Optimization of Process Parameters on SS410 in Cylindrical Grinding Process

V. Saravana Kumar
Department of Mechanical Engineering,
SriGuru Institute of Technology
Coimbatore, Tamil Nadu

Hridul Pavithran, Sachin K. V
Department of Mechanical Engineering,
SriGuru Institute of Technology
Coimbatore, Tamil Nadu

***Abstract*—Cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. Metal removal rate and surface finish are the important out put responses in the production with respect to quantity and quality respectively. The Experiments are conducted on Micrometric Grinding Tech machine with L9 Orthogonal array with input machining variables as depth of cut, job rotating speed, feed rate and coolant flow rate. The optimal condition for surface roughness is obtained by analyzing the values in Minitab software. The results are further confirmed by conducting confirmation experiments.**

Keywords—Cylindrical grinding, Surface roughness, Design of experiments, L9 orthogonal array

I. INTRODUCTION

A surface recognition system is to predict the surface roughness of grind parts in the cylindrical grinding process is developed in this project to assure product quality by predicting the surface finish parameters in real time. Cylindrical Grinding is an essential process for final machining of components requiring smooth surfaces and precise tolerances. As compared with other machining processes, grinding is a costly operation that should be utilized under optimal conditions. Although widely used in industry, grinding remains perhaps the least understood of all machining processes. The following input process parameters namely depth of cut, job rotation speed, feed and coolant flow rate. The main objective of this paper is to show how our knowledge on grinding process can be utilized to predict the grinding behavior and achieve optimal operating process parameters. The experiments are conducted on Micrometric Grinding Tech Machine with L9 Orthogonal array. The developed model can be used by the different manufacturing firms to select right combination of machining parameters to achieve an optimal Surface Roughness (Ra). The main objective of this project is analyze effect of various process parameters in machining of SS 410 for obtaining required surface roughness. In order to optimize these values Taguchi method is used.

A. TAGUCHI METHOD

Genichi Taguchi has developed a methodology for the application of designed experiments, including a practitioner's hand book. This methodology has taken the design of experiments from the exclusive world of the statistician and brought it more fully into the world of manufacturing. His contributions have also made the practitioner work simpler by advocating the use of fewer experimental designs, and providing a clearer understanding of the variation. To solve this task, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. A loss function is then defined to calculate the deviation between the experimental value and the desired value. Taguchi recommends the use of the loss function to measure the performance characteristic deviating from the desired value. The value of the loss function is further transformed into a signal-to-noise (S/N) ratio g usually; there are three categories of the performance characteristic in the analysis of the S/N ratio, that is, the lower-the-better, the higher-the-better, and the nominal- the-better. The S/N ratio for each level of process parameters is computed based on the S/N analysis. Regardless of the category of the performance characteristic, the larger S/N ratio corresponds to the better performance characteristic. Therefore, the optimal level of the process parameters is the level with the highest S/N ratio.

II. OBJECTIVES

To analyze effect of various process parameters in machining of SS 410 for obtaining required surface roughness.
The parameters considered are depth of cut, feed, job rotation speed and coolant flow rate.
To develop an optimized condition for getting best surface finish possible by implementing the mathematical tools in machining process.

III. EXPERIMENTAL PROCEDURE

A. Experiment

According to the Design of Experiments, a standard orthogonal array is selected as per the constraints and levels. In this project we are considering three levels namely Low, Medium and High. Since there are four parameters and three levels, according to the combination we have 3^4 =81 experiments (i.e. number of levels raised to number of parameters). Thus we have to conduct 81 experiments. For our project work we have selected L9 Orthogonal Array, according to L9 Orthogonal Array nine experiments are enough for the above condition.

TABLE 1: Levels and Factors

LEVEL	DOC mm	FEED mm/s	JOB SPEED rpm	FLOW RATE L/s
1	0.02	7.333	80	0.088
2	0.05	11.406	160	0.126
3	0.1	15.400	320	0.276

The above table denotes the various levels and factors which have to be followed in L9 orthogonal array.

B. Procurement of material

SS410 was bought from United Steels,Coimbatore. The steel rods of diameter 24mm and length 150mm, totally twenty five in number. After that work pieces were turned and center drilled.

C. Grinding of work piece

After turning the work pieces they are grinded using Micromatic Grind Tech 6CU 260x500. The coolant used was Cim cool 602 in the ratio of 1:30. The head speed was kept at 1440rpm constant. Dressing of the wheel was done at regular interval of time.

