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Experimental Investigation of Surface Roughness in Turning Operation of 16MNCR5

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Abstract: Machining operations are involv3ed in many manufacturing industries. Turning process is one of the most fundamental cutting processes. Cutting used in metal cutting. 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 has been employed for the optimization of input parameters for the improvement of quality of the product of the turning operation on CNC lathe. The input process parameters taken are feed rate, depth of cut and spindle speed and the surface roughness is taken as the output response parameters in the present investigation Taguchi's L_9 has been used in design of experiment for optimization of input parameters in present investigation. This paper accessed to introduce and thus verifies experimentally to introduce and thus verifies experimentally to has now the Taguchi' parameters design could be used to identify the valuable processes parameters and optimize the surface roughness. In turning operation. The present work shows that spindle speed is the main factor for minimizing the surface roughness factor for minimizing the surface roughness.

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

1. Introduction

The mechanical manufacturing industries are regularly challenged for achieving higher productivity and high quality products in order to remain competitive. The desired shape, size and finished ferrous and non ferrous materials are conventionally produced through turning the preformed blanks with the help of cutting tools that moved past the work piece in a machine tool. Turning is an important and widely used machining processes in engineering industries. Surface quality is an important performance characteristic to evaluate the productivity of machine tools as well as machined components. Among various cutting processes, turning process is one of the most fundamental and most applied metal removal operations in a real manufacturing environment. The surface roughness of the machined parts is one of the most significant product quality characteristic which refers to the deviation from the nominal surface. Surface roughness plays a vital role in many applications such as precision fits, fastener holes, aesthetic requirements and parts subject to fatigue loads. Surface roughness imposes one of the most significant constraints for the selection of cutting parameters and machine tools in development of a process . Turning is the primary process in most of the production activities in the industry and surface finish of turned components has greater influence on the quality of the product. Surface finish in turning has been found to be influenced in varying amounts by a number of factors such as feed rate, work material characteristics, work hardness, unstable built-up edge, cutting speed, depth of cut, cutting time, tool nose radius and tool cutting edge angles, stability of machine tool and work piece setup, chatter, and use of cutting fluids.

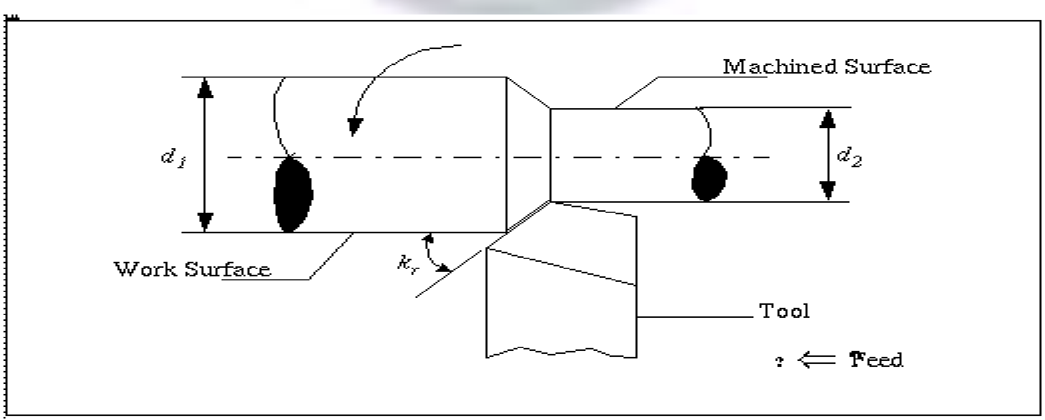

Figure 1: Basic turning operation

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

- With the work piece rotating.
- With a single-point cutting tool, and
- With the cutting tool feeding parallel to the axis

To cop up with global manufacturing industries, high functional work pieces are required. In view of this machining operation is considered as important manufacturing process that contributes in economic and best quality manufacturing. Surface roughness and material removal rate plays a vital role in deciding about the productivity in global manufacturing. Surface roughness is one of the important quality control parameter for evaluating of production process. Efficient turned component improves many functional attribute like excellent tolerance, less tool wear, fatigue strength, load bearing capacity, corrosion strength and contact friction etc. To achieve mentioned attributes, opting for CNC machine tool is the best choice for increase the productivity in terms of reduced machining time and increased profit. But to obtain minimum surface roughness, optimum selection of turning process parameter is very important factor. Therefore taguchi is used for finding out the optimum set of turning process parameters. Optimization of the CNC process parameter in the turning of 16MnCr5 for multiple performance response is the aim of this research work.

