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EXPERIMENTAL INVESTIGATION OF MACHINING PARAMETERS FOR EDM USING U-SHAPED ELECTRODE OF AISI P20 TOOL STEEL

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***Abstract*—** The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.

AISI P20 Plastic mould steel that is usually supplied in a hardened and tempered condition. Good machinability, better polishability, it has a grooving rang of application in Plastic moulds, frames for plastic pressure dies, hydro forming tools These steel are categorized as difficult to machine materials, possesgreater strength and toughness are usually known to create major challenges during conventional and non- conventional machining. The Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time and diameter of tool of AISI P20 tool steel material. Using U-shaped cu tool with internal .

***Keywords* --** Aluminum Metal Matrix , continuous fibers, discontinuous fibers, particulates or whiskers

I. INTRODUCTION

Aluminum Metal Matrix Composites (AMMCs) are making in roads in various engineering applications requiring higher strength and stiffness than those offered by conventional aluminum alloys. Traditional machining of AMMCs however is difficult due to the hard reinforcement present in the AMMC material which tends to wrap around the cutting tool-bit leading to tool breakage. Over the past few years, there has been growing interest in non-conventional cutting of composite materials with regard to cutting rate, edge quality and the extend of damage incurred in the composite materials. Non-conventional machining has been applied on reinforced aluminum alloy. In these studies, specific machining performance characteristics on AMMCs reinforced with different percentage is assessed .

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1) Classification and Processing of Aluminum based MMCs

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. The reinforcements can be in the form of continuous fibers, discontinuous fibers, particulates or whiskers. Continuous ceramic fibers and single-crystal ceramic whiskers are the reinforcements which provide the largest increases in strength and stiffness. Particulate-reinforced AMMC is driven by the combination of improved mechanical and physical properties imparted by the reinforcement of the metal matrix while still maintaining the favorable metalworking characteristics and predominantly metal-like behavior. A second significant driver is the ability to tailor the mechanical and physical properties through selection of the reinforcement composition and amount along with the matrix alloy. Figure 1 shows the type of non metallic and metallic reinforcements used in AMMCs. The reinforcements are usually inorganic (ceramic) materials such as alumina, silicon carbide. Fiber materials used in AMMCs are graphite, aluminum oxide, silicon carbide, boron, molybdenum and tungsten.

On the basis of Material Structure AMMCs are classified as follows: **Particulate Composites** Particulate Composites consist of a matrix reinforced by a dispersed phase in form of particles.

Composites with random orientation of particles.

Composites with preferred orientation of particles.

Dispersed phase of these materials consists of two-dimensional flat platelets (flakes), laid parallel to each other. Particulates are of silicon carbide, boron carbide.

2) Fibrous Composites

Short-fiber reinforced composites**.** Short-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibers (length < 100 diameter).

(i) Composites with random orientation of fibers.

(ii) Composites with preferred orientation of fibers. Discontinuous fibers generally used are: alumina, alumina-silica.

Long-fiber reinforced composites**.** Long-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibers.

(i) Unidirectional orientation of fibers. (ii) Bidirectional orientation of fibers (woven). Continuous fibers are in use: boron, silicon carbide, alumina, graphite.

Following are the processing methods of Al based MMCs:

Solid State Processing

Liquid state processing

Powder Metallurgy

Physical Vapor Processing (PVD)

Direct Processing/Spray Deposition

3) Principle of EDM

Despite the fact that the material removal mechanism of EDM is not absolutely identified and is still contentious, the most widely established principle is the transformation of electrical energy into thermal energy through a sequence of distinct electric discharges. Fig. 1.1 shows a representative diagram of a typical EDM setup. Build-up of suitable voltage across tool and work-piece (cathode and anode respectively) that are submerged in an insulating dielectric, causes cold emission of electrons from the cathode. These liberated electrons accelerate towards the anode and collide with the dielectric fluid, breaking them into electrons and positive ions. A narrow column of ionized dielectric fluid molecules is established connecting the two electrodes. A spark generates due to the avalanche of electrons. This results in a compression shock wave. Very high temperature (8,000 to 12,000 ºC) is developed which induces melting and evaporation of both the electrodes. The molten metal is evacuated by the mechanical blast (of the bubble), leaving tiny cavities on both tool and workpiece.

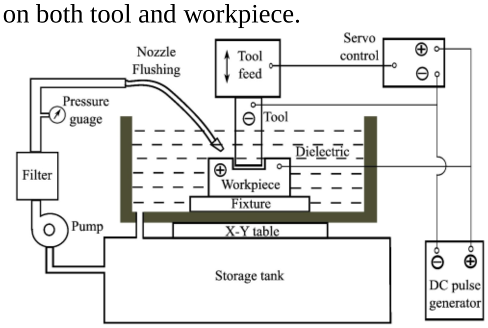

Figure 1 A typical EDM setup

A step by step description of the material removal process due to sparking is presented in Fig. 1.2. There is no direct contact between the two electrodes (held at a small distance) and a high potential is applied between them (Fig. 1.2(b)). The electrode moves towards the workpiece and enhances the electric field in the inter electrode gap, until the breakdown voltage of dielectric is reached. The spot of discharge is normally between the nearest points of the tool and the workpiece. However, the spot location may change depending on the impurities or debris present in the inter electrode gap. Voltage drops and current flows from workpiece to electrode due to ionization of dielectric and formation of plasma channel (Fig. 1.2(c)). The flow of discharge current continues and there is a constant attack of ions and electrons on the electrodes which ultimately lead to intense heating of the workpiece. The temperature rises between 8,000 °C and 12,000 ºC, resulting in the formation of a small molten metal pool at both the electrode surfaces and some of the molten metal directly vaporizes. During this period, plasma channel widens and radius of the molten metal pool increases (Fig. 1.2(d)).

