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OPTIMIZATION OF TURNING PROCESS PARAMETERS FOR EN-31 STEELUSING TAGUCHI METHOD

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ABSTRACT

Productivity play significant role in today's manufacturing market. The current state of economy and consequent market pressure has forced manufacturers to simultaneously improve the surface finish and increase the metal removal rate. The manufacturing industries are continuously challenged for achieving higher productivity within lesser time. This research investigates the effect of process parameters during the machining of EN-31steel using Taguchi method. In this Speed, feed and doc are considered as the process parameters. Here Taguchi L27 orthogonal array is selected as for machining EN-31 and tungsten carbide inserts are used as the tool. Signal to noise ratio and ANOVA are used to identify the optimum parameter combination for getting better surface finish and MRR.

The conclusion drawn from this study is that the optimum condition for getting better surface finish is the spindle speed with level 3(2250 rpm), feed rate with level 1 (0.15 m/min) and depth of cut with level 2 (0.6 mm) and for MRR, the optimum condition for getting larger MRR is spindle speed with level 3 (2250 rpm), feed rate with level 3 (0.25 m/min) and depth of cut with level 3 (0.8mm). From ANOVA it is concluded that the feed rate is the most significant factor affected on surface roughness and spindle speed is the most significant parameter affected on MRR.

KEYWORDS: ANOVA, MRR, Taguchi Design, Turning, Surface Roughness

INTRODUCTION

In a turning operation it is important to select cutting parameters so that the high cutting performance can be achived. Selection of desired cutting parameters by experience or by using handbook doesnot ensure that the cutting parameters are optimal for particular machine and environment. The effect of cutting parameters is reflected on surface roughness, surface texture and dimensional deviation of the product. Surface roughness, which is used to determine and to evaluate the quality of a product, is one of the major quality attributes of a turning product. Surface roughness is a measure of the technological quality of a product and a factor that generally influences manufacturing cost. It describesthe geometry of the machined surface and commbines with the surface texture. The machinability of a material provides an indication of its adaptability to manufacturing by a machining process. Good machinability is defined as an optimal combination of factors such as low cutting force, good surface finish, low tool tip temperature, and low power consumption. Process modelling and optimization are the two important issues in manufacturing products. The selection of optimal cutting parameters, like depth of cut, feed and speed, is a very important issue for every machining process. In workshop practice, cutting parameters are selected from machining databases or specialized handbooks, but the range given in these sources are actually starting values, and are not the optimal values. Optimization of machining parameters not only increases the utility for machining economics, but also the product quality to a great extent. In today's manufacturing environment, many industries have attempted to introduce flexible manufacturing systems (FMS) as their strategy to adapt to the ever changing competitive market requirements. To ensure quality of machined products, and to reduce the machining costs and to increase the machining effectiveness, it is very important to select appropriate machining parameters when process parameters are selected for machining. Optimization methods in turning processes, considered being a vital role for continual improvement of output quality in product and processes include modelling of input-output and in process parameters relationship and determination of optimal cutting conditions. Aspects such as tool life and wear, surface finish, cutting forces, material removal rate, power consumption, cutting temperature (on tool and work piece's surface) decide the productivity, product quality, overall economy in manufacturing by machining and quality of machining

EXPERIMENT DETAILS

Experiments are performed by investigators in virtually all fields of inquiry, usually to discover something about a particular process or system. More formally experiment is a test or series of tests in which purposeful changes are made to the input variables of a process or system so that one can observe or identify the reasons for changes that may be observed in the output response. In this work to optimize turning process, actual experimental data should be available. In order to do that experiments in dry turning of EN31 have been performed.

When developing models on the basis of experimental data, careful planning of experimentation is essential. Experiment helps us in understanding the behavior of mechanical system. Data collected by systematic variation of influencing factors helps us to quantitatively describe the underlying phenomena. The factors considered for experimentation and analysis were spindle speed, feed rate and depth of cut. A large number of experiments have to be carried out when the number of process parameters increases. To solve this problem Taguchi method has been implemented in this context. The experiment is performed on EN31 steel in the form of round bars having 30 mm diameter and length of 60mm. The cutting tool for turning is coated carbide inserts of ISO designation CNMG 120408 (80°diamond shaped insert) with chip breaker geometry has been used for experimentation.

