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A Review on Optimizations Parameters in Drilling using Taguchi Method

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Abstract- Metal matrix composite has widespread applications because of its excellent properties like high strength, fracture toughness and stiffness which draw a quite more attention now-a-days. Drilling is one of most common conventional machining processes being applied on MMCs. For obtaining high product quality and satisfactory process performance yield it is indeed necessary to control and optimize several drilling parameters. Taguchi's philosophy has been manly concerned with optimization of single objective function, whereas drilling involves multi-response characteristics viz. thrust force, torque and circularity at entry and exit; hence exploration of an appropriate multi-objective optimization technique is certainly essential. This review paper aims at studying the effect of drilling parameters (cutting speed, feed rate and the drill point geometry) on the output responses such as, thrust force (TF), specific cutting pressure (SCP) and surface roughness (SR). Taguchi's technique has been also studied to obtain an optimal setting for drilling process parameters for optimizing the output quality characteristics.
Keywords- Metal matrix composite, S/N Ratio, Surface Roughness, Taguchi

I.INTRODUCTION

A need for thorough and systematic analysis of their machining behaviour was expected due to increased engineering applications of these composites. The accurate and low cost drilling is needed for the desired surface finish. The surface of the machining component is greatly influenced by parameters such as recrystallization, cracking, cavities, plastic deformation, micro hardness and residual stress.[1], [2], [3] Features such as roughness of the surface and surface damage of the machined component also affect properties such as corrosion, creep, fatigue life and dimensional accuracy of a machined component. [4], [5], [6]The main alarm when machining MMCs is the variation of micro structure just under the drilled surface. Machining causes different geometric and metallurgical defects in the surface area and it is not possible to make conclusive decisions about the machinability of any material by looking wear rates of the tool.[7] Nevertheless, due to the poor drilling properties of MMCs [8], it becomes a challenging task for manufacturing engineers. Unlike conventional materials machining, there are many problems with MMC drilling, such as high thrust forces burr formation and tool wear.
Drilling is a cutting technique that uses a drill bit to create a circular cross-section hole in solid materials. The drill bit is usually a multi-point rotary cutting tool. The drill is pressed against the work piece and rotated at speeds between hundreds and thousands of revolutions per minute.[9], [10], [11]

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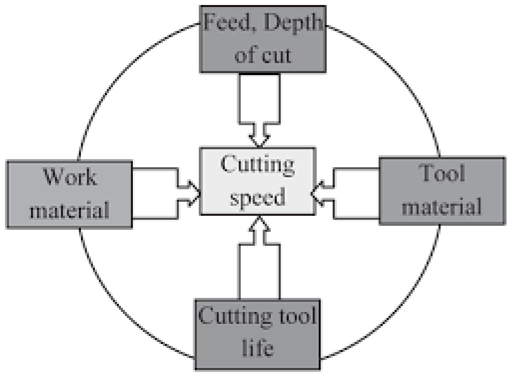

Figure 1: Drilling parameters

Taguchi is a powerful tool for the development of high-quality systems. To optimize the model for efficiency, quality and cost, it provides a simple, effective and systematic approach. [12] If development parameters are qualitative and distinct, the technique is valuable. The development of Taguchi parameters will optimize performance characteristics by setting design parameters and increasing system performance sensitivity to the origin of variation.[13]

