Investigation on K20 Coated Carbide Insert Behavior on Turning OHNS Material

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Abstract: *Development of new material replaced the existing one in many ways. More over the complexity and machining behavior of developed material increases the production cost. OHNS (Oil Hardened Non Shrinking Steel) is categorized under tool steel and has a carbon content of around 0.9% to 1.3%. Its typical applications include springs, rails, etc. But poor machinability characteristics and improper surface finish obtained by the commercially available tool limits its usage. The present work has been undertaken to determine the performance of K20 (PVD coated) tool on OHNS under different cutting parameters. The machining operation was performed with three levels of cutting speeds, three level of feed rates and three level of depth of cut. The worn out surface of the insert was examined by a Scanning Electron Microscope (SEM) .The effect of cutting speed, feed rate and depth of cut on the surface finish of OHNS was examined. It was found that wear rate increases with increase in cutting speed and also with increasing depth of cut.*

Keywords: *OHNS, K20 coated insert, turning, tool wear.*

1. Introduction

Steel is being used in almost all the engineering structures and the quality of steel used depends on various design factors of the particular component. Strength is primarily a function of carbon content, more the carbon contents more the strength and hardness [1]. OHNS steel is one such material with carbon content of around 1% [2]. Hardness increases with increase in carbon content, weldability and ductility decreases with increase in carbon content. One of the main drawbacks of OHNS is its poor machinability [3]. As the fatigue life of an industrial component depends on the degree of surface finish provided to it, better the surface finish better the fatigue life and hence a super finish is always desirable [4]. The *K20 insert*,which is mainly a compound of Tungsten carbide, has high strength and resists mechanical failure [5]. The insert was given a coating of Titanium aluminium nitride (TiAlN), which was chosen to effectively reduce the tool wear and thus help in increasing the tool life, which is desired in many industrial fields [6]. In this paper an attempt has been made to determine the tool wear, surface finish and other cutting parameters like MRR, Gross Power, Specific power, heat generated and Power consumed while dry machining of *OHNS*.

2. Experimental procedure

To determine the performance of K20 PVD (TiAlN) coated tool (CNMG type, 0.8 mm nose radius, PCLN R 2525 holder was obtained from WIDIA India Ltd), OHNS of about 25RC obtained from local market was taken as the base material in the form of a cylindrical rod of 50mm diameter and 200 mm length. The composition of the material is:

%C	%Si	%Mn	%P	%S	%Cr	%Ni
1.08	0.28	0.62	0.035	0.030	1.44	0.16

A center lathe of 8 kW spindle power was used for turning test in dry condition. The machining of OHNS was performed at three different speeds 50, 100 and 150 m/min, three different feed rates of 0.1, 0.2 and 0.3 mm/rev and three depth of cut as 0.5, 1.0 and 1.5 mm

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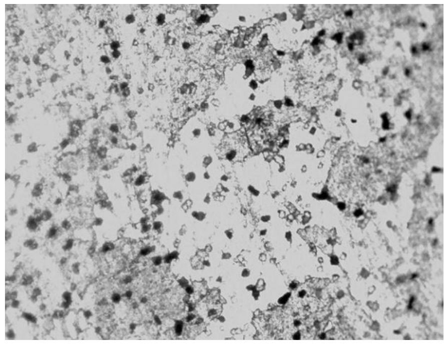

Microstructure of OHNS

The worn tip of the tool was then examined by using the Scanning Electron Microscope (SEM) to check its wear on the tool surface and tip. Also the surface finish obtained at the end of each trial was measured by using Surftest 301, Mitutoyo with a sampling length of 25mm. The arithmetic average roughness (Ra) was chosen as the evaluation factor of surface roughness of machined part. The power consumed while machining was calculated by 2 Wattmeter method using 600V-5Amp UPF wattmeter dynamometer type.

