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Optimization Of Process Parameters in End Milling For FG260 Grey Cast Iron Using Taguchi Technique

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Abstract:
In this paper the Taguchi technique was utilized to optimize the process parameters in End milling. The process parameters considered were depth of cut, feed and Speed. The investigation was carried out on FG 260 grade Grey cast iron material. Roughness average (Ra) and Root mean square roughness (Rq) of Surface texture was considered as output response. L9 orthogonal array of Taguchi technique, Signal to noise ratios and Analysis of variances (ANOVA) were employed with the help of Minitab 18 software to investigate the surface roughness characteristics for End milling operation. This study showed that Speed has a greater effect on both Ra and Rq surface roughness value followed by depth of cut and feed respectively.

Keywords: Taguchi method, End milling, Surface roughness, Grey Cast iron, Minitab

1. INTRODUCTION

Milling operations are one of the most widely used processes in the machining of metals. Many parts are designed such that they must be processed on milling machines in at least one stage of their fabrication. Part design and specification, along with economical and quality reasons; make the revision of the finish of an end milled surface is vital. The process of generating a milled surface is affected by several factors, some of them, namely the cutting conditions and tool geometry, are of primary importance in influences the quality of a milled facade. Past research studies on milling and similar operations have focused on the different aspects of tool performance, forces involved in the process, and on the resulting surface roughness But, so far less number of investigation has been made to analyze the characteristics of surface roughness in milling operations considering various factors simultaneously in order to evaluate their main effects, as well as their interactions. End milling cutters are tools with teeth on the circumferential surface and on one end. Roughness must be considered as superimposed feed marks on a curvy surface. The final surface roughness, obtained throughout a realistic machining maneuvering, may be considered as the sum of the two self-governing effects mentioned above. FG 260 Gray cast iron find its applications in automobiles mainly in clutch housing, intermediate plate, pressure plate, Axle tube, front transmission etc., where the surface finish plays a critical role. For that reason it's imperative to maintain a desired level of surface finish on the component made up of this material. Taguchi's optimization technique is an exclusive and commanding optimization method that permits optimization with minimum number of trials. The Taguchi experimental designs reduce expenditure, perk up eminence, and offer a robust design solution. In this study we considered factors like feed rate, speed and depth of cut for optimization with respect to surface roughness for FG260 Gray cast iron material in end milling. Roughness average (Ra) and Root mean square roughness (Rq) of Surface roughness was considered as output response. L_9 orthogonal array of Taguchi technique, Signal to noise ratios and Analysis of variances (ANOVA) were employed with the assistance of Minitab 18 software to scrutinize the surface roughness characteristics for grinding operation. To improve comprehend of Taguchi design, the method followed in the Taguchi technique as shown in Figure 1 is useful reference. The Taguchi technique is alienated into three stages: system design, factor design, and tolerance design of the three design stages, out of these three phases the second phase, which is the parameter or factor design is the vital phase [1]. The phase of Taguchi parameter design requires that the factors affecting quality distinctiveness in the production technology have been determined. The aim of this phase is to identify the optimal cutting conditions that give up the minimum surface roughness value. The steps included in the Taguchi parameter design are: choosing the right orthogonal array pertaining to the numbers of controllable factors, conducting the trials based on the orthogonal array; analyzing the data; identifying the optimum condition; and carrying out confirmation experiment with the optimal levels of all the factors [2].

