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Experimental Investigation of the Surface Roughness through Optimization in Turning Operation of 16MnCr5

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ABSTRACT

Machining operations are involved now a day in all manufacturing industries. Surface finish and dimensional tolerances are used to determine quality of product and are the important quality attributes of turned product. In the present paper of investigation the experimental work was carried out to find out the optimal solution of input parameters for the enhancement of quality of the product in turning process on CNC lathe. The input process parameters taken are feed rate, depth of cut and spindle speed. The surface roughness is taken as the output response parameters in the present investigation. Taguchi's L_9 method is utilized in the design of experiment (DOE) for optimization of input parameters in machining operation. Present paper verifies that Taguchi' parameters design could be used to identify the valuable processes parameters and optimize the surface roughness in turning operation.

Keywords: Turning operation, Taguchi methods, OA L_9, CNC lathe and surface roughness.

1. INTRODUCTION

The study of metal cutting is very important and its basic knowledge of the machining of work piece material will develop a scientific approach in problems encountered in machining processes. Even though the machine tool industries in our country have attained a degree of excellence of progress, the metal cutting industries using various machine tools still suffer a lot of drawback of not utilizing the machine tools at their full efficiency. Optimum parameters which give minimum surface roughness are to be achieved [1]. A major cause leading this problem is to be failure to run cutting tools at optimum operating conditions. The influence of parameters is evaluated using signal to noise ration analysis. In modern era one of the trends is to manufacture low cost, high quality products in minimum time [2]. The problem of achieving the optimum levels of the operating parameters has attracted the attention of the research scholars and practitioners in engineering for a long tenure.

Surface roughness, power consumption, material removal rate and cutting time are some important parameters to decide the capability and suitability of high speed turning [3]. Therefore in today's rapidly changing scenario of manufacturing industries, use of optimization tool techniques in metal cutting and manufacturing process is essential to compete and leading to demand of well machined products of good quality in the market. The temperature that develops in the turning process has a significant effect on the performance of a cutting tool and the quality of the machined component [4]. For the evaluation of machining accuracy surface roughness is an important control factor. For optimization purposes, each output variable associated with the turning process such as production cost, production time, tool life etc. are taken as a function of a set of input variables [5]. As it plays a vital role in many applications such as precision fits, fastener holes, aesthetic requirements and parts subject to fatigue loads.

It can be observed that cutting speed (v) has a negative influence, while feed rate (f) and depth of cut (d) have a positive influence on the surface roughness (R_a) [6]. The machining process to produce parts in cylindrical shape by a single point cutting tool on lathes is known as turning. For complex rotational shape the cutting tool is put in the direction parallel or perpendicular to the axis of rotation of work piece or along a specific path. The measurement of the work pieces in no. of runs during testing led to the conclusion that the selected parameter values from this process produced a surface roughness

that was much lower than the other combinations tested in this study [7]. There are two types of motion namely- primary motion (rotation of work piece) and secondary motion (feed motion). Decrease in feed rate lead to better surface roughness and increase in cutting speed significantly increase tool wear but resulted in better surface roughness[8]. Many functions like excellence tolerance, load bearing capacity, less tool wear, tools contact friction etc. can be improved by efficient turned components. The main advantage of proposed methodology is the minimum machining time while considering technological and material constrains [9]. To obtain the mentioned aspects, opting for CNC machine tool is the best alternate for augmented productivity in terms of increased profit and reduced machining time. To obtain minimum surface roughness, optimum selection of turning process parameter is the most important factor. It is impossible to find all the variables that impact surface roughness in turning operations. In order to simplify the problem, one needs to eliminate or select specific variables that correspond to practical applications [10]. Hence for the selection of optimum set of turning process parameters Taguchi method is used. Optimization of the CNC process parameters in the turning of work piece material 16MnCr5 is the aim of this present research thesis work.