Figure 1:Experimental setup.

Machine specification
Make : Micromatic Grinding Technology Ltd.
Model : 6CU 260x500
Serial No: 501041
Weight: 3500kg

D. Design of experiments-L9 0rthogonal array

Table 2: Design of experiments

doc mm	feed mm/s	speed rpm	flow rate L/s
0.02	7.331	80	0.088
0.02	11.406	160	0.126
0.02	15.400	320	0.276
0.05	7.331	160	0.276
0.05	11.206	320	0.088
0.05	15.400	80	0.126
0.1	7.331	320	0.126
0.1	11.406	80	0.126
0.1	15.400	160	0.088

IV. MEASUREMENT OF SURFACE ROUGHNESS

Surface roughness was measured at Coindia Modern Tool Room Citra,Coimbatore,Tamil Nadu. It was measured using surface roughness measuring machine. It is a digital machine; a stylus is made to move along the profile of the specimen so that the digital meter shows the reading in micro meter.

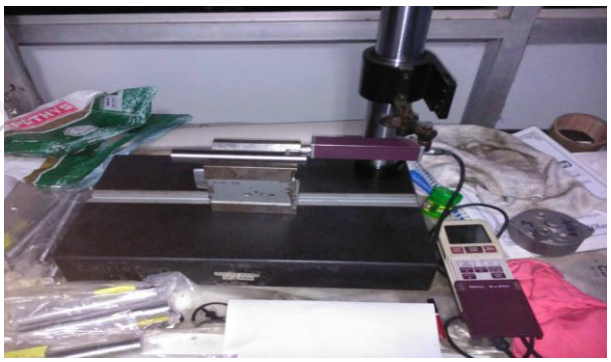


Figure 2: surface roughness measuring machine.

Table 3: Average Ra value.

DOC mm	FEED mm/s	SPEED rpm	FLOW RATE L/s	AVG RA µm
0.02	7.331	80	0.088	0.456
0.02	11.406	160	0.126	0.335
0.02	15.400	320	0.276	0.300
0.05	7.331	160	0.276	0.320
0.05	11.206	320	0.088	0.430
0.05	15.400	80	0.126	0.400
0.1	7.331	320	0.126	0.490
0.1	11.406	80	0.126	0.355
0.1	15.400	160	0.088	0.415

V. RESULTS AND DISCUSSIONS

After obtaining the machined data, it was statistically analyzed in Taguchi method with the help of Minitab Software.

A. Main effects plot for means

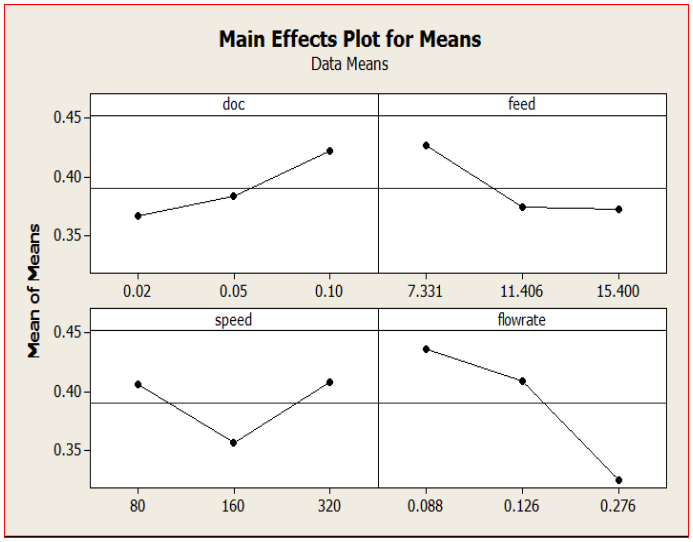


Figure 3: Analysis of means

1. Level 1 of doc i.e. 0.02mm is indicated as the optimum condition in terms of surface roughness.
2. Level 3 of feed i.e. 15.400mm/s is indicated as the optimum condition in terms of surface roughness.
3. Level 2 of speed i.e. 160 rpm is indicated as the optimum condition in terms of surface roughness.
4. Level 3 of flow rate i.e. 0.276L/s is indicated as the optimum condition in terms of surface roughness.

