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Tool life comparison and optimization on different cutting tool parameters on cnc turning for coated & uncoated cutting tool insert

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ABSTRACT:

In the previous paper we have find the optimized tool parameters for cutting based on MRR and surface roughness 1. Now in this paper we will find the tool life comparison between coated and uncoated cutting tool insert. Also, three cutting parameters: Cutting Speed (m/min), Feed, depth of cut (mm), rate (mm/rev), is parameterized. The parameterized study helps us to select the optimized tool parameter along with comparison based on taylor's life equation The present work deals with comparative study on tool life performance of (BUSH P-780308A) made up of C-20 plain carbon steel using HSS, TiN Coated HSS cutting tool. The tool life optimization is one of the most important parameters in manufacturing industry for cost optimization hence our study can help in deciding the best tool parameter which will enhance the tool life and reduce the manufacturing cost.

Keywords: Tool life calculation

Introduction

In the competitive manufacturing industry of today, productivity and quality are important with cost saving because this will increase the overall margin of the industry. Every industrial sector strives to produce many goods in a comparatively short amount of time. It is vital to strike a balance between the item's production and quality levels to accept these two opposing requirements. The best devices and tool lives are essential requirements for the successful implementation of bulk steel forming in commercial production. Any cutting tool's tool life is a crucial factor to consider because it tells us how long the tool will be in use. They directly impact manufacturing costs and, as a result, the technique's competitiveness. They can also have a sizable impact on device supply, manufacturing balance, and, finally, delivery performance. Cutting tool failure cannot be avoided, so tool life must be carefully considered while estimating tool costs and planning how to deliver devices for production. Because time is lost every time a tool needs to be reset on the machine and re-sharpened, tool life is an essential factor in production work.

Materials and method

Work piece material

The work piece material used for present work was C20 plain Carbo steel. Table 1 and Table 2 show the chemical composition and mechanical properties of C20 plain Carbo steel same as per refer previous published paper.

Table -1: Chemical Composition C20 Plain carbon steel

Mechanical Properties of C20 Plain carbon steel	
Property	**Value**
Carbon (C)	0.15-0.25
Manganese (Mn)	0.60-0.90
Silicon (Si)	0.15-0.35
Phosphorus (P)	0.0-0.06

Table -2: Mechanical Properties of C20 Plain carbon steel

Mechanical Properties of C20 Plain carbon steel	
Property	**Value**
Tensile Strength	425 MPa
Density	7.8 g/cm3
Elongation	0.15%
Machinability	65%

Cutting inserts

The cutting tool used for experimentation with the standard specification is TiN Coated HSS same as per refer previous published paper.

Table -3: Cutting Tool Detail.

Single Point Cutting Tool	
Material	HSS, TiN Coated HSS
Type	Rhombus 80°,12mm side,4mm thickness
No. of edge	4

Coated HSS tools have shown better performance when compared to the uncoated carbide tools.

Selection of controls factors

Modeling and analysis were done by 3k factorial design is the most widely used factorial design having three levels for each of 'k' factors. We describe the three factor levels as low (0), medium (1), and high (2).

All three levels of these parameters had been decided based on machine tool design handbook and full factorial approach has been employed for experimentation.

Cutting experiments are conducted considering. Three cutting parameters: Cutting Speed (m/min), Feed, depth of cut (mm), rate (mm/rev), and a total of 27 trials were conducted as per refer previous paper published after that tool life calculated in all 27 experiments. All three levels of these parameters had been decided based on machine tool design handbook and full factorial approach has been employed for experimentation fully described reference paper. Table 5 number shows the values of various parameters used for experiments already described in reference paper.

