Comparison of Performances of Novel Titanium carbide tool Insert and Uncoated Tool in CNC Turning of HCHC D2 Steel for Minimizing Surface Roughness and Maximizing Material Removal Rate

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Abstract

Aim:-*The Present study is focused on the comparison of performances of Titanium carbide(TIC) and Uncoated carbide tool inserts with CNC turning of HCHC D2 Steel for minimizing surface roughness and maximizing material removal rate.* ***Materials And Methods:-*** *Machining of HCHC D2 steel material was compared with Titanium carbide(TIC) and Uncoated carbide tool inserts. It was divided into two groups of 27 samples each. The samples were machined with two different tool inserts one was control group and other was experimental group.* ***Results:-*** *Surface roughness was decreased and material removal rate was increased when machining was done with TIC carbide compared to HSS tool insert (P=0.028).****Conclusions:*** *It is concluded that the surface roughness was decreased and material removal rate was increased when TIC carbide tool insert was used for machining.*

Key-words: CNC Turning, Novel TiC Insert, Surface Roughness (R_a), Material Removal Rate (MRR), Feed, Speed, Depth of Cut, Cutting Threading Dies, Green Manufacturing.

1. Introduction

CNC machining is a advanced manufacturing process that typically employs computerized controls and machine tools to remove layers of materials, including metals, plastics, wood, glass, foam, and composites. The present study was focused on the comparison of Titanium carbide(TIC) and uncoated tool inserts in CNC turning of HCHC D2 Steel. It is used for long run tooling applications and has the ability to wear resistance. (Kumar, Saravanan, and Patnaik 2020; Yadav and

Shrivastava 2021). The applications were cold stamping, tyre shredders, punches, slitters which are used in day-to-day life.

In 2018 (Vipin et al. 2018) the author compared the machining performances of pcd insert with pcbn insert and concluded that the material removal rate was high when pcd tool insert was used (Meshram et al. 2020). Multiple regression analysis was done to predict the model and optimal parameters were found by using the WEDM process for this paper. ("Study of Surface Modification by Electrical Discharge Machining" 2007). Powder mixed electric discharge machining (PMEDM) is the 6 process used for machining to calculate surface roughness and material removal rate.(Rout and Jena 2021) optimization of surface roughness and analyzing through taguchi and anova methods. (Biswas, Singh, and Mukherjee 2021).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S. R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

Currently, the research was about turning studies Of HCHC D2 steel with different turning tools is limited. Hence in this study, Comparing the HCHC D2 steel material with Titanium carbide and Uncoated ceramic tool insert is carried out (Shah et al. 2011). The parameters like speed was decreased and increased in feed resulted during a poor surface roughness and fewer material removal rate. The material removal is found high for HCHC D2 steel with Titanium carbide turning tool. Aim of the study was to compare the surface roughness with two different tools and acquire a good surface finish to decrease the machining time and increase the assembly rate and increase the productivity.

2. Material And Methods

This study was done in Saveetha Industries, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai. The total number of samples were divided into two groups. One was an experimental group and the other one control group. The tool used for machining titanium carbide is an experimental group and the tool used for machining with HSS is the control group. A total number of 54 samples are required. G Power is allowed to utilize programming used to figure measurable force. 80% G power is obtained. Confidence percentage was 90% and the

enrollment ratio was 1.The HCHC D2 steel of cylindrical length is 2700*36mm. It is cut into 54 pieces of 100mm length. The rough turning of 1mm is machined in the conventional lathe machine.

Titanium carbide, (TIC) is an incredibly hard unmanageable artistic material, like tungsten carbide (Singh, Khatirkar, and Sapate 2015). It resembles dark powder with the sodium chloride gem structure. It occurs in nature as a form of a very rare mineral (Biradar and Lathkar 2014). The VOEDM identifies the major contributing factor of pulse off time for EWR (50.33%) and MRR (34.78% (Meshram et al. 2020). The effect of these parameters has been investigated by using Response Surface Methodology (RSM) (Walia, Srivastava, and Jain 2019). Speed, feed rate and depth of cut is compared with the uncoated Carbide tool at the same parametric values in the CNC turning machine (Shirpurkar, Waghmare, and Date 2019).

