Performance Evaluation of Ti(C,N) Based Cermet Inserts for Dry Turning of SAE 1018

K.V. Parmar[1] & Dr. H. R. Thakkar[2]

[1]Ph.D. Scholar, Gujarat Technological University, Ahmedabad, (Gujarat), INDIA.

[1]Assistant Professor, Department of Mechanical Engineering, Atmiya University, Rajkot, (Gujarat), INDIA.

(Email id: keyurme032@gmail.com Whatsapp no.99099 15700)

[2]Associate Professor, Department of Mechanical Engineering, G.H. Patel College of Engineering & Technology, V.V.Nagar, (Gujarat), INDIA.

(Email id: hemantthakkar@gcet.ac.in whatsapp no.98257 40462)

(Corresponding author: **K.V. Parmar** Email id: keyurme032@gmail.com whatsapp no. 9909915700)

ABSTRACT: **Selection of cutting tools stands as a marvel of ultimate significance for machinists and manufacturing personnel which hamper the quality of surface, machining time and energy requirement. Cermet insert is a key preference for particular dry machining finishing operation in many industries. It possesses characteristic like high-temperature hardness, wear resistance, plastic deformation resistance, high chemical stability, and welding resistance. On the other hand, it is a moderate value of fracture resistance, thermal crack susceptibility, and shock resistance. The uncoated cermet insert has the capacity to the machining of the workpiece having hardness range between 35 to 40 HRC. In this research paper, the performance of Ti(C, N) based cermet insert is evaluated for the machining of low carbon steel (SAE 1018) with no coolant supply (dry turning condition). The Material removal rate (MRR) and surface finish of the component has been evaluated for cutting speed, feed and machining time. Depth of cut is considered as constant for the experimentation.**

Keywords: Cermet inserts, uncoated cermet, constant depth of cut, Ti(C,N), Dry turning.

Abbreviations: MRR, Material Removal Rate; HRC, Hardness Rockwell C; HSS, High Speed Steel; WC, Tungsten carbide chemical formula; BHN, Brinell hardness Number; CNC, Computerize Numeric Control; SAE, Society of Automotive Engineers;.

I. INTRODUCTION

Cermet is made by combining the properties of CERamic (TiC, TiN or TiCN) such as hardness, resistance to oxidation and heat resistance with the properties of METals (binder like Ni, Ni-Co, Fe, etc.) such as toughness and impact strength in order to create ideal cutting material [1]. Generally composites of cermet have been used as cutting tool material which will give properties in between cemented carbide tools and ceramic tools [2]. In a modern industries Ti(C,N) based cermet is most widely used as tool material due to its excellent properties like higher wear resistance, low friction coefficient, greater hardness, high strength, good surface finishing and outstanding resistance to high-temperature oxidation[3]. Cermet inserts are generally used for machining component having hardness of 35 to 40 HRC. The Ti(C,N) based modern cermets are generally used for finishing and semi finishing of steels and stainless steel at higher speeds [4]. Such material is not suitable for aluminium similar material. Cermet insert will give good surface and better machining accuracy for different workpiece when compared with the conventional Tungsten Cobalt cemented carbide insert [5].Ti (C,N) based cermets properties were increased by adding different ceramics such as TaC, Mo_2C, WC, TiN, Cr_3C_2 and VC [6]. Ti(C, N) based cermet cutting tool insert will give longer tool life and better surface quality of work piece compared to conventional cutting tool material such as HSS, WC based cemented carbide and TiC based cermet [7] .

II. EXPERIMENTAL PROCEDURE

A. Work piece material:

Generally cermet is used for steels and its different grades. Cutting tool material which is being used at different hardness of material and at different cutting speed are mentioned as given in figure 1.[8]

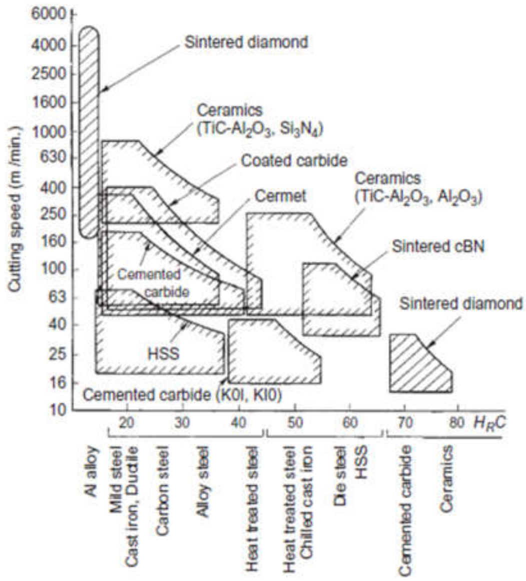


Fig. 1. Work piece hardness and cutting speed application range for a range of tool grades

As per ISO 3685: 1993 dimensions of works piece material is so selected that L/D ratio should not exceed 10 [9]. Hence Diameter of work piece is 32 mm and length as 100 mm respectively. Figure 2 shows optical emission spectrometer used for chemical analysis of work piece. Chemical analysis of selected component (SAE 1018) is done by Optical Emission Spectrometer for machining at dry condition is given in table 1. SAE 1018 is selected as work piece material for machining (turning) on CNC with uncoated cermet insert. Hardness of the work piece material is 125 BHN while measuring with conventional hardness tester.

