OVAT Analysis for Surface Finish in CNC Turning

M. S. Harne, Manish M. Dandge

Abstract—Metal cutting is one of the most important and widely used manufacturing processes in engineering industries and in today's manufacturing scenario, optimization of metal cutting process is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality which has to be achieved at minimal cost. Surface finish is one of the prime requirements of customers for machined parts. The purpose of this research paper is focused on the analysis of optimum cutting conditions to get lowest surface finish in facing by regression analysis. This paper presents an experimental study to investigate the effects of cutting parameters like Cutting speed, feed and depth of cut on surface finish on 16MnCr5H Steel

Keywords-CNC Turning, Surface Finish, One Variable at a Time Analysis.

I. INTRODUCTION

Surface finish is one of the most important requirements in machining process, as it is considered an index of product quality. It measures the finer irregularities of the surface texture. Achieving the desired surface quality is critical for the functional behavior of a part. Surface finish influences the performance of mechanical parts and their production costs because it affects factors, such as friction, ease of holding lubricant, electrical and thermal conductivity, geometric tolerances and more. The ability of a manufacturing operation to produce a desired surface finish depends on various parameters. The factors that influence surface finish are machining parameters, tool and work piece material properties and cutting conditions. For example, in turning operation the surface finish depends on cutting speed, feed rate, depth of cut, tool nose radius, lubrication of the cutting tool, machine vibrations, tool wear and on the mechanical and other properties of the material being machined. Even small changes in any of the mentioned factors may have a significant effect on the produced surface. [1]. Therefore, it is important for the researchers to model and quantify the relationship between finish and the parameters affecting its value. The determination of this relationship remains an open field of research, mainly because of the advances in machining and materials technology and the available modeling techniques. In machinability studies investigations, statistical design of experiments is used quite extensively.

Statistical design of experiments refers to the process of planning the experiments so that the appropriate data can be analyzed by statistical methods, resulting in valid and objective conclusions [1].

II. EXPERIMENTAL WORK

CNC turning process parameters are classified according to Tool, Machining parameters, Work piece, machine tool and cutting process parameters as shown in below Figure. Machining parameters are feed, cutting speed, depth of cut, cutting fluid and kinematics.CNC turning parameters related to work piece are hardness, structure, heat treatment and chemical composition. From the discussion with company peoples and on the basis of some research paper it felt that that a selected four process parameters like cutting speed, feed rate, and depth of cut having certain effect on surface finish.

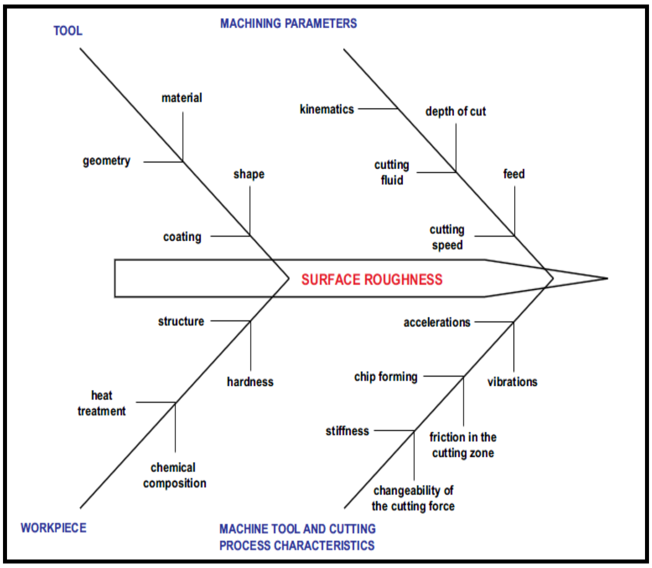

Chart 2.1 Influential Parameters on the Surface Finish

A Series of experiments was conducted to evaluate the influence of CNC Turning process parameters on surface finish. The tests was carried out on ACE CUB LM CNC Machine (Micromatic Group.). The specification and description of ACE CUB LM CNC Machine as follows.

