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Optimization of Process Parameters in Turning Operation of AISI-1018 with Carbon boron nitride cutting tool Using Taguchi Method And ANOVA

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ABSTRACT
Now a days most of the manufacturing industry aims at producing more number of products within relatively lesser time/lesser cycle. This case applies Taguchi design of experiment methodology for optimization of process parameters in turning of AISI 1018 Low carbon steel usingCubic boron nitride tool. Experiment have been carried out based on L9 standard orthogonal array design with three process parameters namely Cutting Speed, Feedrate, Depth of Cut for Material removal rate and Machining time. The signal to noise ratio and analysis of variance were employed to study the performance characteristics in turning operation. The results of the machining experiments for AISI-1018 were used to characterize the main factors affecting surface roughness by the Analysis of Variance (ANOVA) method. Thus, it is possible to increase machine utilization and decrease production cost in an automated manufacturing environment
Key words: *AISI-1018 Material ,ANOVA, Surface Roughness ,Taguchi method, Turning.*

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INTRODUCTION

Today's modern/highly automated machining industries face the challenges to achieve high/better quality in terms of work piece dimensional accuracy, surface finish , less wear on cutting tools, economy of machining in terms of cost saving. Surface roughness of the machined part is the most important criteria to judge the quality of operation.
most of the researcher worked on various types material like Inconel 718, AISI1040 steel, AISI 52100 steel, AISI 4140 (51 HRC) with coated carbide, C45 steel, and AISI 4340 steel with the various cutting tools. They have measured the cutting force, surface roughness and the tool wears with the help of the various process parameters like speed, feed and the depth of cut. Some of them have measured the response with the varying tool geometry and also the material hardness and then after they compare with each other and gave the best optimal solution. Also they have focuses on the optimizing the turning parameters based on the Taguchi method to minimize the surface roughness and also analyze the effects of process parameters like the cutting speed, feed, and the depth of cut on surface roughness and to obtain the optimal setting of these parameters that results in good surface finish. Also it was seen that the researchers trying to find the best work piece for getting the satisfaction for making the components of a good quality.

Taguchi method

Taguchi's parametric design is the effective tool for robust design. It offers a simple and systematic qualitative optimal design at a relatively low cost. The Taguchi method of off-line (Engineering) quality control encompasses all stages of product/process development. However the key element for achieving high quality at low cost is Design of Experiments (DOE). In this paper Taguchi's (DOE) approach is used to analyze the effect of process parameters like cutting speed, feed, and depth of cut on Surface Roughness of AISI-1018 work material.

Anova

Anova is statical treatment most commonly applied to the experiment to determine contribution of each factors. Study of anova table for given analysis help to determine which factor need to control or not. Once the optional condition determine it is usually good practice to the run conformation experiment. The purpose of the statistical analysis of variance (ANOVA) is to investigate which design parameter significantly affects the material removal rate and surface roughness. Based on the ANOVA, the relative importance of the machining parameters with respect to material removal rate and surface roughness is investigated to determine more accurately the optimum combination of the machining parameters. Two types of variations are present in experimental data:

1) within treatment variability
2) Observation to observation variability

Experiment details

In this case the experiment was conducted using work piece material AISI-1018. The cutting tool used was Cubic boron nitride. The tests were carried for a length of 400mm in a Jobber XL CNC lathe. The cutting parameters are shown in the Table -1. Three levels of cutting speed, feed and depth of cut were used and are shown in the Table-1.

Parameters	Unit	Level		
		1	2	3
Cutting speed (V)	RPM	1400	1600	1800
Feed rate (F)	Mm/rev	0.17	0.19	0.21
Depth of cut (D)	Mm	0.80	1.20	1.60

Table No 1 parameters

Work-piece material

American Iron and Steel Institute AISI 1018 i.e. mild/low carbon steel has good or excellent weld ability and it is to be considered as the best steel for carburized parts. Also it produces a uniform and harder case. Thenet weight of the material is 4.67 kg. It has good toughness,, strength and ductility balance. The mild carbon steel with hot rolled also helps improving machining characteristics and Brinell hardness. for surface preparation, chemical composition, rolling and heating processes. Specific controls are used. The material which we have to work having the dimensions of 50 mm in diameter and 30 cm in length i.e.1 foot.For this experiment we have selected Cubic boron nitride (CBN or c-BN) having point cutting tool.The physical properties ofAISI 1018 is shown below.