It is frequently utilized in power sharp edges and boring apparatus. It is better than the more established high carbon steel instruments utilized widely and they can withstand higher temperatures without losing their hardness. Material Removal Rate It is defined as the ratio of difference in weights before and after machining to time taken for machining. MRR=(Weight before machining - weight after machining)/Time taken(Kumar, Saravanan, and Patnaik 2020).

A Rough turning of 1mm was done using a conventional lathe machine. CNC machining was done with TIC and HSS tool inserts with input parameters Speed Feed Depth of cut. The HCHC D2 steel was inserted in the three-jaw chuck of the CNC machine of 30mm length in chuck 70mm for smooth roughness. The parameters had changed at regular intervals for every sample like Speed, Feed rate, Depth of Cut. The tool inserts were fixed in the tool holder and changed the tool for every specimen and noted down the values and time taken for machining for the single workpiece (and Adinarayana. 2014). Time taken for machining was calculated. Significance was calculated using SPSS software. Error bar graph was plotted between material removal rate and groups.

The obtained results are subjected to normality tests such as SPSS Software and Minitab. An independent t-test is performed to compare the mean and standard errors. The independent sample t-test was done to define the groups.

3. Result

The material removal rate is increased in the HCHC D2 steel compared with the uncoated ceramic insert. Also, it increases the lifetime of the tool and gets good surface roughness. With increased feed and depth of cut, the material removal rate was high and the surface finish was

smooth. From the independent sample test, the significance values of Levene's test for equality of variance is 0.028.

Data collections of speed, feed, depth (L9 Orthogonal array table). All the values were different parameters. The tabulated values are the Titanium carbide tool insert. The input parameters speed, feed, depth of cut varies from 1310-1330rpm, 0.16-0.18mm/rev, 0.16-0.18mm respectively (Table 1). The table values shows the material removal rate of Titanium carbide and uncoated ceramic tool after calculating the weights of the workpieces. Titanium carbide has the highest material removal rate of 0.03692. Uncoated ceramic has the material removal rate of 0.13070(Table 2). Represents the means and standard deviation of material removal rate. The mean and standard deviation of TIC and HSS is 0.0280265 0.0514726; .00738290 .03426953 (Table 3). Independent sample test represents the significance and Levene's test for equality of variances and t-test for equality of means in material removal rate. The significant value is P(p=0.028) for levene's test for equality of variances (Table 4). Signal to noise ratio(S/n)ratio graph was plotted. The optimum conditions for obtaining maximum MRR is with a speed of1310, feed 0.16,depth of cut 0.16mm(Fig 1). Represents Means of means graph is plotted for speed, feed and depth of cut(Fig 2).

Table 1 - Data collections of speed, feed, depth (L9 Orthogonal array table). All the values were different parameters. The tabulated values are the Titanium carbide tool insert. The input parameters speed, feed, depth of cut varies from 1310-1330rpm, 0.16-0.18mm/rev, 0.16-0.18mm respectively.

S.NO	Speed(rpm)	Feed(mm/rev)	Depth(mm)
1	1310	0.16	0.16
2	1310	0.17	0.17
3	1310	0.18	0.18
4	1320	0.16	0.17
5	1320	0.17	0.18
6	1320	0.18	0.16
7	1330	0.16	0.18
8	1330	0.17	0.16
9	1330	0.18	0.17

Table 2 - The table values shows the material removal rate of Titanium carbide and uncoated ceramic tool after calculating the weights of the workpieces. Titanium carbide has the highest material removal rate of 0.03692. Uncoated ceramic has the material removal rate of 0.13070.

S.NO	MRR (TIC tool insert)	MRR (Uncoated tool insert)
1	2.027310	1.128000
2	2.027450	1.133750
3	2.032040	1.131760
4	2.038000	1.145790
5	2.040000	1.124620
6	2.032940	1.147690
7	2.043660	1.138640
8	2.043910	1.158640
9	2.056920	1.182040

Table 3 - Represents the means and standard deviation of material removal rate.The mean and standard deviation of TIC and HSS is 0.0280265 0.0514726; .00738290 .03426953

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
MRR	TIC	9	.0280265	.00738290	.00246097
	HSS	9	.0514726	.03426953	.01142318

Table 4 - Independent sample test represents the significance and Levene's test for equality of variances and t-test for equality of means in material removal rate.The significant value is P(p=0.028) for levene's test for equality of variances.