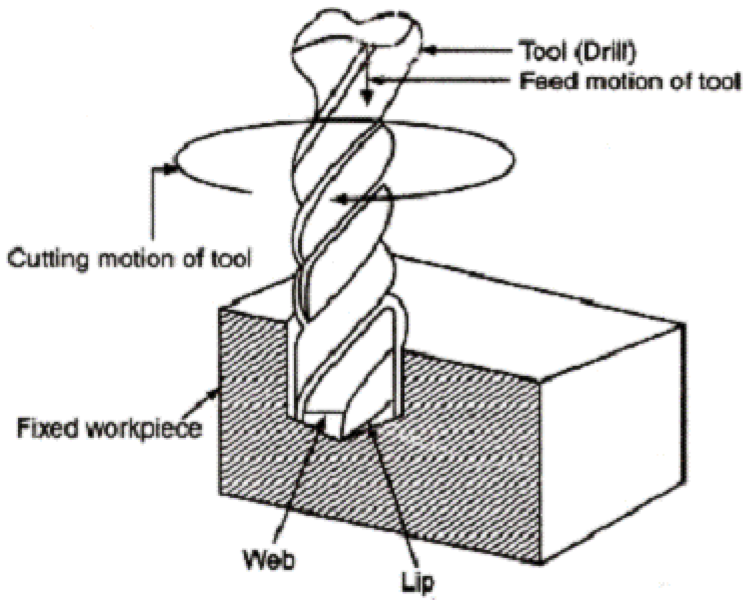

Figure 2: Drilling Process

Nomenclature

S/N ratio: Signal to noise ratio
y: observed response value
n: number of replications
σ: mean
μ: variance

II.LITERATURE REVIEW

[14] Lipin & Govindan focused on a comprehensive and in-depth review on optimization of drilling parameters using Taguchi methods. The quality and productivity aspects are equally important in the analysis of drilling parameters. Taguchi methods are widely used for design of experiments and analysis of experimental data for optimization of processing conditions. The research contributions are classified into methodology for investigation and analysis, input processing conditions and response variables.

[15] Jebarose Juliyana & Udaya Prakash made an attempt to find out the best machining parameters in the drilling of (LM5/ZrO2) using Taguchi Technique. A novel composite made of LM5 aluminum alloy reinforced with Zirconia with three different weight percentages (3, 6 & 9%) was fabricated by stir casting process. Using the Stir casting process, aluminum matrix composites (LM5/ZrO2) was successfully produced. Drilling tests were carried out in line with the Taguchi DoE. Optimization was carried out using Signal/Noise Analysis for obtaining minimum Thrust Force.

[16] Prasad & Chaitanya have focused on the effect of cutting parameters and material parameters on delamination of the drilled hole is analysed and optimum cutting condition for minimizing the delamination is determined to improve the hole quality. From the S/N ratio, the optimal process parameters for minimum peel-up delamination are speed at level 1(400rpm) feed at level 1(0.0 2 mm/rev) thickness at level 3(8 mm) and fiber orientation at level 1(0o) Similarly, the optimal conditions for push-down delamination are speed at level 2 (800 rpm) feed at level 1\ (0.02mm/rev) thickness at level 1(4 mm) and fiber orientation at level 3 (90o).

[17] Aamir et al. worked on the optimization of drilling parameters and two drilling processes—namely, one-shot drilling and multi-hole drilling—using the Taguchi method. Analysis of variance and regression analysis was implemented to indicate the significance of drilling parameters and their impact on the measured responses i.e., surface roughness and hole size. From the Taguchi optimization, optimal drilling parameters were found to occur at a low cutting speed and feed rate using a poly-drill head. Furthermore, a fuzzy logic approach was employed to predict the surface roughness and hole size.

[18] Rubi & Prakash analysed that Metal matrix composites are a new course of materials with superior properties to those of the components. Such materials ' machining is distinct from that of traditional materials. So the optimization of machining process parameters becomes inevitable. By applying Taguchi's Signal-to-Noise ratio method, this paper examines the effects of drilling process parameter such as feed, spindle speed, drill material and percentage reinforcement on the drilled holes surface roughness. Variance analysis was used to evaluate each system parameter's contribution to surface roughness. The composites were manufactured by stir casting technique using aluminium alloy (LM6) as matrix material and boron carbide particulates at 3%, 6% and 9% by weight as material for the reinforcement. There are four factors investigated each at three levels, so 34 which implies 81 experiments has to be conducted, but by using Design of Experiments

approach 27 experiments were conducted using L27 orthogonal array The minimum surface roughness measured for the hole was 1.08 µm at combination of 3000 rpm spindle speed, 50 mm/min feed rate, 3% reinforcement and Carbide drill.

[19] Modi et al. described the effective approach for the single response optimization of drilling parameters based on the Taguchi's method. This research work also reported about the influence of input process parameters i.e. spindle speed and tool diameter on the material removal rate (MRR). Taguchi L9 orthogonal array was used for planning and conduction of experiments. Analysis of Variance (ANOVA) was carried out to find which drilling parameters significantly affect the output response and it also determined the percentage contribution of individual parameter over the response.