3. Results and discussions

3.1. Effect of cutting speed on Metal Removal Rate (MMR)

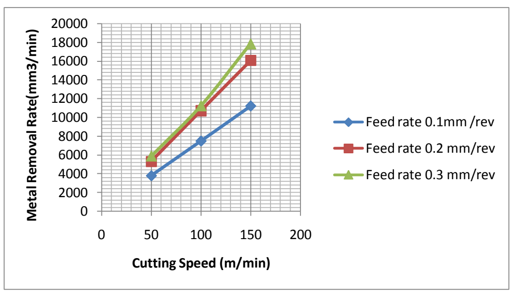

Fig. 1 Metal removal rate versus Cutting speed for depth of cut 0.5mm

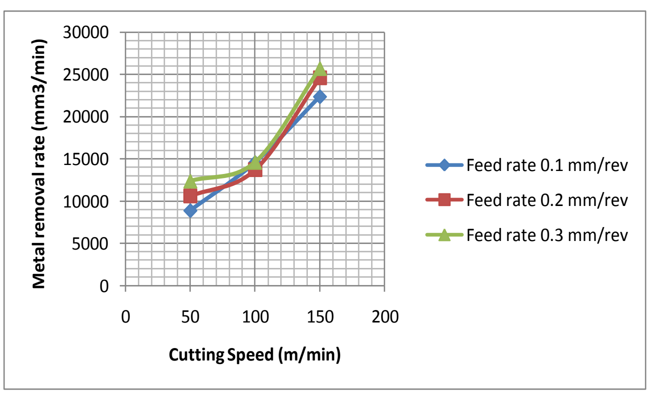

Fig. 2 Metal removal rate versus Cutting speed for depth of cut 1.5mm

Figure -1and 2 show the plot between cutting speed and metal removal rate for depth of cut 0.5 and 1.5 mm respectively. It is clearly evident that, there is a linear variation of MRR with the increase in cutting speed. The MRR is more for a depth of cut of 1.5mm when compared to a depth of cut of 0.5mm. The maximum MRR for a feed of 0.1mm/rev and depth of cut of 0.5mm is 11203 mm^3/min, compared to a feed rate of 0.3 mm/rev and depth of cut of 1.5mm is 25698 mm^3/min. So the machining of OHNS is better at a higher feed rate and higher depth of cut.

3.2. Effect of Cutting speed on Gross power (Pg)

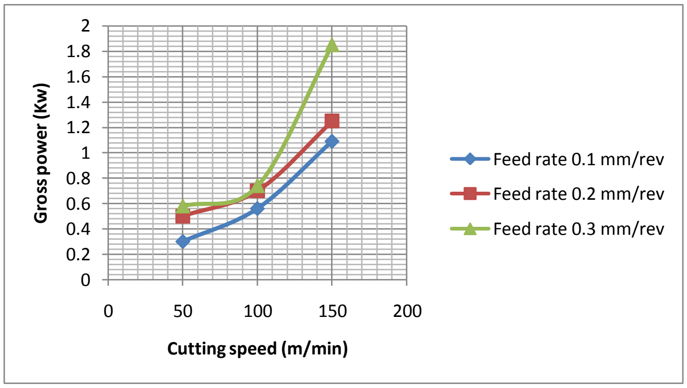

Fig – 3 Gross power versus Cutting speed for depth of cut 0.5 mm

From Figure 3 and 4, it is noted that the gross power has a fluctuating trend with cutting speed. This is due to the fluctuations in the supply. But the general trend shows that gross power increases with cutting speed. The minimum value of gross power consumed is at feed rate of 0.1 mm/rev and depth of cut 0.5mm and cutting speed 50 m/min. In 1.5 mm depth of cut feed rate of 0.2 mm/ rev shows more power at higher cutting speed. This can be attributed to the less initial torque at the higher cutting speeds.

