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OPTIMIZATION OF MACHINING PARAMETERS FOR EN8 STEEL THROUGH TAGUCHI METHOD

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ABSTRACT

Surface roughness is one of the important parameter in conventional machining. Optimising these parameters is most challenging task in turning process. In this experiment we consider the parameters of alloy of steel to attain best surface finish. Here we undertake speed, feed and depth of cut as machining parameter. Taguchi method is further implemented to find the various levels of chosen parameter and thus using statistical analysis we find the optimum range of speed, feed and depth of cut to minimize the surface roughness and employed in working model for real time experiment. Here we use work material of EN8 steel and tungsten carbide tipped tool.

Key words: Material removal rate, Tool wear rate, surface roughness, Taguchi method.

INTRODUCTION

Surface roughness says about the quality of machining and also about the quality of product. The materials made of good surface finish enhance the property compared to lower surface finish of that material. Such surface roughness plays a major role as parameter in conventional machining process. The material removal rate and tool wear rate decide the surface finish.

To enhance this we take few experimental trials that clarify about the basic parameters of machining and optimization of those parameters. For a conventional method the basic input factors needed arespindle speed, feed rate, and depth of cut. Spindle Speed defines the speed of the spindle while the work piece is positioned at the chuck, feed rate is amount of growthsupplied or provided to the tool and depth of cut is distance downwards of increment given to cut while machining. As the machining is over for the limited number of experimental trial the hardness of the work piece and the SEM images are been studied clearly to know the variation occurred over the physical metallurgical property of machined layer.

On further, Taguchi method is employed to perform the remaining variable parameter and calculate the approximate values for material removal rate, tool wear rate and surface roughness of EN8 steel with tungsten carbide tipped tool. We hereby use Mini tab software for implementing taguchimethod as a result to input data we arrive the output that helps to check for optimization over the spindle speed, feed rate and depth of cut thus channelizing at what speed the feed and depth of cut for the chosen material of work piece with the chosen tool material could afford to increase the metal removal rate and reduce surface roughness

MATERIALS USED

Work Material: We selected EN8 steel work material as: The composition of this material is Manganese 0.8 %, Carbon 0.4%,Silicon 0.25%,Phosphorous 0.015%, Sulphur 0.015%.

Table 1: Chemical composition

EN 8 Chemical composition	
Carbon	0.36-0.44%
Silicon	0.10-0.40%
Manganese	0.60-1.00%
Sulphur	0.050 Max
Phosphorus	0.050 Max

This enriches the material in properties of:

1. High strength
2. Good toughness
3. Good ductility
4. High hardenability

It is one of the most commonly used type steel over the manufacturing section due to its properties.EN8 is widely used for many general engineering applications. Typical applications include shafts, studs, bolts, Connecting rods, screws, rollers, etc.

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Table 2: Mechanical properties

EN8 Mechanical properties with specific radius R		
Max Stress	700-850 n/mm^2	
Yield Stress	465 n/mm^2 Min	(19mm LRS)
0.2% Proof Stress	450 n/mm^2 Min	(19mm LRS)
Elongation	16% Min	(12% if cold drawn)
Impact KCV	28 Joules Min	(19mm LRS)
Hardness	201-255 Brinell	

Fig 1: Work piece before machining (EN8)

Application of the material are Dynamo, motor shafts,Heat treated bolts,Crankshaft Connecting rods, driving rings and flanges.

TOOL MATERIAL - TUNGSTEN CARBIDE TIPPED TOOL

Here the chemical composition is: The composition of this material is Tungsten of 94% and Carbide of 6 %.

Table 3: Chemical properties

Chemical composition of Tungsten carbide	
Tungsten	0.36-0.44%
Carbide	0.10-0.40%

The property of the material is:

1. High strength
2. Rigidity
3. Impact resistant
4. Heat and oxidation resistance
5. Resistance to corrosion and wear.

EXPERIMENTAL PROCESS

The process parameters of machining that are to be optimized as spindles speed, the feed rate and depth of cut are decided and classified to three different levels individually. This is given at table-4. The entire process is been differentiated with distinct phase.