Table 1Chemcial Analysis report of SAE 1018

Sr. No.	Name of Element	Composition in %
1	Carbon	0.179
2	Silicon	0.236
3	Manganese	0.652
4	Phosphorus	0.013
5	Sulphur	0.021
6	Chromium	0.032
7	Aluminum	0.028

C. Experiments:

SAE 1018 raw material was initially machined on conventional lathe machine for reference cutting. Finish turning operations were performed on Jober XL CNC machine by Ace Micromatics Inc. Turning process was carried out by cermet insert at constant depth of cut (0.2 mm). Many researchers have mentioned that cutting time is one of the significant factors which will affect turning process output [11].

B. Cutting tool material:

Cutting tool Insert is selected from Kyocera Inc. with has ISO P-10 grade cermet insert of ISO designation TNMG160408HQ for this dry machining process. Ti(C,N) based cermet insert of TN 6020 grade is having super micro grain structure.[10] As per the recommendation of manufacturer parameter, this cermet based insert will be used at cutting speed of 180 to 340 m/min and feed of range 0.1 to 0.25 mm/rev. But the information collected from different industries that cermet insert can work efficiently at cutting speed nearer to 400 m/min.

Fig. 2. Chemical Analysis by optical Emission Spectrometer

During finish turning operation value of process parameters mentioned as cutting speed - 150, 250 and 350 m/min, feed rate - 0.2, 0.3 and 0.4 mm/rev and cutting time - 5, 10 and 15 min. By using Minitab 16, Design of Experiments was generated for performing experiments.

Table 2 Process Parameters with range [12]

Sr. No.	Cutting Speed (m/min)	Feed (mm/rev)	Time (min.)	Depth of Cut (mm)
1	150	0.2	5	0.2
2	250	0.3	10	0.2
3	350	0.4	15	0.2

Fig. 3. Machining of SAE 1018

III. RESULT AND DISCUSSION

As far as turning process is concern material removal rate (MRR) and surface roughness are two major output parameters for checking performance of process. MRR were calculated at each point by standard equation. Surface roughness was checked with surface roughness tester (Mitutoyo SJ- 201). As workpiece is circular roughness were checked at three different degrees as 0°, 120° and 240° respectively. Longitudinal direction also checked at each degree at three or two different location. At the end average surface roughness were calculated and mentioned in table 3.

Table 3 Result of surface roughness measured

Experiment No.	Value of Roughness in Ra-μm (At 0°)	Value of Roughness in Ra-μm (At 0°)	Value of Roughness in Ra-μm (At 0°)
1	4.26, 4.98	5.30, 4.59	5.27, 4.07
2	8.42, 7.58	8.76, 8.87	7.76, 8.74
3	12.34, 12.95, 13.23	12.39, 13.01, 12.91	12.86, 12.89, 12.85
4	7.39, 7.61, 6.67	7.51, 7.72, 6.89	7.89, 7.37, 7.21
5	11.47, 10.86, 11.58	11.79, 10.93, 11.83	11.52, 11.23, 11.95
6	7.87, 7.99, 7.54	7.56, 8.21, 7.89	7.97, 7.82, 8.3
7	11.13, 10.24 (In between 0 and 120°)	10.37, 11.20 (In between 120 and 240°)	10.54, 10.09 (In between 240 and 0°)
8	6.35, 6.67, 7.15	6.59, 6.53, 7.27	6.24, 6.43, 6.79
9	10.07, 10.37	10.46, 11.08	10.24, 10.89

Fig. 4. Surface roughness testing at 0°

Averages surface roughness were calculated and mentioned in table 4.

Table 4 Output result of experiment with average surface roughness

Sr. No.	*Cutting Speed (m/min)*	*Feed (mm/rev)*	*Time (min.)*	*MRR (mm^3/min)*	*Avg. Surface Roughness (Ra-μm)*
1	150	0.2	5	292.594	4.74
2	150	0.3	10	424.677	8.35
3	150	0.4	15	605.123	12.82
4	250	0.2	10	470.108	7.36
5	250	0.3	15	635.053	11.46
6	250	0.4	5	955.166	7.90
7	350	0.2	15	648.86	10.59
8	350	0.3	5	973.61	6.66
9	350	0.4	10	1176.324	10.51

These results of MRR and surface roughness were further analysed with ANOVA in MINITAB 16. And Significance of output with input parameters were checked. Analysis of Variance shows that for getting higher MRR, cutting speed is most significant parameter
and for getting lower surface roughness Time taken for machining is most significant parameter as shown in table.

