Process Parameters Optimization Through Taguchi and ANOVA Analysis - A Review

Dr. Ravi Shankar Raman¹, Mr. Nitin Kukreja ², Ms. Nidhi Singh³

¹Department of Mechanical Engineering, ABES Engineering College, Ghaziabad,
²Department of Mechanical Engineering, GLA University Mathura, UP,
³Computer Science & Engineering, ABES Engineering College,Ghaziabad,UP

corresponding author’s e-mail: ravi.raman21@gmail.com

Abstract. In the present scenario the period of rivalry and financial disturbance, a wide range of organizations are using the various optimization techniques or strategies that are helpful for keeping up and enhance the quality and efficiency. In this paper the outline on, the improvement of various boundaries in milling and drilling operation is discussed through some research survey. The ANOVA technique was used to found the significance control factors which help to measure the required surface roughness parameter. The response surface methodology and DOE methods are generally utilized in the various research study on milling and drilling operation. The quality of machining process are depends on various machining parameters like cutting speed, feed rate, tool diameter and structure, cutting depth, work piece material etc. The all above parameters are the key factors for machining optimization process and discussed through this review paper surface roughness has been analyzed Taguchi strategy.

Keywords: ANOVA, Signal to Noise ratio, Milling, Drilling, Surface Roughness

1. Introduction

Milling and drilling are the broadly utilized machining process to create finishing and holes in various components. The milling operation is a sort of material removal process that permits demonstrating in complex structures and trimming pieces of a materials. So forth and in the interim the expulsion of chips and handling deposits. The milling is completed utilizing machine, for example, milling machines or machining focuses [1].Drilling is a cutting operation that utilizes a tool called as drill bit to cut or create a circular hole of roundabout cross-area in strong materials. The tool bit is typically a rotational cutting tool, frequently multi-point. Rather, the hole is typically made by pounding a drill bit into the hole with immediately rehashed short movements. So to accomplish this superior of machining, different advancement strategies are utilized like, DOE, Response Surface Methodology, MRR and surface roughness [1-3].The basic drilling and milling operation is as shown in figure I
1.1 Need For Optimization

Every industries are trying to increase their Production rate with minimum cost and improve their product quality, but the manufacturing is mainly depends on their machining process. So for enhance their product quality with low cost deep knowledge of machining process is must to know for every operators. For traditional machining process only few workers having rich experience and high skill can operate the machine very effectively so for continuous production the possibility to achieve the required product quality is very less[6-8]. Therefore, to avoid such circumstances every industries needs to upgrade their system and move toward optimization technique for better product quality. For optimization, every industry are trying to upgrade their system and going to optimize their machining parameters to improve quality as well as reduced the total production cost and win the customers loyalties.

1.2 Literature Summary

Raman et. al. [1] has conducted experiment on milling machine and analyzed the minimum surface roughness by the concept of Taguchi technique and validate the results through ANOVA analysis with Minitab software. Experiments were performed on Mild steel square block of 100 mm by milling tool. Nine experiments were conducted on CNC milling machine and reduced the surface roughness parameter with the help of L9 orthogonal array. It has been observed during the experiment the variations in the machine parameters are optimized with various combinations of parameters and thus the performances of surface quality is noted. Finally, after Taguchi and ANOVA analysis, the variation in parameter was noted and found that the speed of spindle is around 1000 rpm, feed rate of 0.3 and depth of cut 1.5 are the most significance combination that produced the high value of Signal to noise for better surface roughness. The machining parameter and their optimum value is shown in the table I.
Table I: Process Optimization Values

| Parameter     | Optimum Value |
|---------------|--------------|
| Speed         | 1000         |
| Feed Rate     | 0.3          |
| Depth of Cut  | 145          |

Once set all the parameters, run the confirmation test and values are tabulated as below in table II. Therefore, the minimum surface roughness value after optimization is 2.036.

