COMPARING MACHINABILITY PERFORMANCE OF NOVEL TISIN COATED HSS TOOL WITH UNCOATED HSS TOOL FOR CNC TURNING OF HIGH STRENGTH STEEL ALLOY (EN24) FOR IMPROVING MACHINING RATE AND SURFACE FINISH

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Abstract

Aim: The main of this work is about Comparing machinability performance of Novel TiSiN coated HSS tool with uncoated HSS tool for CNC Green machining (CNC Turning) of high strength steel alloy (EN24) for improving machining rate and surface Finish.

Materials and method: EN24 Steel rod of diameter 22mm and 50mm of length of rod is used in the research work, En24 steel was normalized at 800-860°C. Hold at this temperature then quench in oil .Test samples per (N=16+16=32) were CNC turning operation is used for find the surface finish and material removal rate taken from each rod of experimental group and control group.(Unalloyed EN24).Total sample size used for the Groups is 32 and 80% of G power is calculated using the software G Power 3.1.

Result: Within this limitations of study the confidence level of cutting parameters and the response Surface Roughness values are obtained for all machined specimens with both HSS tool and Novel Titanium Silicon Nitride coated High speed steel tool and the results done by Turning were conducted with speed, feed and depth cuts to turning process with an MRR is 350mm^3/min and depth of cut affects considerably cutting force and power (62.31% and 60.72%). And the Surface Roughness is 25.885%. Using TiSiN coated HSS tool gives lower surface roughness than HSS tool in Computerized Numerical Control machining.Surface roughness of samples, group wise statistically evaluated with SPSS software. T-test results show significance values are $p=0.020<0.05$ for Material Removal Rate (MRR) and $p=0.033<0.05$, for Surface roughness. Which reveals that the observations are statistically independent and observed statistical assumptions with no violation. The mean surface roughness for samples prepared with novel TiSiN coated HSS tool gives lesser surface roughness than HSS tool. **Conclusion:** Within the limits of study, the optimization of EN24 Material removal rate, Surface finish and Surface Roughness using response of Novel Titanium silicon Nitride Coated Tool. The results obtained revealed that spindle speed, feed rate and depth of cut have a significant influence on the MRR. The optimum machining setting of spindle at 500 rpm, the feed rate of 0.4mm/rev and depth is 0.2mm resulted in a turning process with an MRR.

Keywords: High speed steel, Nickel Chromium Molybdenum High Tensile Steel, Novel Titanium silicon Nitride coat, Surface finish, CNC Turning, Green Manufacturing**.** Material Removal Rate.

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1. Introduction

This research is about investigating the possibility of improving material removal rate and surface roughness with use of Titanium Silicon Nitride (TiSiN) coated high strength steel tool for CNC turning of unalloyed Nickel chromium molybdenum high tensile steel (EN24). Design of experiments (DOE) and influence of machining process parameters on the surface roughness characteristics is investigated. The multiple responses are optimized simultaneously using Taguchi based grey relational analysis. Analysis of Variance (ANOVA) for grey relational grade reveals that cutting speed is the most significant parameter followed by feed and the influence of depth of cut is insignificant (Das et al. 2018). The machinability of different materials which are commonly used to produce automotive parts such as shafts, gears and bearings. Surface quality is one of the most impellent customer requirements in machining of soft and hard turning. The main aspect of surface quality on machined parts is probably surface integrity, such as roughness and residual stresses. There are three controllable factors in the turning process viz. cutting speed, feed and depth of cut. Optimization of cutting parameters is usually a difficult work, where the following aspects are required: knowledge of machining; empirical equations relating the tool life, forces, power, surface finish, etc., to develop realistic constraints; specification of machine tool capabilities; development of an effective optimization criterion; and knowledge of mathematical and numerical optimization techniques (Das et al. 2018; Panwar et al. 2021)The turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine. The cutting tool feeds into the specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size, and more. Turning parameters that can affect the processes are: Cutting speed,Spindle speed,Feed rate, Depth of cut (Ozturk 2016).Surface roughness is one of the parameters that greatly influence the friction under certain running conditions. Surface roughness of the contacting surfaces influences the frictional properties of those surfaces during the forming processes (Kumar et al. 2012).

