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Optimization of Input Parameters with Carbide Inserts and HSS Tool on CNC Turning of EN19 Steel

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Abstract*: This paper deals with the experimental investigation and testing on a single point cutting tool with carbide inserts and high speed steel tool. Cutting tool has to be strong enough to withstand the wear resistance. It is to be proved that carbide inserts have better performance than HSS tools on machining operation. Components with higher surface quality, higher material removal rate in less time and lower tool wear is only possible by carbide insert tools. The tool material selected for this experiment are cemented & tungsten carbide inserts along with high speed steel tool on machining medium carbon steel EN19. The complete machining process is performed on cnc lathe machine Hence the intention of this project is to minimize the surface roughness, tool wear, machining time and increasing the material removal rate. Taguchi's L9 orthogonal array is favor for this investigation work. The result obtained in this project can be further used for optimizing the process parameters there by optimized results helps the operator to improve the quality as well as production rate.

Keywords: Single point Cutting tool, carbide inserts, HSS, surface roughness, MRR, Tool wear and Tool life.

I. INTRODUCTION

Machining process is one of the metal removal process in which the unwanted substance from the work piece is detached by cutting tool in the type of chips. The cutting tool rake angle plays an important role in surface finish also wear. Heat is generated at the tip of the tool during the machining process that affects the tool geometry and properties. Therefore, proper material selection with accurate rake angles is provided to tool in order to overcome the failure of tool. It is also determined that any sudden change in cutting speed, cutting depth & feed rate has the maximum cause on increasing cutting temperature, wear as well as surface unevenness.

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Hence any improvement in tool life will have a direct impact on the cost of production. The cutting tool geometry includes back rake angle, end relief angle, side cutting edge angle, end cutting edge angle, lip angle, side rake angle and side relief angle.

During machining operation enormous amount of heat and resistance is developed among tool and work piece. Coolant supplying during the machining operation is also plays an important role to overcome the tool failure and it acts an lubricant.

II. OBJECTIVES

- To determine the optimum surface finishing of work piece by varying the cutting parameters.
- To maximize the material removal rate (MRR) with in less machining time. It helps to increase the production rate.
- In order to reduce the tools wear without failure such that tool life increases.

III. EXPERIMENTAL DETAILS

A. Selection of tool material

In this investigation the carbide inserts material used are Cemented and Tungsten carbide inserts with tool holder PCLNL 12x12 H12 WIDAX and also High-speed steel M2 is selected for machining. The complete investigation is done on CNC lathe machine. The dimensions of tools and work pieces are tabulated below.

Table 1 Dimensions and materials of tools and work pieces

	Name of the cutting tools	Work piece material
Material used	1.Cemented carbide insert 2.Tungsten carbide insert With Tool holder 3.High speed steel bit M2	Medium carbon steel EN19
Dimensions	1.Insert sizes – 12-04-04 2.Tool holder size – 10cm length with 12 x12 C/S 3.HSS Bit size 10cm length with 12 x 12 C/S	50 mm diameter with 100 mm length

Fig 1. Different cutting tools

B. Selection of work piece material

The work piece substance preferred for this experimental investigation is Medium carbon steel EN19. It is also designated in AISI 4140 alloy steel. EN19 steel is most widely available in market and industries. The demand for this material is more in many sectors because it has wide spread application in automobile parts, gears, spindles, shafts, axles, bolts, pinions, and also in machinery equipment. The raw material selected is in the form of rods with dimension 50 mm diameter and 100 mm length.

Fig 2. Work pieces before machining (EN19 steel)

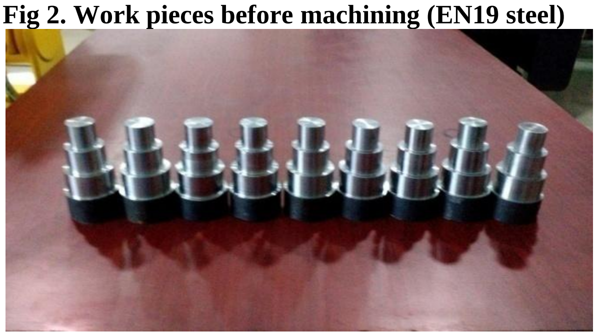

Fig 3. Work pieces after machining (EN19 Steel)

AISI 4140 alloy steel be heated at 845^0C and quenched in oil. Before is hardened it is normalized by heating at 913^0C for a long time. It is hot worked at 816 to 1038^0C. The composition of medium carbon steel EN19 is presented in below table.

