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Optimisation of Machining Parameters of Face Milling by Using Taguchi Method

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Abstract:

To be successful in a competitive industrial situation producer has to provide output which has distinctive advantages over others. Quality is a good tool for competition. For achieving quality we have to start right from the inception stage of the product and continue till product is giving service. The new approach, which is emerging, is based on Zero Defect system, quality control circles and off line quality control. Out of these, Taguchi’s method of off-line quality control is most comprehensive and effective system. It gives a design of product, which is requiring very less on-line quality control. Taguchi's approach has both philosophical and mathematical contents. The methodologies developed to implement his ideas are known as Taguchi methods. In this paper, Taguchi Method has been used to identify the optimal combination of influential factors in the milling process. Milling experiment has been performed on EN 36 material block, according to Taguchi orthogonal array (L9) for various combinations of controllable parameters viz. spindle speed, feed and depth of cut. The surface roughness (Ra) is measured and recorded for each experimental run and analysed using Taguchi method and finally the optimal combination is chosen.

Keywords: Experimental design, Controllable parameters, EN36, Milling, Taguchi method, MINITAB software.

I. INTRODUCTION

Experimental design (ED) is a powerful technique which involves the process of planning and designing an experiment so that appropriate data can be collected and then analyzed by statistical methods, resulting in objective and valid conclusions. The Taguchi Technique for quality engineering is one of the ED technique which is intended as a guide and reference source for Industrial practitioners involved in product or process experimentation and development. His definition stressed the losses associated with a product. Taguchi stated, "Quality is the loss a product causes to society after being shipped, other than losses caused by its intrinsic functions." Taguchi asserted that losses in his definition "should be restricted to two categories: (a) loss caused by variability of function, and (b) loss caused by harmful side effects." Taguchi says that a product or service has good quality if it "performs its intended functions without variability, and causes little loss through harmful side effects, including the cost of using it”. Roughness is often a good predictor of the performance of a mechanical component. There has been increased interest in monitoring all aspects of the machining process. Quality of machining can be judged by surface roughness. Higher the surface finish higher will be the quality. Surface finish mainly depends on cutting speed, Depth of cut, Feed. Most of the operators use trial and error method to find the appropriate cutting condition but this not an efficient method and its deals with the increase in production cost and affecting the time management factor. So Taguchi method is used to find the most optimal parameters for machining. Mild steel EN 36 is being used in various industries and it's important to know the optimal machining parameters of it.

II. METHODS

The Taguchi method is widely used because it can be performed using a lower number of experiments with the advantage of getting an overview of the parameters which are influencing the performance of the process.

Various steps which are carried out for applying the Taguchi parameter design approach are

- Determine the quality parameters to be optimized.
- Select the significant controlled parameters and their different levels for the study.
- Select suitable orthogonal array.
- Conduct the required number of experiments.
- Analyse the result obtained from the experiment and determine the optimized level of controlled parameters.
- Predict the performance of optimized parameters
- Conduct a confirmation run to get the actual output

The Taguchi method is used as a function to determine the quality characteristics. Loss function values are also converted to a signal-to-noise (S/N) ratio (η). Generally, there are three different quality characteristics in S/N ratio analysis, namely 'nominal the best', 'larger the better' and 'smaller the better'. For each level of process parameters, the S/N ratio is calculated based on S/N analysis. The main purpose of this research paper is to apply Taguchi parameter design for predicting the major factors which affect the face milling operation and to optimize the same for surface roughness. Milling In wet and dry condition CNC milling machine VM 20 model 3 axis has maximum spindle speed 10000 rpm and a 14.9-kW motor is used. The set-up is made for Face milling to test the material EN 36 having size 60x20x20mm blank. The process for three various cutting speed (1000, 2000, 3000 m/min) and three various feed rates (500, 1000 and 1500 mm/rev) and the three various depth of cut (0.3, 0.4, 0.5 mm).A Surface roughness of machined area was tested by the portable surface tester. The roughness tested from point parallel to the machined path and used for the experiment.

III. EXPERIMENTAL DESIGN AND MILLING OF WORK MATERIAL

Taguchi design is used for conducting milling experiments by considering different speed, feed and depth of cut combinations and the values of surface roughness are measured using surface tester recorded. Based on the methodology suggested earlier first step was to select the quality parameters which are to be optimized. Therefore, surface roughness was selected as concern parameters which has to be optimized. Then after observing the face milling operation carefully for finding out the governing parameters which influence the quality of face milling operation and subsequently analyzing the process, it was found that there are three major parameters: speed, feed rate and depth of cut which were influencing the process significantly. Therefore, the parameters speed, feed rate and depth of cut are selected as controlling factors and the values that are being used in this experiment is tabulated in Table 1.

Table 1 Parameters for machining.

