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Optimization of Machining Parameter on Surface Roughness in Drilling of SG 500/7 Material: A Review

Mr.Pruthviraj Chavan[1], Dr. Anant Gujar[2]
Department of Mechanical Engineering,
Ashokrao Mane Group of Institutions,Vathar , India.

Abstract- *In recent days main objective of every manufacturing industries is to produce low cost and high quality products in short time. The selection of optimal cutting parameters is a very important problem for every machining process in order to increase the quality of machining products and reduce the machining costs. In this study, focuses on the optimization of drilling parameters using the Taguchi technique to obtain minimum surface roughness. A number of drilling experiments will conduct using the orthogonal array on vertical machining centre. The experiments is perform on Spheroidal Graphite material plate using three different twist drills under dry cutting conditions. The measured results are collects and analyze with the help of the commercial software. Analysis of variance is employed to determine the most significant control factors affecting the surface roughness. The spindle speed feed rate and tool material is selected as control factors. The main and interaction* effect of the input variables on the predicted responses are investigate. The predicted values and measured values are fairly close.

Keywords *- Optimization process, VMC Machine, Spheroidal Graphite material, Various types of tools, Taguchi Method.*

I.INTRODUCTION

In recent days Drilling is one of the most vital material removal processes that have been widely used in various industries. Although modern metal-cutting methods, including electron-beam machining, ultrasonic machining, electrolytic machining and abrasive jet machining, have improved in the manufacturing industry. Conventional drilling still remains one of the most common machining processes. The quality and productivity aspects are equally key in the analysis of drilling parameters. The research contributions are classified into methodology for investigation and analysis, input processing conditions and response variables. It is observed that the optimal speed for a machine tool is influenced by several processing parameters such as hardness, composition, stiffness of work/tool and tool life. Furthermore, it is evident that surfaces finish necessary and power available significantly controls the feed. The roughness of drilled surfaces depends severely on the input conditions, material of the workpiece or tool and condition of the machine tool. This study has indicated that for VMC drilling process Taguchi method is the most efficient combination.

Drilling can be described as a process where a twist drill is used to remove unwanted materials to produce a desired hole. Productivity can be interpreted in terms of material removal rate in the machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers. There are number of research papers related to drilling, reaming and boring. In most of these research works carried out, material removal rate (MRR) and surface roughness are selected as objective functions. Furthermore, optimum values for input parameters such as speed, feed are calculated to obtain maximum MRR and minimum surface roughness value. The other aspect governing drilling systems is quality of design. The quality of design can be improved through improving the value and yield in company-wide activities.

Optimization is a technique through which better results are obtained under certain circumstances. The selection of optimal cutting parameters is a very important issue for every machining process in order to enhance the quality of machining products and reduce the machining costs. This research work represents on an optimization of tool wear and surface roughness in drilling operation by the effects of machining parameters applying Taguchi & ANOVA(Analysis of Variance) method to improve the quality of manufactured goods & engineering development of designs for studying variations .For investigation SG500/7 material plate is considered as work piece and spindle speed, feed rate have been considered as cutting parameters, while a HSS(High Speed Steel),Uncoated Iron carbide & coated (TiAlN) iron Carbide has been used as cutting tool.

II. LITERATURE REVIEW

S.V. Alagarsamy *et al*. [1] had carried out experiment on Aluminium alloy 7075 for measuring surface roughness and material removal rate during machining of drilling. In this study, researcher were considered machining process parameters like Speed, Feed and Depth of Cut of the drill. The Taguchi's experimental design and Analysis of Variance (ANOVA) techniques have been implemented to understand the effects, contribution, significance and optimal machine settings of process parameters, namely, spindle speed, feed rate and Depth of Cut. They revealed that From response table for S/N ratio of MRR, Depth of Cut is the most significant factor influencing MRR followed by Feed rate and Cutting Speed is the least significant factor and From response table for S/N ratio of surface roughness, Cutting Speed is the most significant factor influencing MRR followed by Feed rate and Depth of Cut is the least significant factor.

V. N. Rane *et al*. [2] In this Study researcher had conducted experiment on AISI 316 stainless steel under dry cutting conditions for optimizing process parameters for resharpened HSS drill based on Taguchi L16 orthogonal array was used for better surface roughness and tool life. Cutting parameters such as cutting fluid, speed, feed and point angle, each at four levels were considered. The analysis of variance (ANOVA) was carried out to determine which machining parameter considerably affects the surface roughness and tool life and also the percentage contribution of individual parameters. The results revealed that the feed was the most significant factor affecting the surface roughness with a percentage contribution of 39.14%, and that the point angle was the most significant factor affecting the tool life with a percentage contribution of 82.77%.