TABLE 4: Levels of control factors

Level	**Cutting Speed (rpm)**	**Feed (mm/rev)**	**Depth of Cut (mm)**
-1 (low)	500	0.10	0.4
0 (medium)	1000	0.12	0.8
+1 (high)	1500	0.14	1.2

Graph1 level of control factors

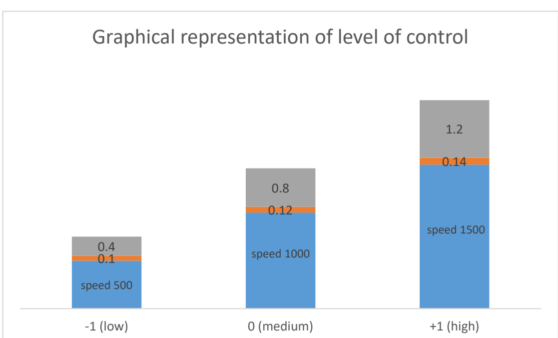
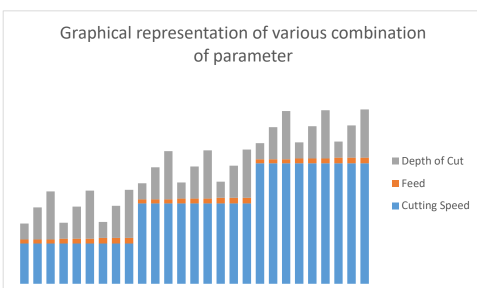


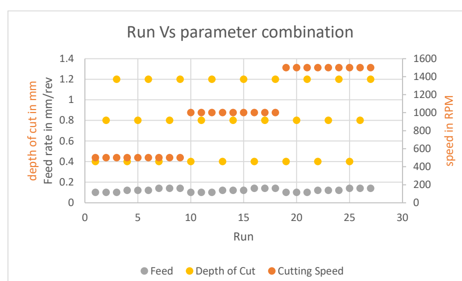
TABLE 5: Full factorial design with system parameters

Run	**Cutting Speed (RPM)**	**Feed (mm/rev)**	**Depth of Cut (mm)**
1	500	0.10	0.4
2	500	0.10	0.8
3	500	0.10	1.2
4	500	0.12	0.4
5	500	0.12	0.8
6	500	0.12	1.2
7	500	0.14	0.4
8	500	0.14	0.8
9	500	0.14	1.2
10	1000	0.10	0.4
11	1000	0.10	0.8
12	1000	0.10	1.2
13	1000	0.12	0.4
14	1000	0.12	0.8
15	1000	0.12	1.2
16	1000	0.14	0.4
17	1000	0.14	0.8
18	1000	0.14	1.2
19	1500	0.10	0.4
20	1500	0.10	0.8
21	1500	0.10	1.2
22	1500	0.12	0.4
23	1500	0.12	0.8
24	1500	0.12	1.2
25	1500	0.14	0.4
26	1500	0.14	0.8
27	1500	0.14	1.2

Graph 2: Various combination of 3 parameters



Graph 3: Run vs parameter value



Experimental procedure

Preparation of work piece

To perform the experiments as same as refer previous published paper, work pieces from the 25mm diameter cylindrical bars of C-20 material were cut up to required length of 100mm with the help of power saw as shown in the fig: 1. As per reference previous published paper.

FIGURE: 1 Cutting of work piece by power saw as per reference paper.

FIGURE: 2 samples after cutting from power saw

Conducting the turning operation

Further, the diameter of rough turned work pieces were measured and approximately 30 pieces having in range of outer diameter 25 mm were collected for conducting the experiments. Using the various combinations of cutting parameters created by the Design of Experiment on Experimental CNC turning center—refer to the previously published paper—the final turning operation was performed on these rough turned work pieces same experiment data used in tool life selection.

FIGURE: 3 Turning machine used for cutting operation

Determination of tool life

Further, the diameter of rough turned The tool life calculated from modified Taylor's tool life equation for uncoated HSS and TiN coated HSS tool inserts.

The following formula is used to calculate tool life depending on the volume of material removed:

Taylor's tool life calculation According to F.W. Taylor, the following is how cutting speed and tool life are related.

Tool Life = $VT^n f^a d^b = K_t$

where **V**= cutting speed in RPM, **T** = Time for tool failure/min**, f** = feed in mm/rev, **d** = Depth of cut in mm, & **n, a, b** = Tool life exponent $\mathbf{K_t}$ = Machining constant.