Regression equation generated for Surface Roughness is given by:

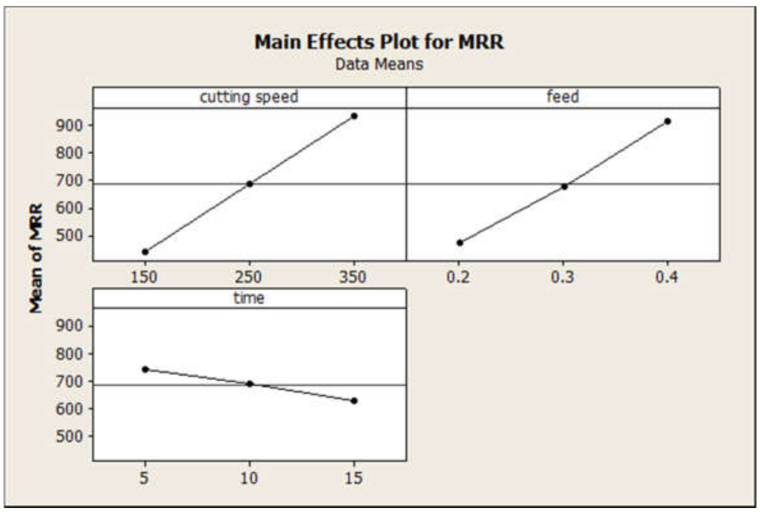
$$\text{Surface Roughness} = -1.2890 + 0.0030\ \text{Cutting Speed} + 14.2192\ \text{Feed} + 0.5186\ \text{Time} \quad (1)$$

Table 6 Analysis of Variance for Surface roughness

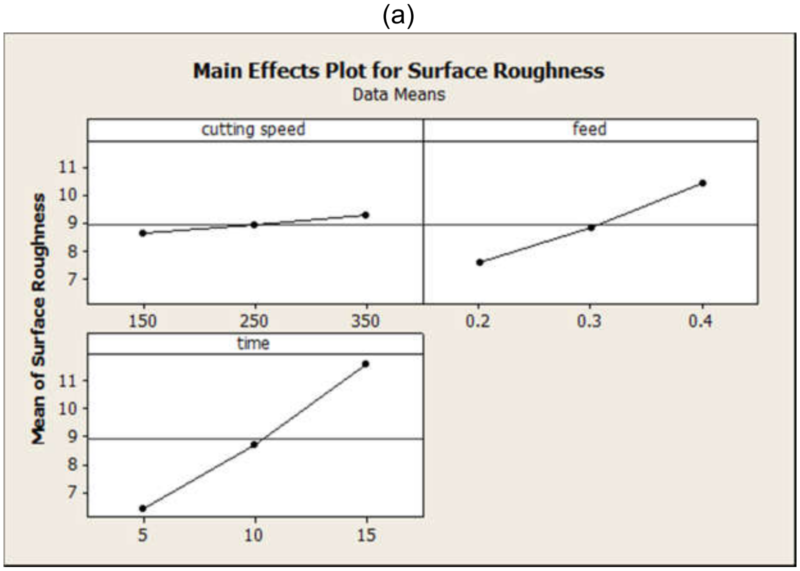
Source	***DF***	***Seq SS***	***Adj MS***	***F***	***P***	***% Contribution***
Cutting Speed	2	0.5694	0.2847	158.86	0.006	1.07
Feed	2	12.1869	6.0934	3399.97	0.000	22.97
Time	2	40.5146	20.2573	11303.04	0.000	76.37
Error	2	0.0036	0.0018			
Total	8	53.2744				

S = 0.0423344 R-Sq = 99.99% R-Sq(adj) = 99.97%

Main effect plot for MRR and surface roughness shows the effects of different parameters on both output parameters.



(a)



(b)

Fig. 5. Main effect plot for (a) MRR and (b) Surface Roughness

IV. CONCLUSION

From the results it is clear that cutting speed is most contributing factor for MRR and for surface roughness time plays major role. Main effect plot of MRR shows that as cutting speed is increasing MRR will increase and time increases MRR decrease which fulfil basic requirement of any manufacturing industry. Main effect plot of surface roughness shows higher surface roughness when time is higher and it shows minor increment when cutting speed increases. So from this result it can be concluded that when cutting speed increased MRR will increase and minor surface roughness increment noted for cermet insert in turning SAE 1018.

V. FUTURE SCOPE

The research work of this paper can be extended by working on following few points: Cermet insert can also be evaluated with coating in dry turning method. Also Life of a cermet insert is also affected by its chemical composition. By changing the coating type cermet insert can be used for functionally.

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