Figure 1. Surface Tester

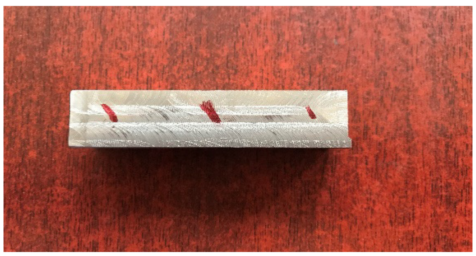

Figure 2. Work Piece 1

Figure 3. Work Piece 2

Figure 4. Work Piece 3

Spindle speed	Feed rate	Depth of cut
1000	500	0.3
1000	1000	0.4
1000	1500	0.5

Figure 5. Work Piece 4

Figure 6. Work Piece 5

Figure 7. Work Piece 6

S.NO	Spindle speed	Feed rate	Depth of cut	Roughness value
1	1000	500	0.3	2.15
2	1000	1000	0.4	2.8
3	1000	1500	0.5	1.69
4	2000	500	0.5	1.82
5	2000	1000	0.3	1.05
6	2000	1500	0.4	2.9
7	3000	500	0.4	1.68
8	3000	1000	0.5	1.77
9	3000	1500	0.3	0.97

Figure 8. Work Piece 7

Figure 9. Work Piece 8

Figure 9. Work Piece 9

Table 2 Roughness value for different process parameters

In Table 2 the roughness value of different work piece is tabulated after testing in the surface roughness tester.The S/N ratio is the statistic that combines the mean and variance and it depends on the kind of quality characteristic. Moreover, the effects of the level of each factor on the quality characteristic can be analyzed using S/N ratios. These effects can be defined and evaluated according to total mean values of experimental results or S/N ratios. Therefore, the optimum surface roughness values were calculated by means of total mean values of experimental trial results of the surface roughness. Effect of face milling machining parameters on surface roughness was successfully performed. Measured value of surface roughness and corresponding values of surface roughness and corresponding values of SN ratio, MEAN is computed as per Taguchi L9 orthogonal array as in Table 3 using the MATLAB software.

Table 3. (SNR) Signal to Noise ratio and Means for all the parameters.

S.NO	SNR	MEAN
1	-6.6488	2.15
2	-8.9432	2.8
3	-4.5577	1.69
4	-5.2014	1.82
5	-0.4238	1.05
6	-9.248	2.9
7	-4.5062	1.68
8	-4.9595	1.77
9	0.26457	0.97

Table 4. Response Table for Signal to Noise Ratios

Level	**Spindle speed**	**feed rate**	**Depth of cut**
1	**-6.717**	**-5.452**	**-6.952**
2	**-4.958**	**-4.775**	**-4.627**
3	**-3.067**	**-4.514**	**-3.163**
Delta	**3.650**	**0.938**	**3.789**
Rank	**2**	**3**	**1**

Table 5. Response Table for Means

Level	**Spindle speed**	**feed rate**	**Depth of cut**
1	**2.213**	**1.883**	**2.273**
2	**1.923**	**1.873**	**1.863**
3	**1.473**	**1.853**	**1.473**
Delta	**0.740**	**0.030**	**0.800**
Rank	**2**	**3**	**1**

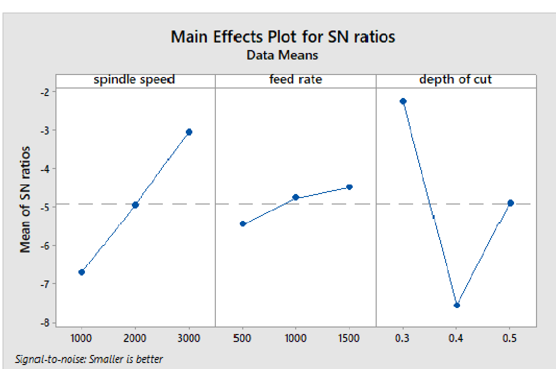

Figure 11. Plot for SN ratio

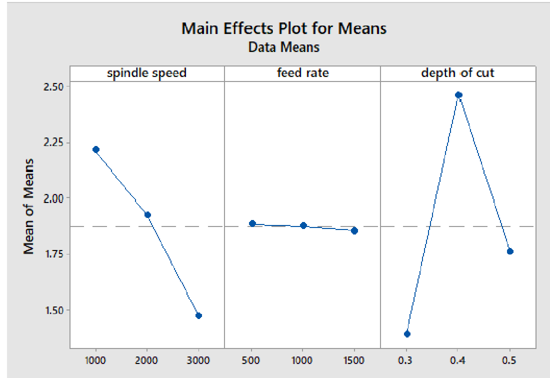

Figure 12. Plot for Means

From Table 4 and Table 5 it can be observed that Depth of cut and spindle speed are the significant factors. From the Figure 11 (SN ratio plot), surface roughness decreases with increase in spindle speed and decrease in depth of cut. Whereas the effect of feed rate is very small on the surface roughness. Higher the SN ratio better the surface finish. It can be seen that the optimal combination of machining parameters for surface roughness is A_3 B_3 C_1 that is Spindle speed – 3000 rpm, depth of cut – 0.3mm, feed rate – 1500 mm/rev. Figure 12 (MEAN plot), surface roughness decreases with increase in spindle speed and decrease in depth of cut. Whereas the effect of feed rate is very small on the surface roughness. Lower the mean value better is the surface finish. It can be seen that the optimal combination of machining parameters for surface roughness is A_3 B_3 C_1 and now it is verified with the SN ratio plot.

IV. CONCLUSION

In this paper, the minimum surface roughness values is determined by using the Taguchi technique. Feed rate, speed, and depth of cut of the face milling operation were the significant controlling factors which affects the quality of surface finish operation. Taguchi design was able to produce the best surface roughness in metal cutting operation. This was accomplished with a relatively small number of experimental runs. It is observed that the Taguchi parameter design method is easy to understand and also easy to implement for optimizing the controlled factors. According to experimental results, the optimized control factors settings for minimum surface roughness are spindle speed – 3000rpm, feed rate – 1500 mm/rev and depth of cut – 0.3mm.