2. Literature Review

The most willingly controlled factors in a turning operation are feed rate, cutting speed, and depth of cut; each of which may have an effect on surface finish. Spindle speed and depth of cut were found to have differing levels of effect in each study, often playing a stronger role as part of an interaction. The controlled parameters in a turning operation that under normal conditions affect surface finish most profoundly are feed rate and cutting speed [1]. Recent studies that explore the effect of setup and input parameters on surface finish all find that there is a direct effect of feed rate and spindle speed's effect is generally nonlinear and often interactive with other parameters, and that depth of cut can have some effect due to heat generation or chatter [2, 3, 4, and 5]. Several studies exist which explore the effect of feed rate, spindle speed, and depth of cut on surface finish [6, 7, 5, 8]. These studies all supported the idea that feed rate has a strong influence on surface finish. Feng and Wang (2002) [9] investigated for the prediction of surface roughness in finish turning operation by developing an empirical model through considering working parameters. Kirby et al. (2004)[1].

Several experimental investigations have been carried out over the years in order to study the effect of cutting parameters, tool geometries on the work pieces surface integrity using several work pieces. Tool geometry plays an important role in machining. It is mentioned that the nose radius will affect the performance of the machining process [21]. Nose radius is a major factor that affects the surface finish of work piece. It is proved that high values of nose radius causes rough surface with high value of run out [20]. But very few researchers have studied the interaction effect of nose radius [19]. The effect of nose radius on the surface roughness was investigated by Ravindra [19], A. Saad kariem [20], Kishawy [12], Chou [8], Sundaram [21], Lambert [14] and B. hattacharya et al. [6]. Machining of austenitic stainless steels result Poor surface finish and high tool wear [1]. Vishal Parashar et al., [23] conducted investigation to machine Wire Cut Electro Discharge Machining of 304L stainless steels to optimize surface roughness using Taguchi Dynamic Experiments concept. Lanjewar et al., [15] conducted experiments to evaluate the performance of AISI304 steel on auto sharpening machine by using Taguchi method. Results revealed that tools shape and feed are significant factors. Empirical models for tool life, surface roughness and cutting force are developed for turning of AISI302 developed by Al-Ahmari [2].

3. Materials and Method

3.1 Work piece Material

16MnCr5 is type of case hardened steel.16MnCr5 Case hardening steel's applications fields are Alloyed case hardening steel for parts with a required core tensile strength and good wearing resistance: piston, bolts, camshafts, levers, mechanical engineering components, small cog wheels, shaft, cardan joints, parts of control. High Strength Alloy Steel for parts with a required core tensile strength of 800 – 1100 N/mm² and good wearing resistance as piston bolts, camshafts, levers and other vehicle and mechanical engineering components. Higher stressed components – gears, shafts, crankshafts, connecting rods, cam shafts, etc.

Table 1: chemical composition of work piece material

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

3.2 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 workpiece : ϕ46 mm.
Environment : Dry machining

Table-2: Process parameters and levels used in the experiment

Code	Process parameters	Levels		
		I	II	III
A	CUTTING SPEED	3000	3400	3800
B	FEED	0.24	0.26	0.28
C	DEPTH OF CUT	0.5	0.7	0.9

Figure 2- CNC Lathe Machine set up

3.3 Experimental Procedure

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

Table-3: Experimental Layout Using an L-9 Orthogonal Array

Experimental run	Speed	Feed	Depth of cut
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

4. Results and discussion

The test data is given in Tables and plots are developed with the help of a software package MINITAB 14. These results are analyzed using DOE Taguchi for the purpose of identifying the significant factors, which affects the surface roughness.