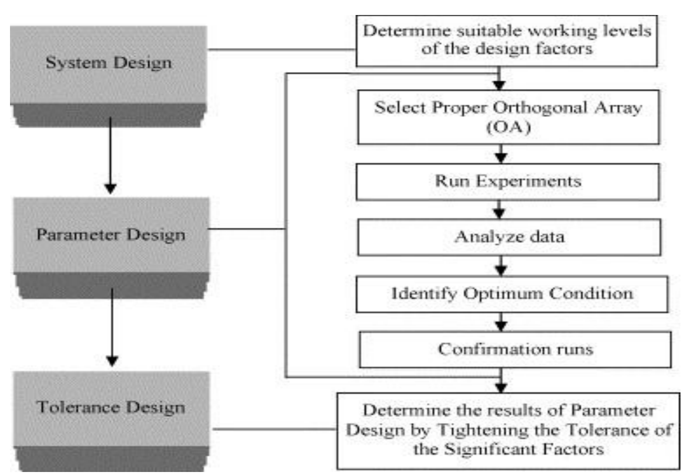

FIGURE 1. Taguchi Method

Employing Taguchi factorial design involve the recognition of factors affecting embattled quality features, pertinent literature must be reconsidered to monitor the most significant factors or conditions affecting surface quality of end milled surface[3]. As a multi-point machining process, additional impending variability makes it even harder to obtain a surface quality sculpt in milling operations when taken contrast with single point machining [4]. Pare, V et al, mentioned in their study that the likely factors affecting surface finish were found to be cutter force, cutter run out, feed rate, cutting speed, depth of cut, cutter geometry, tool wear, and the and vibration under vibrant cutting circumstances [5]. Using Taguchi design, Malvade et.al.,included feed rate, depth of cut, tool nose radius, cutting speed, and flank as managing factors for the configuration of a statistical model to envisage surface roughness for aluminum parts in end milling operations[6]. Ko et al., carried out research to acquire optimal cutting parameters such as cutting speed, feed per tooth, and cutting depth for surface roughness in end milling operations by using alloy steel as work pieces or samples [7]. Moreover applying these three cutting parameters as control factors, Lou et al., studied multiple features including removed material removal rate, surface roughness, and cutting force, and in this research a weighted value was used to optimize the cutting condition for end milling operations. The studies reviewed above showed even though applied in a variety of working conditions for solving different, specific problems, they all selected the three frequently applied machining parameters – feed rate, cutting speed, and depth of cut as control factors[8] . Ghani et al., conducted a study to optimize cutting conditions for hardened steel under semi-finish and finish circumstances. Applying cutting speed, feed rate, and depth as control factors, they used measured responses and their calculated signal-to-noise ratio to establish the optimal cutting condition [9] .These research works showed that the technique of Taguchi factors design worked well in optimizing cutting parameters to realize the surface finish effect. Subsequently by the review of above literatures, this research work included feed rate, spindle speed, and depth of cut as control variables. Since surface cutting speed is linearly correlated to feed rate, the control variable of cutting speed was specified as spindle speed in revolutions per minute, in this swot.

2. EXPERIMENTAL SETUP AND CUTTING CONDITIONS

2.1 Material Chosen

The material chosen for the study is FG260 of size 60X60X25mm Square cross section with the chemical composition as shown in the Table 1.The tool i.e., end mill cutter used was 12mm diameter HSS C00684D

TABLE 1. Chemical Composition of FG260

C %	Si%	Mn %	S%	P %	Fe
3.3	1.7	0.8	0.1	0.15	Remaining

2.2 Machining Process

The end milling of the work piece material was carried out on the Universal Milling machine of BFW company make. The experiments were carried out as per the orthogonal array and the surface roughness values for the various combinations of factors were measured using portable Surface Roughness Measuring instrument called tally surf of Mitutoya company make. The nine different work pieces were used for each experiment respectively and the corresponding surface roughness values in terms of Ra and Rq were noted down.

2.3 Plan of Experiment

The experiment was figured using Taguchi's design of experiment in which L9 orthogonal array, this array usage reduces in performing many number of experiments. Table 2 and Table 3 illustrate the factors and their levels for the experiment and L9 orthogonal array respectively.

TABLE 2. Factors and their levels

Level	Speed(rpm)	Feed rate (mm/min)	Depth of cut(mm)
1	250	16	0.1
2	500	20	0.2
3	1000	25	0.4

TABLE 3. L9 Orthogonal array

Expt.	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

2.4 Experiment Details

A set of experiments were carried out on Universal Milling machine using different feed rate , speed and depth of cut factors and the resulting surface roughness values, Roughness average Ra(µm) and Root mean square roughness Rq (µm) were noted as shown in the Table 4.

TABLE 4. Surface roughness values obtained

Sl.No	Speed (rpm)	Feed rate (mm)	DOC (mm)	Ra (µm)	Rq (µm)
1	250	16	0.1	3.072	3.745
2	250	20	0.2	3.584	4.69
3	250	25	0.4	3.849	4.887
4	500	16	0.2	7.776	9.573
5	500	20	0.4	7.63	9.208
6	500	25	0.1	5.715	7.431
7	1000	16	0.4	6.813	8.336
8	1000	20	0.1	7.0814	8.451
9	1000	25	0.2	7.585	8.834

3. RESULTS AND DISCUSSION

The Table 5 below shows the Signal to Noise ratio respectively for R_a and R_q surface roughness values. Selecting the Smaller is the better S/N ratio conditional formula

$$S/N = -10 \log [1/n (\Sigma y_i^2)] \quad (n=1) \qquad (1)$$

where 'y_i' is the performance response to the i^{th} setting of the parameter combination, and 'n' is the number of samples and calculating we get the Signal to Noise ratio values for both Ra and Rq.

