Effect of Turning Process Parameter on Surface Roughness using Inconel as a Material

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Abstract: ***Inconel 718 is nickel- based superalloy extensively used in aerospace industries, marine industries, steam turbine power plant, and nuclear reactor. Present work focuses on optimization of turning process parameters of Inconel 718 using taguchi optimization technique. Surface roughness was the response variable investigated. Experimental results indicate that proposed mathematical model suggested adequately describe performance indicator within the limits of factors that are being investigated. Tool is the most influencing factor on surface roughness followed by depth of cut, speed and feed.***

Keywords: Inconel 718, surface roughness, Anova, S/N ratio

1. Introduction

The recent developments in science and technology have put tremendous pressure on manufacturing industries. The manufacturing industries are trying for increasing the quality of the machined parts, decreasing the cutting costs and machine more hard materials. High efficiency of machine is obtained by reducing the machine time with high speed of machining. When cutting of hard materials such as Steels, Inconel, Titanium and super alloys, softening temperature and chemical stability of tool material limits the cutting speed [1.1]

The machining operations such as turning, drilling, milling, etc. are carried out on different machines but now a day's CNC machines are most commonly used. While machining, different parameters such as spindle speed, feed rate, depth of cut and type of tool must be considered to get good surface finish and less tool wear with good efficiency of machining. Thus it is necessary to compare surface roughness and tool wear by using different tools [1].

Inconel 718 material is the most difficult material to machine. Improper selection of machining parameters causes cutting tools to wear and break quickly as well as economical losses such as damaged workpiece and rejected surface quality. Machining parameters and tool geometry are the important parameters which affect the machinability properties Nalbant et al (2007) [2]. A machinability model may be defined as a functional relationship between the input parameters (cutting speed, feed, and depth of cut) and the output responses (tool life, surface roughness, cutting force, power and material removal rate) of machining process Choudhury and El-Baradie (1999).

Coated and uncoated carbide inserts are widely used in metal working industry for machining of different material. These two inserts have their own advantages and disadvantages. This experimentation will help to investigate the best cutting insert is whether coated or uncoated carbide insert for the machining of Inconel 718 in CNC turning considering two variables as surface roughness, tool wear and material removal rate. In this investigation the machining parameters used are spindle speed, feed rate and depth of cut [3].

2. Methodology

In current experimentation five process parameters are selected as control factors. The remaining process parameters kept as constant. Controlled and constant parameters are given in table 1 and table 2.

Table 1: Controlled parameters

Sr. No	Controlled parameters
1.	Speed(RPM)
2.	Feed(mm/min)
3.	Tool nose radius (mm)
4.	Depth of cut (mm)

Table 2: Constant parameters

Sr. No	Constant parameters	
1.	Cutting fluid	W4 CBF
2.	Work material	Inconel 718
3.	Work-piece dimension	25 mm x 65mm
4.	Tool holder	SPMG060204DG

For present experimentation, we use L18 design of experiment. There are four process parameters, three process parameter have three levels and one process parameter have two level there parametric combination as shown in Table 3.

Table 3: Parametric combinations

Sr.No	Tool	Speed	Feed	Deth of cut
1	T1	S1	F1	D1
2	T1	S1	F2	D2
3	T1	S1	F3	D3
4	T1	S2	F1	D1
5	T1	S2	F2	D2
6	T1	S2	F3	D3
7	T1	S3	F1	D2
8	T1	S3	F2	D3
9	T1	S3	F3	D1
10	T2	S1	F1	D3
11	T2	S1	F2	D1
12	T2	S1	F3	D2
13	T2	S2	F1	D2
14	T2	S2	F2	D3
15	T2	S2	F3	D1
16	T2	S3	F1	D3

17	T2	S3	F2	D1
18	T2	S3	F3	D2

For the current experimental work, for turning of the Inconel 718, the coated carbide tool insert is selected. Experiment were performed on CNC machine.

3. Results and Discussion

Surface roughness was measured using the Mitutoyo surface roughness tester model name sj-210. The arithmetic average roughness value is measured. The surfaces finish value of the machined Inconel 718 bar was measured after completion of one machining.

Specifications:
Traverse Speed: 0.5 mm/sec.
Cut off values: 5mm
Display: LCD.
Battery: Alkaline 500
Measurements of 5 mm length.

Surface roughness measured on external face of specimen having a stroke length 0.25 x 5 µm. Average of two repetitions for surface roughness is given in table 4

Table 4: Experimental results of surface roughness in µm

Expt. No	Tool	Speed	Feed	Deth of cut	Surface roughness
1	T1	900	0.111	0.4	3.1
2	T1	900	0.138	0.6	2.178
3	T1	900	0.166	0.8	1.926
4	T1	1000	0.111	0.4	3.173
5	T1	1000	0.138	0.6	2.399
6	T1	1000	0.166	0.8	1.74
7	T1	1100	0.111	0.6	2.677
8	T1	1100	0.138	0.8	2.7
9	T1	1100	0.166	0.4	2.9
10	T2	900	0.111	0.8	1.062
11	T2	900	0.138	0.4	0.914
12	T2	900	0.166	0.6	1.17
13	T2	1000	0.111	0.6	0.814
14	T2	1000	0.138	0.8	0.481
15	T2	1000	0.166	0.4	1.1
16	T2	1100	0.111	0.8	0.711
17	T2	1100	0.138	0.4	1.218
18	T2	1100	0.166	0.6	1.41