A. N. Siddiquee *et al*. [3] In this Study researcher had conducted experiment on optimizing deep drilling parameters based on Taguchi L18 orthogonal array was used for minimizing surface roughness. The deep drilling experiments were conducted on CNC lathe machine using 10mm diameter solid carbide cutting tool on AISI 321 austenitic stainless steel. Cutting parameters such as cutting fluid, speed, feed and hole-depth, each at three levels and cutting fluid at two levels were considered. 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. The results revealed that the machining done in the presence of cutting fluid, at a speed of 500 RPM. with a feed of 0.04 mm/s and hole-depth of 25 mm yielded minimum surface roughness. Further, the results of ANOVA indicated that all four cutting parameters significantly affected the surface roughness with maximum contribution from speed (27.02%), followed by cutting fluid (25.10%), feed (22.99%), and hole-depth (14.29%).

E. Kabakli *et al.* [4] In this Study researcher were conducted experiment on hot-rolled low-alloyed medium-carbon steel of 207 HB for evaluation of the surface roughness and Geometric accuracies in a drilling process using the Taguchi analysis. The experimental results was indicated that the hole
diameter and the feed rate have significant effects on the surface roughness. This was shows that one of the important sources of the variation in the surface roughness is the hole diameter, as the power requirement changes during drilling when the hole diameter is changed.

H. Prakash [5] observed that the SG Iron components produced using the drilling process has high rejection, because of surface roughness in drilled hole. This was indicated that the Taguchi method is used to find the effects of cutting parameters on the surface finish in the drilling process of SG Iron. It had Shows that the type of shank, Feed rate, Cutting speed, Drill tool, Spindle speed and Type of coolant affect the surface finish for the drilling of SG Iron. Statistical Results revealed that Type of shank, Feed rate ,Cutting speed, Drill tool, Spindle speed and Type of coolant affect the surface finish by 44%, 41.64%, 5.24%, 8.94%, 1.32%, and 14.3% for the drilling of SG Iron.

R .Adikesavulu [6] explained that optimize process parameters to be specific cutting speed, feed, and point angle of cutting edge in drilling of EN31 steel. In their present test optimization of cutting process parameters namely, cutting peed, feed and point angle during in drilling of EN 31 steel material using the application of Taguchi and ANOVA analysis to minimize tool wear and improve surface finish has found. The ANOVA results reveal that feed rate and point angle are the most significant influencing on the thrust force, torque and surface finish.

A. Taskesen and K. Kutukde [7] carried out experiment using drilling operation of MMCs were carried out to study the effects of machining parameters such a particle mass fraction, drill material, spindle speed and feed rate on the tool wear and dimensional accuracy of the drilled hole using Taguchi's L27, 3-level, 4-factor orthogonal array . Grey relational analysis used for Machining parameters optimization. Based on the experimental results, researcher revealed that mostly abrasive wear and BUE were observed in the cutting tools and higher BUE formation was observed with HSS tools than TiAlN coated carbide tools. By grey relational analysis, the largest grey relational grade, feed rate, spindle speed and drill material of TiAlN coated carbide. These were the suggested levels of the drilling parameters when the minimization of the tool wears.

III. PROBLEM DEFINITION

The major operation carried out in the machining industry is drilling process. In Shree VYANKATESHWARA METALLIKS Pvt. Ltd., it is observed that the produced parts under the drilling process have high rejection because of surface roughness in drilled hole. Here an effort is made to solve the above problem using Robust design methodology. We identified three factors with three levels and experiment is carried out using L9 orthogonal array. The data obtained is analyzed using manual method and solver (Minitab). This methodology can be used for process improvement of similar kind. Daily 1000 number of components is produced in the company. There is a rejection of 7 parts out of 100 parts because of surface roughness in drill hole. So there is need to reduce the rejection ratio to avoid huge loss to company because of high machining cost, high labor cost, high tooling cost and, etc. The defective part will creates problems like wear out, leakage, difficulty in assembling and surface friction.

IV. TAGUCHI APPROACH

The Taguchi method involves reducing the variation in a process through robust design of experiments. Generally objective of the method is to produce high quality product at low cost to the manufacturer. Taguchi method uses a special design of orthogonal arrays to study the complete parameter with a small number of experiments only. The experimental results are then converted into a signal – to – noise (S/N) ratio to measure the quality characteristics different from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., Smaller the better, larger the better, and nominal the best. The S/N ratio for each level of process parameter is compared based on the S/N ratio analysis. Regardless of the category of the quality characteristic, a smaller S/N ratio corresponds to better quality characteristics. The optimal blend of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. The formula for Smaller-The-Better signal to noise ratio is designed so that an experimenter can always select the smallest S/N ratio value to optimize the quality characteristic of an experiment. Smaller-The-Better, S/N ratio is determined by following equations:

$$S/N = -10log_{10}\frac{1}{n}\{\Sigma {Y_i}^2\}$$

For the smaller surface roughness, the solution is "Smaller-The-Better". Where, S/N = Signal to Noise Ratio, n = No. of Measurements, Y = Measured Value of surface roughness.

