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A Review on Experimental Investigation and Optimization of Process Parameters in Drilling Mild Steel with HSS Drill Bit using Taguchi Method

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***Abstract*— The primary objective of this paper is to make a review of literature on Optimization of Cutting Parameters in Drilling mild steel using Taguchi Methodology to obtain minimum surface roughness. The settings of the parameters were made by using Taguchi's orthogonal array for performing the experiment. Analysis of variance (ANOVA), signal to noise (S/N) ratio, regression analysis were employed by the various researchers to find out the optimal value by investigating the effects of the cutting parameter. It has been observed that the minimum surface roughness of a machined workpiece is influenced by several process parameters such as spindle speed, feed rate, cutting fluid, drill tool diameter etc.**

Keywords — Signal to noise ratio, Analysis of Variance, Taguchi Methodology, Regression analysis, Orthogonal Array, cutting parameters.

I. INTRODUCTION

In today's competitive market satisfaction of customers plays the most important role in gaining profits. Every company focuses on employees to fulfil customer's expectation. Quality means conformance to specification. It is necessary for meeting the customer satisfaction. To become competitive it is desirable to produce high quality products at low cost in a short duration of time. But it is difficult to achieve in practical due to which every company must have to adopt some quality strategies and philosophies. Drilling is one of the most important machining process as 60% of the parts rejection is due to poor quality hole. It has been estimated that 33% of all metal cutting operations are spent in drilling [17]. The process parameters such as cutting speed, drill tool diameter and cutting fluid plays a significant role in surface finish of drilled hole [14]. So proper selection of process parameters are very important to obtain good quality drill hole [8]. Now a days Taguchi method is extensively used to produce high quality low cost products [18]. Genichi Taguchi, an engineer and statistician has developed this method which becomes the prominent statistical tool in Total quality management.

A. Taguchi Method

Taguchi Method has been developed by a Japanese engineer Dr Genichi Taguchi. It is a statistical tool for standardize the fractional factorial design. He designed orthogonal array (OA) to standardize it and to optimize the levels of process parameters. Taguchi believed in offline quality control. To produce robust design, which are less sensitive to the uncontrollable environmental factors, is the main aim of the Taguchi Method. Taguchi developed the concept of Taguchi loss function and signal to noise (S/N) ratio. S/N ratio is divided into
Three groups namely: 1) Smaller the better, 2) Larger the better, 3) Nominal the best type

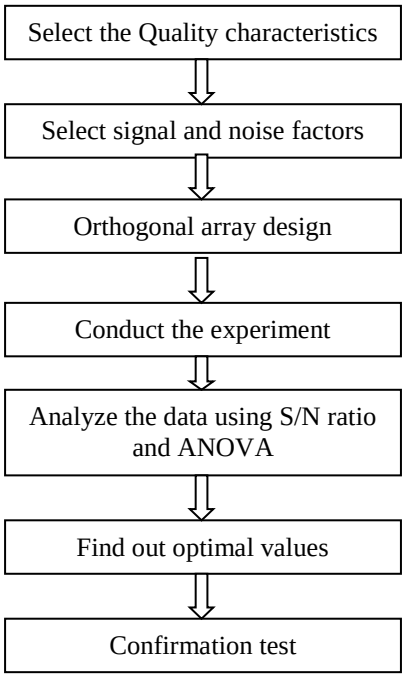

Fig. 1: Taguchi method

Figure 1 shows the block diagram of the Taguchi method used.

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B. Surface Roughness

Surface Roughness is a measure of the surface structure of a machined surface. The fluctuation of the surface from a reference plane is the surface roughness. If the fluctuation from the reference line is low then it means low roughness and vice versa. It is one of the good predictors of performance of a machined part. That is why optimal settings of the cuttings parameters are necessary for obtaining low surface roughness [2]. The definition of a surface includes Ra (Arithmetic Average Roughness), Rv (Maximum Valley Depth), Rp (Maximum Peak Height), Rz (average Rt over a given length) and Rt (Maximum Peak-to-Valley Roughness Height). Surface roughness creates a trade-off between the performance of machined parts and its manufacturing cost.

