International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4753

Parameters Optimization of CNC Machining using Taguchi Methodology

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Abstract: Metal cutting operations still represent the largest class of manufacturing operations where turning is the most commonly employed material removal process and there are lots of studies to investigate this complex process in both academic and industrial world. Predicting the better cutting condition during turning is of great importance as it helps in getting the Surfaces quality before machining starts. The major indication of surfaces quality on machined parts is surface roughness. Again, optimization of cutting parameters is one of the most important elements in any process planning of metal parts as economy of machining operation plays a key role in gaining competitive advantage. Control parameters being consider in this thesis are spindle speed, feed rate and depth of cut. After experimentally turning sample work pieces using the selected orthogonal array and parameters, this study expected to produce an optimum combination of controlled parameter for the surface roughness. In this work, Taguchi Design is used to identify the optimal combination of turning parameters to minimize the surface roughness. Turning experiments are carried out according to Taguchi orthogonal array L9 for various combinations of three parameters: cutting speed, feed rate, and depth of cut. For each experiment run, the surface roughness Ra and time is measured, recorded and analysed using Taguchi method.
Keywords: CNC Machining, Cutting Speed, Feed, Depth of Cut, Surface roughness, Time, Taguchi Methodology, Minitab.

I. INTRODUCTION

For all machining process nowadays it is important to obtain accurate dimensions along with good surface finish and for achieving high production high material removal rate is important. A machining process involves various parameters which can directly or indirectly affect surface roughness and material removal rate. Feed, speed and depth of cut are very important parameter by varying which surface roughness and MRR can be mostly affected. A good knowledge of optimizing the parameter can help in reducing the machining cost, improve product quality and decrease machining time. Extensive study is done for optimization of parameter so that better product is achieved. Current study is done on Taguchi method applied for most effective process parameters which are speed, Feed and depth of cut while machine mild steel work piece with HSS tool. Three levels of the feed, three levels of speed, three values of the depth of cut, only one type of work material have been used to generate a total 9 readings in a single set. After getting data from the experiment surface roughness of the test sample was taken on profile meter and time is calculated using timer. To analyze the data set, statistical tool Minitab (Software) has been used to reduce the action and help to arrive at proper improvement plan of the Manufacturing process.

Turning involves rotation of the work piece while the cutting tool moves in a linear motion. This results in a cylindrical shape. A lathe is the machine of choice for all turning operations. Like most machining operations, turning is either one manually or automatically. The downside to manual turning is it requires continuous supervision. Automatic turning does not. With Computer Numerical Control, or CNC, you program all the movements, speeds, and tooling changes into a computer. These instructions then get sent to the lathe for completion. CNC allows for consistency and efficiency of high production runs.

II. PROBLEM STATEMENT

A. In traditional machining on laser beam machining the kerf taper is large and surface roughness is not uniform and optimum.
B. due to this the quality of work pieces may get affected
C. To get minimum kerf taper and surface finish, the input parameter of laser beam machine is optimized by using Taguchi method.

III. METHODOLOGY

A. Taguchi Methodology

Taguchi has envisaged a new method of conducting the design of experiments which are based on well defined guidelines. This method uses a special set of arrays called orthogonal arrays. These standard arrays stipulates the way of conducting the minimal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in choosing the level combinations of the input design variables for each experiment The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Genichi Taguchi. He developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varied. Instead of having to test all possible combinations like the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect the product quality with a minimum amount of experimentation, thus saving time and resources. The Taguchi method is best used when there is an intermediate number of Variables (3 to 50), few interactions between variables, and when only a few variables contribute significantly.

1) *Process parameters*

a) Cutting speed (Vc)-It is a travel of a point on the cutting edge relative to the surface of cut in unit time in the process accomplishing the primary cutting motion. It is expressed in mm/min.

b) Feed: Feed is the rate of travel of machine tool is programmed to move the cutting tool through the material. It is expressed in mm/rev

c) Depth of cut: Depth of cut is literally how deep your cutting tool is extending into the work piece. It is expressed in rev/min.

2) *Material selection:* Literature survey reveals that material selection is not mentioned in many papers. Selection of material is a crucial step in optimization procedure. Material should be selected which has wide applications in industry and also not in focus or in less focus, so it has scope for further optimization. M.S.steel is well known and popular material.