Table 1: Mechanical Properties of EN31 Steel

Hardness (after Heat Treatment)	61-65 HRC
Hardness (before heat treatment)	18 HRC
Tensile Stress	750 N/mm²
Elongation	30%
Yield Stress	450 N/mm²
Density	7800 kg/m³

Figure 1: CNC Lathe (Lakshmi Smart Junior)

Table 2: Input Variables with their Levels

Parameters	Unit	Level 1	Level 2	Level 3
Spindle speed	rpm	750	1500	2250
Feed Rate	m/min	0.15	0.2	0.25
Depth Of Cut	mm	0.4	0.6	0.8

EXPERIMENTAL OBSERVATIONS

Table 3

Sl No.	Speed (rpm)	Feed m/min	DOC Mm	W1 Kg	W2 Kg	Time (sec)	Ra (µm)	MRR (mm^3/sec)
1	750	0.15	0.4	0.328	0.32	9.67	1.033	106.06
2	750	0.15	0.6	0.314	0.312	10.62	1.156	24.14
3	750	0.15	0.8	0.326	0.312	12.01	1.173	149.44
4	750	0.2	0.4	0.312	0.31	7.55	1.903	33.96
5	750	0.2	0.6	0.33	0.318	7.97	1.611	193.03
6	750	0.2	0.8	0.328	0.314	8.46	1.854	212.15
7	750	0.25	0.4	0.34	0.33	6.24	1.226	205.45
8	750	0.25	0.6	0.326	0.318	6.89	2.414	148.85
9	750	0.25	0.8	0.348	0.334	7.33	2.44	244.86
10	1500	0.15	0.4	0.33	0.318	5.13	1.224	299.89
11	1500	0.15	0.6	0.318	0.314	5.25	1.166	97.68
12	1500	0.15	0.8	0.35	0.336	6.7	2.351	267.89
13	1500	0.2	0.4	0.332	0.322	4.01	1.769	319.71
14	1500	0.2	0.6	0.326	0.318	4.07	1.822	252.00
15	1500	0.2	0.8	0.328	0.316	4.47	1.752	344.17
16	1500	0.25	0.4	0.334	0.324	3.36	2.379	381.56
17	1500	0.25	0.6	0.328	0.316	3.49	1.821	440.81
18	1500	0.25	0.8	0.344	0.32	4.31	2.237	713.90
19	2250	0.15	0.4	0.318	0.31	2.66	1.016	385.57
20	2250	0.15	0.6	0.34	0.324	3.03	0.541	676.99
21	2250	0.15	0.8	0.348	0.334	3.33	1.154	539.00
22	2250	0.2	0.4	0.338	0.328	2.44	1.747	525.43
23	2250	0.2	0.6	0.33	0.298	2.84	1.602	1444.56
24	2250	0.2	0.8	0.336	0.324	2.97	1.668	518.00
25	2250	0.25	0.4	0.342	0.336	2.08	2.306	369.82
26	2250	0.25	0.6	0.322	0.316	2.13	1.966	361.14
27	2250	0.25	0.8	0.342	0.324	2.30	2.235	1003.34

RESULTS AND DISCUSSIONS

The plots show the variation of individual response with the three parameters; spindle speed, depth of cut and feed separately. In the plots, the x- axis indicates the value of each process parameters at three level and y-axis the response value. The main effect plots are used to determine the optimal design conditions to obtain the low tool wear and low surface temperature