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Specification	Description
Control System	Fanuc 0i-Mate-TD
Swing Over Bed	450 mm
Distance Between Centers	280 mm
Maximum Turning Dia	140 mm
Between Centre Turning Dia	125 mm
Maximum Turning Length	200 mm
Spindle Motor Power	3.7 KW
Spindle Motor Power	1000-3000 RPM
Standard Chuck Size	135 mm
COOLANT TANK CAPACITY	110 Litre
Hydraulic Pump Capacity	12 lpm
Hydraulic Power Pack Tank Capacity	20 litre
System Pressure	30 Kg/cm²

With the help of standard test specification manuals, discussion with concerned engineers and also with the help of research paper it strongly felt that surface finish has direct relationship with input parameters such as cutting speed,feed rate, depth of cut, tool radius and cutting oil. The purpose of this OVAT analysis is to select control factors and there levels for experimentation. Levels of input parameters are selected on basis of following analysis. Experiments are carried out by taking the set of respective values. The surface finish is measured in µm. SR is measured using surface texture measuring instrument having following specification.
Description: Surface measuring machine
Type: MarSurf GD 120
Manufacturer: Mahr Metrology India Pvt. Ltd.

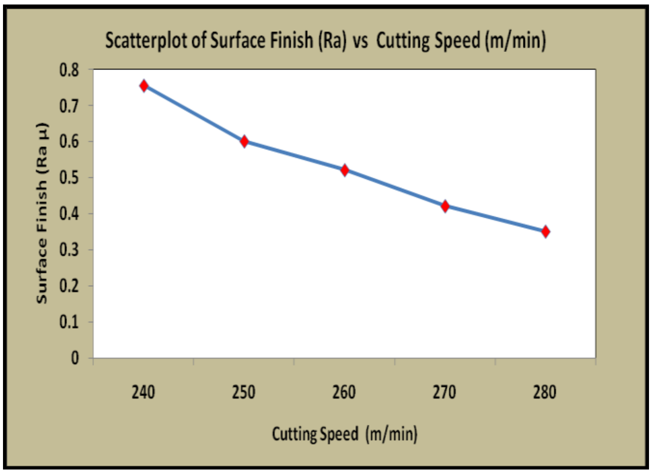
III. EXPERIMENTAL RESULTS AND ANALYSIS

A. Effect of Cutting Speed

The experiment is conducted by varying cutting speed, keeping all other parameters constant. From Table 1, it is clear that with increase in cutting speed and by keeping other parameters like feed rate, depth of cut, tool radius and cutting oil are constant at mean level the surface finish is continuously reducing. Hence cutting speed is influencing factor on surface finish. The levels of wheel speed are selected on the basis of avg. surface finish. Required surface finish is 0.6 Ra µ maximum. At 240 m/min and 250 m/min surface finish value is more than 0.6 Ra µ so the optimum operating range selected for investigation is 260-280 m/min.

Job No	Cutting Speed (m/min)	Surface Finish (Ra µ)			Average Surface Finish Ra µ
		1	2	3	
1	240	0.7562	0.7566	0.7559	0.7562
2	250	0.6006	0.602	0.6018	0.6015
3	260	0.5203	0.5216	0.5219	0.5213
4	270	0.4215	0.4198	0.4216	0.421
5	280	0.3489	0.3521	0.3508	0.3506

Table 1 OVAT Analysis of Cutting Speed



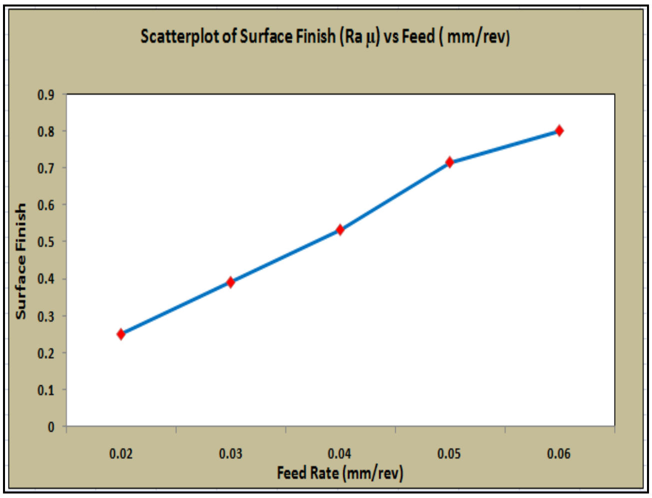
Graph 1 Scatter Plot of Surface Finish vs Cutting Speed