Table-4: Taguchi's L9 array experimental layout with output results

Experimental run	Speed	Feed	Depth of cut	Surface roughness
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

4.1 Interpretation of plots

In order to find the optimum set of conditions, the individual level averages of S/N ratios are calculated. The objective is to maximize the S/N ratio (LB) values. Thus, the optimized conditions chosen are A1-B1-C1 and their levels are shown in table 6.

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

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

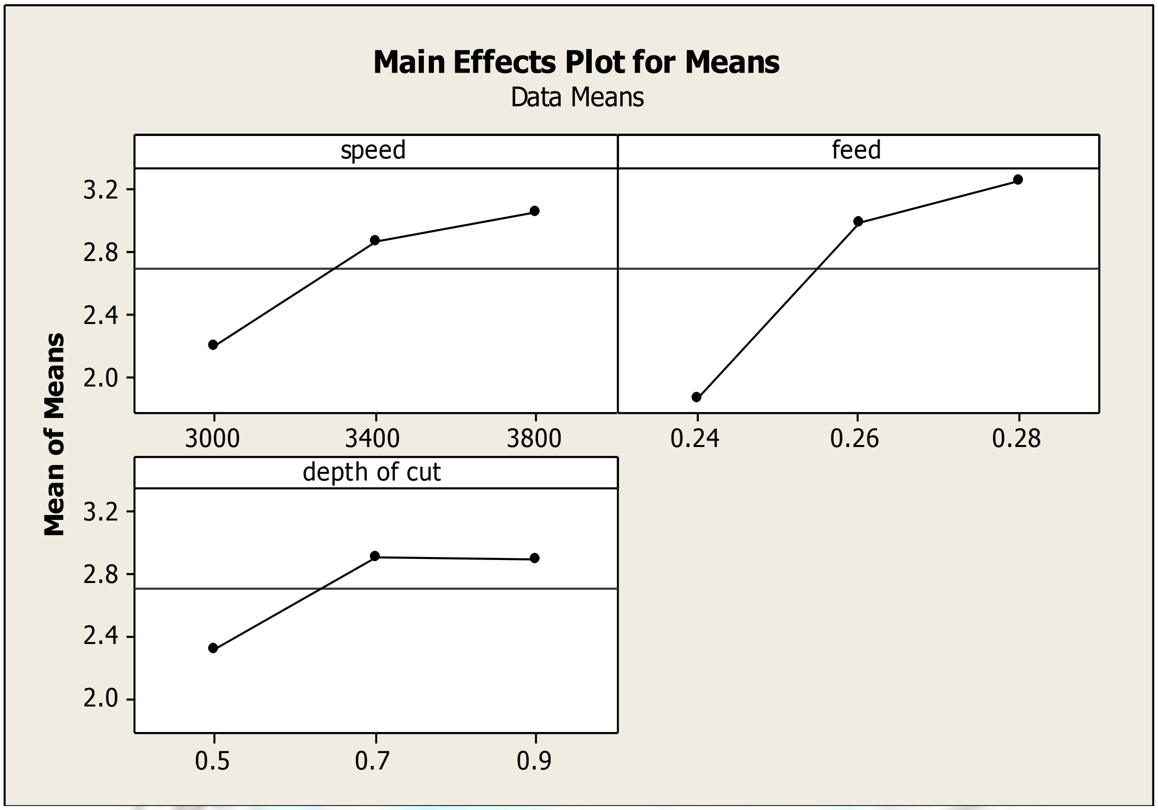

Figure-3: Main effects Plots for Means of Ra

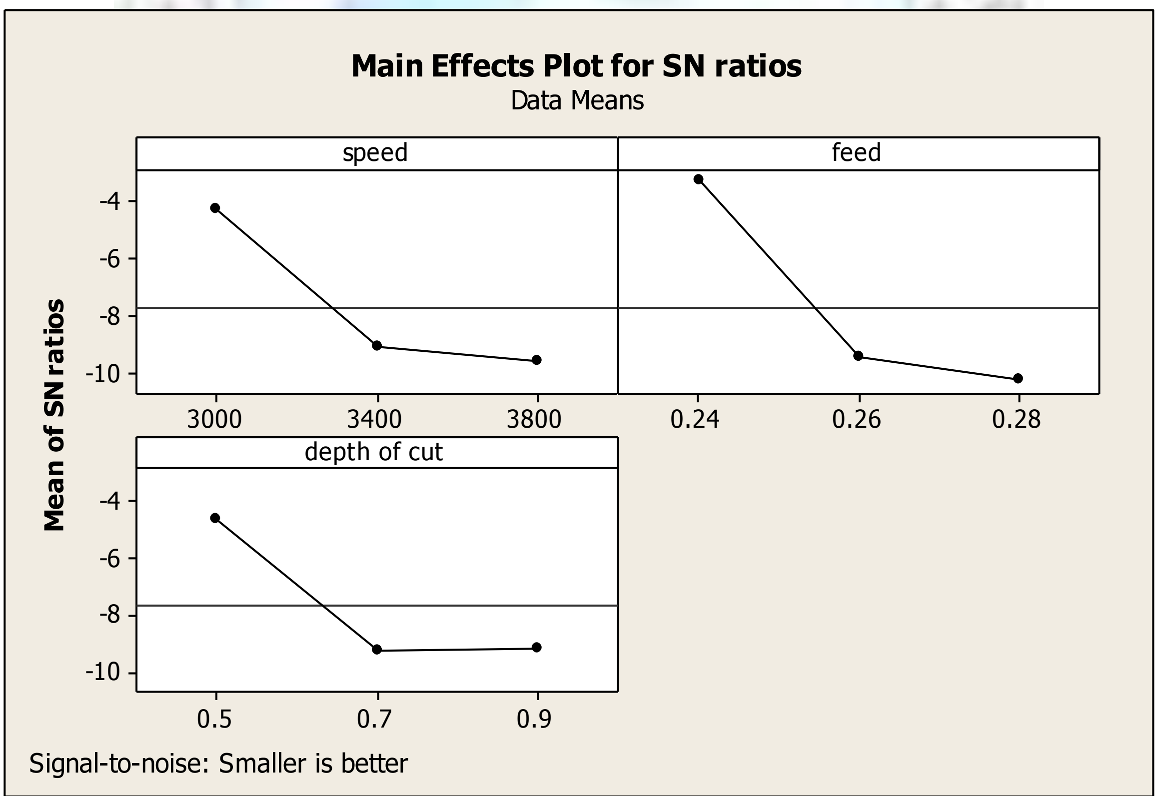

Figure-4: Main effects Plots for S/N ratio of Ra

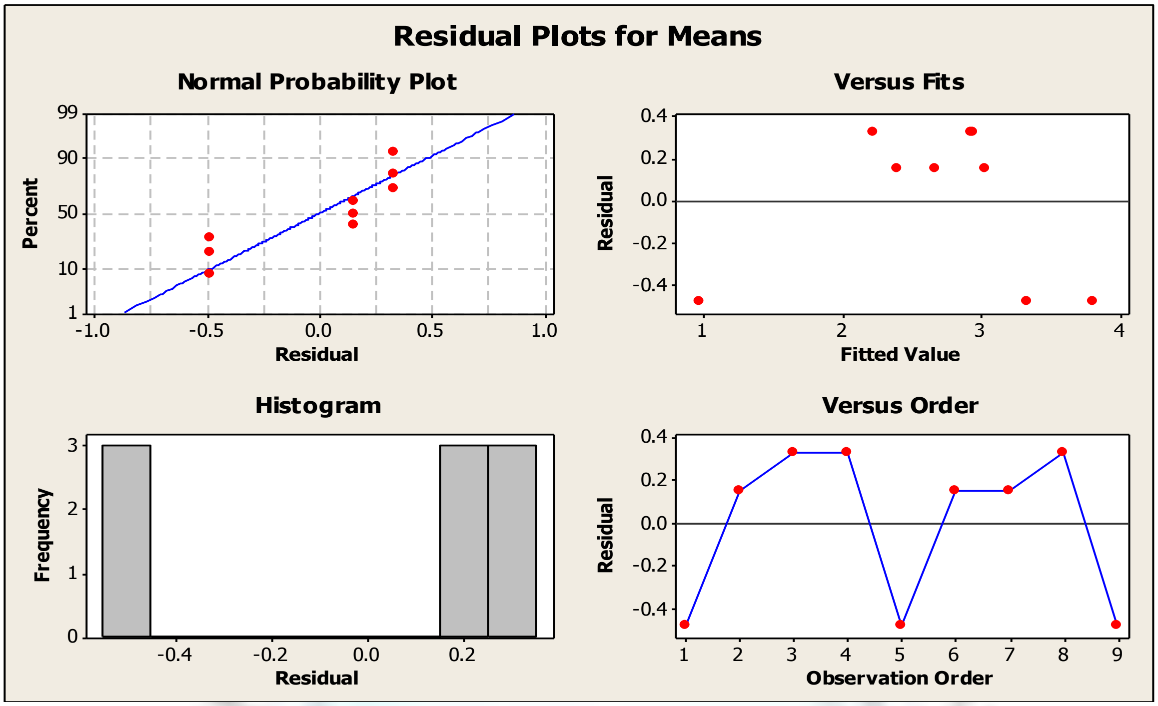

Figure-5: Residual Plots for Means of Ra

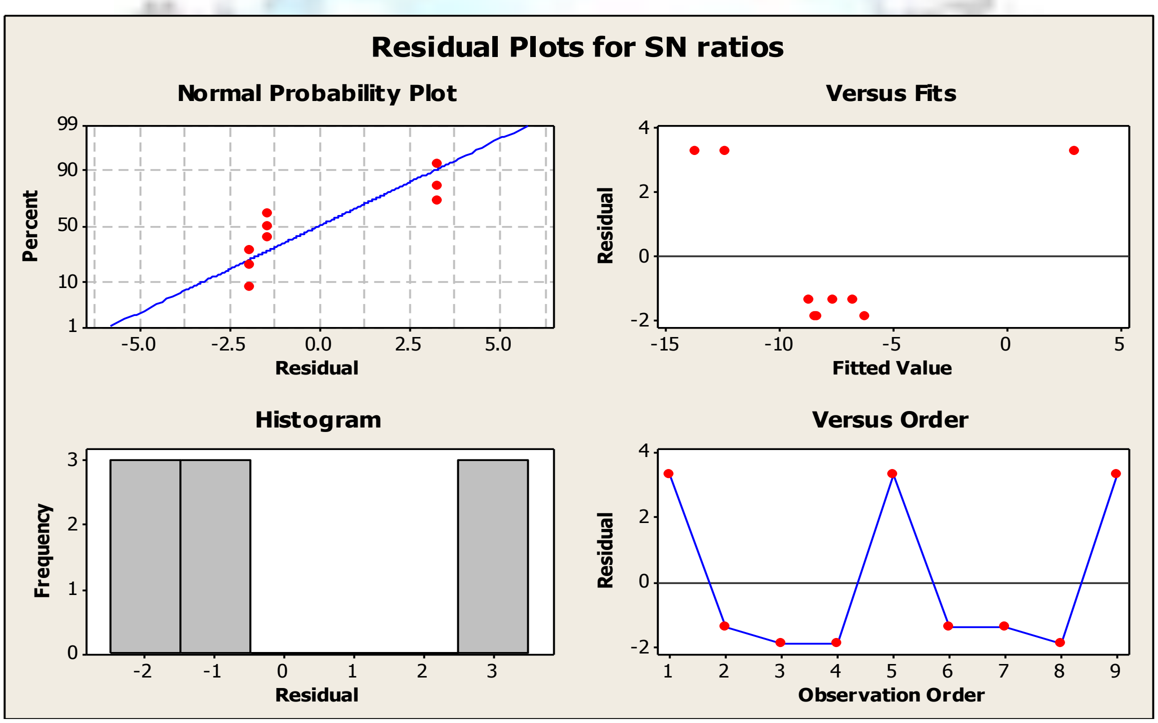

Figure-6: Residual Plots for S/N ratio of Ra

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.
- The most significant parameter in influencing the quality of machined surfaces in turning was feed.
- 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 influence 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 peformed by changing the control factors of turning process..
- The experiment can done with other techniques like ANN, RSM etc.

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