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An Experimental Mathematical Modelling of Surface Roughness in Turning Opertion of En24 with Carbide Tool

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Abstract: **Turning is one of the most widely used metal cutting processes. The increasing importance of turning operations is gaining new dimensions in the present industrial age, in which the growing competition calls for all the efforts to be directed towards the economical manufacture of machined parts as well as surface finish is one of the most critical quality measure in mechanical products. In present work, a Regression Analysis is adopted to construct a prediction model for surface roughness. Once the process parameters (cutting speed, feed, depth of cut, Nose Radius and Speed) are given, the surface roughness can be predicted.**

The work piece material is EN24 which is processed by carbide-inserted tool. All the experiment work is conducted on CNC lathe. The experiments are carried out by using design of experiment. Regression analysis is done considering Non-Linear model. Finally the contributions are summarized and future research directions are highlighted.

1. INTRODUCTION

Surface Roughness is a measure of level of unevenness of the part's surface. It is one of the crucial performance parameters that have to be controlled within suitable limits for a particular process. Therefore, prediction or monitoring of the surface roughness of machined components has been an important area of research. Surface roughness is harder to attain and track than physical dimension, because relatively many factors affect surface roughness. Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, nose radius and tool setup.

1.1Cutting Parameters

The important cutting parameters discussed here are cutting speed, feed, nose radius and depth of cut

Cutting Speed

All materials have an optimum Cutting Speed and it is defined as the speed at which a point on the surface of the work passes the cutting edge or point of the tool and is normally given in meters/min. To calculate the spindle Speed required,

$$N= 1000\ V_C /D\pi$$

Where: N = Spindle Speed (RPM), V_C = Cutting Speed of Metal (m/min), D = Diameter of W/p

Feed

The term `feed' is used to describe the distance the tool moves per revolution of the work piece and depends largely on the surface finish required. For roughing out a soft material a feed of up to 0.25 mm per revolution may be used. With tougher materials this should be reduced to a maximum of 0.10 mm/rev. Finishing requires a finer feed then what is recommended.

Depth of cut

it is the advancement of tool in the job in a direction perpendicular to the surface being machined. Depth of cut depends upon cutting speed, rigidity of machine tool and tool material etc. Depth of cut normally varies between 1 to 5 mm for roughing operation and 0.2 to 1 mm for finishing operation.

2. EFFECT OF CUTTING PARAMETERS

At the optimum cutting speed at which the effect of built up edge is negligible, (high speed, ductile material) the profile of the cutting edge of the tool is reproduced on the work surface and this ideal surface roughness is mainly dependent on cutting feed. That means for a greater feed the average roughness value is more as compared to the lesser feed. It would be noted that the size of chips cross-sectional area has a large effect on surface finish. Surface finish is poor for large cuts which is desirable from considerable of high tool life and power consumption. Large feed is more detrimental to surface finish than a large depth of cut. For very high cutting speeds the chances of built up edge reduces thus surface roughness also expected to reduce, while when cutting speed is low built-up formation of chips would increase the surface roughness.

3. EXPERIMENTAL SETUP AND METHOD IMPLEMENTATION

Problem Identification: The set-up parameters, which were used to get the expected results, are Spindle Speed, Feed, Depth of Cut, Nose radius. The experiments were conducted according to the Taguchi design of experiment i.e. the number of experiments were done as suggested by the Taguchi design of experiment according to number of factors, their levels and their interactions.

Fig. 3. 1: Work piece before Machining

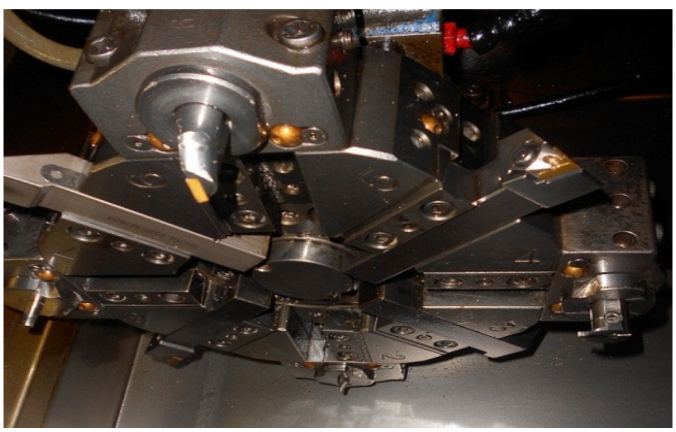


Fig3. 2 : Tool Holder

CNC lathe

Fig 3. 3 Fanuc Controller of CNC Lathe

Fig: 3. 4 Finished Work of Wok Piece

Surface Roughness Measuring Instrument

The Surtronic 3+ is a portable, self-contained instrument for the measurement of surface texture and is suitable for use in both the workshop and laboratory. Parameters available for surface texture evaluation are: R_a, R_q, R_z, R_y, R_t and S_m.