For the research last 5 years, research related to unalloyed nickel chromium molybdenum High tensile steel (EN24) material resulted in around 197 research papers in google scholar and 72 research papers in science direct.Cutting parameters have an effect on the surface roughness, surface texture and dimensional deviations of the product. Surface roughness, that is used to decide and to assess the high-quality of a product, is one of the essential exceptional attributes of a turning product. Three reducing parameters namely, insert radius, feed price, and intensity of reduce, are optimized with issues of surface roughness. The mechanism behind the formation of floor roughness could be very complex and system dependent (Khan and Maity 2017) EN24 is a high quality, high tensile, alloy steel and finds its typical applications in the manufacturing of automobile and machine tool parts. Properties of EN24 steel, like low specific heat, and tendency to strain-harden and diffuse between tool and work material, give rise to certain problems in its machining such as massive cutting forces, high cutting tool temperatures, poor surface end and built-up edge formation. This material is so difficult to machine.The purpose of metal cutting operation commonly called machining is to produce a desired shape, size and finish of an element by removing the excess metal in the type of chips from rough blocks of fabric. Metal cutting processes normally ought to be carried out at high speeds and feeds with the smallest amount of cutting effort at a minimum value (“Website,” n.d.). It is turned in the CNC to high surface roughness and to low material removal rate by the comparison of the performance of novel TiSiN coated HSS tool and High speed steel (HSS) insert for improving the Material Removal Rate in the manufacturing industries (Jadhav and Shaikh 2016). Surface roughness for turning, few researcher taken output parameter: material removal rate We also found that for surface roughness the most significant parameters are speed, feed and nose radius and least significant parameter is DOC and for MRR the most significant parameters are DOC, feed and speed and least significant parameter is nose radius (Shobha et al. 2019).It predicts that the feed is highly influential for good quality of a surface (Thokale, Bidwai, and Yadav 2015). The surface roughness model for predicting surface roughness during machining is built in order to deal with time constraints of adjusting and testing.. The turning forces (cutting force, thrust force and feed force) are observed to be lower using multilayer coated carbide insert in hard turning compared to uncoated carbide insert (Panwar et al. 2021). From the above studies (Shobha et al. 2019)) findings are best and also closely related to this research.

Our team has extensive knowledge and research experience that has translated into high quality publications (Vickram et al. 2022; Bharathiraja et al. 2022; Kale et al. 2022; Sumathy et al. 2022; Thanigaivel et al. 2022; Ram et al. 2022; Jothi et al. 2022; Anupong et al. 2022; Yaashikaa, Keerthana Devi, and Senthil Kumar 2022; Palanisamy et al.

2022). To the best of my knowledge, no research has been carried out to investigate for comparing with Novel TiSiN coated HSS tool and Uncoated HSS tool in this process the best suitable is surface finishing and improve machinability.The chemical composite of Nickel Chromium molybdenum (EN24) Nickel has 1.30-0.44%,Chromium has 1.00-1.40% ,Molybdenum has 0.20-0.35%. EN24 is an extremely high strength steel composite which is provided solidified and tempered. Surface finish is a crucial thing during any machining processes, hence it is very essential to control the required surface quality to have a better choice of optimized cutting parameters. The main intention is to optimize the cutting parameter. The main aim is not only to increase machine utilization but also to decrease production cost and achieve best surface finishing.

2. Materials and methods:

The material considered for the turning process is EN24 material and cutting tools are TiSiN coated HSS insert and HSS insert . EN24 material is a medium strength steel with better tensile strength. Hence the two inserts were considered the process .This study was carried out in the CNC turning center (Figure 5) which is available at Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai.For this research did not involve any human samples for testing, ethical approval was not required. This experimental research compares two groups namely Control group (HSS tool) and Experimental group(TiSiN coated HSS tool). Number of groups should be 2,and therefore the sample size for every group is 16.The Total sample size used for the Groups is 32 and 80% of G power is calculated using the software GPower 3.1. The sample means used are 0.8675 for conventional methods and 0.8773 for proposed methods. If the pretest g power is 80%,Alpha 0.05.(Kane et al. 2021)