B. Effect of Feed Rate

The experiment is conducted by varying feed rate, keeping all other parameters constant. From Table 2 it is clear that as the feed rate increase from 0.02 – 0.05 mm/rev by keeping other parameters like cutting speed, Depth of Cut, Surface Finish is continuously increasing. At feed rate 0.05 mm/rev and 0.06 mm/rev Surface finish is higher against required 0.6 Ra µ so these levels are not selected during study.

Job No	Feed Rate (mm/rev)	Surface Finish (Ra µ)			Average Surface Finish Ra µ
		1	2	3	
1	0.02	0.2518	0.2516	0.2502	0.2512
2	0.03	0.392	0.3914	0.3911	0.3915
3	0.04	0.5331	0.5333	0.5338	0.5334
4	0.05	0.7156	0.7158	0.7162	0.7159
5	0.06	0.7998	0.8016	0.8021	0.8012

Table 2 OVAT Analysis of Feed Rate



Graph 2 Scatter plot of Surface Finish vs Feed Rate

C. Effect of Depth of Cut

The experiment is conducted by varying depth of cut, keeping all other parameters constant. From Table 3 it is clear that as the depth of cut increase from 0.06-0.1 sec by keeping other

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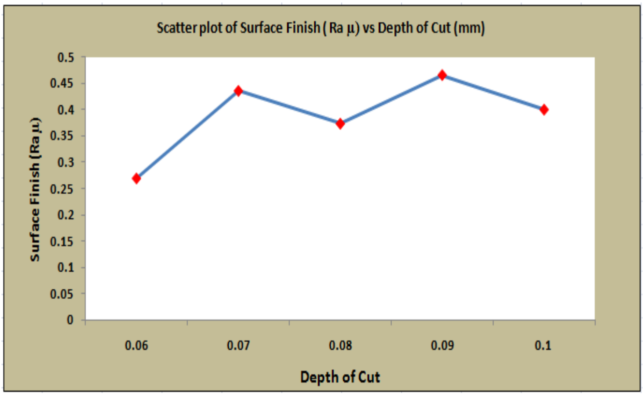
parameters like cutting speed, feed rate, tool radius and cutting oil, surface finish value is slightly increasing. Depth of cut 0.7, 0.8 and 0.09 are selected for study.

Job No	Feed Rate (mm/rev)	Surface Finish (Ra µ)			Avg Surface Finish Ra µ
		1	2	3	
1	0.02	0.2518	0.2516	0.2502	0.2512
2	0.03	0.392	0.3914	0.3911	0.3915
3	0.04	0.5331	0.5333	0.5338	0.5334
4	0.05	0.7156	0.7158	0.7162	0.7159
5	0.06	0.7998	0.8016	0.8021	0.8012

Table 3 OVAT Analysis of Depth of Cut



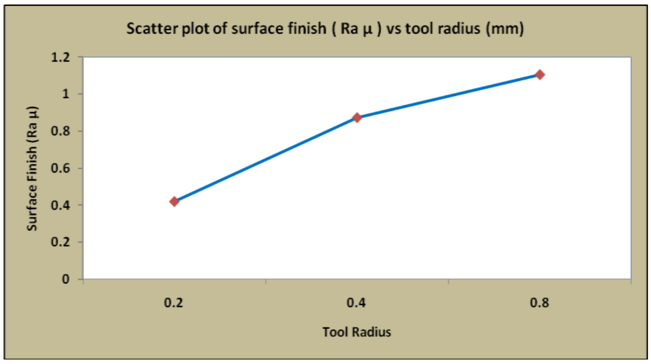
Graph 3 Scatter Plot of Surface Finish vs Depth of Cut

D. Effect of Tool Radius

The experiment is conducted by varying depth of cut, keeping all other parameters constant. From Table 3.10 it is clear that as the tool radius increases from 0.2 to 0.8 mm by keeping other parameters like cutting speed, feed rate, depth of cut and cutting oil constant surface finish value is increasing. Since surface finish values are higher than required values (0.6 Ra µ), 0.2 mm tool radius is selected for study.