Physical Properties	Metric in (g/cc)	Imperial in (lb./in^3)
Density	7.87	0.284

Table No.2

Elements	Contents in (%)
Manganese, MN	0.60-0.90
Iron ,Fe	<0.050
Carbon ,C	0.14-0.200
Phosphorous, P	< 0.040
Iron ,Fe	98.81-99.26

Table No.3

Figure 1 AISI 1018

Selection of machine tool

Computer Numeric Control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium (computer command module, usually located on the device) as opposed to controlled manually by hand wheels or levers, or mechanically automated by cams alone. Tool holding capacity is 8.Most NC today is computer (or computerized) numerical control in which computers play an integral part of the control, The machine tool Jobber XL specification is given as follows :-

Swing Over Diameter	500(mm)
Swing Over Carriage	260(mm)
Maximum Turning Diameter	320(mm)
Distance Between Centres	425(mm)
Maximum Turning Length	400(mm)
Spindle Motor Power(cont./15 min)	5.5/7.5(kw)
Bore Through Spindle	53(mm)
Spindle speed	4000(rpm)
X-Axis stroke	165 (mm)
Z-Axis stroke	400(mm)
X & Z Axis rapid	20(m/min)
No of tools	8
OD Turning tool size	25x25

Table No.4

Experimental results:-

The experiment was conducted the results are recorded in a table as shown below.Experimental Readings

Ex. No.	SPEED	FEED	DOC	MRR (gm/min)	Ra (µm)	Cutting time (min)
1	1300	0.10	0.75	117.41	1.600	0.2307
2	1300	0.15	1.00	237.38	2.700	0.1538
3	1300	0.20	1.50	472.22	2.900	0.1153
4	1500	0.10	1.00	182.60	2.600	0.2
5	1500	0.15	1.50	408.65	2.400	0.13
6	1500	0.20	0.75	270.95	2.800	0.1
7	1700	0.10	1.50	308.75	2.000	0.17
8	1700	0.15	0.75	230.31	2.300	0.11
9	1700	0.20	1.00	413.90	2.500	0.08

Table No 5

The main effects plot for S/N ratio of material removal rateversus feed, speed and DOC it shows that higher material removal rate will meet at feed 0.20mm /rev, speed 1700 RPM and depth of cut 1.50 mm. The graph generate by use of minitab-16 statistical software for material removal rate.