V. SURFACE ROUGHNESS MEASUREMENTS

Portable surface roughness tester instrument is extensively used to measure the surface roughness. A profile measurement device is usually based on a tangible measurement principle. The surface is measured by moving a stylus across the surface. As the stylus moves up and down along the surface, a transducer converts these movements into a signal which is then transformed into a roughness number and usually a visually displayed profile.

5.1 ARITHMETIC SURFACE ROUGHNESS AVERAGE (RA)

Arithmetical mean deviation from the mean life of profile is the average value of the ordinates (y_1, $y_{2...}$) from the mean line is Ra (Roughness average) value.

Figure.1 Surface Roughness Tester.

VI. METHODOLOGY

6.1 WORKPIECE MATERIAL

The selected work piece material for investigation is Spheroidal Graphite **(**SG500/7). The chemical compositions are shown in Table 1. In chemical composition percentage of different composition is shown also various properties like mechanical properties shown in table 2.

Table 1: Chemical Composition of Spheroidal Graphite (SG500/7)

C%	Si%	Mn%	P%	S%	Mg%	Cu%
3.20-3.60	2.30-2.90	0.4-0.6	0.03-0.06	0.02-0.040	0.030-0.055	<0.4

Table 2: Mechanical Properties of SG500/7

Grade	Tensile Strength	Yield Strength	Elonga-tion	Hardness
SG	500 MPa	320 MPa	7%	170~230 BHN

6.2 CUTTING TOOL MATERIAL

165 drilling experiments will be carrying out with vertical machining center under dry cutting conditions. Three different cutting tool materials, which were HSS, TiAlNi coated carbide and uncoated carbide, are used. The materials and Specifications of the cutting tools are listed in Table 3.

Table 3: Cutting Tool Properties

Drill material	Drill diameter(mm)	Drill Length (mm)	Drill Type
HSS	16	104	Twist
Uncoated carbide	16	104	Twist
TiAlNi coated carbide	16	104	Twist

6.3 SELECTION OF PROCESS PARAMETERS FOR EXPERIMENTATION
According to various authors from literature review it is clear that taguchi method is best to determine the main effects, significant factors and optimum machining conditions to obtain better performance characteristics, speed, feed, tool material contribute the most in deciding surface roughness. Hence in a study of process parameter optimization of drilling process, we have selected speed, feed and tool material as a factors for experimentation.

6.4 EXPERIMENTAL PLAN
Computation of optimal drilling parameters (speed, feed rate and tool material) is based on the Taguchi method to minimize surface roughness. To achieve the computation of optimal cutting parameters, three different speeds (850, 1150 and 1440 RPM) with three different feed rates (90, 120 and 135 mm/min) are used to carry out the tests. The vertical machining centre machine is used to conduct the drilling experiment. The surface roughness is measure using surface roughness tester.

Figure.2 Experimental Setup

Figure.3 SG Material Plate

6.5 DESIGNING EXPERIMENTS

Three factors and three levels have been selected for experimental work which is shown in below table.

Table 4: Table indicating different levels of parameters

Factor	Level		
	I	II	III
Speed	850	1150	1440
Feed rate	90	120	135
Tool material	HSS	Uncoated carbide	TiAlNi coated carbide

6.6 ORTHOGONAL ARRAYS (OA)

To select an appropriate orthogonal array for experiments, the total degrees of freedom need to be computed. The degrees of freedom are defined as the number of comparisons between process parameters that need to be made to determine which level is better and specifically how much better it is. For example, a three-level process parameter counts for two degrees of freedom. The degrees of freedom related with interaction between two process parameters are given by the product of the degrees of freedom for the two process parameters. Once the degrees of freedom required are known, the next step is to select an appropriate orthogonal array to fit the specific task. Minimum number of experiment is calculated as,

Minimum number of experiments= [(L-1) x P] +1

Where,

L- Number of level of parameters=3

P- Number of parameters=3

Minimum number of experiment= [(3-1) x3] +1= 7

Therefore L_9 orthogonal array has been used. Experimental design usually involves trying to optimizing a process which involves several factors at several levels.

Table 5: Table indicating proposed orthogonal array

Exp. No	Speed(rpm)	Feed(mm/Min)	Tool Material
1	I	I	I
2	I	II	II
3	I	III	III
4	II	I	II
5	II	II	III
6	II	III	I
7	III	I	III
8	III	II	I
9	III	III	II

VII CONCLUSION

In this study, drilling of Spheroidal Graphite(SG500/7) material is carrying out with input drilling parameters considered as spindle speed, feed rate and tool material, and response obtained is surface roughness through the hole. The drilling parameters are optimized to achieve good quality of holes in drilling of Spheroidal Graphite(SG500/7) material. Optimization of parameters is carry out using Taguchi method. Here we have to conclude that for obtaining minimum surface roughness, proper combination of tool material, feed rate and spindle speed should be selected to achieve minimum surface roughness and maximum tool life with minimum rejection of manufactured components in manufacturing company.

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