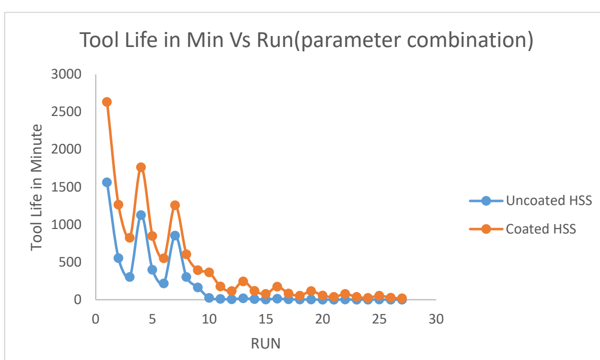
Measurement of tool life

The tool life was measured by using Taylor's equation. As per the reference paper cutting speed, feed, and depth of cut in all 27 experiments carried out and analysis the data of same 27 experiments. After that calculated the data of tool life for bare HSS and tin coated HSS. The values of tool life obtained from the experiments conducted using different combination of cutting conditions were used for finding the optimum combination of cutting conditions.

TABLE 6: Tool life for HSS and Tin coated HSS

S.No	Speed (rpm)	Speed (m/min)	feed (mm/rev)	DOC (mm)	Tool Life (min.) $VT^n f^a d^b = K_t$	
					HSS* (n= 0.167, a= 0.3, b= 0.25, Kt= 50)	TiN Coated HSS** (n= 0.35, a= 0.77, b= 0.37, Kt= 70)
1	500	36.74	0.10	0.4	1561.89	2634.08
2	500	36.74	0.10	0.8	553.36	1265.90
3	500	36.74	0.10	1.2	301.58	824.60
4	500	36.74	0.12	0.4	1125.66	1763.72
5	500	36.74	0.12	0.8	398.81	847.62
6	500	36.74	0.12	1.2	217.35	552.14
7	500	36.74	0.14	0.4	853.38	1256.46
8	500	36.74	0.14	0.8	302.34	603.83
9	500	36.74	0.14	1.2	164.77	393.33
10	1000	73.48	0.10	0.4	24.61	363.53
11	1000	73.48	0.10	0.8	8.72	174.71
12	1000	73.48	0.10	1.2	4.75	113.80
13	1000	73.48	0.12	0.4	17.74	243.41
14	1000	73.48	0.12	0.8	6.28	116.98
15	1000	73.48	0.12	1.2	3.42	76.20
16	1000	73.48	0.14	0.4	13.45	173.41
17	1000	73.48	0.14	0.8	4.76	83.34
18	1000	73.48	0.14	1.2	2.60	54.28
19	1500	110.21	0.10	0.4	2.17	114.14
20	1500	110.21	0.10	0.8	0.77	54.85
21	1500	110.21	0.10	1.2	0.42	35.73
22	1500	110.21	0.12	0.4	1.56	76.42
23	1500	110.21	0.12	0.8	0.55	36.73
24	1500	110.21	0.12	1.2	0.30	23.92
25	1500	110.21	0.14	0.4	1.19	54.44
26	1500	110.21	0.14	0.8	0.42	26.16
27	1500	110.21	0.14	1.2	0.23	17.04

Graph 4: Tool Life graphical representation



Calculation of tool life cost

The tool life was measured by using Taylor's equation. Now based on tool life and considering a daily 8-hour work. Also It is assumed that tool changing time is 10 minute after tool is damaged as calculated from Taylor's equation. Cost of single tool for coated and uncoated is shown in below table 7.

TABLE 7: Tool Cost for HSS and Tin coated HSS

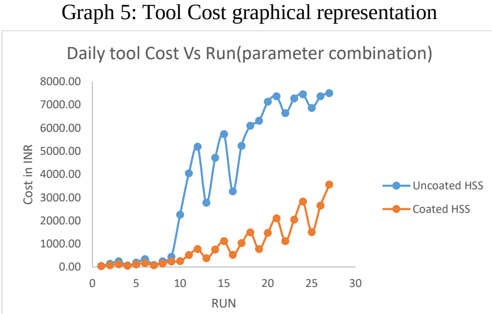
S.No	Tool cost in INR	
	Uncoated HSS	**Coated HSS**
1	160	200

Now daily requirement of minimum number of tool and cost for cutting is calculated, which is shown in table 8.