[20] Subramanian illustrated a literature review on drilling process for various metals and its alloy about the chip thickness, cutting speed, feed rate of machining, and temperature distribution during drilling, surface integrity after machining, surface roughness, burr formation by considering the various input process parameters. This Paper reviews the main difficulties during drilling of various parts. Due to its distinctive properties, titanium and its alloys are used in major aeronautic and automotive industries, also used in jet engine components, turbine blades for its fine corrosion resistance even at high temperature. Titanium also used for replacement of human body parts because of its high strength to weight ratio.

[21] Akhil et al. aimed to optimize drilling parameters for GFRP with multi-objective of Delamination Factor (DF) and Surface Roughness (Ra and Rz) using Grey Relational Analysis (GRA) and Taguchi method. The drilling experiment is designed using Taguchi L 27 (3^{13}) orthogonal array with cutting speed, feed rate and drill diameter as the input factors at three different levels. The GRA shows that the greater Grey Relational grade is the best machining condition, the optimum process parameter which minimizes the response of Ra, Rz and DF are cutting speed (240m/min), feed rate (0.1 mm/rev) and drill diameter (8.5mm)for the range of values selected for the study.

[22] Rosidi et al. suggested that Thermal necrosis results fracture problems and implant failure if temperature exceeds 47°C for one minute during bone drilling. To solve this problem, this work studied a new thermal model by using three drilling parameters: drill diameter, feed rate and spindle speed. Effects of those parameters to heat generation were studied. The drill diameters were 4 mm, 6 mm and 6 mm; the feed rates were 80 mm/min, 100 mm/min and 120 mm/min whereas the spindle speeds were 400 rpm, 500 rpm and 600 rpm then an optimization was done by Taguchi method to which combination parameter can be used to prevent thermal necrosis during bone drilling.

[23] Soepangkat et al. aimed to optimize the drilling parameters such as cutting feed and cutting speed, drill type and drill point angle on the thrust force, torque, hole surface roughness and tool flank wear in drilling EMS 45 tool steel using MQL. In this study, experiments were carried out as per Taguchi design of experiments while an L18 orthogonal array was used to study the influence of various combinations of drilling parameters and tool geometries on the thrust force, torque, hole surface roughness and tool flank wear. The optimum drilling parameters was

determined by using grey relational grade obtained from grey relational analysis for multiple-performance characteristics. The drilling experiments were carried out by using twist drill and CNC machining center.

[24] G. Singh et al. focused on optimization of drilling parameters like rotational speed, feed rate and the type of tool at three levels each used by Taguchi optimization for surface roughness and material removal rate. The confirmation experiments were also carried out and results found with the confidence interval. Scanning electrode microscopy (SEM) images assisted in getting the micro level information of bone damage.

[25] Çiçek et al. studied the effects of cryogenic treat- ment and drilling parameters on surface and hole quality were investigated in the drilling of AISI 304 stainless steel under dry drilling conditions. The control factors to pro- vide better surface roughness (Ra) and roundness error (Re) were determined using the Taguchi method. RSM was also used to determine interactions among the control factors. In addition, analysis of variance was employed to deter- mine the most significant control factors on the surface roughness and roundness error. Three drill categories (con- ventional heat treatment—CHT, cryogenic treatment—CT, cryo-tempering—CTT), cutting speeds, and feed rates were considered as control factors, and an L27 full factorial design with a mixed orthogonal array was selected for experimental trials.

[26] Navanth & Karthikeya Sharma conducted experiments by using the L18 orthogonal array on conventional drilling machine. The experiments were performed on AI 2014 alloy block using HSS twist drills under dry cutting conditions. The measured results were collected and analyzed with the help of the commercial software package MINITAB16. Analysis of variance (ANOVA) was employed to determine the most significant control factors affecting the surface roughness and hole diameter. The cutting tool, spindle speed and feed rate were selected as control factors.