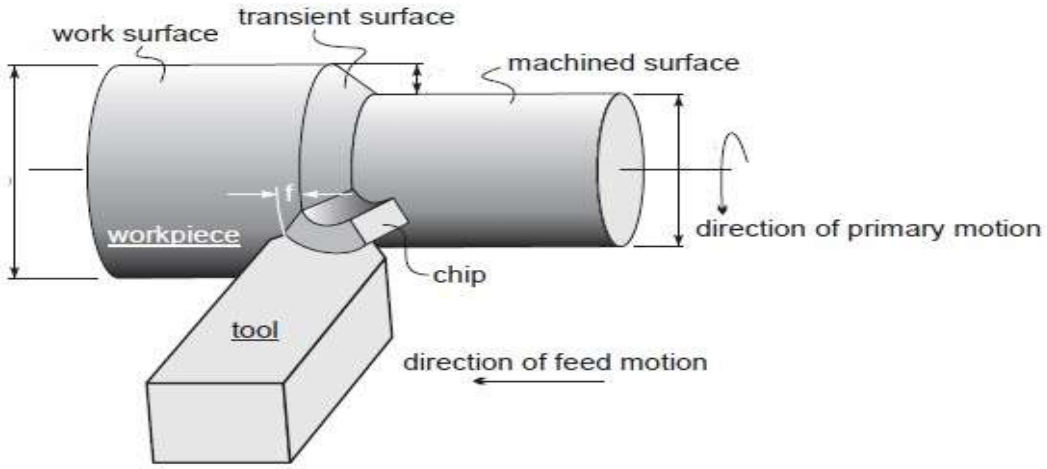

Fig.1- Symmetric view of basic turning operation [IITB]

2. MATERIALS AND METHOD

2.1 WORK PIECE MATERIAL

16MnCr5 is type of case hardened steel.16MnCr5 Case hardening steel's applications fields are alloyed case hardened steel with required tensile strength of 800-1100 N/mm^2 and wearing resistance.

2.2 TYPICAL APPLICATION

Camshafts, piston bolts, levers and other mechanical engineering components. High stressed automobile parts gears, connecting rods, shafts, crank shafts, knuckle joints and other components as used in coupling etc.

Fig.2-Work-piece specimen material case hardening steel 16MnCr5

Table1: Work-piece Material Composition

Element	C%	Si%	Mn%	P%	S%	Cr%
Min.	0.14	-	1.00	-	0.020	0.80
Max.	0.19	0.40	1.30	0.025	0.035	1.10

2.3 CUTTING INSERTS AND CUTTING CONDITION

The Process parameters and levels used in the experiment, experimental set up and conditions are given in the Tables 2.

Experimental setup

Machine tool : Jobber Junior S designer CNC Turning centre
Tool Material : Carbide
Work specimen Material : 16MnCr5 case hardened steel
Size of work piece : ϕ46 mm.
Environment : Dry machining

Table2: Process parameters and levels used in the experiment

Code	Process parameters	Levels		
		I	II	III
A	Cutting Speed (rpm)	3000	3400	3800
B	Feed (mm/rev)	0.24	0.26	0.28
C	Depth Of Cut (mm)	0.5	0.7	0.9

2.4 EXPERIMENTAL PROCEDURE SET UP

In the present investigation, the machining process was studied under DOE with Taguchi's L9 orthogonal array with three factors and three levels. The machining process on CNC lathe is programmed by speed, feed, and depth of cut. In total 9 work pieces (Φ46) are prepared.

Fig.3- Jobber Junior S designer CNC Turning Centre Machine set up

The experiments are done on the 9 work pieces according to L9 orthogonal array table as given below.

Table3: Experimental Layout Using L-9 Orthogonal Array

Experimental run	Speed (rpm)	Feed (mm/min)	Depth of cut (mm)
1	3000	0.24	0.5
2	3000	0.26	0.7
3	3000	0.28	0.9
4	3400	0.24	0.7
5	3400	0.26	0.9
6	3400	0.28	0.5
7	3800	0.24	0.9
8	3800	0.26	0.5
9	3800	0.28	0.7