For the project purpose I bought the unalloyed carbon steel (EN24) material , TiSiN coated HSS tool and HSS tool. I bought Unalloyed carbon steel (EN24) material 20 mm diameter and 3 meter length rod at Sri sati metal shop,17A,Mugappair Road, Padi,chennai,Tamil Nadu,600050.And also I bought TiSiN coated tool and Uncoated High speed steel tool (Fig .1) at Vinayaga Enterprises Dealers in:High Speed Steel CuttingTools,CarbideInserts,CNC Tools MAchines, #250, Kannappar Thidal,Chennai 600003. The specifications were prepared with dimensions 20*50 mm and as shown in (Fig .2).Control group samples are to be dry turning machining with the utilization of an HSS tool. The green machining with different combinations of input parameters. The sample length of 50 mm was prefixed. EN24is a medium strength steel with sensible tensile strength.It is regularly provided in the virus drawn or moved condition. Tensile properties can shift yet are ordinarily between 500-800N/mm2. TiSiN have wear opposition covering for fast cutting.It is covered with acceptable hardness,thermal and Oxidation resistance.TiSiN is commonly covered on rapid cutting devices utilized on CNC machines for machining of solidified prepares from 50 to 60HRC.It is generally utilized in the dry machining. It is mostly used for cutting tools and drill bits. It is suitable for the older high carbon steel tools used extensively through the 1940s in that it can withstand higher temperatures without losing its temper .This property allows HSS to cut faster than high carbon steel,hence the name as high speed steel. HSS have generally displayed high hardness and abrasion resistance compared with common carbon tool steels.

TiSiN (Titanium Silicium Nitride) is a hard, bronze-color coating with high temperature and oxidation resistance. If silicon is added to the coating, a nanocomposite system is formed, with micro TiN grains embedded in an amorphous a-SiNx matrix. This is frequently used in high-speed cutting tools used on CNC machines to make hardened steels with a strength of 50 to 65 HRC.Monolithic hard metal milling cutters, drills, inserts, and shaping knives benefits from TiSiN coating. For the machining process, it can be used in dry or near-dry machining applications.

By the CNC Green machining (turning operation)(Fig.3) the machining for workpiece by using the novel TiSiN coated HSS tool and Uncoated WC tool insert with an individual workpiece.By finishing the machining to get the material removal rate and surface roughness(Fig .4) by comparing both both inserts.For testing standard ISO is 4287(1997) .Sample length is 50mm and measuring speed is 0.25mm/sec. Cut off length is 15mm and the average of each 16 values is taken into consideration The MRR is calculated by having the weight of the sample before and after machining.

Material removal rate =Weight Loss /Machining Time taken for machining *Density of the material

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After machining the sample for limited sample length the MRR is calculated by having the weights of the sample before and after machining. The procedure repeated and average of them was considered for avoiding errors. The input specifications furnished in Table 1 presented the CNC Green machining process parameters,this work took off three parameters with four levels of the rpm of CNC Green machining. Table 2 presented the Control group summary of the material removal rate and surface roughness with the utilization of two tools namely High speed steel and novel TiSiN coated HSS tool.

Statistical analysis

Statistical analysis was administered with the utilization of 'SPSS statistics 26' software. The independent sample test performed for comparing means both the experimental group and control group.The independent variables were cutting speed(50m/min), feed rate (0.10 mm/rev) and Depth off cut(0.25 mm) and therefore the variables was used for determine the MRR and Sa..The statistical analysis like T-test and independent samples test conducted. If the dependent variables are Material removal rate and Surface roughness. In this research analysis done by the SPSS software and ANOVA tables and Graph (Garg, Sangwan, and Kainth 2016).