- The first phase is selection of work piece and tools than Machining is done using conventional machining where machining time is noted by stop watch and measured final weight of all jobs.
- Material Removal Rate (MRR) is calculated by using following relation
- MRR = (Initial weight of job – final weight of job) / (machining time)
- Tool Wear Rate (TWR) is calculated by using following relation
- TWR = (Initial weight of tool – final weight of tool) / (machining time)

Table 4: Table of experimental design

S.No	SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)
1	200	0.071	1.5
2	200	0.11	1.0
3	200	0.25	0.5
4	450	0.071	1.0
5	450	0.11	0.5
6	450	0.25	1.5
7	700	0.071	0.5
8	700	0.11	1.5
9	700	0.25	1.0

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Table 5: L9 orthogonal array

S.No	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	3
5	2	2	1
6	2	3	2
7	3	1	2
8	3	2	3
9	3	3	1

Table 6: Factors and levels

Sl.No	FACTORS	NOTA -TION	LEVELS					
			ACTUAL			CODED		
			LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
1	SINDLE SPEED (rpm)	A	200	450	700	1	2	3
2	FEED RATE (mm/rev)	B	0.071	0,11	0,25	1	2	3
3	DEPTH OF CUT (mm)	C	0.5	1	1.5	1	2	3

- ➢ The second phase of the experiment is analysis of machined work pieces and tool. Tool wear rate and material removal rate are calculated and for surface roughness hardness testing and SEM test helps in understanding the property of machined surface.
- ➢ Table-5 and table-6 says about the arrangement of design order for Taguchi method and its abbreviation.

TAGUCHI METHOD

Any research involves investigate of many parameters with different level. Doing an experiment with all the parameters factors considered is the most complicated and tough and also time consuming. It is not easy to do so many experiments. Here the factor represents the any variables that impact the result of our experiment.Level is defined as the different setting in the variable can be set. There by priority some are considered factors and others are left behind. In normal machining the most disadvantages is that only one factor can be varied at a time, to understand that factor.

Taguchi is one of the solutions to such a problem.

- It allows us to vary the entire factor at time and still allow is to evaluate effect of each individual factors.
- It allows us to experiment in limited number and predict the remaining combinations of the factors.

The main advantage of this methodology is at limited number of trials the remaining way of combination values are calculated using the formula. So for the non-experimented process also we can find the different combination that gives MRR, TWR and Ra values. For the convenience we use mini tab software to calculate the Taguchi method. Now we analyse the basic formulation by the trailed values.

Table 7- MRR and S/N ratio of EN8 Steel

SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	MRR (gm/sec)	SNRA3
200	0.071	0.5	1.53	3.693828616
200	0.11	1	0.466	-6.632281666
200	0.25	1.5	1.26	2.007410902
450	0.071	1	0.74	-2.615365605
450	0.11	1.5	2.44	7.747796527
450	0.25	0.5	2.33	7.347118421
700	0.071	1.5	3.42	10.68052212
700	0.11	0.5	3.28	10.31747687
700	0.25	1	2.5	7.958800173

Table 8- TWR and S/N ratio of EN8 Steel

SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	TWR (gm/sec)	SNRA3
200	0.071	0.5	0.08	21.93820026
200	0.11	1	0.07	23.0980392
200	0.25	1.5	0.13	17.72113295
450	0.071	1	0.12	18.41637508
450	0.11	1.5	0.22	13.15154638
450	0.25	0.5	0.1	20
700	0.071	1.5	0.3	10.45757491
700	0.11	0.5	0.14	17.07743929
700	0.25	1	0.2	13.97940009

Table 9- Ra and S/N ratio of EN8 Steel

SPINDLE SPEED (rpm)	FEED RATE (mm/rev)	DEPTH OF CUT (mm)	Ra (µm)	SNRA2
200	0.071	0.5	2.51	-7.99347443
200	0.11	1	2.65	-8.464917479
200	0.25	1.5	2.86	-9.127320663
450	0.071	1	2.55	-8.130803609
450	0.11	1.5	2.96	-9.425834221
450	0.25	0.5	2.53	-8.062410424
700	0.071	1.5	2.95	-9.39644032
700	0.11	0.5	2.36	-7.458240059
700	0.25	1	2.41	-7.640340851