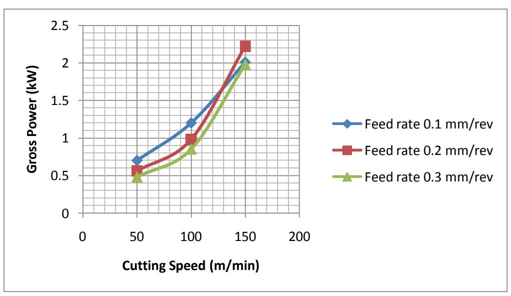

Fig. 4 Gross power versus Cutting speed for depth of cut 1.5 mm

3.3. Effect of cutting speed on Main cutting force

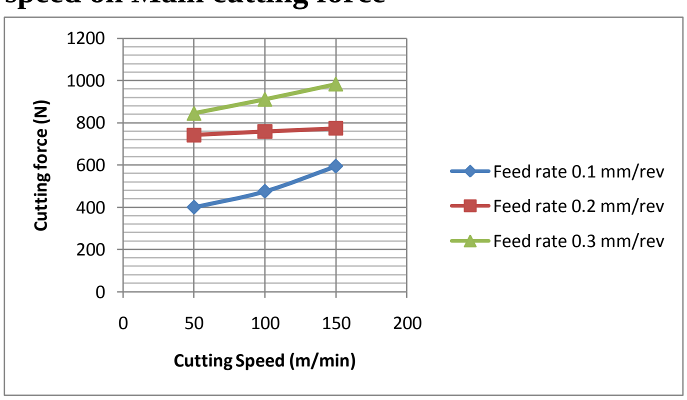

Fig. 5 Main cutting force versus Cutting speed for depth of cut 0.5 mm

From Figure 5 and 6, it is clearly understood that, the Main cutting force Fc has increased with increasing the cutting speed. The value of Fc increases as speed increases. Feed rate of 0.1 mm/rev shows lowest cutting force for all chosen cutting speeds for the depth of cut 0.5 mm. It is evident that the feed rate has more influence on the main cutting force. At depth of cut 1.5 mm, the main cutting force drastically increases. It is evident that, at lower cutting speed the main cutting force for all feed rates are almost equal. There is no much difference in the cutting force. When the cutting speed increases to 100 m/min feed rate of 0.2 and 0.3 shows almost on the same line. Feed rate of 0.1 mm shows much deviation in the force and it shows lowest cutting force at 150 m/min.

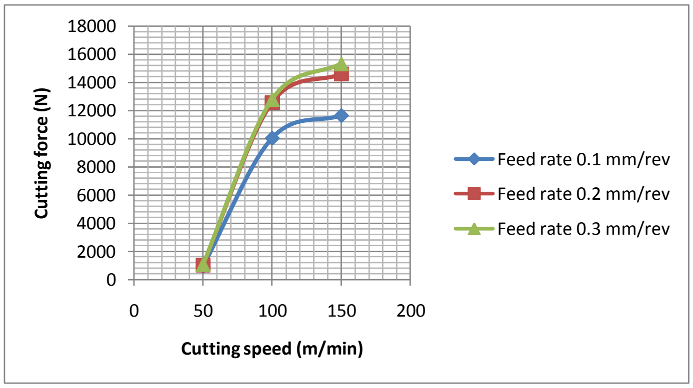

Fig – 6 Main cutting force versus Cutting speed for depth of cut 1.5 mm

3.4. Effect of cutting speed on power consumed

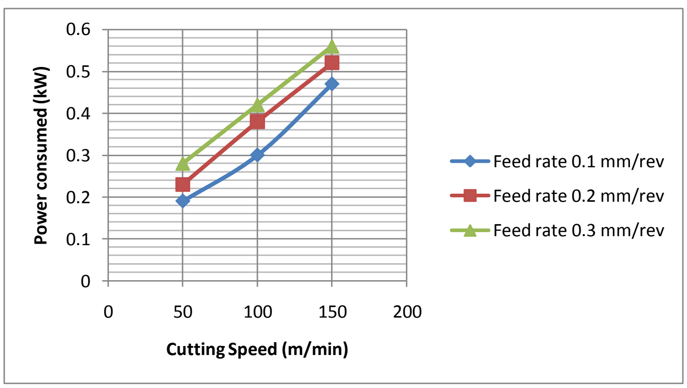

Fig – 7 power consumed versus Cutting speed for depth of cut 0.5 mm

According to the mathematical expression for Power consumed Pc = (Fc*V)/(60*102) the steady increase in Power consumed can be related to the increase in cutting speed. Slight variations were noted in the speeds between 50 and 150 m/min in feed rate of 0.1 mm/rev for depth of cut 0.5 mm. From figure 7 and 8, it is clearly noted that there is a steady increase in the power consumed. At 1.5 mm depth of cut it is evident that there was no much deviation in power consumed by all feed rates. It shows depth of cut has less influence in power consumption.