Independent Samples Test		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MRR	Equal variances assumed	5.841	.028	-2.006	16	.042	-.02344608	.01168526	-.04821772	.00132556
	Equal variances not assumed			-2.006	8.741	.027	-.02344608	.01168526	-.04999985	.00310769

Fig. 1 - Titanium carbide tool insert (TIC)

Fig. 2 - Uncoated ceramic tool insert

Fig.3 CNC Turning Machine

Fig. 4 - Signal to noise ratio(S/n)ratio graph was plotted. The optimum conditions for obtaining maximum MRR is with a speed of 1310,feed 0.16,depth of cut 0.16mm.
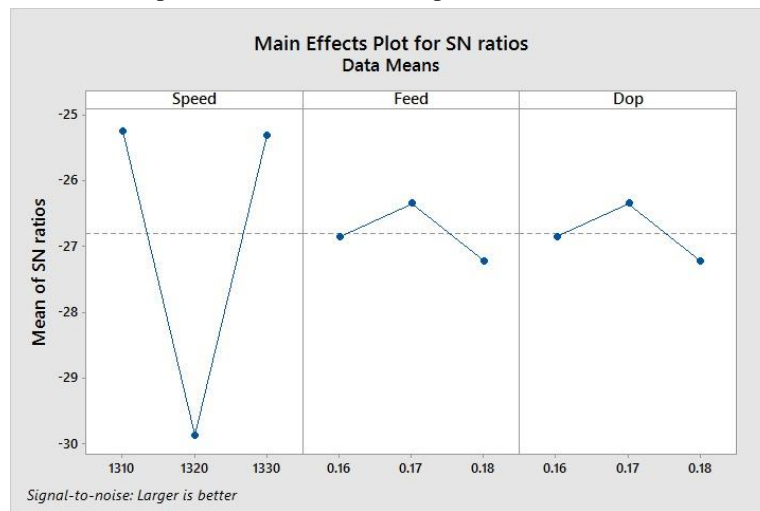

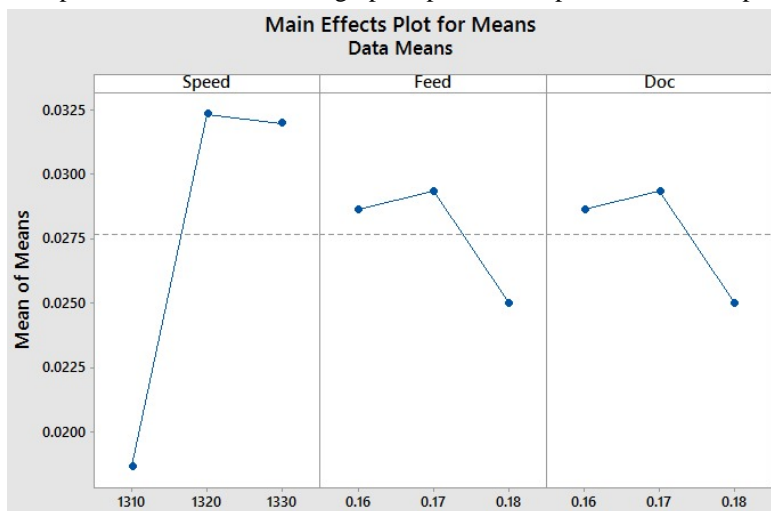Fig. 5 - Represents Means of means graph is plotted for speed ,feed and depth of cut