Job No	Tool Radius (mm)	Surface Finish (Ra µ)			Average Surface Finish Ra µ
		1	2	3	
1	0.2	0.4211	0.4232	0.4187	0.421
2	0.4	0.8756	0.8714	0.8711	0.8727
3	0.8	1.11	1.102	1.1012	1.1044

Table 4 OVAT Analysis of Tool Radius



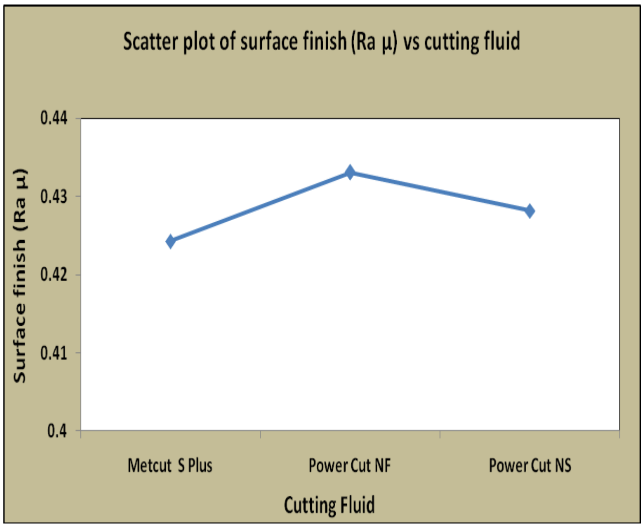
Graph 4 Scatter Plot of Surface Finish vs Tool Radius

E. Effect of Cutting Oil

The experiment is conducted by varying cutting oil , keeping all other parameters constant. From Table 3.11 it is clear that cutting oil is less influencing parameter on surface finish. Hence this parameter is not considered during final experimentation.

Job No	Cutting Oil	Surface Finish (Ra µ)			Average Surface Finish Ra µ
		1	2	3	
1	Metcut S Plus	0.4211	0.4232	0.4287	0.4243
2	Power Cut NF	0.4362	0.4318	0.4326	0.4331
3	Power Cut NS	0.429	0.4286	0.4271	0.4282

Table 5 OVAT Analysis of Cutting Oil



Graph 5 Scatter Plot of Surface Finish vs Cutting Fluid

IV. SELECTED PARAMETERS AND THEIR LEVELS

By performing OVAT analysis and from graph it is found that cutting speed, feed rate, depth of cut, tool radius are influencing parameters on Surface Finish. According to OVAT analysis following input parameters namely cutting speed, feed rate and depth of cut are selected by keeping other process parameters constant which are less influencing on surface finish. So on the basis

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of surface finish selected the levels of input parameters which are as follows, units in parentheses.

NOTATION	PROCESS PARAMETER	LEVEL 1	LEVEL 2	LEVEL 3
A	Cutting Speed (m/min)	260	270	280
B	Feed Rate (mm/rev)	0.02	0.03	0.04
C	Depth of Cut (mm)	0.07	0.08	0.09

V.CONCLUSIONS

OVAT analysis is very much important tool utilized widely in engineering analysis. This work is a part of ongoing research project and the preliminary results are presented in this article. Based on the results of the work, following conclusions could be made: It is found that an increase of cutting speed generally improves surface quality. Experiments show that as feed rate increases surface roughness also increases due to the increase in cutting force and vibration. Increasing the depth of cut increases the cutting resistance and the amplitude of vibrations. As a result, cutting temperature also rises. Therefore, it is expected that surface quality will slightly deteriorate.

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