[27] Siddiquee et al. focused on optimizing deep drilling parameters based on Taguchi method for minimizing surface roughness. The experiments were conducted on CNC lathe machine using solid carbide cutting tool on material AISI 321 austenitic stainless steel. Four cutting parameters such as cutting fluid, speed, feed and hole-depth, each at three levels except the cutting fluid at two levels were considered. Taguchi L18 orthogonal array was used as design of experiment. The signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) was carried out to determine which machining parameter significantly affects the surface roughness and also the percentage contribution of individual parameters. Confirmation test was conducted to ensure validity of the test result.

[28] Kivak et al. studied the optimisation of drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra) and thrust force (Ff). A number of drilling experiments were conducted using the L16 orthogonal array on a CNC vertical machining centre. The experiments were performed on AISI 316 stainless steel blocks using uncoated and coated M35 HSS twist drills under dry cutting conditions. Analysis of variance (ANOVA) was employed to determine the most significant control factors affecting the sur- face roughness and thrust force. The cutting tool, cutting speed and feed rate were selected as control factors.

[29] Gaitonde & Karnik analysed Taguchi's quality loss function approach, a multi-response optimization method for determining the best combination values of cutting speed, feed, point angle and lip clearance angle for specified drill diameters to simultaneously minimize burr height and burr thickness during drilling of AISI 316L stainless steel work pieces. The experiments were planned as per L9 orthogonal array and multi-response signal to noise (S/N) ratio was applied to measure the performance characteristics.

III.METHODOLOGY

Taguchi built up an extraordinary design of orthogonal arrays to examine the whole parameter space with few experiments as it were. The trial results are then changed into a solitary to commotion (S/N) proportion. It utilizes the S/N ratio as a proportion of value characteristics going amiss from or nearing to the coveted values.[1] [30]There are three classes of significant worth attributes in the examination of the S/N proportion, i.e. the lower the better, the higher the better, and the ostensible the better. The formula utilized for calculating S/N ratio is given below.[13] The steps involve solving this problem as shown in below:

1. Data Collection of previous studies on drill surface roughness.
2. Analysis of collected data and setting up the working areas.
3. Actual sample preparation for drilling.
4. Machine selection for drilling process.
5. Selection of drilling parameters as per the analysis by using orthogonal array table.
6. Applying Taguchi's analysis on the collected data.

S/N Ratio Calculation [9]

Smaller the better: It is used where the smaller value is desired

$$\text{S/NRatio} = -10 log \frac{1}{n} \sum_{i=1}^{n} y\, i^2 \qquad (1)$$

Where y = observed response value and n = number of replications.

Nominal the best: It is used where the nominal or target value and variation about that value is minimum.

$$\text{S/NRatio} = -10 log \frac{y^2}{\sigma^2} \qquad (2)$$

Where σ = mean and μ= variance.

Higher the better: It is used where the larger value is desired.

$$\text{S/NRatio} = -10 log \frac{1}{n} \sum_{i=1}^{n} \frac{1}{yi^2} \qquad (3)$$

IV.CONCLUSION

Metal matrix composite (MMCs) are one of the widely known composites because of their superior properties such as high strength, hardness, stiffness, and corrosion resistances. The present paper aims to determine the optimal parametric combination in drilling to produce good quality of holes. The effect of process parameter such as drill speed, feed rate and drill diameter has been studied on thrust force, torque and circularity at entry and exit. In this study, Taguchi method coupled has been found suitable method to handle a multi-objective optimization problem. This technique is more convenient and economical to predict the effects of different influential combinations of the parameters within the levels studied. By applying Taguchi's Signal-to-Noise ratio method, this paper will help in examining the effects of drilling process parameter such as feed, spindle speed, drill material and percentage reinforcement on the drilled holes surface roughness.

The integrated approach presented in this paper can be effectively applied for continuous quality improvement and off-line quality control in any manufacturing process which involves multiple response characteristics correlated with each other.

V.FUTURE SCOPE

This study will help in removing the surface roughness in drilling by using best parameters. In addition, studying best parameters will open various opportunities in the field of drilling. The study will also help in attaining better finish during drilling along with more options and approaches for the same.

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