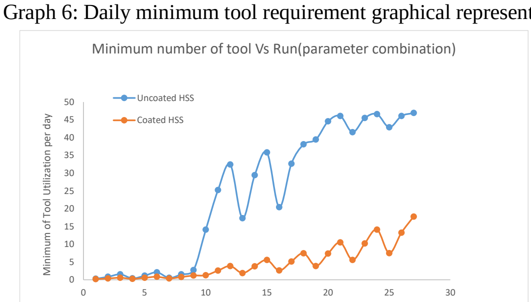
TABLE 8: Minimum no of Tool and Cost for HSS and Tin coated HSS on daily basis.

Run	Cutting Speed	Feed	Depth of Cut	Uncoated HSS			Coated HSS		
	(RPM)	(mm/rev)	(mm)	tool life in minute	Minimum no of tool utilised per day	Cost of tool per day in INR	tool life in minute	Minimum no of tool utilised per day	Cost of tool per day in INR
1	500	0.1	0.4	1562	0.31	48.85	2634	0.18	36.31
2	500	0.1	0.8	553	0.85	136.41	1266	0.38	75.24
3	500	0.1	1.2	301	1.54	246.95	825	0.58	115.03
4	500	0.12	0.4	1125	0.42	67.67	1764	0.27	54.12
5	500	0.12	0.8	399	1.17	187.78	848	0.56	111.94
6	500	0.12	1.2	217	2.11	338.33	552	0.85	170.82
7	500	0.14	0.4	853	0.56	88.99	1257	0.38	75.80
8	500	0.14	0.8	302	1.54	246.15	604	0.78	156.35
9	500	0.14	1.2	164	2.76	441.38	393	1.19	238.04
10	1000	0.1	0.4	24	14.12	2258.82	364	1.28	256.68
11	1000	0.1	0.8	9	25.26	4042.11	175	2.59	518.92
12	1000	0.1	1.2	4.8	32.43	5189.19	114	3.87	774.19
13	1000	0.12	0.4	17.7	17.33	2772.56	243	1.89	378.85
14	1000	0.12	0.8	6.3	29.45	4711.66	117	3.78	755.91
15	1000	0.12	1.2	3.4	35.82	5731.34	76	5.57	1113.69
16	1000	0.14	0.4	13.5	20.43	3268.09	173	2.62	523.45
17	1000	0.14	0.8	4.7	32.65	5224.49	83	5.14	1028.94
18	1000	0.14	1.2	2.6	38.10	6095.24	54	7.47	1493.00
19	1500	0.1	0.4	2.17	39.44	6310.60	114	3.87	774.19
20	1500	0.1	0.8	0.77	44.57	7130.92	55	7.38	1476.92
21	1500	0.1	1.2	0.42	46.07	7370.44	36	10.50	2100.66
22	1500	0.12	0.4	1.56	41.52	6643.60	76	5.58	1116.28
23	1500	0.12	0.8	0.55	45.50	7279.62	37	10.21	2042.55
24	1500	0.12	1.2	0.3	46.60	7456.31	24	14.12	2823.53
25	1500	0.14	0.4	1.19	42.90	6863.27	54	7.50	1500.00
26	1500	0.14	0.8	0.42	46.07	7370.44	26	13.26	2651.93
27	1500	0.14	1.2	0.23	46.92	7507.33	17	17.78	3555.56

Graph 5: Tool Cost graphical representation



Graph 6: Daily minimum tool requirement graphical representation



Result and analysis

A 3*3 full factorial design was used to get the output data uniformly distributed all over the ranges of the input parameters refer to previous published paper. In this manner 27 experiments had been performed with one-of-a-kind combos of the stages of the enter parameters. Taylor's equation to get the relation between different response variables cutting speed and tool life relation.

