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Optimization of Machining Parameters for Milling of Nickel Alloy Inconel 718 Using Taguchi Method

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ABSTRACT

In this thesis experiments are conducted to improve the surface finish quality of a nickel alloy Inconel 718workpiece by using carbide tips. The type is bull nose tip. A series of experiments are done by varying the milling parameters spindle speed, feed rate and depth of cut using L9 orthogonal array in Taguchi technique. The spindle speeds are 1800rpm, 2000rpm and 2500rpm. The feed rates are 200mm/min, 300mm/min and 400mm/min. Depth of cut is 0.2mm, 0.3mm and 0.6mm. The process parameters are optimized for better surface finish using Taguchi technique in Minitab software.

INTRODUCTION TO MILLING

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, workpiece, fixture, and cutter. The workpiece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth that is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter, material is cut away from this workpiece in the form of small chips to create the desired shape.

Cutting parameters

In milling, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size, and more.

- Cutting feed
- Cutting speed
- Spindle speed
- Feed rate
- Axial depth of cut
- Radial depth of cut

LITERATURE SURVEY

The work done by DraženBajić [1] examines the influence of three cutting parameters on surface roughness, tool wear and cutting force components in face milling as part of the off-line process controlTwo modeling methodologies, namely regression analysis and neural networks have been applied to experimentally determined data. Results obtained by the models have been compared. Both models have a relative prediction error below 10%. The research has shown that when the training dataset is small neural network modeling methodologies are comparable with regression analysis methodology and can even offer better results, in which case an average relative error of 3.35%. Advantages of off-line process control which utilizes process models by using these two modeling methodologies are explained in theory. The work done by K. AdarshKumar [2], presents an experimental study to investigate the effects of cutting parameters like spindle speed, feed and depth of cut on surface finish on EN-8. A multiple regression analysis (RA) using analysis of variance is conducted to determine the performance of experimental measurements and to it shows the effect of cutting parameters on the surface roughness. Machining was done using cemented carbide insert. The objective was to establish correlation between cutting speed, feed rate and depth of cut and optimize the turning conditions based on surface roughness. These correlations are obtained by multiple regression analysis (RA).

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EXPERIMENTAL SETUP AND PROCEDURE

Experiments have been performed in order to investigate the effects of one or more factors of the process parameters (spindle speed, feed rate and depth of cut) on the surface finish of the machined surface.The main aim of the project is to determine the influence of radius carbide tips in metal working. The investigation is based on surface roughness during milling of Nickel alloy Inconel 718 with carbide tool. The cutting parameters considered are feed rate, spindle speed and depth of cut.

EXPERIMENTAL PROCEDURE

This experiment employed a CNC vertical milling machine. Carbide cutting tool is used. The experiment has been done under conditions of the spindle speeds are 1800rpm, 2000rpm and 2500rpm. The feed rates are 200mm/min, 300mm/min and 400mm/min. Depth of cut is 0.2mm, 0.3mm and 0.6mm. Square pieces of Inconel 718 material are taken for machining.

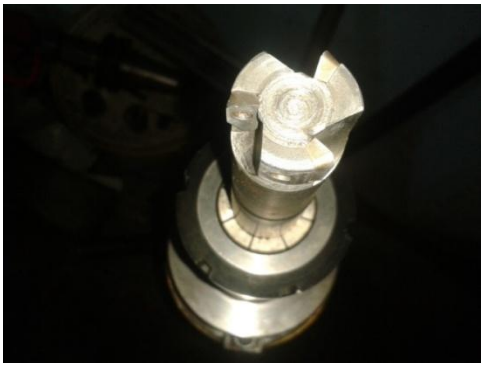

Fig - Carbide tool

Taguchi parameter design for optimizing parameters using Minitab software - Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the three factor interaction effects of process parameters on the selected characteristics.

FACTORS	PROCESS PARAMETERS	LE VEL1	LEVEL2	LEVEL3
A	SPINDLE SPEED (rpm)	1800	2000	2500
B	FEED RATE (mm/min)	200	300	400
C	DEPTH OF CUT (mm)	0.2	0.3	0.6

Table 6-1: Input Process Parameters for Taguchi Method

Results

Using randomization technique, analysis is done by varying the input parameters. The values have been reported in Tables. The values being 'smaller the better' type of machining quality characteristics, the S/N ratio for this type of response was and is given below:

S/N Ratio = $-10 \log [\frac{1}{n} (Y_1^2 + Y_2^2 + \ldots\ldots + Y_n^2]$ .....(1)

Where $Y_1, Y_2, \ldots, Y_n$ are the responses of the machining characteristics for each parameter at different levels.

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	1800	200	0.2
2	1800	300	0.3
3	1800	400	0.6
4	2000	200	0.3
5	2000	300	0.6
6	2000	400	0.2
7	2500	200	0.6
8	2500	300	0.2
9	2500	400	0.3

Table – Arrangement of process parameters as per L9 orthogonal array

Surface finish results

In this project most important output performances in milling such as Surface Roughness (Ra) is considered for optimizing machining parameters. The surface finish value (in µm) was obtained by measuring the mean absolute deviation, Ra (surface roughness) from the average surface level using a Computer controlled surface roughness tester.