B. Main Effects Plot for S/N ratio

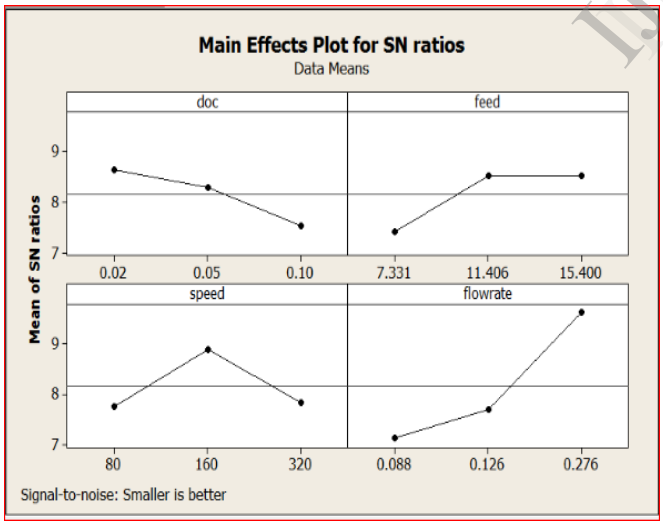
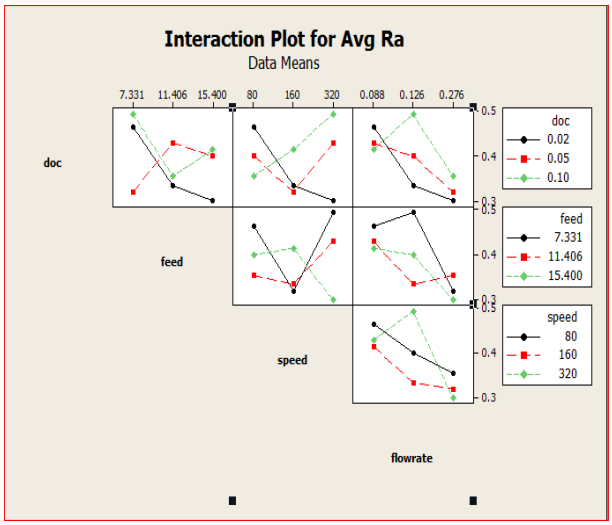


Figure 3: Signal to noise ratio analysis.

1. Level 1 of doc i.e. 0.02mm is indicated as the optimum condition in terms of S/N ratio with S/N ratio=8.651dB.
2. Level 3 of feed i.e. 15.400mm/s is indicated as the optimum condition in terms of S/N ratio with S/N ratio=8.531dB.
3. Level 2 of speed i.e. 160 rpm is indicated as the optimum condition in terms of S/N ratio with S/N ratio =8.880dB.
4. Level 3 of flow rate i.e. 0.276L/s is indicated as the optimum condition in terms of S/N ratio with S/N ratio= 9.626dB.



1.Top Left Plot

It shows interaction of Depth of Cut (DOC) and Feed with Ra at three levels namely Low, Medium and High. When DOC is minimum that is 0.02mm Ra value decreases with increase in Feed indicated by the black line. Similarly red and green lines can be analyzed.

2. Top Second Left Plot

It shows interaction between DOC and Speed with Ra at three levels. Let us take doc as 0.05 medium values shown by red line, it says as the job speed increases from minimum to medium value Ra decreases but increases drastically at high speed.

3. First Plot Second Row

Interaction between Speed and Feed on Ra. It tells us when Feed and Speed are maximum we get the best Ra. But when Speed is maximum and Feed is minimum Ra is high or we get a poor finish. These statements are in very good agreement with practical conditions.

4. Most Bottom Plot

This plot brings out the effect of Coolant Flow Rate along with Speed it says we obtain better surface finishes at higher speed and higher flow rate.

5. Summary

As a whole we can reach a common consensus about the effects of all four parameters, by looking into plots and choosing our interests of interactions.

VI. CONCLUSIONS

The following conclusions are derived during cylindrical grinding of SS 410, during the experiment effects of various machining parameters on Surface Roughness are studied with the help of Taguchi method in Minitab software and optimum conditions for machining were found out. It is observed that level 1 of doc i.e. 0.02mm, feed of level 3 i.e. 15.400mm/s, level 2 of speed i.e. 160rpm, and level 3 of flow rate i.e. 0.276L/s as the optimum conditions to achieve maximum surface finish and value was found to be 0.28µm.

A. Conformation experiment

Table 4: Conformation experiment.

DOC	FEED	SPEED	FLOW RATE	Ra
0.02	15.400	160	0.276	0.28

The table validates the experimental results are in par with the statistically analyzed data. The conformation experiment were done with the optimize condition and the end result gave us the best Ra value.

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