IV. EXPERIMENTAL UNIT

The practical experiment is conducted on CNC lathe turning center on EN19 medium carbon steel. All the trials are conducted with varying cutting factors like cutting depth feed rate and spindle speed respectively. The below fig represent the machining operation on CNC turning lathe as follows.

Fig 4. Experimental unit

3.1 Surface roughness measurement

Roughness can be checked by physical judgment beside a "surface roughness comparator" a trial of known surface unevenness. Surface unevenness often summarized to roughness, is a component of surface texture.. If these abnormalities are large, the surface is irregular; if they are slight, the surface is level.

Fig 5. surface roughness tester

V. EXPERIMENTAL RESULTS

The experimental results achieved after performing the experiments as below the input parameters on CNC turning lathe machine.

Table 2 Cemented carbide insert tool experimental results

SL.NO	TOOL MATERIAL USED	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	SURFACE FINISH Ra (um)	MRR (mm^3/min)	M/C TIME (min)
1	Cemented carbide	1000	0.15	0.50	1.423	37707.00637	0.50
2	Cemented carbide	1000	0.20	0.75	2.191	150828.0255	0.25
3	Cemented carbide	1000	0.25	1.00	1.671	191082.8025	0.10
4	Cemented carbide	1200	0.15	0.75	2.963	45984.15411	0.41
5	Cemented carbide	1200	0.20	1.00	2.412	188535.0318	0.20
6	Cemented carbide	1200	0.25	0.50	1.144	235668.7898	0.08
7	Cemented carbide	1400	0.15	1.00	3.068	52370.84218	0.36
8	Cemented carbide	1400	0.20	0.50	2.412	209483.3687	0.18
9	Cemented carbide	1400	0.25	0.75	1.244	240445.8599	0.08

Table 3 Tungsten carbide insert tool experimental results

SL.NO	TOOL MATERIAL USED	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	SURFACE FINISH Ra (um)	MRR (mm^3/min)	M/C TIME (min)
1	Tungsten carbide	1000	0.15	0.50	3.882	37197.45223	0.50
2	Tungsten carbide	1000	0.20	0.75	2.944	149808.9172	0.25
3	Tungsten carbide	1000	0.25	1.00	1.638	196178.3439	0.10
4	Tungsten carbide	1200	0.15	0.75	2.908	44889.2933	0.42
5	Tungsten carbide	1200	0.20	1.00	2.249	179557.1732	0.21
6	Tungsten carbide	1200	0.25	0.50	2.387	170237.4059	0.11
7	Tungsten carbide	1400	0.15	1.00	2.892	51309.27105	0.36
8	Tungsten carbide	1400	0.20	0.50	2.338	210898.7969	0.18
9	Tungsten carbide	1400	0.25	0.75	0.905	234076.4331	0.08

Table 4 High speed steel tool experimental results

SL.NO	TOOL MATERIAL USED	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	SURFACE FINISH Ra (um)	MRR (mm^3/min)	M/C TIME (min)
1	HSS	1000	0.15	0.50	1.640	37197.45223	0.50
2	HSS	1000	0.20	0.75	2.770	150318.4713	0.25
3	HSS	1000	0.25	1.00	1.844	194904.4586	0.10
4	HSS	1200	0.15	0.75	0.916	44889.2933	0.42
5	HSS	1200	0.20	1.00	2.225	178343.9490	0.21
6	HSS	1200	0.25	0.50	1.512	219391.3659	0.09
7	HSS	1400	0.15	1.00	4.415	52370.84218	0.36
8	HSS	1400	0.20	0.50	4.050	211606.5111	0.18
9	HSS	1400	0.25	0.75	3.695	224522.2931	0.08

VI. RESULT AND DISCUSSION

6. ANALYSIS OF VARIANCE (ANOVA)

6.1 Statistical analysis of surface roughness for cemented carbide tool

It indicates that feed rate is the most important factor for surface roughness which has p- value of 0.228. Statistical ANOVA is shown in below table 5.

