A Review on Mild Steel Drilling Process Parameter for Quality Enhancement

[1] Sarwar Alam, S Mojahid Ul Islam[2]
1M.Tech Student, Departmentof Mechanical Engineering Al- Falah University, Faridabad, Haryana
2Asst. Professor, Departmentof Mechanical Engineering Al- Falah University, Faridabad, Haryana

Abstract— in manufacturing industry drilling process is very common and hence, plays a vital role in quality, establishing the quality goals of manufactured product. The aim of this paper is to make a review the optimization of cutting parameters in drilling using Taguchi method to get minimum surface roughness. In this review, the major factors namely speed; feed and depth of cut are considered. The orthogonal array, signal-to-noise ratio and the analysis of variance were employed to find out the optimal value by studying the effect of these parameters.

Index Terms— Drilling machine, Surface roughness, Taguchi method, ANNOVA

1. Introduction

Drilling is a machining process used to make hole of circular cross section by using a drill bit. The quality and cost is one of the prime requirements of customers for machined parts productivity is also necessary to fulfill the customers demand. For this purpose quality of a product and productivity should be high and cost should be low. For achieving good quality at low cost there is a strong need of recognising the optimal cutting parameters. Based on work piece material, tool material, tool dimension and some other criteria, the cutting parameters can be selected for each process. They may be cutting speed, feed rate, depth of cut, cutting fluid, tool diameter can affect every process. For designing high quality systems efficiently and effectively the Taguchi method is very commonly used in process optimization.

2. Taguchi Method

Taguchi method is a powerful tool for the design of high-quality systems. It provides a simple, efficient and systematic approach to optimize the designs for performance, quality, and cost. The methodology is valuable when the design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the settings of the design parameters and reduce the sensitivity of the system performance to sources of variation. In recent years, the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries and countries. Basically, experimental design methods were developed originally Fisher. However, classical experimental design methods are too complex and not easy to use. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal – to – noise (S/N) ratio to measure the quality characteristics deviating from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the – lower – better, the – higher – better, and the – nominal – better. The S/N ratio for each level of process parameter is compared based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio. Furthermore, a statistically significant with the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. Taguchi method gained popularity in engineering and science.

Community as the user can apply with limited knowledge of statistics for obtaining good quality at low cost. Taguchi uses signal to noise (S/N) ratio and orthogonal array to achieve optimal condition of the process parameter. S/N ratio is divided into three groups i.e.

1) Smaller the better
2) Larger the Better
3) Nominal the best type

1. SMALLER IS BETTER S/N = -10*log(S (Y2)/n)

The signal-to-noise (S/N) ratio is calculated for each factor level Where Y = responses for the given factor level combination and n combination. The formula for the smaller-is-better S/N ratio using number of responses in the factor level combination.

2. LARGER IS BETTER S/N = -10*log(S (1/Y2)/n)

The signal-to-noise (S/N) ratio is calculated for each factor level Where Y = responses for the given factor level combination and n combination. The formula for the larger-is-better S/N ratio using number of responses in the factor level combination.

3. NOMINAL IS BEST S/N = -10*log (s2)

The signal-to-noise (S/N) ratio is calculated for each factor level Where s = standard deviation of the responses for all noise factors combination. The formula for the nominal-is-best I S/N ratio for the given factor level combination.

2.1 General steps involved in the Taguchi Method are as FOLLOW:

1. Define the process objective, or more specifically, a target value for a performance measure of the process. This may be a flow rate, temperature, etc. The target of a process may also be a minimum or maximum; for example, the goal may be to maximize the output flow rate. The deviation in the performance characteristic from the target value is used to define the loss function for the process.
2. Determine the design parameters affecting the process. Parameters are variables within the process that affect the performance measure such as temperatures, pressures, etc. that can be easily controlled. The number of levels that the parameters should be varied at must be specified. For example, a temperature might be varied to a low and high value of 40 C and 80 C. increasing the number of levels to vary a parameter at increases the number of experiments to be conducted.
3. Create orthogonal arrays for the parameter design indicating the number of and conditions for each experiment. The selection of orthogonal arrays is based on the number of parameters and the levels of variation for each parameter, and will be expounded below.
4. Conduct the experiments indicated in the completed array to collect data on the effect on the performance measure.
5. Complete data analysis to determine the effect of the different parameters on the performance measure.

2.2Data analysis to determine the optimum levels for control factors:

After the experiments have been conducted, the optimal test parameter configuration within the experiment design must be determined. To analyse the results, the Taguchi method uses a statistical measure of performance called signal to noise (S/N) ratio borrowed from electrical control theory.

2.3 Signal to Noise (S/N) ratio

The S/N ratio developed by Dr. Taguchi is a performance measure to choose control levels that best cope with noise. The S/N ratio takes both the mean and the variability into account. In its simplest form, the S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). The S/N equation depends on the criterion for the quality characteristic to be optimized.