Fig. 6 - Barchart Comparison of mean MRR (+/-1SD) of uncoated ceramic tool and titanium carbide tool insert method. Titanium carbide method appears to produce most variable results with its standard deviation ranging from the lower 1.200000 to the upper 2.000000.Uncoated ceramic tool appears to produce consistent results with minimal standard deviation. X Axis: Uncoated ceramic tool vs Titanium carbide tool Y Axis: Mean MRR +/- 1SD.
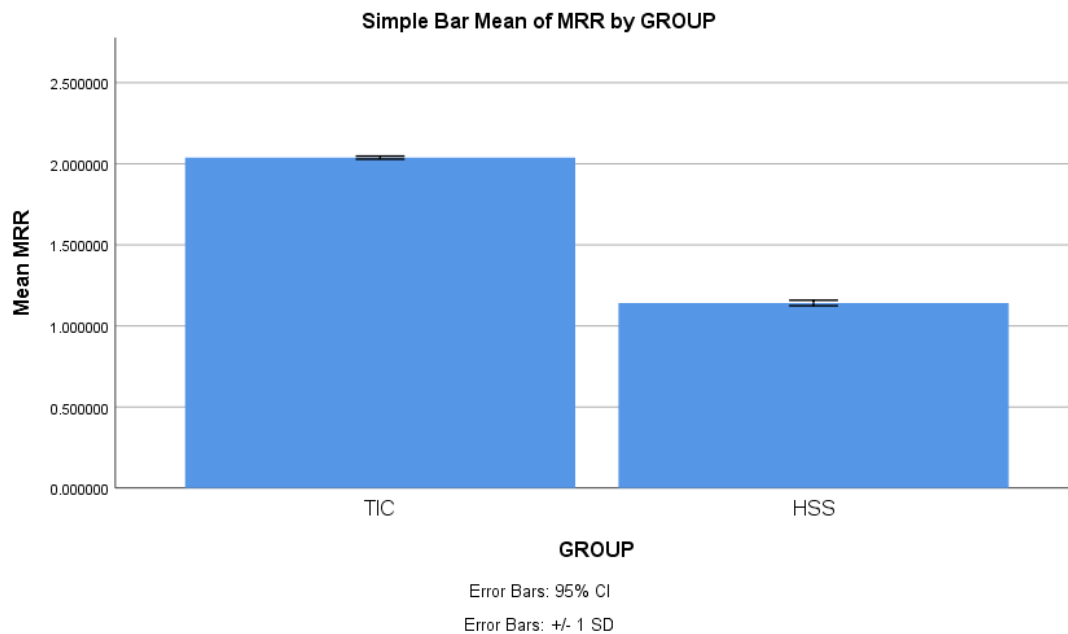
4. Discussion

The results show that the material removal rate increases when the depth of cut is increased. Depth of cut is the main reason to increase the material removal rate.The material removal rate is increased by approximately 10% for Tic tool insert There was an 5% error (approx) in surface roughness It reduces the tool ware and frictional losses because of a good surface finish. Tool wear rate is low and the surface finish is good. The time taken for production has decreased and the life time of the tool has increased. The significance value was (P=0.028)

Various methods were used to do the surface roughness and material removal rate. Powder mixed electric discharge machining (PMEDM) is a recent outcome. The R_a and MRR are not better with this method compared with the CNC machine (Rout and Jena 2021). Optimization of CNC turning machines using taguchi analysis in the dry turning operations are not better when compared with wet turning operations (Gadekula et al. 2018). Electrical discharge machining(EDM) process was not better compared with CNC machining process (Pushyanth and Bhaskar 2018). Different suitable lubricants are used for obtaining good surface roughness (Shankar and Krishnakumar 2016).

Our institution is passionate about high quality evidence based research and has excelled in various fields (Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019;

Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

The tool wear rate is low due to hard machining of HCHC D2 Steel. When speed is increased the tool gets damaged. Poor surface finish is observed when the lubricant is not used and tool wear rate is high. In future it is used for cold stamping and die forgings, punches and slitters. Die used for forging will have a smooth surface finish which results in a good quality product.

5. Conclusion

From the above findings surface roughness was decreased and material removal rate was increased when machining of HCHC D2 Steel was done with TIC tool insert. The life time of the tool was increased. The optimum conditions for obtaining good surface finish is when speed, feed, depth of cut are 1320 rpm, 0.17mm/rev, 0.17 mm respectively.

Declarations

Conflict of interest: No conflict of interest in this manuscript.

Authors Contributions

Author CRT was involved in data collection, manuscript writing. Author SL was involved in conceptualization, data validation, and critical review of manuscript.

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