3. Results

The calculated Material Removal rate (MRR) and Surface roughness(Ra) value for samples of both groups (16 Samples per group) are statistically analyzed. Hence the MRR significantly improved with use of novel TiSiN Coated HSS Tool than those samples machined with conventional HSS tools. Table 1 gives the specification of inputs utilized from the 16 experiment types. Table 3 shows the MRR of samples which were machined by HSS tools. The Surface roughness values are between 0.715 and 0.873 Material removal rate of samples which were machined by HSS tools. The Material removal rate values are between 2699.083 and 13737.98. Table 4 Describes the Input Parameters for Titanium silicium Nitride coated High speed steel Inser. Table 5 reveals the results of T test like means, standard deviation, standard deviation errors of groups of novel TiSiN Coated HSS tool and HSS tool of Material Removal Rate(MRR). Table 6 shows the results of the Independent sample test to examine the test of significance. Table 7 exhibits the Results of t-test for sample of Unalloyed Nickel Chromium molybdenum High tensile steel, (EN24)Material which were machined by two methods. Group A samples are machined by HSS tool and Group B samples are machined by TiSiN coated HSS tool. The sample means of the proposed method (Group B) is significantly lower than the conventional HSS tool used in the sample group A for Surface Roughness. Table 8 illustrates the Results for Independent samples test for CNC turning of Nickel Chromium molybdenum High tensile steel(EN24) Material machined with conventional TiSiN Coated HSS tool (Group 1) and proposed coated HSS tool (Group 2).

Figure 1 shows the synthesis of novel light weight material of Unalloyed Nickel Chromium molybdenum high tensile steel (EN24). Figure 2 Shows the sixteen specimens after machining images. Figure 3 Represents the sixteen experimental runs with the response value of Material Removal Rate and Surface roughness. Figure 4 exhibits the comparison of group mean at ± 1 standard deviation level for Material Removal Rate and Surface Roughness. The observations are significant as the T test output significant values $P<0.05$ and $p=0.020<0.05$ for Material Removal Rate (MRR) and $p=0.033<0.05$, for Surface roughness. If feed rate and depth of cut increases then Material rate rate also will increase and Surface roughness reduced supported this it is often stated that MRR was improved by 19.967% and the surface roughness reduced by 25.885% with the utilization of novel TiSiN coated HSS tool than conventional HSS tool. Figure 5 exhibits the research facility of the CNC turning center.

4. Discussion

The above result shows that the Material removal rate increases when the feed and depth of cut is more. High depth of cut will increase material removal rate. High material removal rate results in a good surface finish and Performance and durability of the parts are increased. Significance of P value is 0.002. From the Bar graph, it shows the parameters of speed, feed, depth of cut. This formula is used for both TiSiN coated High speed steel insert and HSSTool insert. The influence of cutting conditions is that the cutting speed has a small effect compared with that of the feed rate and the depth of cut and this can be noted in SPSS analysis. It was observed that Cutting forces were small compared with that of the feed rate and depth of cut.(Sousa and Silva 2020) In general, a decrease in cutting force can be achieved as speed increases, tool nose radius is increased. When high cutting speed, lower depth of cut, and high feed rate provide increased MRR(C. 2021).They show smart significance statistically with a significance worth $p<0.05$(Saini and Pradhan 2014) .The MRR of the composite was considerably reduced with the usage of the TiSiN coated HSS tool once it is compared to the HSS tool. Also, alternative parameters that were influencing MRR and surface roughness are unit depth of cut and feed rate that's equally declared.If feed rate and depth of cut increases then Material rate rate also will increase and Surface roughness reduced supported this it is often stated that MRR was improved by 19.985% and the surface roughness reduced by 25.885%

with the utilization of KTRN coated HSS tool than conventional HSS tool. Because of the usage of a minimal range of input parameters. Also, usage of coated TiSiN Tool in CNC machining in turning. Further, this study showed that TiSiN coated HSS tool is suitable for this particular composite to urge maximized MRR as increased MRR is required for each application to urge improved MRR. Since the TiSiN coated HSS tool is usually recommended tool for CNC machining in specific operation namely contour turning with this maximal range of input parameters during which higher speed, higher feed rate, and lower depth of cut gives maximized MRR for this composite this work reports experimental analysis of the CNC turning process to measure the effect of cutting parameters to urge the highest quality of turning materials . During this research, only three factors namely Material removal rate , Surface roughness and die material are considered.(Sousa and Silva 2020)

From the above discussions, it is understood that apart from standard input variables (feed, speed, and depth of cut) the tool hardness and cutting zone temperatures play an enormous role in Material Removal Rate and Surface Roughness. Because the TiSiN coated HSS tool is way harder than the HSS tool the results improved high Material removal rate and low surface roughness significantly.