Chemical composition Mild Steel

Constituent	C	Si	Mn	P	S
% Composition	0.16-0.18%%	0.25%	0.30%	0.040% Max	0.040% Max

Physical Properties of Mild Steel

Sr. No	Properties	Metric
1	Density	7.85 g/cc
2	Melting Point	2600˚c

Mechanical Properties of Mild Steel

1	Max Stress	400-560 n/mm^2
2	Yield Stress	300-440 n/mm^2 Min 0.2%
3	Proof Stress	280-420 n/mm^2 Min
4	Elongation	10-14% Min

B. Design of Experiment Using Taguchi Method

Classical experimental design methods are too complex and are not easy to use. A large number of experiments have to be carried out when the 86 number of process parameters increase. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments. Three super plastic forming parameters are considered as controlling factors. They are Pressure, Temperature and Time. Each parameter has three levels –

namely low, medium and high, denoted by 1, 2 and 3 respectively. According to the Taguchi method, if three parameters and 3 levels for each parameters L9 orthogonal array should be employed for the experimentation. Orthogonal Arrays (often referred to Taguchi Methods) are often employed in industrial experiments to study the effect of several control factors. Popularized by G. Taguchi. When two-level fractional factorial designs are used, it begins to confound our interactions, and often lose the ability to obtain unconfused estimates of main and interaction effects. It was seen that if the generators are chosen carefully then knowledge of lower order Communications can be obtained under that assumption that higher order interactions are negligible. Orthogonal arrays are highly fractionated factorial designs.

Table: Taguchi L9 runs of experimental design

Run	Speed (mm/min)	Feed (mm/rev)	Depth Of Cut (m/min)
1	500	0.1	0.2
2	500	.02	0.4
3	500	0.3	0.6
4	1000	0.1	0.4
5	1000	0.2	0.6
6	1000	0.3	0.2
7	1500	0.1	0.6
8	1500	0.2	0.2
9	1500	0.3	0.4

C. Methodology for Analysis of changing Parameter

1) *Surface Roughness:* A digital Surface Roughness Tester is used for measuring the roughness of the work pieces after machining.
2) *Surface Roughness (Ra) :* Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if small, the surface is smooth. Surface roughness is denoted by SR in this report.

In this work the surface roughness was measured by Government College of Engineering Karad. The surface tester is a shop–floor type surface-roughness measuring instrument, which traces the surface of various machined parts and calculates the surface roughness based on roughness standards, and displays the results in µm.

IV. EXPERIMENTAL RESULT

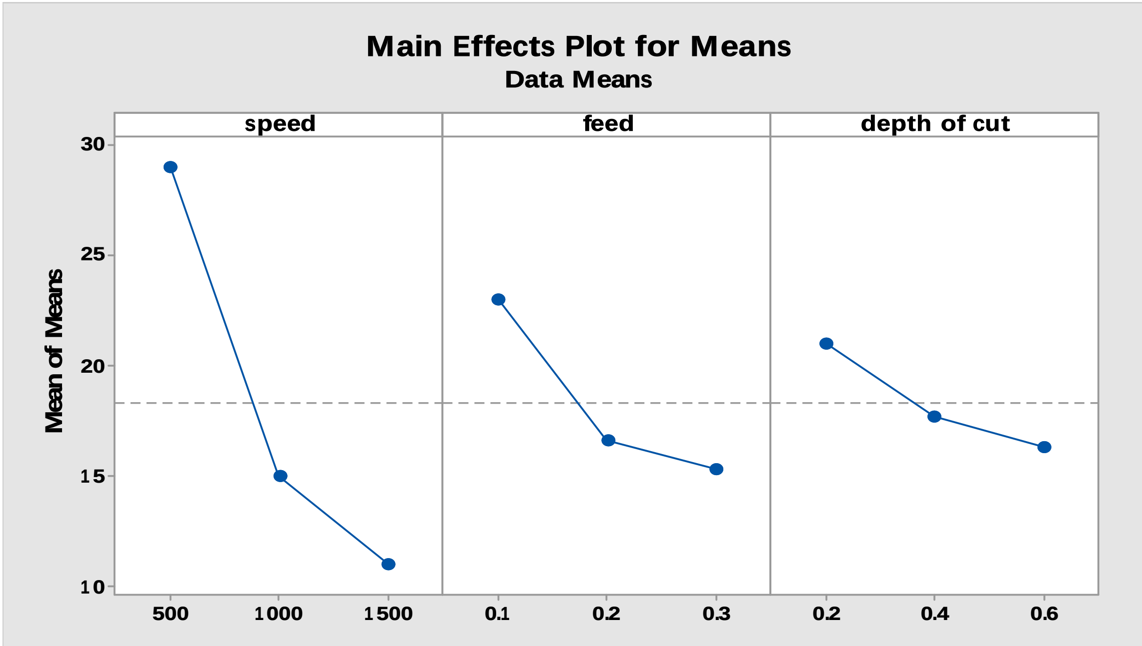
After completion of experimentation, surface roughness of 9 specimens measured. Their results are given in table