Table 5 surface unevenness ANOVA table

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	0.4039	0.2020	0.60	0.624
Feed rate	2	2.2730	1.1365	3.39	0.228
Cutting depth	2	0.8109	0.4055	1.21	0.453
fault	2	0.6706	0.3353	-	-
Total	8	4.1584	-	-	-

The interaction plot as shown in the figure examines that as the speed and feed increases surface roughness rises so as the feed and cutting depth reduces surface unevenness decreases.

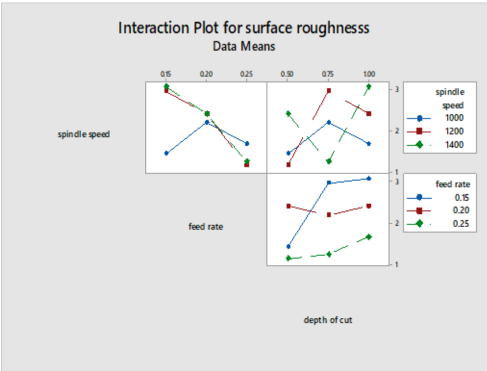

Fig 6. Surface unevenness Interaction plot

6.2 Statistical analysis of surface roughness for tungsten carbide tool

Table 6 ANOVA table for surface unevenness

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2.0	0.9101	0.4551	2.52	0.284
Feed rate	2.0	3.7912	1.8956	10.48	0.087
Cutting depth	2.0	0.7557	0.3778	2.09	0.324
fault	2.0	0.3617	0.1808	-	-
Total	8	5.8186	-	-	-

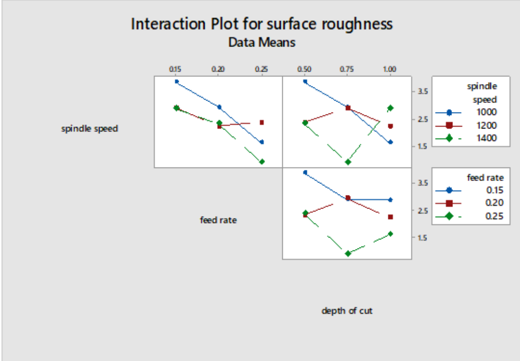

Fig 7. Surface unevenness Interaction plot

6.3 Statistical analysis of surface roughness for High Speed steel tool

Table 7 surface unevenness ANOVA table

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	10.4221	5.2111	17.32	0.055
Feed rate	2	0.9204	0.4602	1.53	0.395
Cutting depth	2	0.3214	0.1607	0.53	0.652
fault	2	0.6018	0.3009	-	-
Total	8	12.2657	-	-	-

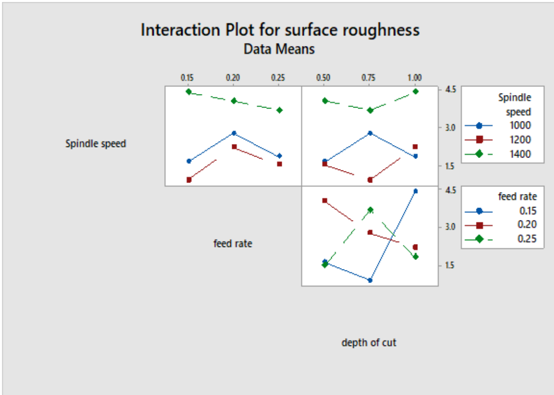

Fig 8. Interaction plot for surface roughness

6.4 Statistical analysis of MRR for cemented carbide tool

It indicates that all the cutting parameters like spindle speed, feed rate and cutting depth are the significant factors. Statistical ANOVA is shown in below table.

Table 8 ANOVA table for MRR

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	2673248455	1336624228	17.33	0.055
Feed rate	2	51545873934	25772936967	334.11	0.003
Cutting depth	2	479683217	239841609	3.11	0.243
fault	2	154280294	77140147	-	-
Total	8	54853085900	-	-	-

It is also observed that increasing amount of cutting depth increases the metal removal rate .The interaction plot is shown in below figure.

