and their effect on material removal rate (MRR) and tool wear which are taken as the output parameters is analyzed by conducting experiments.

3. RESULTS AND DISCUSSION

3.1 Influence of process parameters on MRR The influence of process parameters on MRR and tool wear is given in Table 2 and are discussed in following sections The effect of spindle rotation on MRR is given in Fig.2. For all feed rate and depth of cut, at low spindle rotation (600 rpm) MRR is observed to be small and at high spindle rotation (1800 rpm) MRR is high. As the spindle rotation is increased, the circumferential length of the material encounter the tool nose radius increases. This resulted in increased MRR at higher spindle rotation. Also, the volume of material removed per unit length increases, this leads to increased MRR.

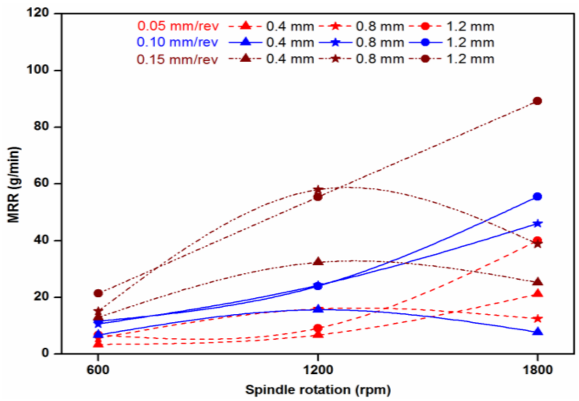

Fig. 2 Effect of spindle rotation on MRR

The effect of feed rate on MRR is given in Fig. 3. It is observed for all depth of cut and spindle rotation, varying feed rate MRR increases. For fixed depth of cut increasing spindle rotation MRR increases for all feed rate. The distances come across by the tool per unit revolution of work piece increases that leads to increased MRR.

The effect of depth of cut on MRR is shown in Fig. 4. It is observed at low feed rates (0.05 mm/rev & 0.10 mm/rev) for all spindle rotation, varying depth of cut MRR is invariant and is maintained around 20 g/min. At higher feed rate (0.15 mm/rev) for all spindle rotation, varying depth of cut increased value of MRR is observed. At higher feed rate, the cutting force at tool work piece interface is larger compared to that at lower feed rates. The increase in cutting force at higher feed rate removes more amount of material from the work piece surface that resulted in increased MRR.

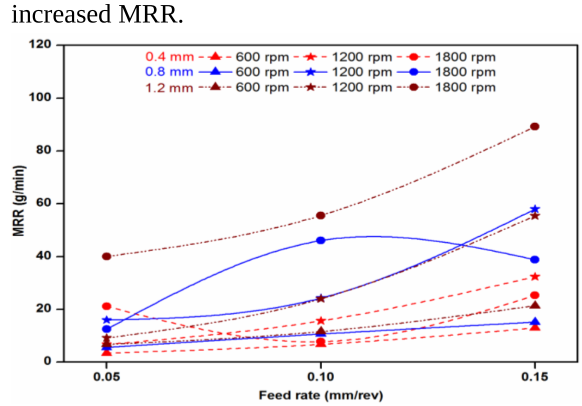

Fig. 3 Effect of feed rate on MRR

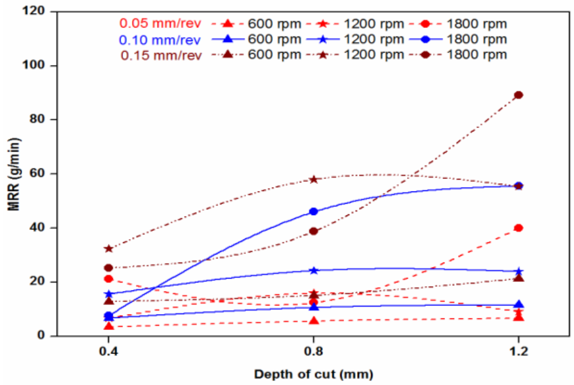

Fig. 4 Effect of depth of cut on MRR

3.2 Influence of process parameters on tool nose wear

The effect of spindle rotation on tool nose wear is given in Fig. 5. It is observed, for all feed rate and depth of cut increasing the spindle rotation tool nose wear decreases. At low feed rates (0.05 mm/rev and 0.10 mm/rev) tool nose wear increases upto 1200 rpm and beyond it shows a decreasing trend. At higher feed rate (0.15 mm/rev) as the spindle rotation increases tool nose wear decreases. At low spindle rotation (600 rpm and 1200 rpm), high surface temperature and low surface velocity exist at tool work interface which resulted in increased tool nose wear.