Exp. No.	Speed (mm/min)	Feed (mm/rev)	Depth Of Cut (m/min)	Surface roughness (R a)	Time (Seconds)
1	500	0.1	0.2	5.021	39
2	500	0.2	0.4	5.937	25
3	500	0.3	0.6	6.431	23
4	1000	0.1	0.4	5.579	18
5	1000	0.2	0.6	5.675	14
6	1000	0.3	0.2	5.024	13
7	1500	0.1	0.6	5.606	12
8	1500	0.2	0.2	5.41	11
9	1500	0.3	0.4	5.619	10

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

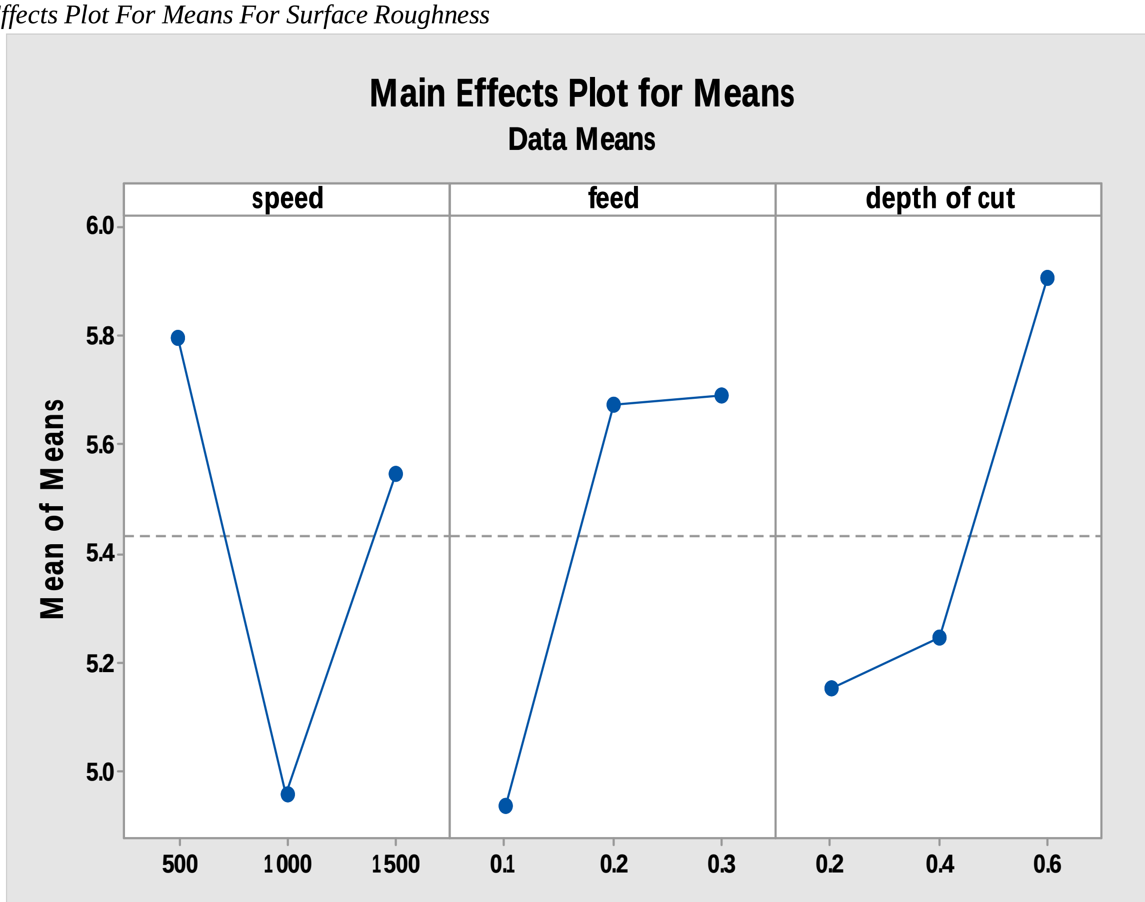
A. Graphs

1) Main Effects Plot for Means for TIME



Main effects plot for means for Time

2) Main Effects Plot For Means For Surface Roughness



Main effects plot for means for Surface Roughness

V. CONCLUSION

A. Conclusion

Is this project, Taguchi Design of Experiments was applied for turning parameters to obtain the optimal surface roughness.

For our project, we have selected four turning parameters for optimization Cutting speed, feed rate, depth of cut. For each parameter, we selected three levels: low, medium and high.