Though the results improved significantly this research features a couple of limitations. As this study focused on Green manufacturing it doesn't consider coolant effects on MRR but coolant will significantly contribute to reducing the MRR. The study was limited to using TiSiN coated HSS tools to increase Material removal rate and reduced surface roughness.

5. Conclusion

Within the research of the study,the CNC turning of the Unalloyed Nickel chromium molybdenum high tensile steel (EN24) material with Titanium silicium Nitride (TiSiN)coated HSS tool and HSS were compared for increasing Material Removal Rate and decreasing Surface Roughness discussed.The result shows that the group of samples which machines with novel TiSiN coated HSS tool and Uncoated HSS tool resulted in less surface roughness than HSS tool.Hence the proposed tool reduce surface roughness by 25.885% and material removal rate by 19.967%.

Declarations

Conflict of internet

The author of this paper declare no conflict of internet

Authors Contribution

Author ST was involved in data collection, data analysis and manuscript writing. Author TS was involved in Conceptualization, data validation and critical review of the manuscript.

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1.Sri sati Metal Shop,Padi,Chennai.

2.Saveetha University

3.Saveetha Institute of Medical and Technical Sciences

4.Saveetha School of Engineering

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"Website." n.d. The International Journal of Engineering And Science (IJES)||Volume||2 ||Issue||1||Pages||103-113||2013||ISSN:2319 –1813ISBN:2319 –1805www.theijes.com The IJESPage 103Optimization of Different Performance Parameters i.e.Surface Roughness, ToolWear Rate & Material Removal Rate with the Selection of Various Process Parameters Such as Speed Rate,Feed Rate,Specimen Wear , Depth Of Cut in CNC Turning of EN24 Alloy Steel–An Empirical Approach.

Yaashikaa, P. R., M. Keerthana Devi, and P. Senthil Kumar. 2022. "Algal Biofuels: Technological Perspective on Cultivation, Fuel Extraction and Engineering Genetic Pathway for Enhancing Productivity." *Fuel*. https://doi.org/10.1016/j.fuel.2022.123814.

Tables and Figures

Table 1. Machining parameters

Factors	Level 1	Level 2	Level 3	Level 4
Cutting speed (RPM)	**500**	**800**	**1100**	**1400**
Feed (mm/rev)	**0.4**	**0.8**	**1.2**	**1.6**
Depth of cut (mm)	**0.5**	**0.6**	**0.7**	**0.9**

Table 2.Surface roughness testing description

Parameter	Value
Standard ISO	4287 (1997)
Sampling length	50mm
Measuring speed	0.25 mm/sec
Cut off length	15mm

Table 3. Input Parameters for High Speed Steel (HSS) Insert

Trail	Speed (RPM)	Depth of Cut (mm)	Feed (mm/rev)	Before Machining weight (gm)	After Machining Weight (gm)	CNC Run Time (sec)	Material Removal Rate (g)	Surface Roughness (µm)
1	500	0.2	0.4	148	147	6.33	1207.4743	1.234

2	500	0.4	0.8	148	146	6.73	2271.4152	1.432
3	500	0.6	1.2	148	145	6.8	5498.7857	1.224
4	500	0.8	1.6	148	143	6.95	2373.6994	1.226
5	800	0.2	0.4	148	146	6.44	2374.6994	1.142
6	800	0.4	0.8	148	145	6.84	3352.3299	1.021
7	800	0.6	1.2	148	144	6.91	4424.4933	1.331
8	800	0.8	1.6	148	144	7.06	4330.4884	1.008
9	1100	0.2	0.4	148	146	6.55	2333.8358	1.724
10	1100	0.4	0.8	148	145	6.95	3299.2714	1.851
11	1100	0.6	1.2	148	147	7.02	1088.7909	1.14
12	1100	0.8	1.6	148	146	7.17	2132.0257	1.214
13	1400	0.2	0.4	148	147	7.12	1073.4989	1.606
14	1400	0.4	0.8	148	146	7.09	2156.0824	1.654
15	1400	0.6	1.2	148	146	7.1	2153.0457	0.987
16	1400	0.8	1.6	148	145	7.4	3098.64	1.034