Fig. : 3. 5 Surface roughness measurement apparatus.

Fig: 3. 6: Close view Reading of Work –piece

4. WORK PIECE MATERIAL

Standardized material was selected to ensure consistency of the alloy, which is an EN24 used in industry thus, EN24 made in the form of bars with the varying size of diameter (in steps) so as to fit under the chuck. To more closely replicate typical finish turning processes and to avoid excessive vibrations due to work piece dimensional inaccuracies and defects, each work piece was rough-cut just prior to the measured finish cut.

The dimensions were taken so as to keep travel the stylus on the best surface as the cutting could improper at the starting or at the end. In this way the error in measurement could also be reduced and there is less chance of measuring the wrong side values.

5. CUTTING TOOL MATERIAL

The cutting tool which is provided with the CNC lathe Machine was a 30 mm square tool with 60 mm Length having the same tool angles as for a normal turning tool. The basic properties of CARBIDE tools are Superior hot hardness and wear resistance. These can retain hardness at temperatures above 600C but soften rapidly at higher temperatures. Cutting Speeds are limited upto 0.75 to 1.8 m/sec. The tool used was cemented carbide insert type. The geometry of tool is: Rake angle 6^0 (+ve), 5^0 (+ve) clearance angle, 60^0 (+ve) major cutting edge angle, 60^0 (+ve) included angle and 0^0 cutting edge inclination angle. The work piece material was EN24 alloy with the chemical composition as under:

Table. 5. 1 Chemical Composition of Work Piece

Element	Weight %
Carbon	0.35-0.45%
Nickel	1.30-1.80%
Chromium	0.90-1.40%
Molybdenum	0.20-0.35%
Silicon	0.10-0.35%
Manganese	0.45-0.7%
Phosphorous	0.05%max
Sulphur	0.05%max

Table. 5. 2. Process Parameters

Process parameters	Levels		
R.P.M.	400	600	800
Depth of Cut (mm)	0.4	0.6	0.8
Feed (mm/rev.)	0.1	0.15	0.2

Table. 5. 3: Data Collection for Surface Roughness Reading of EN-24 Work piece

Speed (RPM)	Cutting speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Diameter (mm)	Actual Ra – value (um)	Nose radius (mm)
400	37.71	0.1	0.4	30.02	2.92	0.4
600	60.33	0.1	0.4	32.02	1.80	0.4
800	85.46	0.1	0.4	34.02	0.92	0.4
400	45.24	0.15	0.4	36.02	3.28	0.4
600	71.63	0.15	0.4	38.02	2.46	0.4
800	100.53	0.15	0.4	40.02	2.12	0.4
400	52.78	0.2	0.4	42.02	3.60	0.4
600	82.93	0.2	0.4	44.02	3.46	0.4
800	115.60	0.2	0.4	46.02	2.76	0.4
400	37.71	0.1	0.6	30.02	2.60	0.4
600	60.33	0.1	0.6	32.02	2.00	0.4
800	85.51	0.1	0.6	34.04	1.04	0.4
400	45.24	0.15	0.6	36.02	2.28	0.4
600	71.63	0.15	0.6	38.02	2.02	0.4
800	100.53	0.15	0.6	40.02	1.86	0.4
400	52.78	0.2	0.6	42.02	3.30	0.4
600	82.93	0.2	0.6	44.02	2.34	0.4
800	115.60	0.2	0.6	46.02	2.02	0.4
400	37.71	0.1	0.8	30.02	1.54	0.4
600	60.33	0.1	0.8	32.02	1.30	0.4
800	85.46	0.1	0.8	34.02	1.06	0.4
400	45.24	0.15	0.8	36.02	1.96	0.4
600	71.63	0.15	0.8	38.02	1.84	0.4
800	100.53	0.15	0.8	40.02	1.78	0.4
400	52.78	0.2	0.8	42.02	3.10	0.4
600	82.93	0.2	0.8	44.02	2.96	0.4
800	115.60	0.2	0.8	46.02	2.82	0.4

By Using the reading from Table 4.2 and the Software Minitab 13 Regression Analysis RA versus v, f, d the following Ra equation has been developed and graphs shown below have been generated:

SOFTWARE MINITAB 13

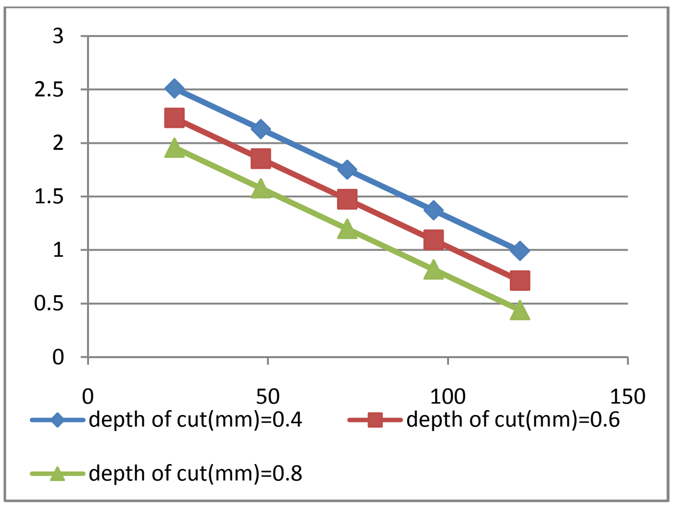
Regression Analysis: Ra versus V, d, f

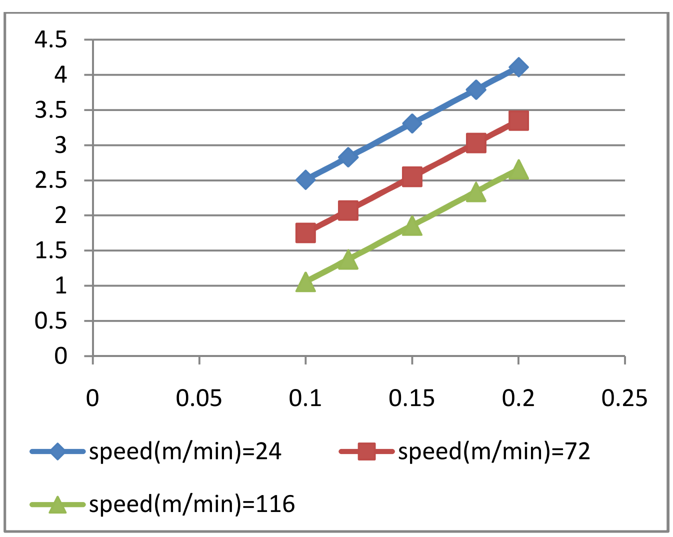
The regression equation is

Ra = 1.84	- 0.0158 v		+ 16.0 f	- 1.38	D
Predictor	Coef	SE Coef	T	P	VIF
Constant	1.8374	0.3962	4.64	0.000	
V	-0.015805	0.003138	-5.04	0.000	1.2
F	15.994	1.885	8.48	0.000	1.2
D	-1.3778	0.4366	-3.16	0.004	1.0

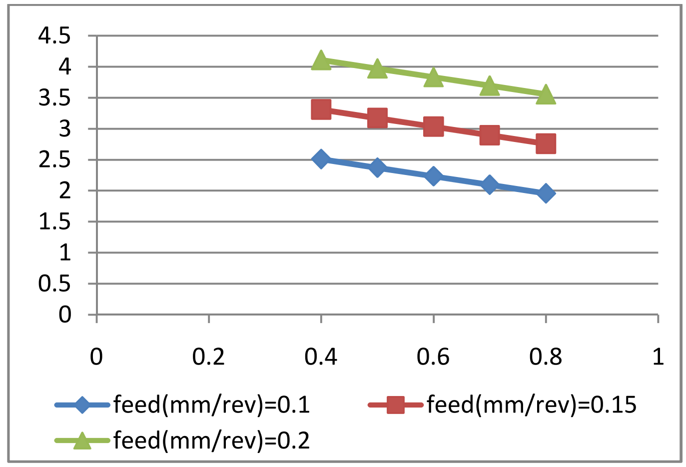
S = 0.3705 R-Sq = 78.9% R-Sq(adj) = 76.1%
PRESS = 4.46846 R-Sq(pred) = 70.11%

Effect of Speed on Surface Roughness: Effect of Feed on Surface Roughness





Effect of Depth of Cut on Surface Roughness:



6. RESULTS AND CONCLUSION

This work presented an experimentation approach to studying the impact of machining parameters on surface roughness. Strong interactions were observed among the machining turning parameters. From the data collection and Graphical Representation the following Observation are made in the EN24 Work-piece.

SPEED: From the observations of the Graphical Reading if the speed increases the surface roughness value decreases.

FEED: It is observed that when the feed increases the surface roughness value simultaneously increases.

DEPTH OF CUT: The increase in depth of cut influences the surface roughness value slightly increases.

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