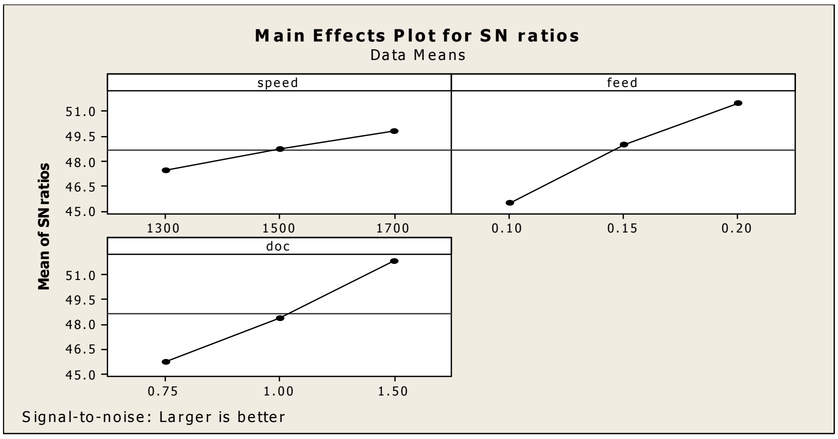

Figure 2 Effect of control factor on material removal rate

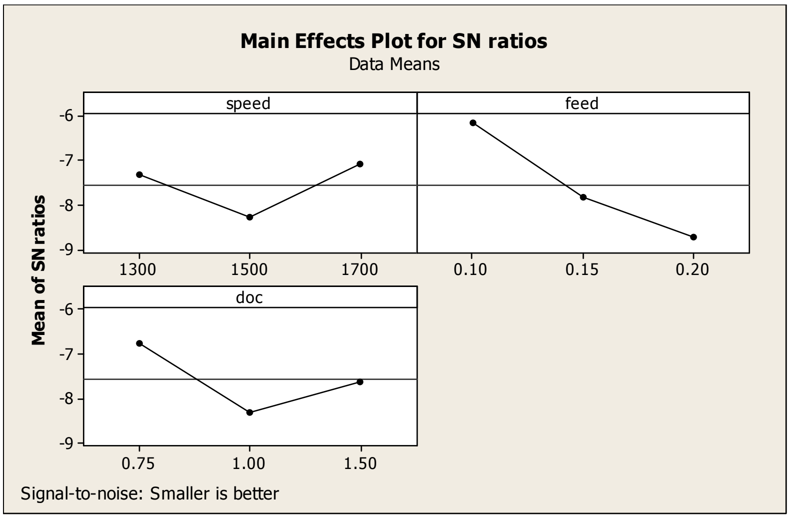

Figure 3 Effect of control factor Surface Roughness

The main effects plot for S/N ratio Surface roughness versus feed, speed and DOC are shown in fig.5.3, and Fig.5.3 shows that lower Surface roughness will meet at cutting speed 1500 RPM, feed 0.20 mm/rev and depth of cut 1.00 mm. From the figure it has been conclude that the optimum combination of each process parameter for lower feed force is meeting at high Speed [A2], low Feed [B1] and low DOC [C1].

Response Table for Signal to Noise Ratios

Level	Speed	Feed	Doc
1	-7.319	-6.134	-6.753
2	-8.282	-7.822	-8.295
3	-7.071	-8.717	-7.624

Table No 6

Speed	Feed	DOC	RA	SNRA1
1300	0.10	0.75	1.6	-4.08240
1300	0.15	1.00	2.7	-8.62728
1300	0.20	1.50	2.9	-9.24796
1500	0.10	1.00	2.6	-8.29947
1500	0.15	1.50	2.4	-7.60422
1500	0.20	0.75	2.8	-8.94316
1700	0.10	1.50	2.0	-6.02060
1700	0.15	0.75	2.3	-7.23456
1700	0.20	1.00	2.5	-7.95880

Table No 7

Summary of ANOVA Calculation for Material Removal Rate

Source of Variance	F	Sum of Squares	Variance (mean squares)	Variance Ratio(F)	Percentage Contribution (P)
FACTOR A (Speed)	2	2815.4573	1407.72865	1.1144	0.0253
FACTOR B (Feed)	2	50116.9161	25058.45805	19.8381	0.4519
FACTOR C (Depth of Cut)	2	55427.79933	27713.89967	21.9403	0.4998
ERROR -E	2	2526.29187	1263.145935	1	0.0227
TOTAL	8				

Table No 8

From ANOVA result it is observed that the speed is the influencing parameter for material removal rate, because the value of p is less than 0.05 p values. Summary of ANOVA Calculation for roughness analysis

Source of Variance	F	Sum of Squares	Variance (mean squares)	Variance Ratio(F)	Percentage Contribution(P)
FACTOR A (Speed)	2	0.1656	0.0828	0.5063	0.1221
FACTOR B (Feed)	2	0.6656	0.3328	2.0243	0.4910
FACTOR C (Depth of Cut)	2	0.1956	0.0978	0.5948	0.1442
ERROR -E	2	0.3288	0.1644	1	0.2425
TOTAL	8	1.3556			

Table No 9

From ANOVA result it is observed that there no influencing parameter for material removal rates well as for surface roughness. Because of not having the value of p is less than 0.05 p values.

Grey relational analysis calculation

Sr. No.	SPEED	FEED	D.O.C	G R A		G R C		G R G
				M R R	R A	M R R	R A	
1	1300	0.10	0.75	0.0000	1.0000	1.0000	1.0000	1.00000
2	1300	0.15	1.00	0.3381	0.1538	0.7466	0.7349	0.74075
3	1300	0.20	1.50	1.8455	0.0000	0.4990	0.7011	0.60005
4	1500	0.10	1.00	0.1837	0.2307	0.8443	0.7530	0.79865
5	1500	0.15	1.50	0.8208	0.3846	0.5482	0.7922	0.67020
6	1500	0.20	0.75	0.4327	0.0769	0.6971	0.7176	0.70735
7	1700	0.10	1.50	0.5392	0.6923	0.6488	0.8840	0.76640
8	1700	0.15	0.75	0.3181	0.4615	0.7579	0.8133	0.78560
9	1700	0.20	1.00	0.8356	0.3076	0.5438	0.7721	0.65795

Table No 10 Summary of Grey Relational

CONCLUSION

While studying the effect of the cutting parameters on the material removal rate, it was observed that the higher material removal rate will meet at feed 0.20 mm /rev, speed 1700 RPM and depth of cut 1.50 mm. The optimum condition for machining to reduce material removal rate would be A2 B3 C3.

The lower Surface roughness will meet at cutting speed 1300 RPM, feed 0.10 mm/rev and depth of cut 0.75 mm. The optimum condition for machining to reduce material removal rate would be A2 B1 C1

From grey relational grade , we came to know that the all this responses maximum material removal rate, minimum surface roughness will obtain at optimum at0.79865 the value that we have obtained is our effective parameter

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