TABLE 5. S/N Ratio for R_a and R_q respectively

Sl.No	Speed (rpm)	Feed rate(mm)	DOC(mm)	Ra(µm)	Rq(µm)	S/N Ratio Ra	S/N Ratio Rq
1	250	16	0.1	3.072	3.745	-9.7484	-11.469
2	250	20	0.2	3.584	4.69	-11.0874	-13.4235
3	250	25	0.4	3.849	4.887	-11.707	-13.7808
4	500	16	0.2	7.776	9.573	-17.8151	-19.621
5	500	20	0.4	7.63	9.208	-17.6505	-19.2833
6	500	25	0.1	5.715	7.431	-15.1403	-17.4209
7	1000	16	0.4	6.813	8.336	-16.6668	-18.4192
8	1000	20	0.1	7.0814	8.451	-17.0024	-18.5382
9	1000	25	0.2	7.585	8.834	-17.5991	-18.9231

The response values for signal to noise ratio for Ra is as shown in Table 6 which is obtained by using Minitab 18 a statistical analysis software. Table 6 shows indicates that Speed is the rank 1followed by Depth of cut and Feed rate as rank 2 & 3 respectively by considering the larger value of delta.

TABLE 6. Response Table for Signal to Noise Ratio for R_a

Level	Speed(rpm)	Feed rate (mm/min)	Depth of cut(mm)
1	-10.85	-14.74	-13.96
2	-16.87	-15.25	-15.5
3	-17.09	-14.82	-15.34
Delta	6.24	0.5	1.54
Rank	1	3	2

Figure 2 shows the Main effect plots for Mean value of Signal to Noise ratio of Ra. From this it is clear that the 250rpm speed, 25mm/min feed rate and 0.1mm depth of cut has larger effect on Surface roughness value Ra

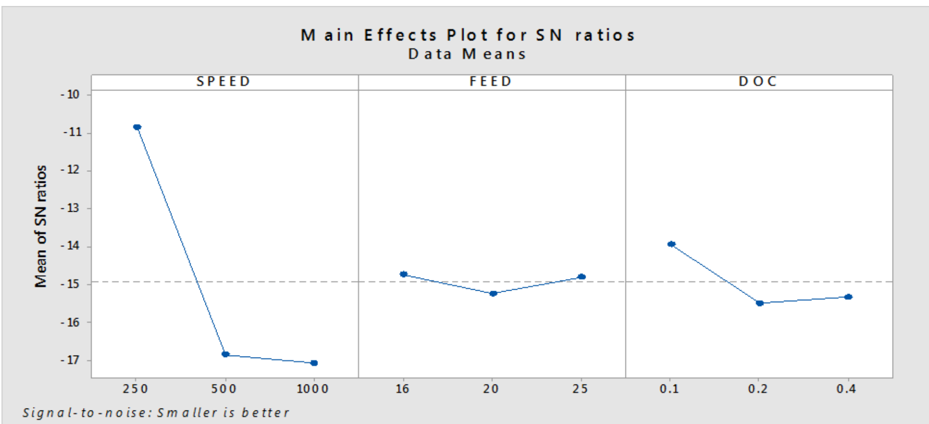

FIGURE 2. Main effect plots for Mean S/N Ratios of Ra and Rq

The response values for signal to noise ratio for Rq is as shown in Table 7 which is also obtained by Minitab 18 statistical analysis software. Table 7 shows indicates that speed is the rank 1followed by Depth of cut and feed rate as rank 2 & 3 respectively by considering the larger value of delta.

TABLE 7. Response Table for Signal to Noise Ratio for R_q

Level	Speed(rpm)	Feed rate (mm/min)	Depth of cut(mm)
1	-12.89	-16.5	-15.81
2	-18.78	-17.08	-17.32
3	-18.63	-16.71	-17.16
Delta	5.88	0.58	1.51
Rank	1	3	2

Figure 2 also shows the Main effect plots for Mean value of Signal to Noise ratio of Rq. From this it is clear that the 250rpm speed, 25mm/min feed rate and 0.1mm depth of cut has larger effect on Surface roughness value Rq. The results for surface roughness are analyzed using ANOVA in Minitab 18 software. The criterion for evaluation, "smaller is better" is used [10]. ANOVA Table 8 for Surface Roughness clearly indicates that the speed and depth of cut is more influencing for surface roughness, and feed rate is least influencing for surface roughness in both the cases of Ra and Rq. The percent contribution of all factors is also shown. The speed contributes maximum 88.81 %, depth of cut contributes 6.0 % and feed has least contribution about 0.75% towards the surface roughness Ra.

