ABSTRACT

In this thesis our work deals with the application of Taguchi method to optimize the process parameters like machining voltage, electrolyte concentration, frequency will produce much impact on the response parameter like Surface Roughness, over cut and Material Removal Rate (MRR). This work discusses a methodology for the optimization of the machining parameters on drilling of LM6 Al/B4C composites using Electrochemical Micro Machining (EMM).

In minitab 17 software Taguchi L27 orthogonal array was chosen for the experiment. We investigates the effect of the process parameters like machining voltage, electrolyte concentration, frequency on the response parameter Surface Roughness, over cut and Material Removal Rate (MRR) on drilling of LM6 Al/B4C composites using Electrochemical Micro Machining (EMM) through taguchi methodology.

Keywords— EMM, MRR, ANOVA

I. INTRODUCTION

It is important to know the effect of ECM on the mechanical properties of electrochemically machined parts. This will greatly affect the acceptability of the process in different industries. Hardly any evidence is available about the hydrogen embrittlement of the ECM components. The basic reason being that hydrogen is evolved at cathode while metal removal is taking place due to anodic dissolution at the anode. It has been reported that there is no effect of ECM on ductility, yield strength, ultimate strength, and micro hardness of the machined component. Surface layers damaged during conventional machining or by some other processes, may be removed by ECM and this may result in improvement in the properties of the work material. However, such removal of layers from the work surface reduces fatigue strength of a conventionally machined components. The conventionally machined surfaces have compressive.

II. METHODOLOGY

Our problem is to find In Electrochemical machining parameters for achieving machining performance. Usually the desired machining parameters are determined based on experience or handbook values. However this does not ensure that the selected machining parameters result in optimal or near optimal machining performance for that Electro-Chemical Machine and environment. Detailed analysis of cutting involves certain costs, particularly in case of small series. In case of individual machining it is particularly necessary to shorten as much as possible the procedure of determination of the optimal cutting parameters, otherwise the cost analysis might exceed the economic efficiency which could be reached if working with optimum conditions.

In this paper our main objective to analyze the settings of electrochemical machining parameters by Taguchi’s experimental design method. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA), are using to find the optimal levels and also to analyze the effect of the electrochemical machining parameters such as material removal rate, surface roughness and over cut values.

Taguchi method

In traditional experimental design procedures, a large number of experimental works have to be done when the number of process parameters increases that problem is solved with the help of Taguchi method, which uses design of experiment a special design of orthogonal arrays to study the entire parameter space with only a few number of experiments depend upon % accuracy. The greatest advantage of this method is the saving of effort in conducting experiments, saving experimental time, reducing the cost and discovering significant factors quickly. Taguchi’s robust design method is a powerful tool for the design of a high-quality system. The steps followed for Taguchi optimization in this work are presented. In the Taguchi method, the term ‘signal’ represents the desirable value (mean) for the output characteristic and the term ‘noise’ represents the undesirable value (standard deviation, SD) for the output characteristic. Therefore, the S/N ratio is the ratio of the mean to the SD. Taguchi uses
the S/N ratio to measure the quality characteristic deviating from the desired value. Three type of S/N ratios available, depending on the type of characteristic; lower the better (LB), nominal the best (NB) or higher the better (HB). The S/N ratio for the higher-the-better criterion is given by Taguchi as:
1. Smaller the better (for making the system response as small as possible)
2. Nominal the best (for reducing variability around a target)
3. Larger the better (for making the system response as large as possible)

III. PRIOR APPROACH

Chakradhar et al. developed the multi-objective optimization models for electrochemical machining of EN31 steel using grey relational analysis by considering electrolyte concentration, feed rate and voltage as process parameters. [9]

Ye Yang et al. (2011) have fabricated micro pins and micro holes using everyday mineral water as an electrolyte. [10]

Sharma et al. (2002) machined holes in inconel super alloy that is used for turbine blades with acidified neutral salt electrolyte to minimize sludge formation in the Inter Electrode Gap (IEG). They obtained a good and uniform hole with an aspect ratio of 11. [11]

Lee et al. (2002) have applied two electrolytes, aqueous sodium nitrate and aqueous sodium chloride. The study reveals that the former electrolyte has better machinability than the latte. [12]

Mithu et al. (2011) have used less toxic and dilute electrolyte, 0.2 M HCl for micromoles fabrication. The acidic electrolyte allowed refreshing electrolyte in the machining area easily, due to the reason that acid electrolyte usually produced by-product much less than common salt electrolytes. [13]

Dhobe et al. (2011) have used sodium bromide electrolyte for machining of titanium, since simple chloride and nitrate electrolyte require higher potential difference to break down passive film. The use of sodium bromide improves the MRR and corrosion resistance. [14]

Senthilkumar et al. developed mathematical models for ECM based on response surface methodology (RSM) for Al/10%SiC composites. They have taken electrolyte flow rate, applied voltage, electrolyte concentration and tool feed rate as process parameters and material removal rate and surface roughness as responses. [15]