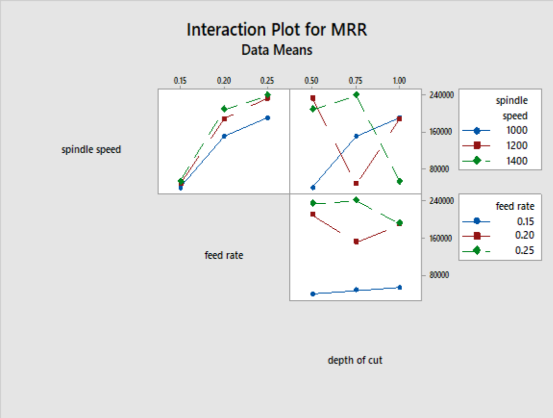

Fig 9. MRR Interaction plot

6.5 Statistical analysis of MRR for tungsten carbide tool

Table 9 ANOVA table for MRR

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	2582942269	1291471134	1.81	0.355
Feed rate	2	4303871483	2151935741	30.22	0.032
Cutting depth	2	20876721	10438361	0.01	0.986
fault	2	1423971789	711985894	-	-
Total	8	4706650560	-	-	-

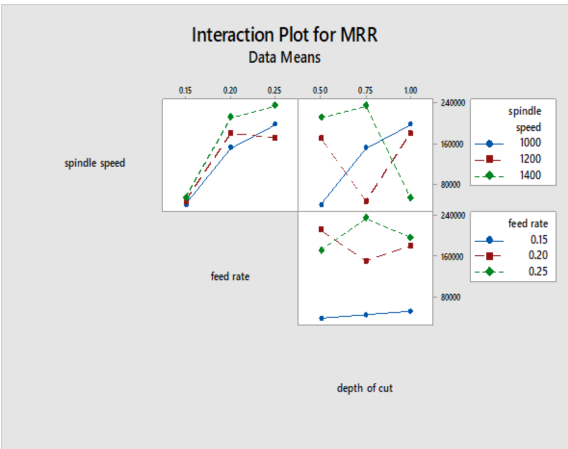

Fig 10. MRR Interaction plot

6.6 Statistical analysis of MRR for High speed steel tool

Table 10 ANOVA table for MRR

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	1886875363	943437682	12.95	0.072
Feed rate	2	47641592542	23820796271	326.92	0.003
Cutting depth	2	466254185	233127093	3.20	0.238
fault	2	145727178	72863589	-	-
Total	8	50140449268	-	-	-

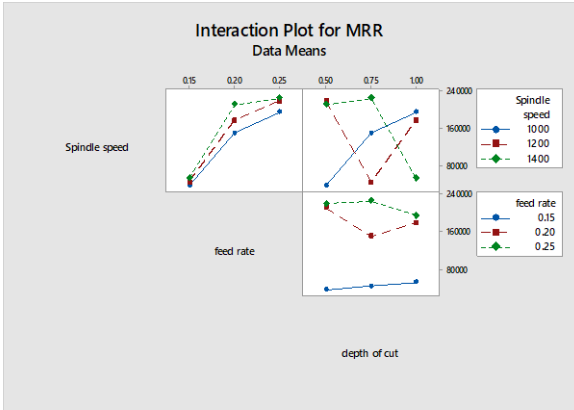

Fig 11. Interaction plot for MRR

6.7 Statistical analysis of machining time for cemented carbide tool

It indicates that as the spindle speed and cutting depth increases machining time decreases. The table for statistical analysis is shown in below.

Table 11 ANOVA table for M/C time

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	02	0.009267	0.004633	5.15	0.163
Feed rate	02	0.174067	0.087033	96.70	0.010
Cutting depth	02	0.001867	0.000933	1.04	0.491
fault	02	0.001800	0.000900	-	-
Total	08	0.187000	-	-	-

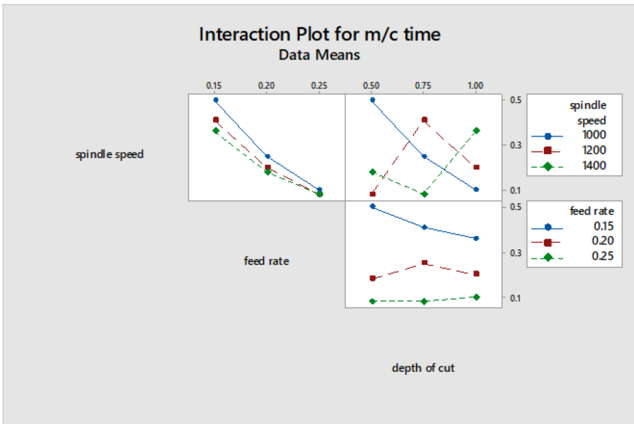

Fig 12. M/c time Interaction plot

6.8 Statistical analysis of machining time for tungsten carbide tool

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Table 12 ANOVA table for M/C time