The basic terminologies used in surface roughness are as follows

1) Lay

It is the direction of the primary surface pattern found by the production method adopted.

2) Surface roughness

It is a measure of the deviation of surface irregularities in the machined surface from reference plan.

3) Waviness

It is the measure of surface irregularities having spacing greater than surface roughness. It occurs during the machining due to vibration, warping etc.

4) Profile

It is a contour of any specified section.

II. LITERATURE REVIEW

Many researchers have studied the effect of various cutting parameters such as cutting speed, feed rate, drill tool diameter, cutting fluid, point angle, depth cut etc on the surface finish in drilling. Some of the literature related to this has been discussed below:

Yogendra Tyagi, Vedansh Chaturvedi, et al. (2012) [1] studied the effect of cutting parameters such as spindle speed, feed rate and depth of cut for maximizing the material removal rate as well as minimizing the surface roughness in drilling mild steel. Taguchi L9 orthogonal array used in the experiment and the results were analyzed using Taguchi DOE software. They have found spindle speeds affects significantly surface roughness and feed rate largely affects material removal rate.

M Sundeep, M Sudhahar, et al. (2014) [2] have investigated the drilling of Austenitic stainless Steel (AISI 316) using Taguchi L9 array. Spindle speed, feed rate, and drill diameter were taken as process parameters. They found that spindle speed plays the most dominating role in the surface finish as well as Material removal rate in drilling.

Kadam Shirish, M. G. Rathi (2013) [3] focused on optimization of drilling parameters by using the Taguchi Method. Taguchi L9 orthogonal array was used to drill on EN-24 steel blocks. Uncoated M32 HSS twist drill has been used under dry condition. Cutting speed, feed rate and depth of hole were taken as the process parameter. They found that cutting speed has the most significant effect on surface roughness and the tool life.

Turgay Kıvak, Gurcan Samtas, et al. (2012) [4] studied the effect of cutting parameters such as cutting tool, cutting speed and feed rate on drilling of AISI 316 stainless steel. Experiments were conducted in CNC vertical machine using Taguchi L16 array. Coated and uncoated M35 HSS twist drill bit were employed under the dry condition for this purpose. Analysis of variance was employed to draw the effects of the control factors. They found that cutting tool and feed rate were the most significant factor on surface roughness and thrust force respectively.

Adem Çiçek, Turgay Kıvak, et al. (2012) [5] studied the effect of deep cryogenic and cutting parameters on surface roughness as well as roundness error in the drilling of AISI 316 austenitic stainless steel. Cutting tools, cutting speeds and feed rate were taken as the control factors. M35 twist drill bit was used in the experiment. Taguchi L8 orthogonal array was employed and multiple regression analysis was performed to find out the predictive equation of surface roughness.

A. Navanth, T. Karthikeya Sharma (2013) [6] concentrated on optimization of drilling parameters for obtaining minimum surface roughness and hole diameter by using Taguchi method. Al 2014 material and HSS twist drill bit have been selected for performing the experiment. Taguchi L18 orthogonal array was used and the results obtained were analyzed with the help of MINITAB 16. Analysis of variance (ANOVA) was employed to find out the optimal parameters from cutting tool, spindle speed and feed rate.

Reddy Sreenivasulu (2014) [7] concentrated on optimization of surface roughness in the drilling of Al 6061 using Taguchi design methodology and artificial neural network method. In their study cutting speed, feed rate, drill diameter, clearance angle and point angle were taken as process parameters and HSS twist drill bit as a tool. Taguchi L27 orthogonal array, S/N ratio, ANOVA were used to study the effects of the process parameters. They found that cutting speed, feed rate, drill diameter and point angle all were significant on surface roughness. The Optimal settings for roughness were found to be speed 800 rpm, feed rate .3 mm/rev, drill diameter 10 mm, clearance angle 40, point angle 1180.