The influence of feed rate on tool nose wear is given in Fig. 6. It is observed for all depth of cut and spindle rotation increasing feed rate, marginal increase in tool nose wear is observed. At low depth of cut of 0.4 mm for all spindle rotation increasing the feed rate tool nose wear decreases. At higher depth of cuts (0.8 mm and 1.2 mm) increasing the feed rate tool nose wear increases upto 0.10 mm/rev. At 1.2 mm/rev of feed rate tool nose wear decreases due to thermal softening.

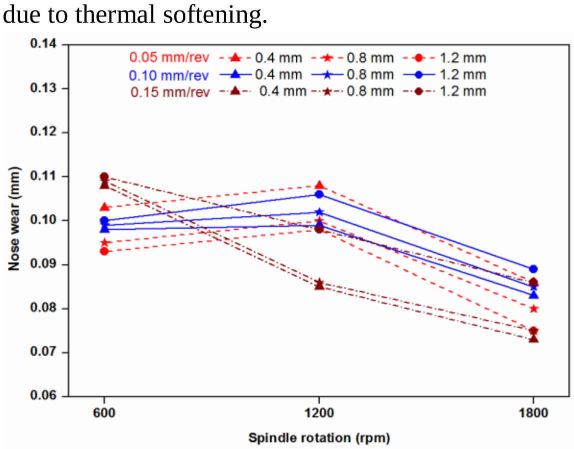

Fig. 5 Effect of spindle rotation on tool nose wear

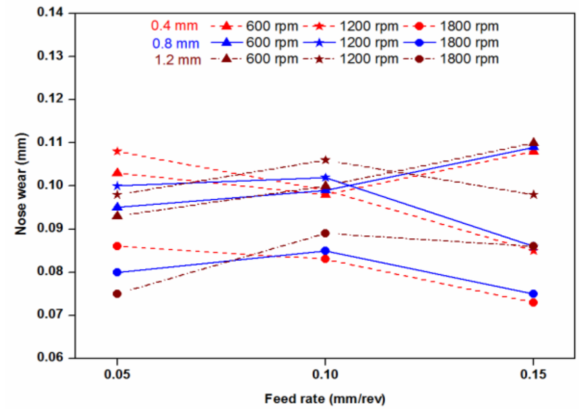

Fig. 6 Effect of feed rate on tool nose wear

The effect of depth of cut on tool nose wear is given in Fig. 7. For all feed rate and spindle rotation increasing the depth of cut tool nose wear varies marginally.

4. CONCLUSION

The influence of process parameters such as spindle rotation, feed and depth of cut on output parameters such as MRR and tool nose wear are analyzed. It is found that MRR increases with increase in spindle rotation. As the spindle rotation increases, the circumferential length of the material encountering the tool nose radius per unit time increases, which resulted

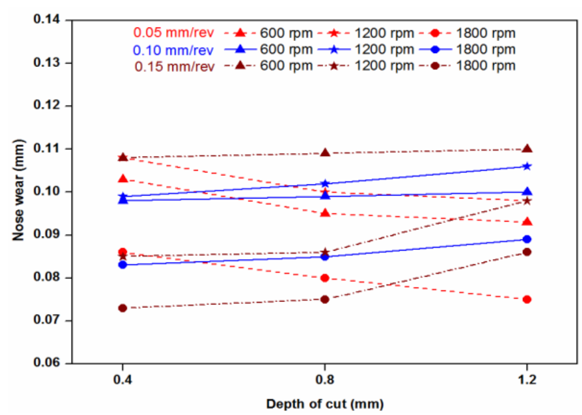

Fig. 7 Effect of depth of cut on tool nose wear

in increased MRR. For all depth of cut and spindle rotation MRR is invariant at low feed rates (up to 0.10 mm/rev). At 0.15 mm/rev of feed rate, MRR increases due to increase in cutting force at tool work piece interface that removes more amount of material from work piece. MRR increases with increase in feed rate for varying spindle rotation and depth of cut. As the feed rate increases, the distance encountered by the tool per unit revolution of the work piece increases that leads to increased MRR. The effect of process parameters on tool nose wear is also analyzed. It is found that spindle rrotation is having dominant effect on tool nose wear compared to feed rate and depth of cut.

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