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface Roughness (R_a) µm
1	1800	200	0.2	1.65
2	1800	300	0.3	1.09
3	1800	400	0.6	0.93
4	2000	200	0.3	0.79
5	2000	300	0.6	1.5
6	2000	400	0.2	1.16
7	2500	200	0.6	1.18
8	2500	300	0.2	1.3
9	2500	400	0.3	1.92

Table – Measured Surface Roughness values

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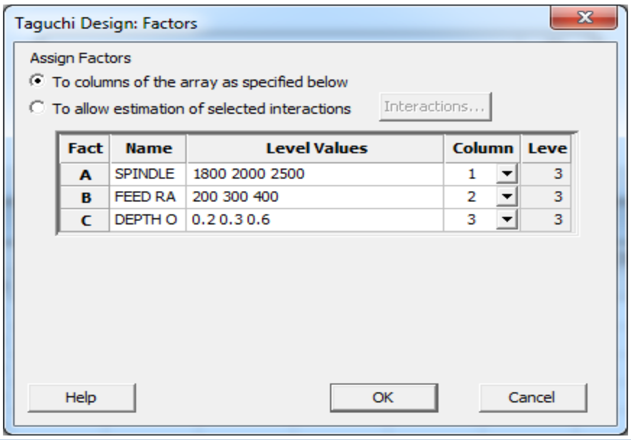
OPTIMIZATION OF MACHINING PARAMETERS USING MINITAB SOFTWARE FOR MINIMUM SURFACE ROUGHNESS

Select Factors



Worksheet 1 ***

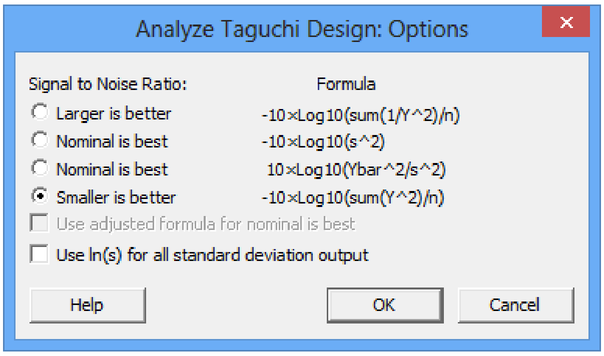
↓	C1	C2	C3
	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	1800	200	0.2
2	1800	300	0.3
3	1800	400	0.6
4	2000	200	0.3
5	2000	300	0.6
6	2000	400	0.2
7	2500	200	0.6
8	2500	300	0.2
9	2500	400	0.3

Enter Surface Roughness Values in the table

Worksheet 1 ***

↓	C1	C2	C3	C4
	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface ROughness Ra
1	1800	200	0.2	1.65
2	1800	300	0.3	1.09
3	1800	400	0.6	0.93
4	2000	200	0.3	0.79
5	2000	300	0.6	1.50
6	2000	400	0.2	1.16
7	2500	200	0.6	1.18
8	2500	300	0.2	1.30
9	2500	400	0.3	1.92

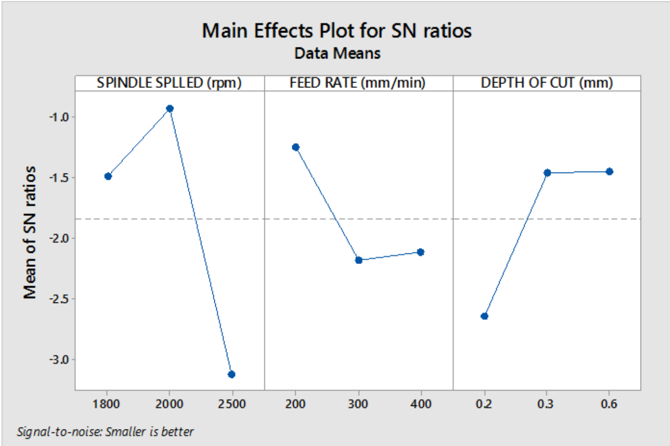
Options



S/N Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface ROughness Ra	SNRA1
1	1800	200	0.2	1.65	-4.34968
2	1800	300	0.3	1.09	-0.74853
3	1800	400	0.6	0.93	0.63034
4	2000	200	0.3	0.79	2.04746
5	2000	300	0.6	1.50	-3.52183
6	2000	400	0.2	1.16	-1.28916
7	2500	200	0.6	1.18	-1.43764
8	2500	300	0.2	1.30	-2.27887
9	2500	400	0.3	1.92	-5.66602



Effect of milling parameters on surface finish for S/N ratio

Analysis and Discussion

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Spindle Speed :-The effect of parameters spindle speed on the surface finish is shown above figure for S/N ratio. So the optimum spindle speed is 2500 rpm.

Feed Rate:-The effect of parameters feed rate on the surface finish is shown above figure S/N ratio. So the optimum feed rate 200 mm/min.

Depth of Cut :-The effect of parameters depth of cut on the surface finish is shown above figure for S/N ratio. So the optimum depth of cut is 0.3mm.

CONCLUSION

The optimization of parameters is done using Taguchi technique in Minitab 17. By observing the S/N ratio, the optimum parameters are spindle speed 2500rpm, feed rate 300mm/min and depth of cut 0.3mm for lesser surface roughness values.So it can be concluded that machining Inconel 718 with spindle speed of 2500rpm, feed rate of 300mm/min and depth of cut 0.3mm yields better surface finish quality.

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