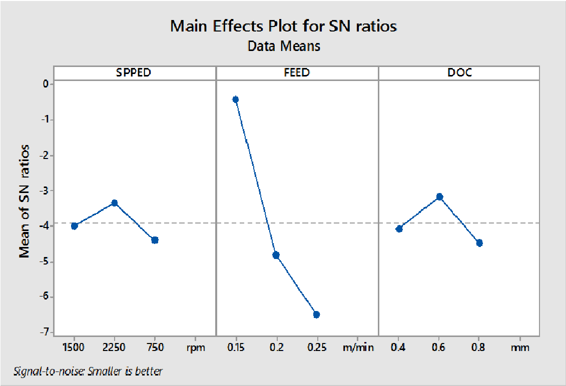

Figure 2: Main Effect plot for Ra

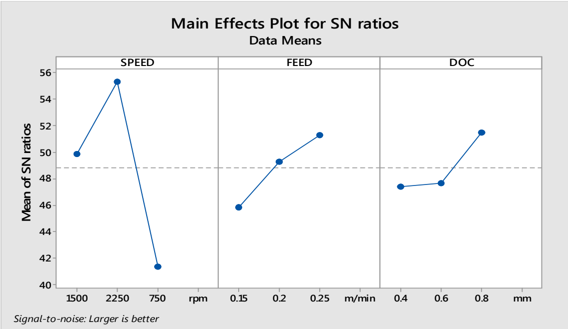

Figure 3: Main Effect Plot for MRR

In the Taguchi, The optimum condition for getting smaller surface roughness is the spindle speed with level 3(2250 rpm), feed rate with level 1 (0.15 m/min) and depth of cut with level 2 (0.6 mm)... For MRR, the optimum condition for getting larger MRR is spindle speed with level 3 (2250 rpm), feed rate with level 3 (0.25m/min) and depth of cut with level 3 (0.8mm).

In this work, the experimental results were used for modeling using regression analysis. The purpose of developing mathematical models was to relate the machining responses to the parameters and thereby to facilitate the optimization of the machining process.

The regression equations are

Surface Roughness = 1.6482 - 0.0252 SPPED_1500 - 0.0623 SPPED_2250 + 0.0875 SPPED_750- 0.5726 FEED_0.15+ 0.0994 FEED_0.2 + 0.4733 FEED_0.25 + 0.0173 DOC_0.4 - 0.0939 DOC_0.6 + 0.0766 DOC_0.8

MRR = 0.000000 - 0.000000 SPEED_1500 + 0.000000 SPEED_2250 - 0.000000 SPEED_750 - 0.000000 FEED_0.15 + 0.000000 FEED_0.2 + 0.000000 FEED_0.25 - 0.000000 DOC_0.4+ 0.000000 DOC_0.6 + 0.000000 DOC_0.8

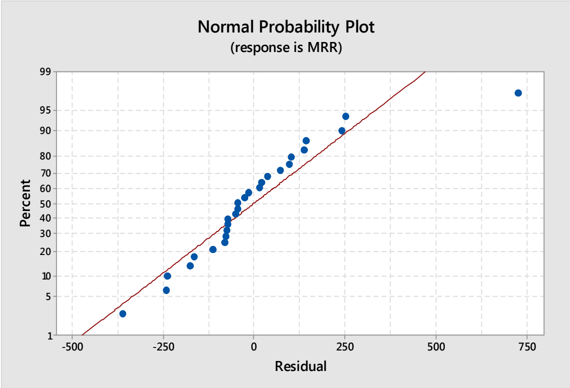

Figure 4: Normal Probability Plot of Residuals (MRR)

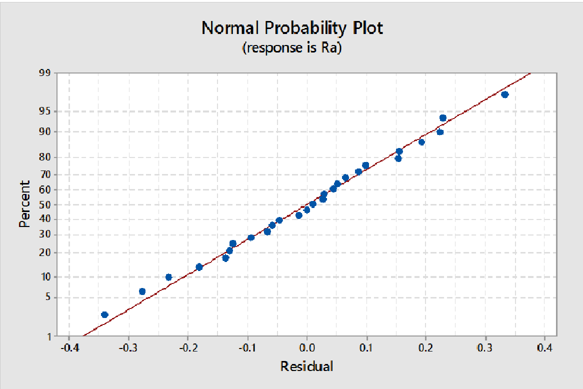

Figure 5: Normal Probability of Residuals (Ra)

The normal probability plots of the response; Ra and MRR are depicted in figures respectively. The graphs show that the data closely follow the straight lines, denoting a normal distribution. From ANOVA it can see that the feed rate is the most significant factor affected on surface roughness and spindle speed is the most significant parameter affected on MRR.

CONCLUSIONS

Determination of optimal cutting parameters is one of the most important elements in any process planning of metal parts. This work presents a optimization of turning process parameters for EN-31 steel using taguchi method. The objective was to find out cutting parameters of turning process (spindle speed, feed rate, and depth of cut) which minimizes simultaneously surface roughness and MRR subject to practical constraints. Before that experimentation is done and ANOVA has also been performed. Mathematical model is developed using Regression analysis. Hence, it can be concluded from the optimization results that it is possible to select a proper combination of spindle speed, feed, and depth of cut to achieve better surface finish and MRR.

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