Table 4. Input Parameters for Titanium silicium Nitride coated High speed steel Insert

Trail	**Speed (RPM)**	**Depth of Cut (mm)**	**Feed (mm/rev)**	**Before Machining weight (gm)**	**After Machining Weight (gm)**	**CNC Run Time (sec)**	**Material Removal Rate (g)**	**Surface Roughness (µm)**
1	500	0.2	0.4	150	148	6.54	6070.501	0.741
2	500	0.4	08	150	147	6.94	8492.569	0.721
3	500	0.6	1.2	150	146	7.1	11026.42	0.732
4	500	0.8	1.6	147	143	7.16	10919.02	0.874
5	800	0.2	0.4	151	148	6.65	8928.471	0.734
6	800	0.4	0.8	149	147	7.05	5558.772	0.715
7	800	0.6	1.2	149	144	7.12	13737.98	0.742

8	800	0.8	1.6	149	146	7.27	8045.592	0.871
9	1100	0.2	0.4	149	146	6.76	8757.962	0.754
10	1100	0.4	0.8	149	147	7.15	5468.386	0.739
11	1100	0.6	1.2	149	148	7.23	2699.083	0.761
12	1100	0.8	1.6	149	146	7.35	7906.875	0.873
13	1400	0.2	0.4	149	146	7.33	7969.33	0.746
14	1400	0.4	0.8	147	145	7.3	5338.186	0.738
15	1400	0.6	1.2	147	144	7.32	7981.94	0.765
16	1400	0.8	1.6	147	142	7.63	12681.21	0.852

Table 5. Results of t-test for sample of Unalloyed Nickel Chromium molybdenum High tensile steel(EN24)Material which were machined by two methods. Group A samples are machined by HSS tool and Group B samples are machined by TiSiN coated HSS tool. The sample means of the proposed method (Group B) is significantly lower than the conventional HSS tool used in the sample group A for Material removal rate.

Group statistics					
	Composite	**N**	**Mean**	**Std.Derivation**	**Std.Error Mean**
Ra	HSS	16	1.22294	0.227143	0.056786
	TiSiN Coated HSS Tool	16	0.77238	0.058295	0.014574

Table 6 Results for Independent samples test for CNC turning of Unalloyed Nickel Chromium molybdenum High tensile steel(EN24) Material machined with conventional HSS tool (Group 1) and proposed TiSiN coated HSS tool (Group 2). It is observed that on performing One-Way ANOVA, there is a statistically significant difference for MRR (p= 0.020, p<0.05).

Independent Samples Test									
	Levens test for Equality of Variances		**T test for equality of Means**						
	F	**Sig.**	**t**	**df**	**Sig.(2 tailed)**	**Mean Difference**	**Std.Error Difference**	**95% Confidence interval of the Difference**	
								Lower	**Upper**

MRR	Equal variance assumed	12.1	0.02	7.685	30	0.00	0.4505	0.586	0.330	0.57427
	Equal variances not assumed	-	-	7.685	16.9	0.00	0.4505	0.586	0.326	0.57427

Table 7 Results of t-test for sample of Unalloyed Nickel Chromium molybdenum High tensile steel, (EN24)Material which were machined by two methods. Group A samples are machined by HSS tool and Group B samples are machined by TiSiN coated HSS tool. The sample means of the proposed method (Group B) is significantly lower than the conventional HSS tool used in the sample group A for Surface Roughness.

Group statistics					
	Composite	**N**	**Mean**	**Std.Derivation**	**Std.Error Mean**
MRR	HSS	16	2760.370	1254.683	313.670
	TiSiN Coated HSS Tool	16	8223.893	2883.097	720.774

Table 8. Results for Independent samples test for CNC turning of Nickel Chromium molybdenum High tensile steel(EN24) Material machined with conventional TiSiN Coated HSS tool (Group 1) and proposed coated HSS tool (Group 2). It is observed that on performing One-Way ANOVA, there is a statistically significant difference for Ra (p= 0.033, p<0.05).