2.4 ANALYSIS OF VARIANCE (ANOVA)

The Analysis Of Variance (ANOVA) is a powerful and common statistical procedure in the social sciences. It is the application to identify the effect of individual factors [10].In statistics, ANOVA is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. In its simplest form ANOVA gives a statistical test of whether the means of several groups are all equal, and therefore generalizes.

ANOVA is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest. The statistical significance of the experiment is determined by a ratio of two variances. This ratio is independent of several possible alterations to the experimental observations: Adding a constant to all observations does not alter significance. Multiplying all observations by a constant does not alter significance. So ANOVA statistical significance results are independent of constant bias and scaling errors as well as the units used in expressing observations

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3. Surface Roughness is a measure of the surface texture of a manufactured surface. It is the fluctuation of the surface from a reference plane. Low fluctuation from the reference line means low roughness. Optimal settings of the cuttings parameters are most important for obtaining low surface roughness. Complete definition of a surface includes Ra (Arithmetic Average Roughness), Rp (Maximum Peak Height), Rv (Maximum Valley Depth) and Rt (Maximum Peak-to-Valley Roughness Height), Rz (average Rt over a given length).

4. FINDINGS FROM LITERATURE REVIEW

The purpose of this study is to investigate the influence of cutting parameters, such as cutting speed and feed rate, and point angle on surface roughness produced when drilling Mild steel. Design method, was performed drilling with cutting parameters in Mild steel. The orthogonal array, signal-to-noise ratio, and analysis of variance (ANOVA) were employed to investigate the optimal drilling parameters of Mild steel. From the analysis of means and ANOVA, the optimal combination levels and the significant drilling parameters on surface roughness were obtained.

Yogendra Tyagi and Vedansh Chaturvedi et al. (2012) [1] investigated the effect of cutting parameters spindle speed, feed rate and depth of cut for maximizing material removal rate and minimizing surface roughness in drilling mild steel. Taguchi L9 orthogonal array is used. Results are analyzed using Taguchi DOE software. They concluded that spindle speeds affects most surface roughness and feed rate largely affects Material removal rate.

Kadam Shirish, M. G. Rathi (2013) [2] focused on optimization of drilling parameters using the Taguchi technique. L9 orthogonal array has been used to drill on EN-24 steel blocks. Uncoated M32 HSS twist drill was used under dry condition. Cutting speed, feed rate and depth of hole were taken as process parameter. S/N ratio was employed to get optimal control factors. They found that cutting speed was the main significant factors on surface roughness and the tool life.

A. Navanth, T. Karthikeya Sharma (2013) [3] focused on optimization of drilling parameter for minimum surface roughness and hole diameter by using Taguchi methodology. Al 2014 material and HSS twist drill bit has been taken for performing experiment. L18 orthogonal array has been used and the result obtained were analyzed in MINITAB 16 .Analysis of variance (ANOVA) was used to find out the optimal factors from cutting tool, spindle speed and feed rate. Optimal values are spindle speed 300 rpm, point angle and helix angle 1300/200 and feed rate .15 mm/rev for minimum roughness.

Anil Choubey, Vedansh Chaturvedi et al. (2012) [4] studied on mild steel with high speed steel tool using Taguchi L9 orthogonal array and analysis of variance(ANOVA) are applied to study the performance characteristics of machining parameter (spindle speed, feed, depth, width) with consideration of high surface finish and high material removal rate(MRR). It was found that the feed is most effective factor for MRR. And spindle speed is the most effective factor for surface roughness.

M Sundeep, M Sudhahar, et al. (2014) [5] have done an experimental investigation on drilling of Austenitic stainless Steel (AISI 316) using Taguchi L9 array. Spindle seed, feed rate and drill diameter was taken as process parameter. It was found that spindle speed plays the most dominating role in
surface finish as well as Material removal rate in drilling.

Vishwajeet N. Rane and Ajinkya P.Edlabadkar et al. (2015) [6] focused in optimizing drilling parameters such as cutting speed, feed and point angle for resharpened HSS twist drill bit on hardened boron steel using Taguchi method. L16 orthogonal array has been used to perform the experiment in a double spindle drilling machine. Analysis of variance was employed to find out effects of control factors on surface roughness. It was found that point angle was the main significant factor for tool wear and feed rate for surface roughness.

Nalawade P.S. and Shinde S.S. (2015) [7] optimizes the cutting parameters speed, depth of cut, feed and type of tool to get better Surface Finish and Hole Accuracy in dry Drilling of EN-31 material. Taguchi L9 orthogonal arrays, S/N ratio, ANOVA, Regression analysis were done to find out the optimal settings. Optimal settings for surface roughness were Cutting speed (30 m /min), feed (.2 mm/min) and type of tool (HSS uncoated).