J.Pradeep Kumar, P.Packiaraj (2012) [8] studied the effect of cutting parameters such as cutting speed, drill tool diameter feed and feed on the surface finish of OHNS material using HSS spiral drill bit as cutting tool. Taguchi L18 orthogonal array, S/N ratio, ANOVA and Regression analysis were employed to study the effect of process parameters on surface roughness. Experimental data were

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analysed using MINITAB 13 and they found that both speed and feed plays most important role in surface roughness, material removal rate.

B.Shivapragash, K.Chandrasekaran, et al. (2013) [9] focused on optimization of cutting parameters namely feed rate, spindle speed, depth of cut to study their influence in drilling composite Al-TiBr2. Taguchi methods with Grey Relational analysis were employed to optimize the factors. Taguchi L9 orthogonal array was used and optimal settings found for better surface finish were feed rate (1.5 mm/rev), spindle speed (1000 rpm) and depth of cut 6 mm.

Nalawade P.S. and Shinde S.S. (2015) [10] optimizes the process parameters speed, depth of cut, type of tool and feed to get better Surface Finish and Hole Accuracy in Drilling of EN-31 material. Taguchi L9 orthogonal array, Regression analysis, S/N ratio and ANOVA were employed to find out the optimal settings. Optimal settings for surface roughness were found to be Cutting speed (30 m /min), feed (.2 mm/min), type of tool (HSS uncoated).

Nisha Tamta, R S Jadoun (2015) [11] analyzed the effect of spindle speed, feed rate and drilling depth in drilling Aluminium alloy 6082. They used Taguchi L9 orthogonal array to perform the experiment. Analysis of variance (ANOVA), Signal to noise ratio (S/N) were employed to study the effects drilling parameters on surface roughness. For analyzing statistical software MINITAB-15 were used. They found that spindle speed 3000 rpm, feed rate 15 mm/min, drilling depth 9 mm were the optimum value. According to them, drilling depth was the most significant factor for surface roughness followed by spindle speed.

Srinivasa Reddy, S. Suresh, et al. (2014) [12] studied the impact of process parameters such as cutting speed, point angle and feed rate on surface roughness in the drilling of AL 6463 material. HSS drill bit was used as a tool and the experiment was performed in CNC drilling machine using Taguchi L9 orthogonal array. Analysis of variance (ANOVA), signal to noise ratio (S/N) were employed to find out the optimal drilling parameters. They found that Cutting speed, feed rate and point angle plays the most significant role on surface roughness during drilling of AL 6463 material.

Sathish Rao U And Lewlyn .L.R. Rodrigues (2014) [13] have made an attempt to investigate the effect of spindle speed, fibre orientation, feed rate and drill diameter on tool wear during dry drilling of GFRP components. HSS drill bit was used in the experiment. Taguchi L9 orthogonal array was used. S/N ratios, regression analysis, ANOVA were used to find out the optimal settings. They found that speed, feed rate, drill diameter has a significant effect on tool wear.

Arshad Noor Siddiquee, Zahid A. Khan, et al. (2014) [14] concentrated on optimising drilling parameters such as cutting fluid, speed, feed and hole depth in drilling AISI 312 material. All the experiments were done in CNC lathe machine using solid carbide cutting tool. Taguchi L18 orthogonal array was used for the experiment. Signal to noise ratio (S/N), analysis of variance (ANOVA) were employed to find out the effects of cutting parameters on surface roughness. They found that in the presence of cutting fluid, speed 500 rpm, feed .04 mm/sec, hole depth 25 mm were the optimum value of process parameters. It is seen from the ANOVA analysis that speed was the most significant factor followed by cutting fluid, feed and hole depth for surface roughness.

Vishwajeet N. Rane, Ajinkya P.Edlabadkar, et al. (2015) [15] concentrated on optimizing drilling parameters such as cutting speed, feed and point angle for resharpened HSS twist drill bit on hardened boron steel using Taguchi method. Taguchi L16 orthogonal array was used to perform the experiment in a double spindle drilling machine. Analysis of variance was employed to find out effects of process parameters on surface roughness. They found that point angle was the most significant factor for tool wear and feed rate for surface roughness.