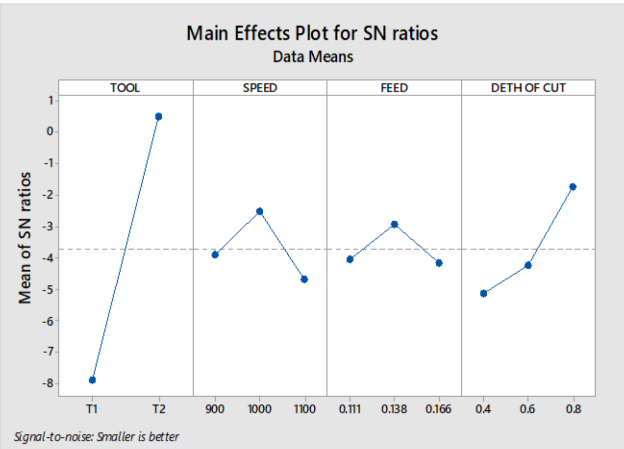

Figure 1: Main effect plot of S/N ratio for surface roughness

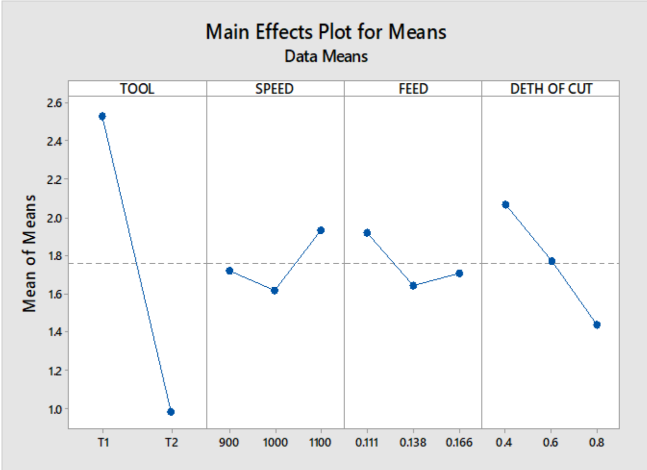

Figure 2: Main effect plot of mean for surface roughness

In main effect plot of S/N ratio for tool war, X-Axis indicates different levels of process parameters and Y-Axis shows average of S/N ratio. It can be observed from figure4.4 that tool wear decreases as speed and feed increases whereas depth of cut increases tool wear also increases. Tool wear is minimum for tool T2.

Table 5: Analysis of variance for surface roughness

Source	DF	Adj.SS	Adj.MS	F value	P value
Tool	1	10.7540	10.7540	113.60	0.000
Speed	2	0.3145	0.1572	1.66	0.238
Feed	2	0.2503	0.1252	1.32	0.309
Depth of cut	2	1.1959	0.5979	6.32	0.017
Error	10	0.9466	0.0947		
Total	17	13.4613			

Table 6: Response Table for S/N Ratios for Ra value, Smaller is better

Level	Tool	Speed	Feed	Depth of Cut
1	-7.9056	-3.8978	-4.0303	-5.1441
2	0.4974	-2.5207	-2.9273	-4.2459
3		-4.6938	-4.1547	-1.7224
Delta	8.4031	2.1731	1.2274	3.4217
Rank	1	3	4	2

As seen from Table 6 tool is the most influence parameter for surface roughness followed by depth of cut, speed and feed.

The optimal level for different performance parameters are given below.

a) For surface roughness: -S2-F2-T2-D3

The purpose of the confirmation experiment is to verify the conclusions drawn during the analysis phase. The response was correlated with the factors using the first order polynomial. The relationship between surface roughness and process parameters

Regression Equation
Ra value =

1. T1 = 2.96 + 0.001055 *Speed – 3.87* Feed -1.577* Depth of cut.
2. T2 =1.41 + 0.001055* Speed – 3.87* Feed -1.577* Depth of cut.

For this model R^2 value = 92.97%, R^2 (adj) = 88.05% this indicate that the model is desirable and 88.05 %variability is explained by the model after considering significant parameters.

Ra value =1.41 + 0.001055 *1000 – 3.87 *0.138 -1.577 *0.8 = 0.6694µm

Table 7: Confirmation of experiments for surface roughness

	Prediction	Experiment
Level	S2-F2-T2-D3	
Surface roughness (µm)	0.6694	0.62

Experiments are conducted by using optimal level for each parameter. Table 7 shows the comparison of the predicted and the actual responses obtained during experimental trial. The predicated and actually measured response for surface roughness is in good agreement, indicating that optimization of the control parameters was appropriate.

4. Conclusions

Taguchi's design of experiment is used tool for conducting analysis in current experimentation. Most significant parameters and their contributions for surface roughness is determined with help of ANOVA. The optimal value and optimal level for performance characteristics is also finding out.

The following are conclusions obtained from the experimentation.

a) From the response table for surface roughness indicates that tool is most influencing factor for surface roughness followed by depth of cut, speed and feed.
b) The second level of speed is 1000r pm, second level of feed is 0.138 mm/min, third level if depth of cut 0.8 is and tool T2 indicates minimum value of surface roughness.

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