Table II: Confirmation Test

| Experiment No. | Surface Roughness, Ra |
|----------------|-----------------------|
| 1              | 2.02                  |
| 2              | 2.06                  |
| 3              | 2.04                  |
| 4              | 2.02                  |
| 5              | 2.04                  |
| Mean Value     | 2.036                 |

Saravanakumar et.al [2] has conducted an experimental investigation is made on the effect of various factors like speed of tool, feed rate and weight percentage of alumina particle in reducing the surface roughness during the drilling operation. The carbide material drill bit of having 6 mm diameter is used to performed the drilling operation. Taguchi’s experimental design concept is used for optimizing the design parameters with three levels for better surface finish. The experimental outcomes and microstructure of machined surface reveal that the drilled samples at lowest feed rate shows better performance on surface roughness. The weight percentage of alumina has its influence to improve and minimize the surface roughness parameter by the spindle speed while drilling the fabricated samples. The confirmation test based on the initial and optimal level can be shown in the table III.

Table III: Confirmation Test

| Surface Roughness          | Initial Level | Optimal Level | Experimental | Predicted |
|----------------------------|---------------|---------------|--------------|-----------|
| A1B1C1                     | 2.5           | A3B1C2        | 1.64         | 1.86      |
| Improvement in Surface finish from initial level | 0.86          |

Pragajibhai et.al [3] found that in his research that the Taguchi technique gives a basic and effective approach for the enhancement of parameters. The outcomes acquired in this investigation, the following parameters can be optimized as follows:

1. After successfully completed the experiment the total % contribution regarding machine parameters are cutting speed 31.30%, feed rate 33.70 %, depth of cut is 33.59% and thus finally the error is 1.13% for obtaining the minimized surface roughness value.
2. The minimum value of surface roughness is obtained at maximum depth of cut 33.70% (percentage contribution).
3. The minimum surface roughness value and RA value of 1.81 microns can be obtained at combination of the said parameters and their levels A2B2C1. The percentage contribution of all the factor is shown in the table IV.

| Table IV: Surface Roughness Measurement through S/N and ANOVA |
|----------------|-------------|-------------|-------------|-----|-----|-----|
| Factor         | DOF | Average S/N Values | SS | % contribution |
|                |     | Level-I | Level-II | Level-III |
| Cutting speed  | 2   | 6.7     | 4.4      | 2.3      | 31.3 | 31.59 |
| Depth of Cut   | 2   | 2.16    | 4.0      | 4.0      | 33.4 | 33.7  |
| Feed           | 2   | 4.4     | 6.9      | 6.9      | 33.3 | 33.5  |
| Error          | 0   | --      | --       | --       | 1.1  | 1.1   |
| Total          | 8   | --      | --       | --       | 177.4| 100   |

Parashar et.al [4] has conducted an experimental on End Milling process and analysed their results through Taguchi parameter design. After successfully completion the experiments found that the the spindle speed 26.9 , feed rate of 50mm/min and depth of cut 0.4mm can achieve to minimized the surface roughness value. The most significance factor is spindle speed, which effect the surface roughness values can be predicted through ANOVA analysis. Further experimental values shows that the surface roughness value can be affect by changing the spindle speed. Therefore combining all the experimental result it was observed that if increase the spindle speed will reduced the surface roughness value and if reduce the spindle speed will increase the surface roughness value. Through this great result as shown in the table V, it is concluded that the Taguchi analysis is very effective tool for optimization of machining parameter

| Table V: Confirmation Run and Surface roughness value |
|----------------|----------------|---------------|
|                | Initial parameter | Optimal parameter |
| Level          | S1F1D1           | S3D3F1         |
| Surface roughness | 2.18,2.10,2.14   | 1.20,1.15,1.11 |
| Average        | 2.14             | 1.033          |

Alagarsamy et.al [5] has conducted a drilling experiments on the Aluminum alloy of grade 7075 by using the spiral drill bit which is made of high speed steel and with the help of Taguchi analysis to determine the study and the effect of various factors of drilling like the depth of cut, tool speed and their cutting performance , variation in feed rate , nature of the surface roughness at varying these parameters and the material removal rate. Based on the outcomes acquired in this investigation, the following parameters can be optimized as follows,
1. The cutting speed is around 1000 revolution per minutes, tool feed rate 0.12 mm per revolution and depth of cut is 3.4 mm is the optimized factor after analysis through Taguchi technique for material removal rate during the defined drilling operation on the basis of all the above machining parameters.
2. The depth of cut is the most significance factor and other factors feed rate and cutting speed is the least significant factors, which effect the MRR as per the analysis through ANOVA and S/N ratio response table.