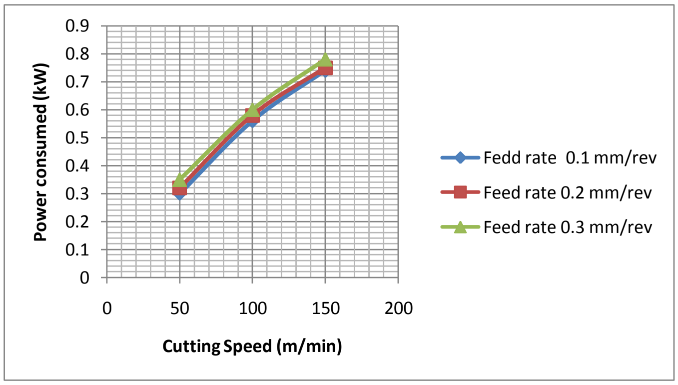

Fig. 8 Power consumed versus Cutting speed for depth of cut 1.5 mm

3.5. Effect of cutting speed on heat generated

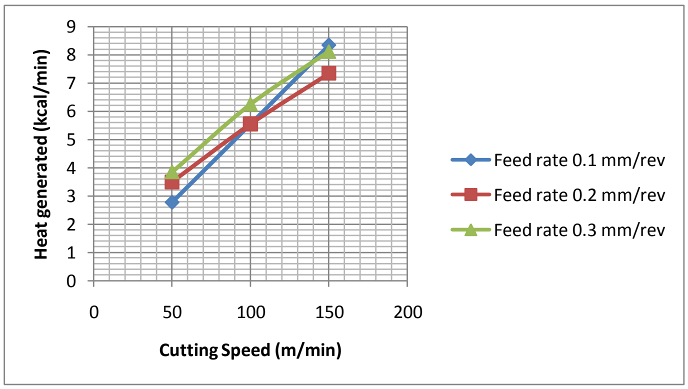

Fig. 9 Heat generated versus Cutting speed for depth of cut 0.5 mm

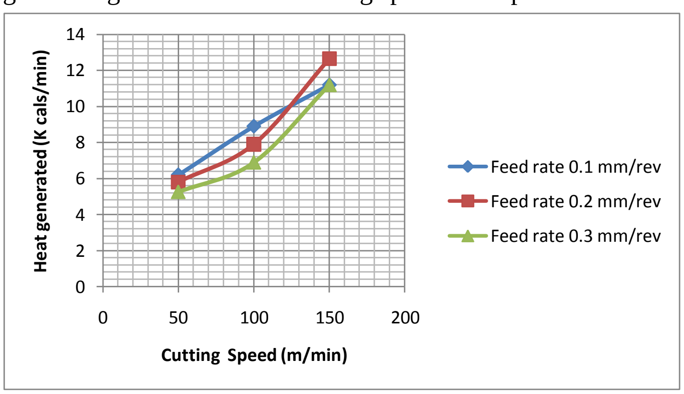

Fig. 10 Heat generated versus Cutting speed for depth of cut 1.5 m

The heat generated increases with the increase in feed and also cutting speed.

(I). as per the formula of Q = Fc*V/427 Kcal/min it follows that as cutting speed V increases the heat generated will also increase.

(II). As the feed increases the cutting forces increases, which in turn increase the heat generated as per the above-mentioned formula. But the increase in cutting force Fc is slower than the increase in feed and hence the heat generated is slower than the increase in feed.

From Figure 9 and 10, it can be seen that for depth of cut 0.5 & 1.5 mm the increase in Q is very high with the increase in speed. But in 0.5 mm depth of cut, feed rate of 0.2 mm/rev shows lowest heat generated at cutting speed of150 m/min compared to the same cutting speed at 1.5 mm depth of cut heat generated for feed rate of 0.2 mm/rev shows highest one.

3.6. Effect of cutting speed on surface roughness (Ra)

It can be seen that Ra produced is strongly dependent on cutting speed, surface finish at low speeds is very poor but much less values of Ra are obtained at higher speeds. Also in contrary to cutting speed the surface finish is found to be good at lower feed and lower depth of cut rather than at higher values. This can be contributed to loss of point of contact in the tool tip after continuous machining due to tool wear, which in turn increases the contact area between tool and work piece.