Table 10 - Optimized range of Material removal rate of tungsten carbide

SOURCE	DF	Seq SS	Adj SS	Adj MS	F	P	% of Contribution	RANK
SPINDLE SPEED (rpm)	2	6.0031	6.0031	3.0015	22.93	0.042	67.32	1
FEED RATE (mm/rev)	2	0.0461	0.0461	0.0231	0.18	0.85	0.517	3
DEPTH OF CUT (mm)	2	2.6054	2.6054	1.3027	9.95	0.091	29.22	2
Error	2	0.2619	0.2619	0.1309			2.937	
Total	8	8.9164					100	

S=0.361840 R-Sq=97.06% R-Sq(Ad)=88.2%

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Fig 2: After Machining

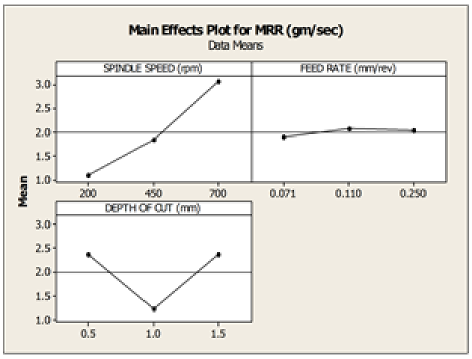

Fig 3- Graph for optimized range of MRR

RESULT

From the experiment we have derived the output for optimum range for machining EN8 steel with tungsten carbide tipped tool. The above table and graph shows the optimized value and the ranking helps to say which is best to be used to attain best MRR.

Table 11 – ANOVA Analysis of Tool Wear rate of tungsten carbide

SOURCE	DF	Seq SS	Adj SS	Adj MS	F	P	% of Conribution	RANK
SPINDLE SPEED (rpm)	2	0.021689	0.021689	0.010844	10.06	0.09	48.1	1
FEED RATE (mm/rev)	2	0.001089	0.001089	0.000544	0.51	0.664	2.41	3
DEPTH OF CUT (mm)	2	0.020156	0.020156	0.010078	9.35	0.097	44.7	2
Error	2	0.002156	0.002156	0.001078			4.78	
Total	8	0.045089					100	

S = 0.0328295 R-Sq = 95.22% R-Sq(Ad) = 80.88%

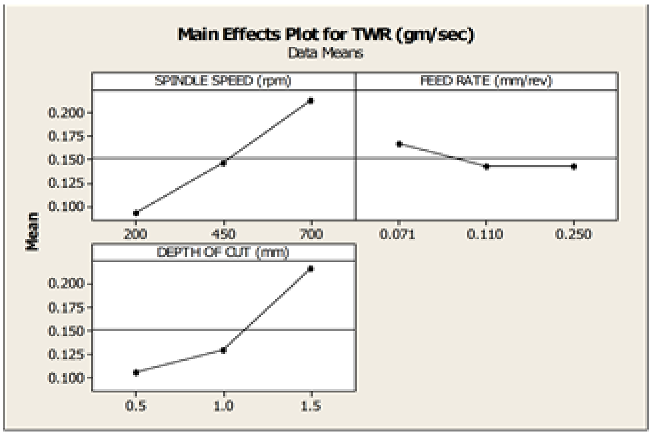

Fig 4- Graph for optimized range of TWR

The above table and graph shows the optimized value and the ranking helps to say which is best to be used to attain best TWR.