3. The majorly contributing of about 56.96% is stand for depth of cut, 20.11% is for feed rate and 3.56% is for depth of cut in obtaining optimal MRR. The percentage contribution of factor is as shown in table VI.

**ANOVA Result for MRR**

| Factor       | DOF | SS     | MS   | F    | % contribution |
|--------------|-----|--------|------|------|----------------|
| Cutting speed| 3   | 96090  | 32030| 0.36 | 3.5            |
| Feed         | 3   | 541414 | 180472| 2.0  | 20.1           |
| Doc          | 3   | 1533071| 511024| 5.8  | 56.9           |
| Error        | 26  | 521231 | 86872|--   | 0.19           |
| Total        | 15  | 2691807|--   |---   | 100            |

Navanth et.al.[6] has discussed in detailed about the optimization of various drilling parameters by utilizing Taguchi method to acquire least surface roughness and the hole created through the conventional machine and their related drilling operation were led utilizing the L18 orthogonal array. For conducting the experiment Al 2014 alloy material and HSS twist drill bit was used under dry conditions and the outcome results was analyzed through ANOVA and MiniTab Software. After analyzing the result the speed of spindle was 300 RPM. Tool Structural and their Helix angle and tool feed rate of around 0.15 mm per revolution is the optimum condition to produced high S/N ratio for hole roughness. And furthermore the spindle was of 200 revolution per minutes. Tool Structural like point and the associated Helix angle of 900/150 and 0.36 mm per revolution feed rate are the another optimum values that provided the high Signal to noise ratio for hole diameter.

Tyagi et. al. [7] has detailed discussion about the feasibility of CNC drilling with HSS tool on the MS block and analyzed the Machinability behavior. The optimization of machining process is studied through Taguchi analysis and the results was further verified by ANOVA analysis. The S/N ratio’s is used to determine the main factors which effect the machining process and shown their performance significance during drilling the hole in MS plate. After analysed all the parameters through ANOVA the spindle speed of machine is a major factor which affects the drilling operation. The other factor like feed rate is responsible and affects the MRR process. The various parameter and S/N are shown in table VII & VIII.

| Parameters | Level | Observed Value |
|-----------|------|----------------|
| Speed     | I 1000 | 2.Machinability behavior |
| Feed      | 0.5   | 2.2.Materials removal rate |
| Depth of cut | 0.3 | 2.3.Surface roughness |

| Level | A | B | C |
|-------|---|---|---|
|       |   |   |   |
Sharma et. al. [8] has conducted CNC drilling operation on AISI 304 SS material block to study the performance characteristics with various input parameters like spindle speed, point and helix angle feed rate and depth of cut to obtain the minimum value of surface roughness and maintain the minimum ovality. Experiments are conducted on variation and combination of all the above machining parameters and based on Taguchi L16 orthogonal array. The Taguchi analysis and S/N ratio is used to obtain the most significance factors that affect the surface roughness, minimum ovality and performance characteristics. The outcome result of this experiment was came from S/N ratio and ANOVA is feed rate which having great significance.

Madhavi et al [9] have described the correlation between quality and productivity. In order to do this the studied the turning process may improve by good surface finishing and enhance their hardness by optimizing the process parameters through Taguchi and DOE technique. Further in this study it is noticed that the traditional design was based on Taguchi approach on the assumption that different types of quality measurement are independent but in actual practice it was seen that they (indices) actually have some correlation among them. To overcome this problem the ANOVA technique was used for composite principle component and found the optimal setting of the process parameter.

Conclusions
In this review paper focus on all the experimental results and Optimization of various parameters which effects the milling and drilling process are analyzed. The investigation of connection and their associated levels between the inside boundaries and the outside boundaries are done so as to optimize all the possible machining parameters to make the milling and drilling operation with enhanced their quality and cost effective analysis. It is also observed from the results that the out of all the machining parameters the impact of cutting speed has more dominant effect on the surface roughness. It is observed from the above research literatures that if cutting speed is increased then the surface roughness parameter is improved and with the other hand if increase in depth of cut and feed rate there is a significant deterioration in surface roughness parameter. From the Taguchi analysis, it is found that the cutting speed of tool should be taken at higher level for all the materials and the other factors like feed rate and depth of cut should be taken at low level. All these interactions of factors can be easily understand through ANOVA and Signal to Noise ratio and it is a very easy way to optimise the machining parameters for drilling and milling process.

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