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TABLE 1: SUMMERY OF LITERATURE REVIEW

Reference No	Year	Author's Name	Workpiece Material	Input Parameter	Method used	Output Parameter	Most Significant
1	2012	Yogendra Tyagi, Vedansh Chaturvedi, et al.	Mild steel	Spindle speed, Depth of cut, Feed rate	Taguchi Method	Surface Roughness	Spindle speed, Feed rate
2	2014	M Sundeep, M Sudhahar, et al.	AISI 316	Spindle speed, Feed rate, Drill diameter	Taguchi Method	Surface Roughness	Spindle speed
3	2013	Kadam Shirish, M. G. Rathi	EN24	Cutting speed, Feed rate, Depth of hole	Taguchi Method	Surface roughness, Tool life	Spindle speed
4	2012	Turgay Kıvak, Gurcan Samtas, et al.	AISI 316	Cutting tool, Cutting speed, Feed rate	Taguchi Method	Surface roughness,	Cutting tool, Feed rate
5	2012	Adem Çiçek, Turgay Kıvak, et al.	AISI 316	Cutting tools, Cutting speeds, Feed rate	Taguchi Method	Surface roughness, Roundness error	Cutting speed, Feed rate
6	2013	A. Navanth, T. Karthikeya Sharma	Al 2014	Cutting tools, Spindle speeds, Feed rate	Taguchi Method	Surface roughness	Feed rate(.15 mm/rev), Spindle Speeds (300 rpm),
7	2014	Reddy Sreenivasulu	Al 6061	Cutting speed, Drill diameter, Point angle, Feed rate and Clearance angle	Taguchi design method, Artificial neural network method	Surface roughness	Cutting speed, Drill diameter Feed rate,
8	2012	J.Pradeep Kumar, P.Packiaraj	OHNS	Cutting speed, feed, Drill tool diameter	Taguchi method	Surface roughness, Tool wear, Material removal rate	Speed, Feed
9	2013	B.Shivapragash, K.Chandrasekaran, et al.	MMC Al-TiBr2	Spindle speed, Feed rate, Depth of cut	Taguchi method, Grey Relational Analysis	Surface finish	Spindle speed, Feed rate
10	2015	Nalawade P.S. and Shinde S.S.	EN-31	Speed, Depth of cut, Feed, Type of tool	Taguchi Method	Surface Finish, Hole Accuracy	Type Of Tool, Speed, Feed, Drill Depth
11	2015	Nisha Tamta, R S Jadoun	Al alloy 6082	Spindle speed, Feed rate, Drilling depth	Taguchi Method	Surface roughness	Spindle speed, Drilling depth
12	2014	Srinivasa Reddy, S. Suresh, et al.	AL 6463	Cutting speed, Point angle, Feed rate	Taguchi Method	Surface roughness	Spindle speed, Feed rate, Point angle
13	2014	Sathish Rao U And Lewlyn .L.R. Rodrigues	GFRP	Spindle speed, Feed rate, Fibre Orientation, Drill diameter,	Taguchi method	Tool wear	Cutting speed, Feed rate, Drill diameter
14	2014	Arshad Noor Siddiquee, Zahid A. Khan, et al.	AISI 312	Cutting fluid, Speed, Feed, Hole depth	Taguchi method	Surface roughness	Speed, Hole depth, Cutting fluid, Feed
15	2015	Vishwajeet N. Rane, Ajinkya P.Edlabadkar, et al.	Harden Boron steel	Cutting speed, Feed, Point angle	Taguchi method	Surface roughness	Point angle, Feed rate

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III. CONCLUSION

From the literature survey, it is seen that most of the researchers took input parameters: cutting speed, feed rate and depth of cut and few took input parameter: Cutting fluid, drill tool diameter, clearance angle, type of tool and output response were taken: surface roughness, material removal rate, Hole Accuracy. It is found that speed, feed, drill diameter and cutting fluids are the most significant factors on surface roughness. Depth of cut is found to be the less significant factor.

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