TABLE 8. **ANOVA for R_a**

Source	DF	Adj SS	Adj MS	F-Value	P-Value	PC
Speed	2	25.9184	12.9592	20.04	0.048	88.81%
Feed	2	0.2199	0.1099	0.17	0.855	0.75%
DOC	2	1.7517	0.8759	1.35	0.425	6.0%
Error	2	1.293	0.6465			4.43%
Total	8	29.183				100%

Table 9 indicates ANOVA for Rq. The percent contribution of all factors is also shown. The speed contributes maximum 90.97 %, depth of cut contributes 5.67 % and feed has least contribution about 0.62% towards the surface roughness Rq.

TABLE 9. **ANOVA for R_q**

Source	DF	Adj SS	Adj MS	F-Value	P-Value	PC
Speed	2	35.3074	17.6537	35.1	0.028	90.97%
Feed rate	2	0.2409	0.1204	0.24	0.807	0.62%
DOC	2	2.2608	1.1304	2.25	0.308	5.67%
Error	2	1.006	0.503			2.59%
Total	8	38.8151				100%

Table 10 below shows the optimum levels of factors for both Ra and Rq obtained by optimization by Taguchi as well as by Analysis of variances.

TABLE 10. **Factors and their optimum levels**

Factors	Ra	Rq
Speed(rpm)	250	250
Feed rate (mm/min)	25	25
Depth of cut (mm)	0.1	0.1

The value of Ra obtained (predicted), by Taguchi optimization method the value was 3.07µm and this was confirmed by using optimum values of the parameters as input, the experimental value obtained was 3.095µm with 0.025 µm error. The value of Rq obtained (predicted), by Taguchi optimization method the value was 3.745µm and this was confirmed by using optimum values of the parameters as input, the experimental value obtained was 3.920µm with 0.175 µm error.

4. CONCLUSIONS

From this study it can be concluded that

1. Gray cast iron produces good surface finish during end milling process without using cutting fluids in comparison to other milling processes. Close tolerance can be procured during end milling. Speed plays an important role in end milling and produces a minimum surface roughness value for FG260 gray cast iron.
2. Minimum values of Ra and Rq surface roughness were predicted according to Taguchi technique. The optimum values of parameters which are obtained include speed of 250rpm, feed of 25mm/min and 0.1mm of depth of cut. The speed and depth of cut plays a vital position in minimizing surface roughness followed by feed.
3. As per the analysis of variances the speed contributes maximum value of 88.80 %, depth of cut contributes 6.0 % and feed has least contribution about 0.75% towards the surface roughness Ra. The speed contributes maximum value of 90.07 %, depth of cut contributes 5.67 % and feed has least contribution about 0.62% towards the surface roughness Rq.

REFERENCES

1. J. R. Box, Journal of Quality. Technology , 189–190 (2002).
2. Shainin, Quality and Reliability Engineering International, 143–150 (1997).
3. G. Taguchi and S. Konishi “Tool for Quality Engg.” *American Supplier Institute*, *Dearborn*, 1987, pp. 35–38.
4. Z. Z. Julie, C. C. Joseph and E. D. Kirby, Journal of Material Processing Technology, 233–239 (2007).
5. V. Pare , G. Agnihotri and C. M. Krishna, Inter. Journal of Mechanical and Industrial Engg, 21–25 (2011).
6. N. V. Malvade and S. R. Nipanikar, Journal of Engineering Research and Studies, 112–121(2012).
7. T. J. Ko and H. S. Kim, International Journal Machining Tool Manufacturing, 414–422 (2011).
8. M. S. Lou, J. C. Chen and C. M. Li, Journal of Industrial Technology, 245–252 (2012).
9. J. A. Ghani, Chuadhray and I. A. Hasan, Journal of Materials Processing Technology, 84–92 (2004).
10. S. F. David and P. D. Geoff, Inter. Journal of Machine Tools & Manufacture , 121–128 (2012).