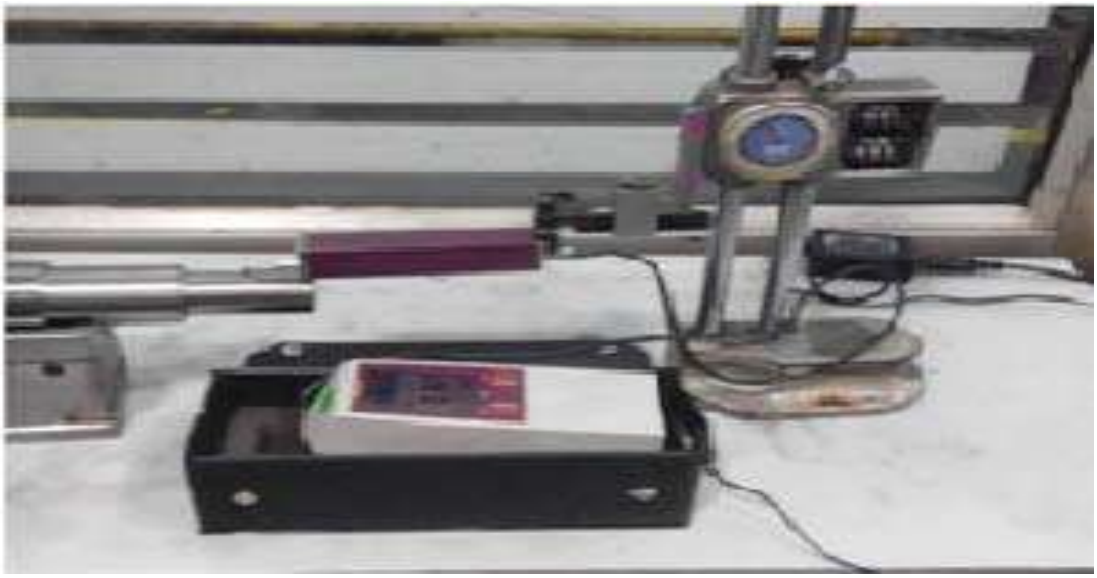

Fig.4-Surface roughness measurement device Mitoyoyo Surf test SJ-201

3. RESULTS AND DISCUSSION

The test data is given in Tables and plots are developed with the help of a software package MINITAB 16. These results are analyzed using DOE Taguchi for the purpose of identifying the significant factors, which affects the surface roughness**.**

Table4: Taguchi's L9 array experimental layout with output results

Experimental run	Speed (rpm)	Feed (mm/min)	Depth of Cut (mm)	Surface Roughness (R_a)
1	3000	0.24	0.5	0.48
2	3000	0.26	0.7	2.83
3	3000	0.28	0.9	3.26
4	3400	0.24	0.7	2.56
5	3400	0.26	0.9	2.85
6	3400	0.28	0.5	3.19
7	3800	0.24	0.9	2.55
8	3800	0.26	0.5	3.28
9	3800	0.28	0.7	3.32

3.1 INTERPRETATION OF PLOTS

To find out the optimum set of conditions, the individual level averages of S/N ratios are calculated. The objective needs to maximize the S/N ratio (LB) values. Hence optimized conditions taken are A1-B1-C1 and their corresponding levels are shown in table 6.

Table-5.Optimal set of control factors for minimum Surface Roughness

Control Factors	Speed (rpm)	Feed (mm/min)	Depth of cut (mm)
Optimum value	3000	0.24	0.5