V.Balakumaran and C. Parthasarathy et al. (2015) [8] have investigate the cutting parameters speed, feed and types of drill tool for better surface roughness and material removal rate in CNC drilling of EN31 material. . Taguchi L9 orthogonal array has been used and the results obtained were analyzed in MINITAB 15 .Analysis of variance (ANOVA) was used to find out the optimal factors from speed, spindle feed rate and types of drill tool. It was found that the feed plays the most dominating role in surface finish.

Ranganath M. S and Sachin Atwal et al. (2016) [9] studied drilling on machinability of glass fibre reinforced polymer laminated composites using Taguchi L27 orthogonal array. The objective of this research paper is to find out optimal values of drilling parameters in order to achieve minimum value of surface roughness is obtained. The combination of optimal process parameters for the work piece under consideration with regards to minimum surface roughness has been obtained at speed 440 rpm, drill diameter 10 mm and feed rate 0.20 mm/rev. Analysis has revealed that feed is dominant parameter followed by speed and drill diameter.

Himanshu Gupta and Umesh Kumar Vates et al (2016) [10] have investigated the effects of four controllable input variables namely-spindle speed, feed, coolant concentration and flow rate on output parameters of surface roughness (SR) and material removal rate (MRR) in drilling process with the help of Response surface methodology. Experiments were conducted on high speed steel (HSS T1 grade) with tungsten carbide drill bit. They found the response through RSM technique, where MRR is 0.0017 g/sec and SR is 1.2718 microns. It was found that the spindle speed and feed plays most dominating role in surface finish as well as Material removal rate.

Inamdar1 and N. S. Bagal et al. (2017) [11] have study on carbon steel EN8. In this work cutting speed, feed rate and depth of cut are taken as performance parameters to achieve better surface roughness. Taguchi L9 orthogonal array is used to design the experiments. After the experiment, it was found that cutting speed has more influenced on the surface roughness.

Reference No	Year	Author's Name	Work piece Material	Input Parameter	Method used	Output Parameter	Most Significant
1	2012	Yogendra Tyagi, Vedansh Chaturvedi, et al.	Mild steel	Spindle speed, Feed rate, Depth of cut	Taguchi Method	Surface roughness , Material removal rate	Spindle speed, Feed rate
2	2013	Kadam Shirish, M. G. Rathi	EN 24	Cutting speed, Feed rate, Depth of hole	Taguchi Method	Surface roughness, Tool life, Thrust force	Cutting Speed
3	2013	A.Navanth, T.Karthikeya Sharma	Al 2014	Cutting tools, Spindle speeds, Feed rate	Taguchi Method	Surface roughness, Hole diameter	Spindle speeds(300 rpm optimum), Feed rate(.15 mm / rev optimum)
4	2012	Anil Choubey, Vedansh Chaturvedi et al	Mild steel	spindle speed, feed, depth, width	Taguchi Method	surface roughness, material removal rate	Spindle speed
5	2014	M Sundeep, M Sudhahar, et al.	AISI 316	Spindle seed, Drill diameter, Feed rate	Taguchi Method	Surface roughness , Material removal rate, Thrust force	Spindle speed
6	2015	Vishwajeet N. Rane and Ajinkya P.Edlabadkar et al.	Harden Boron steel	Cutting speed, Feed, Point angle	Taguchi Method	Tool life, Surface Roughness	Point angle, Feed rate
7	2015	Nalawade P.S. and Shinde S.S.	EN-31	Speed, Depth of cut, Feed, Type of tool	Taguchi Method	Surface Finish, Hole Accuracy	Speed, Feed, Type Of Tool, Drill Depth
8	2015	V.Balakumaran and C. Parthasarathy et al.	EN-31	Speed, Feed, Types of drill tool	Taguchi Method	Surface Finish, Material removal rate	Feed
9	2016	Ranganath M. S and Sachin Atwal et al.	GFRP	Speed, Feed, Drill diameter	Taguchi Method	Surface Roughness	Feed
10	2016	Himanshu Gupta and Umesh Kumar Vates et al	HSS T1 grade	Speed, Feed, Coolant, Flow rate	RSM	Surface Roughness, Material removal rate	Speed, Feed
11	2017	Inamdar1 and N. S. Bagal et al.	EN-8	Cutting Speed, Feed, Depth of cut	Taguchi Method	Surface Roughness	Cutting Speed

4 Conclusion

From the literature survey we observed that many researchers took input parameters : cutting speed, feed rate and depth of cut and few took input parameter: Cutting fluid, drill tool diameter, cutting tools, point angle, clearance angle, type of tool and output parameters were taken: surface roughness, material removal rate (MRR), Thrust force, tool wear, Hole diameter, Hole Accuracy, Roundness error. It is found that for surface roughness the most significant parameters are speed, feed and drill diameter, cutting fluids and least dominant parameter is DOC.

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