Table 12 - ANOVA Analysis of Surface roughness of tungsten carbide

SOURCE	DF	Seq SS	Adj SS	Adj MS	F	P	% of Conribution	RANK
SPINDLE SPEED (rpm)	2	0.02142	0.02142	0.01071	0.94	0.514	5.156	2
FEED RATE (mm/rev)	2	0.00829	0.00829	0.00414	0.37	0.732	1.99	3
DEPTH OF CUT (mm)	2	0.36296	0.36296	0.18148	16	0.059	87.38	1
Error	2	0.02269	0.02269	0.01134				
Total	8	0.41536						

S = 0.10651 R-Sq = 94.54% R-Sq(Ad) = 78.15 %

Table 13-Hardness by Vickers test

Sl. No.	a (0.05)	b (0.001)	TOTAL HARDNESS (a+b)	HARDNESS VALUE FROM TABLE	AVERAGE HARDNESS VALUE
1	0.05*1 = 0.05	0.001*23 = 0.0023	0.073 (0.05+0.023)	174 (W_1)	215.6
2	0.05*1 = 0.05	0.001*11 = 0.011	0.061 (0.05+0.011)	249 (W_2)	(174+249+195+241+219)/5
3	0.05*1 = 0.05	0.001*19 = 0.019	0.069 (0.05+0.019)	195 (W_3)	
4	0.05*1 = 0.05	0.001*12 = 0.012	0.062 (0.05+0.012)	241 (W_4)	
5	0.05*1 = 0.05	0.001*15 = 0.015	0.065 (0.05+0.015)	219 (W_5)	

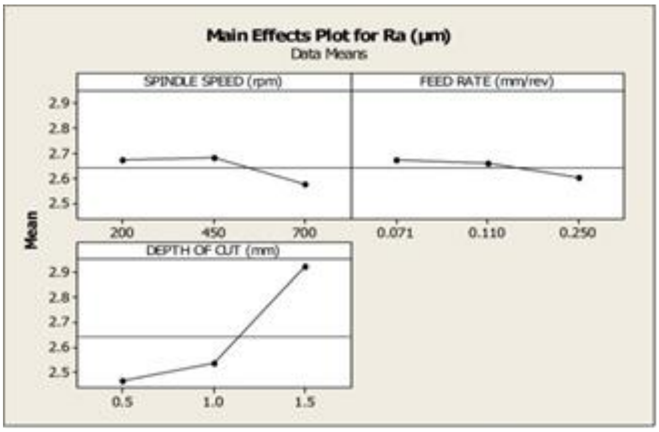

Fig 5- Graph for optimized range of Surface roughness

The above table and graph shows the optimized value and the ranking helps to say which is best to be used to attain best Ra.

For further analysis we have done hardness testing and microscopic analysis.

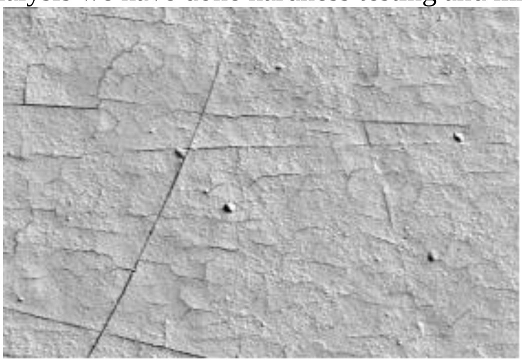

Fig 6- SEM image of work piece

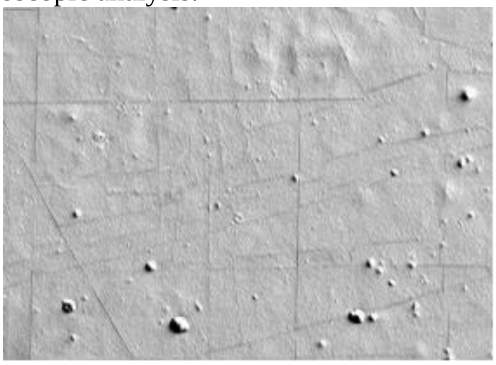

Fig 7- SEM image of tool

CONCLUSION

This study presents the Taguchi method for optimization of metal removal rate, tool wear rate and surface roughness by using tungsten carbide tipped tool and titanium nitride coated tool on EN 8 alloy steel.On the basis of experimental results and derived analysis, one can conclude that cutting speed has most dominant effect on the observed surface roughness, followed by feed rate and depth of cut, whose influences on surface roughness are smaller.

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