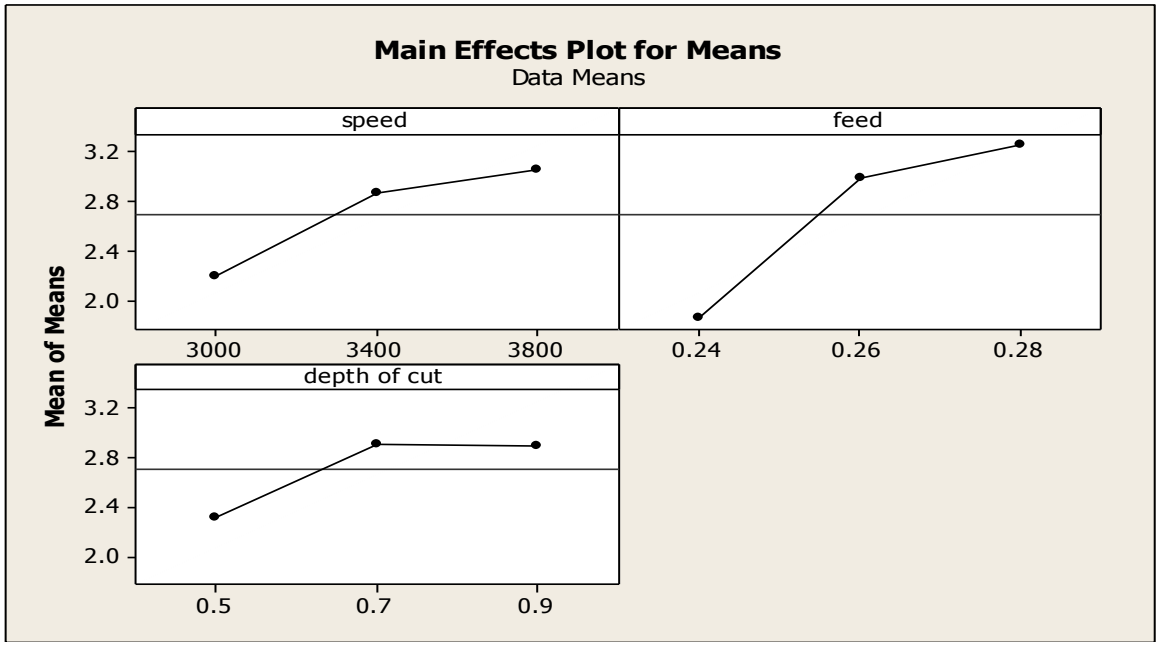

Fig.5- Main effects Plots for Means of Ra

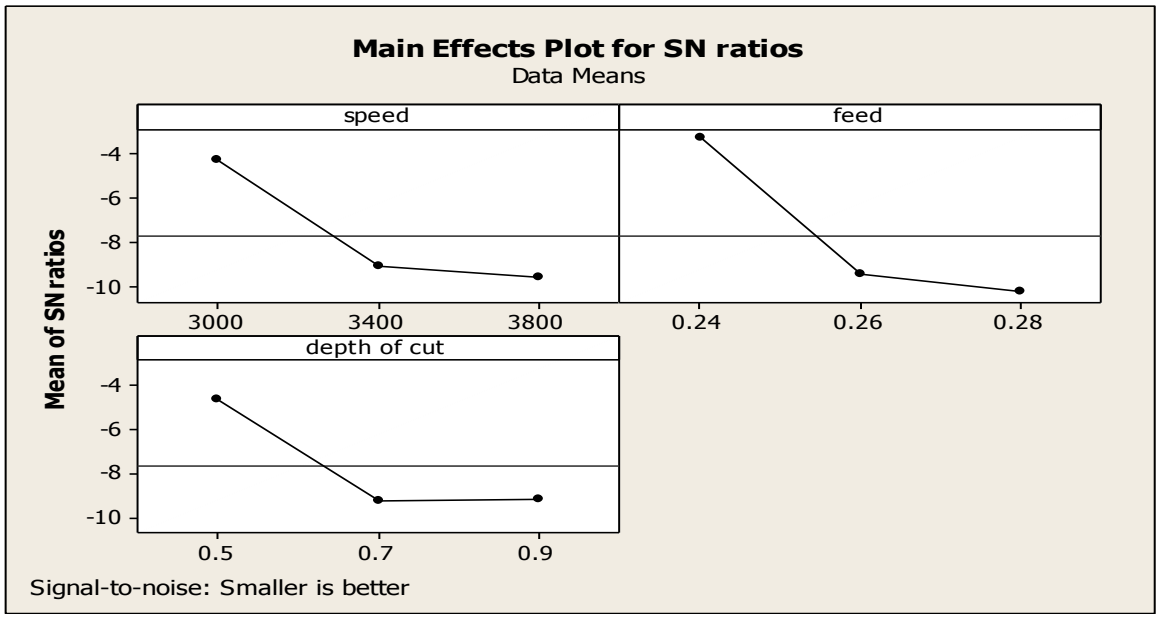

Fig.6- Main effects Plots for S/N ratio of Ra

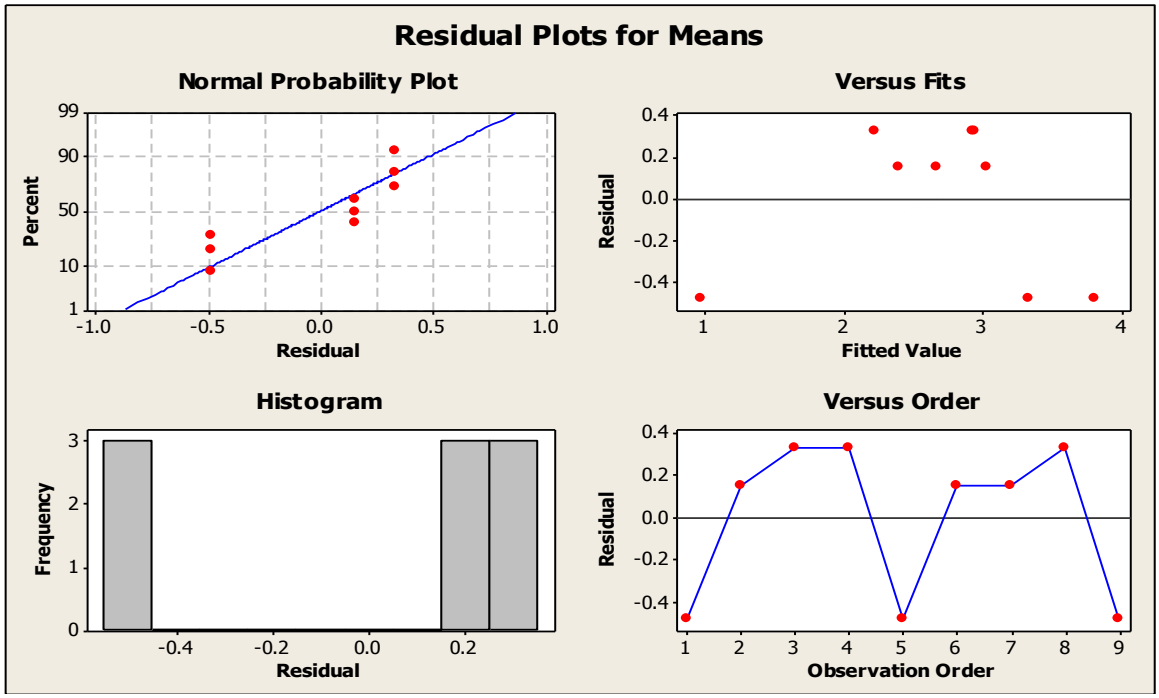

Fig.7- Residual Plots for Means of Ra

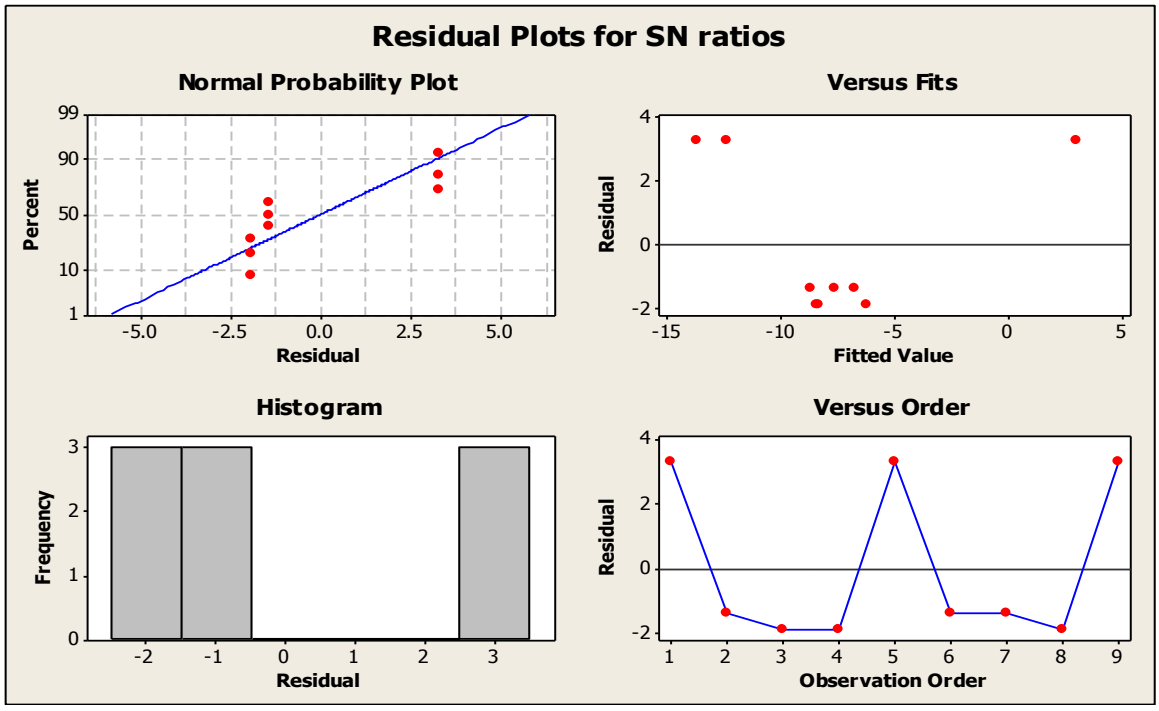

Fig. 8- Residual Plots for S/N ratio of Ra

CONCLUSIONS

The experimental investigation and optimization of CNC turning with the objective function as quality improvement, is presented in this paper. Surface roughness (Ra) was chosen as the response variable. The following conclusions can be drawn from this study:

- The lowest surface roughness (Ra) of 0.33 μm was achieved corresponding to: Speed (3000 rpm), Feed rate (0.24mm/min) and Depth of cut (0.5 mm).
- Feed rate is the most significant parameter in influencing the quality of machined surfaces in turning operation.
- The relative significance of parameters influencing surface quality in CNC turning is evaluated based on their 'F' values as: feed (1.04), speed (1.76) and depth of cut (1.83).
- Feed rate is the significant factor which influences most effect than speed and depth of cut.
- The quality of machined surface decreases with increase in feed rate.

FUTURE SCOPE

- The work can be done on the different material of the work piece other than 16MnCr5.
- The investigation also can be performed by changing the control factors of turning process.
- The experiment can be done with other techniques like ANN, RSM & fizzy method etc.

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