Independent Samples Test									
	Levens test for Equality of Variances		**T test for equality of Means**						
	F	**Sig.**	**t**	**df**	**Sig.(2 tailed)**	**Mean Difference**	**Std.Error Difference**	**95% Confidence interval of the Difference**	
								Lower	**Upper**

Ra	Equal variance assumed	4.97	0.033	-6.95	30	0.000	-5463.52	786.0	-7068.89	-3858.15
	Equal variances not assumed			-6.95	20.48	0.000	-5463.52	786.0	-7100.75	-3826.29

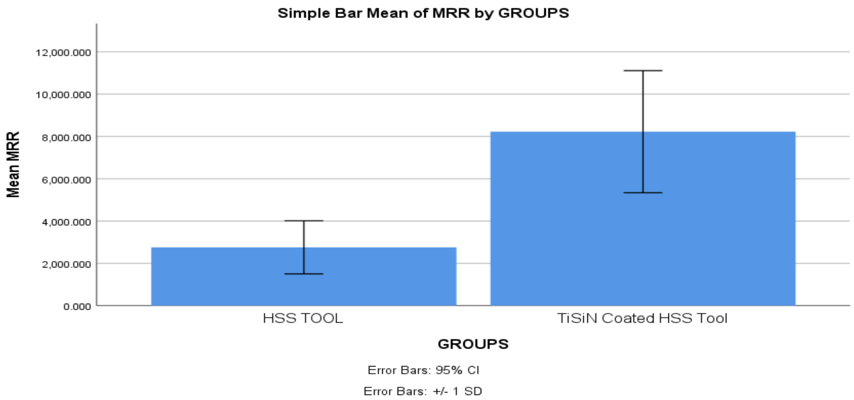

Fig. 1. Shows the Fig for dominating both coated and uncoated tool cutters in Material Removal Rate. From these cutters the TiSiN coated HSS Tool cutter produced high MRR even in variation of cutting speed, feed and depth of cut. X-axis: HSS and TiSiN Coated HSS Tool, Y-axis: Mean MRR of detection ± 1 SD.

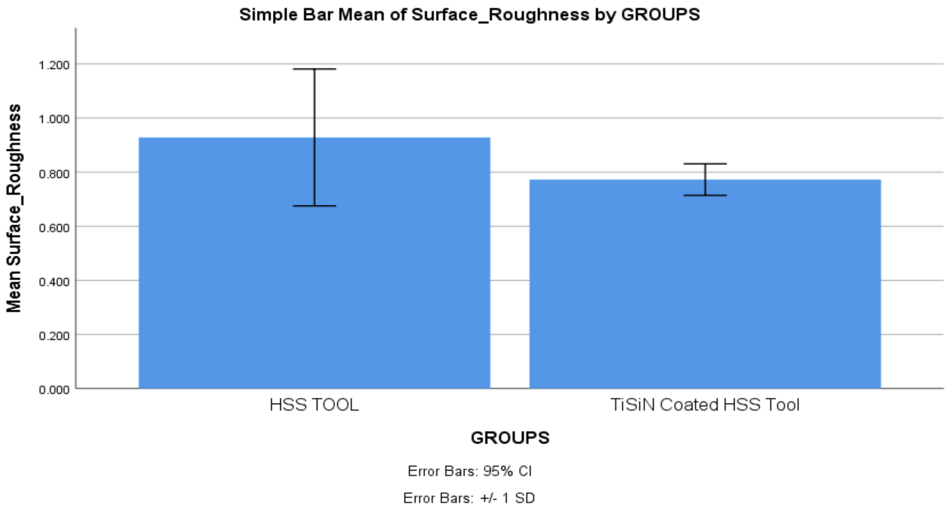

Fig. 2. Shows the fig for dominating both coated and uncoated tool cutters in Surface Roughness. From these cutters the TiSiN coated HSS Tool cutter produced low Surface Roughness even in variation of cutting speed, feed and depth of cut. X-axis: HSS and TiSiN Coated HSS Tool, Y-axis: Mean Sa of detection ± 1 SD.

Fig. 3. Samples after machining

Fig. 4. Surface Roughness testing machine

Fig. 5. CNC Turning machine