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	0.008822	0.004411	5.93	0.144
Feed rate	2	0.168022	0.084011	112.85	0.009
Cutting depth	2	0.002489	0.001244	1.67	0.374
fault	2	0.001489	0.000744	-	-
Total	8	0.180822	-	-	-

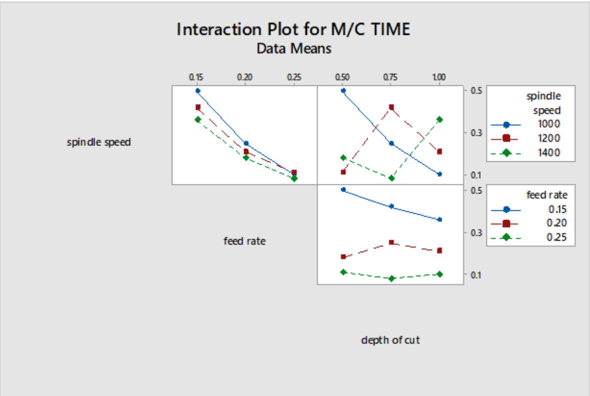

Fig 13. M/c time Interaction plot

6.9 Statistical analysis of Machining time for High speed steel tool

Table 13 ANOVA for M/C time

Basis	DF	Adj SS	Adj MS	F-Value	P-Value
Spindle speed	2	0.008867	0.004433	4.93	0.169
Feed rate	2	0.174067	0.087033	96.70	0.010
Cutting depth	2	0.001867	0.000933	1.04	0.491
fault	2	0.001800	0.000900	-	-
Total	8	0.186600	-	-	-

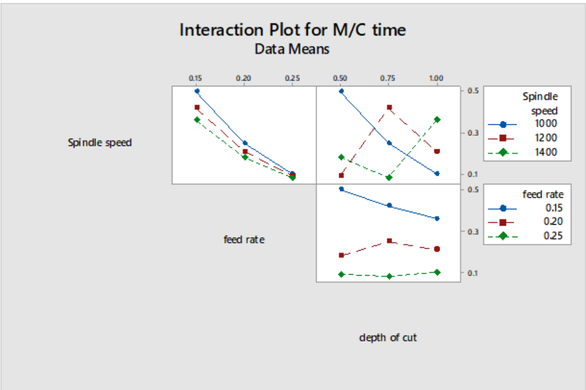

Fig 14. Interaction plot for M/C time

VII. CONCLUSION

The following are the conclusions drawn after conducting the experimental investigation with three different tool materials with varying cutting parameters to optimize the results. From the analysis of results the signal to noise ratio (S/N) approach, taguchi's minimization technique and Analysis of variance (ANOVA) the following conclusions are obtained

- The surface finishing is mainly affected by feed rate and cutting depth. If the feed rate increases the surface roughness increases gradually.
- If spindle speed, feed rate and cutting depth gradually increases the metal removal rate also increases.
- The optimum values for surface finish (1.144 µm) for cemented carbide insert as follows
  i) Spindle speed - 1200 rev per min
  ii) Feed rate - 0.25 mm/rev
  iii) Depth of cut - 0.50 mm
- The optimum values for surface finish (0.905 µm) for tungsten carbide insert as follows.
  i) Spindle speed - 1400 rev per min
  ii) Feed rate - 0.25 mm/rev
  iii) Depth of cut - 0.75 mm
- The optimum values for surface finish (0.196 µm) for High speed steel as follows
  i) Spindle speed - 1200 rev per min
  ii) Feed rate - 0.15 mm/rev
  iii) Depth of cut - 0.75 mm
- Tungsten carbide insert undergoes more tool wear when compared to cemented carbide insert.
- The outcomes of ANOVA and Taguchi technique illustrates that feed rate is more essential factor which damages the surface finishing and tool wear.
- For getting the optimum level of MRR the spindle speed should be high i.e. 1400 rpm, feed rate should also high i.e. 0.25 mm/rev and cutting depth should also high i.e.1.00mm.

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