Kao et al. optimized the electrochemical polishing of stainless steel using grey relational analysis by taking surface roughness and passivation strength of electrolyte as responses. [16]

Munda et al. investigated the electrochemical micromachining through response surface methodology approach. They have taken MRR and ROC as two different objective measures and developed the mathematical models. [17]

Asoken et al. developed multiple regression and Artificial Neural Network (ANN) models for optimizing the electrochemical process parameters like voltage, current, gap and feed rate. [18]

N.K. Jain et al and V.K. Jain et al [1] have proposed the optimization of electrochemical machining process parameters using genetic algorithms. They have considered the three most important ECM process parameters namely tool feed rate, electrolyte flow velocity, and applied voltage with an objective to minimize geometrical inaccuracy subjected to temperature, choking, and passivity constraints using real-coded genetic algorithms. [19]

B.G. Acharya et al, V.K. Jain et al and J.L. Batra et al [2] have proposed a model for the multi-objective optimization of the ECM process. Their work describes the optimization of ECM process parameters by considering only one objective at a time from metal removal rate, geometrical accuracy, and total process cost. Some authors have worked on electrochemical discharge machine (ECDM). [20]

Deng. Chen et al. Proposed the integration of grey relational analysis and the Taguchi Method to resolve multiple quality characteristics. This method transforms multiple quality characteristics into single grey relational grades. By comparing the computed grey relational grades, the arrays of respective quality characteristics are obtained in accordance with response grades to select an optimal set of process parameters. [21]

Beravala et al. (2011) developed mathematical model of ECM process parameters (electrolyte flow rate, electrode feed rate and voltage’s effect) in relation with process output (MRR, surface finish and overcut). Analysis of Variance has been carried out to identify the significant effect of input parameters on output. [22]

Labib et al. (2011) studied the integration of a Fuzzy Logic Controller (FLC) with ECM drilling rig to control feed rate of the tool and the flow rate of the electrolyte with the objective of improving the machining performance and accuracy of FLC. Surface characteristics in electrochemical machining of titanium are investigated experimentally, utilizing cross flow electrolyte system. [23]

(Dhobe et al., 2011). Abuzied et al. (2012) developed artificial neural network models for electrochemical machining process. Applied voltage, feed rate and electrolyte flow rate are considered as input process parameters and metal removal rate and surface roughness are considered as output responses. [24]

IV. OUR APPROACH
The optimization of process parameters is the key step in the Taguchi method. Twenty seven Experimental runs (L27) based on the Orthogonal Array (OA) of Taguchi methods have been carried out. The multi-response optimization of the process parameters viz. MRR, Surface Roughness & Over cut has been performed for making a micro hole in the process of micro-ECM of LM6 Al/B4C composite. For analysis MRR, Surface Roughness & over cut, noted for every trial. MRR is Larger is better, Surface Roughness is smaller is better and Overcut is Smaller is better in this thesis.

Electrochemical micro machining (EMM) characteristics (MRR and Overcut) as output responses for through micro – hole machining. In Electrochemical micro machining Overcut of the micro hole has been closely related to the machining accuracy, hence it is the difference between the diameters of the tool electrode and machined micro hole. With the support of optical microscope the diameter of the machined micro–hole was measured.

MRR= (weight before machining – weight after machining) / machining time
ROC = (Hole diameter – Tool diameter) / 2

Surface is measured by using a SURTRONIC 3+ surface texture measuring instrument, which has a diamond stylus tip with accuracy of 0.005μm and resolution of 1.0 μm horizontal, 10nm vertical and having a maximum measuring range of 25mm.

<table>
<thead>
<tr>
<th>Control Factor</th>
<th>Symbol</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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</thead>
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<tr>
<td>A Voltage (V)</td>
<td>V</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>B Electrolyte Concentration (g/l)</td>
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<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>C Frequency (Hz)</td>
<td>F</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 4.1-Machining process parameters and their levels

MRR is Larger is better and Overcut is Smaller is better chosen for this study.

From the main effect plot for SN ratios parameter combination suggested for the higher MRR is Electrolyte concentration, 30g/l, Voltage, 10 V, Frequency, 50 Hz.

From the main effect plot for SN ratios parameter combination suggested for the lesser Surface Roughness is Electrolyte concentration, 30g/l, Voltage, 8 V, Frequency, 50 Hz.

From the main effect plot for SN ratios parameter combination suggested for the lesser Overcut is Electrolyte concentration, 30g/l, Voltage, 8 V, Frequency, 50 Hz.
V. CONCLUSION

This paper is focused on optimization and analysis of electrochemical micro machining of LM6 Al/B4C composites machining parameters. From the study of result in EMM was using Taguchi methodology. The following can be concluded from the present study.

1. The parameter combination suggested for the higher MRR is Electrolyte concentration, 30 g/l, Voltage, 10 V, Frequency, 50 Hz, for the lower Surface Roughness is Electrolyte concentration, 30 g/l, Voltage, 8 V, Frequency, 50 Hz and lesser overcut are Electrolyte concentration, 30 g/l, Voltage, 8 V, Frequency, 50 Hz.

REFERENCES