Analysis of response: Tool life

After entering all the process parameters and responses in the designed input table given by the software, the Transform level was checked by software. By selecting MRR as response for analysis, the suggested Transform determined by the software.

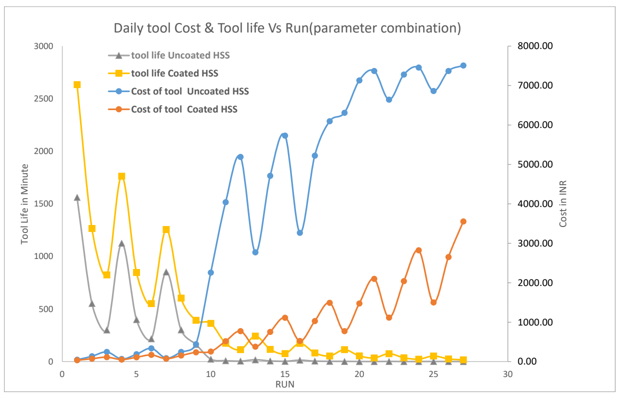
The summary table 8 indicates that sequential source of the model is linear, 2 Factorial Interaction and Quadratic but the software suggests that the desirability of model is Quadratic. The Detailed Summary is proven below.

Optimized result

After analyzing the tool life from Taylors equation on 27 different combination and comparison between coated and uncoated cutting tool insert, it is observed that the coated tool insert has maximum life in all combination compared to non-coated tool insert.

Also, it is observed that tool cost utilization is better for coated cutting tool compared to uncoated cutting tool. Though the single tool cost of uncoated is cheaper but based on MRR and tool life calculated from taylor's equation it is observed that on daily work basis coated cutting tool is much cheaper compared to uncoated tool.

Graph 7: Tool Life and Cost Graph



From previous study1 based on MRR and surface roughness optimization for bare HSS, the tool life at optimal cutting conditions is determined about 0.42 minutes, whereas for TiN-coated HSS, it is 35.73 minutes as shown in table 9.

Table 9: Suggested optimum cutting parameters as per previous published paper and tool life as per present work.

Cutting Speed	Feed	DOC	MRR	Surface Roughness	Tool Life Bare HSS	Tool Life Tin coated HSS
1500.00	0.10	1.20	12126.50	3.52	0.42	35.73

Hence the optimal cost of cutting will be Rs. 2100 for coated cutting tool and Rs. 7370 for uncoated cutting tool as shown in table 10.

Table 10: Suggested optimum cost and tool life

Run	Cutting Speed	Feed	Depth of Cut	Uncoated HSS		Coated HSS	
	(RPM)	(mm/rev)	(mm)	tool life in minute	Cost of tool per day in INR	tool life in minute	Cost of tool per day in INR
21	1500	0.1	1.2	0.42	7370.44	36	2100.66

REFERENCES

1. International Research Journal of Engineering and Technology (IRJET) Volume 11, Issue 05, May 2024 https://www.irjet.net/volume11-issue05 S.No:91
2. Titus .B. Watmon and Anthony .C. Ijeh (2010), "Coating Cutting Tools with Hard Substance Lowers Friction Co-efficient and Improves Tool Life - A Review", Proceedings of Multi-Conference of Engineers and Computer Scientists,Vol-III

3. Chien W.-T. and Tsai C.-S., (2003), “The investigation on the prediction of tool wear and the determination of optimum cutting conditions in machining 17-4PH stainless steel”, Journal of Materials Processing Technology, Volume 140, pp.340–345.
4. Titus .B. Watmon and Anthony .C. Ijeh (2010), “Coating Cutting Tools with Hard Substance Lowers Friction Co-efficient and Improves Tool Life - A Review”, Proceedings of Multi-Conference of Engineers and Computer Scientists,Vol-III
5. B.L. Juneja,G.S. Sekhon,Nitin Seth, “Fundamentals of Metal Cutting and Machine Tools”, New Age International (P) Limited, 2010.
6. Finish Turning”, International Journal of Advanced Manufacturing Technology, Volume 20, pp. 348–356.