Experiments were conducted using L_9 orthogonal array. For each experiment, surface roughness was measured, recorded and analyzed using Taguchi S/N ratios. These ratios were calculated with consideration of performance characteristic: Lower-the-Better, as surface roughness is requested to be low.

The optimum levels of parameters for minimizing the surface roughness were determined from the response table for Signal-to-Noise ratios. The best combination was obtained with:

1) Cutting speed
2) Feed rate
3) Depth of cut To confirm the effectiveness of our optimization, we followed two ways:
4) Confirmation experiment,
5) Development of regression model with interactions between parameters.

Confirmation experiment revealed that Taguchi design cannot identify effectively the optimal parameters as the optimal turning parameters didn't lead to the minimal surface roughness. This result is due to the L_9 Taguchi orthogonal array, which doesn't include interactions between parameters.

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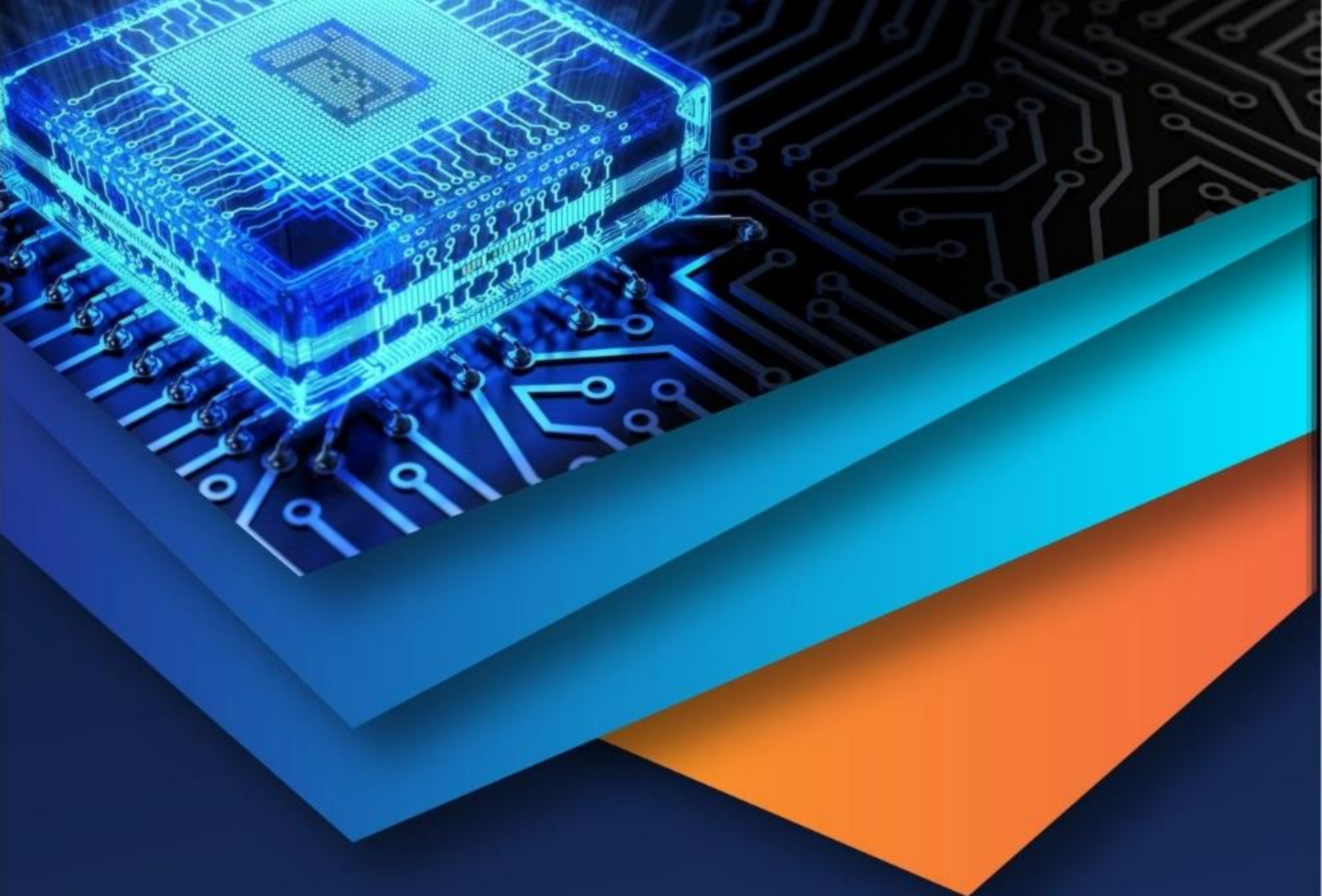

10.22214/IJRASET

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