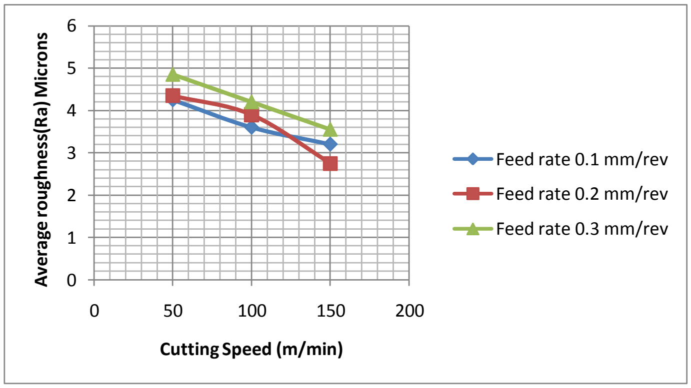

Fig. 11 Average surface roughness versus Cutting speed for depth of cut 0.5 mm

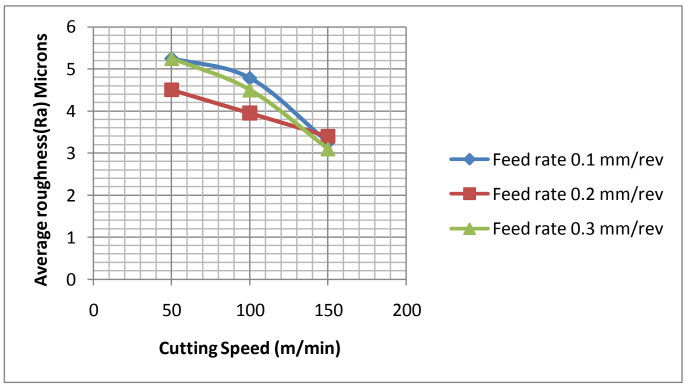

Fig. 12 Average surface roughness versus Cutting speed for depth of cut 1.5 mm

3.7. Tool wear analysis

Tool wear study was carried out for time duration of 30 minutes to predict the tool life by machining the work piece by using optimized cutting parameters (Fig 13). Optimized cutting parameters are found out from the result and discussions of various effects on cutting speed. From analysis it is evident that low feed rate, low depth of cut and high cutting speed produce good surface finish ($A_1B_1C_3$) Hence it is decided to carry out the tool wear study by using 0.1 mm/rev feed rate, 0.5 mm depth of cut with 150 m/min cutting speed

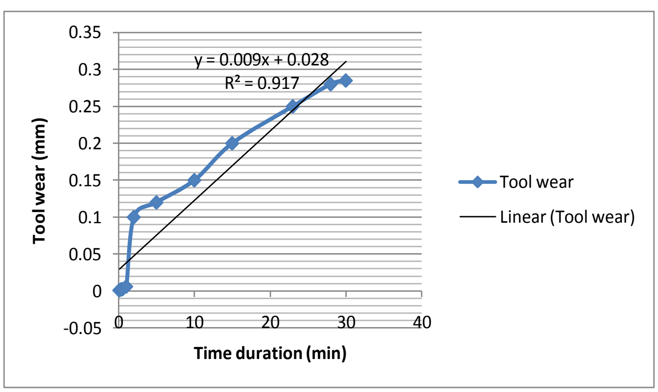

Fig. 13 Tool wears versus time duration

The SEM (Scanning Electron Microscope) analysis was made at the tip of the tool that was used for machining in order to find the extent of tool wear.

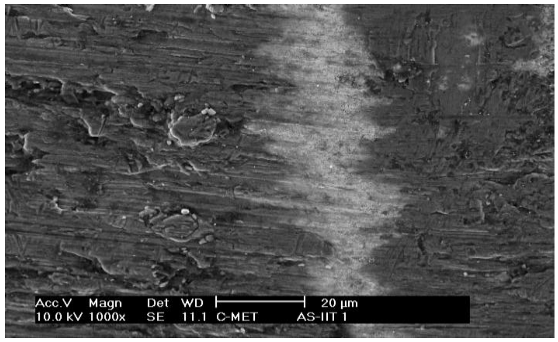

Fig 14 Scanning Electron Microscopic image of worn out insert

The electron microscope image shows the worn surface of the insert. The wear is more in the flank portion. It is also observed that abrasive marks are present in the worn surface of the insert. The white spot as seen in Fig 14 shows the formation of Built up edge (BUE). The built up edge formed is welded to the surface of the tool due to high temperatures that prevailed during the machining of OHNS material.

4. Conclusion

From the above-obtained results on machining of OHNS with K20 PVD coated Carbide insert, it is concluded that,

- The insert is performing well at speeds 150 m/min in order to obtain good surface finish.It increases the fatigue life of the component.
- Feed rate is a dominating parameter of metal removal rate of turning operation
- Spindle speed is a dominating parameter of surface roughness.
- OHNS steel rods having good machinability characteristics and produce reasonable surface finish.
- Depth of cut has less influence on power consumed
- Optimum parameters for good surface finish are feed rate 0.1 mm/re, cutting speed 150 m/min and depth of cut is 0.5 mm.

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