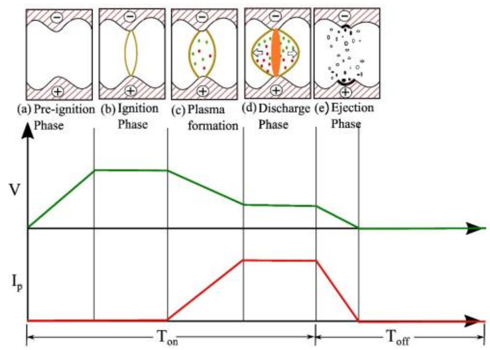

Figure 2 Material removal mechanism in EDM

Towards the end of the discharge, voltage is shut and plasma channel collapses inwards due to the pressure exerted by the neighboring dielectric. As a result, the molten metal pool is powerfully drawn into the dielectric, producing a tiny cavity at the surface of workpiece (Fig. 1.2(e)). The machining process successively removes minute quantities of workpiece material, in the form of molten metal, during discharges. The removed material solidifies to form debris. The flow of dielectric washes away the debris from the discharge zone. The gap increases after material removal at the point of spark, and the position of the next spark shifts to a different place, where inter electrode gap is the smallest. In this manner, thousands of electric discharges take place at different localities of the workpiece surface corresponding to tool-workpiece gap. As a consequence, a negative replica of the tool surface shape is produced in the workpiece.

II. LITERATURE REVIEW

ShaileshDewangan[1] et.al were analyzed Surface integrity remains one of the major areas of concern in electric discharge machining (EDM).During the current study, grey-fuzzy logic-based hybrid optimization technique is utilized to determine the optimal settings of EDM process parameters with an aim to improve surface integrity aspects after EDM of AISI P20 tool steel. The experiment is designed using response surface methodology (RSM)considering discharge current (Ip), pulse-on time (Ton), tool-work time (Tw) and tool-lift time (Tup) asprocess parameters. Various surface integrity characteristics such as white layer thickness (WLT), surfacecrack density (SCD) and surface roughness (SR) are considered during the current research work. Grey relational analysis (GRA) combined with fuzzy-logic is used to determine grey fuzzy reasoning grade (GFRG). The optimal solution based on this analysis is found to be Ip ¼ 1 A, Ton ¼ 10 ms, Tw ¼ 0.2 s, and Tup ¼ 0.0 s. Analysis of variance (ANOVA) results clearly indicate that Ton is the most contributing parameter followed by Ip, for multiple performance characteristics of surface integrity.

Milan Kumar Das[2]et.al were investigated combination of process parameters for optimum surface roughness and material removal rate (MRR) in electro discharge machining (EDM) of EN31 tool steel using artificial bee colony (ABC) algorithm. Forexperimentation, machining parameters viz., pulse on time, pulse off time, discharge current and voltage are varied based on central composite design (CCD). Second order response equations for MRR and surface roughness are found out using response surface methodology (RSM). For optimization, both single and multi-objective responses (MRR and surface roughness: Ra) are considered. From ABC analysis, the optimum combinations of process parameters are obtained and corresponding values of maximum MRR and minimum Ra are found out. Confirmation tests are carried out to validate the analyses and it is seen that the predicated values show good agreement with the experimental results. This study also investigates the influence of the machining parameters on machining performances. It is seen that with an increase in current and pulse on time, MRR and surface roughness increase in the experimental regime. Finally, surface morphology of machined surfaces is studied using scanning electron microscope (SEM) images.

M.Dastagiri[3] et.al were experimentally analyzed pursue the influence of four design factors current (I), voltage (V), pulse on(Ton), and duty factor (η) which are the most connected parameters to be controlled by the EDM process over machining specifications such as material removal rate (MRR) and tool wear rate(TWR) and characteristics of surface integrity such as average surface roughness (Ra) and the hardness (HR) and also to quantify them. In this paper the experiments have been conducted by using full factorial design 23 with three central point in the DOE techniques and developed a mathematical model to predict material removal rate, average surface roughness and hardness using input parameters such as current, voltage, pulse on, and duty factor. The predicted results are very close to experimental values. Hence this mathematical model could be used to predict the responses such as material removal rate, and average surface roughness effectively within the input parameters studied.

Vikas[4] et.al were presented an idea about the effect of the various input process parameters like Pulse ON time, Pulse OFF time, Discharge Current and Voltage over the Surface Roughness for an EN41 material. Here, 5 different output parameters concerned with surface roughness like Ra, Rq, Rsk, Rku and Rsm are taken and optimized accordingly, using the Grey-Taguchi method. The Grey-Taguchi method used in the article considers an L27 orthogonal array, which uses a different combination of the 4-input parameters to obtain an optimized value of the surface roughness for EN41 material. The 5 different output values of the surface roughness are calibrated into a single value (i.e. Grade) by calculating their normalized, Δ and ξ values .On the basis of their Grade, the S/N ratio is obtained and accordingly the ANOVA table is generated. It was found that the Current had larger impact over the Surface Roughness value, followed by the Voltage. The experimental results thus, obtained were compared with the theoretical results and they were found very close to one another.

TABLE 1 EXPERIMENTAL DETAILS

parameter	description
Work piece	Al-Sic- Al_2 O_3
Tool	Copper
Dielectric	I POL fluid
Flushing pressure	0.5 kg/cm^2
Polarity	+Ve
Gap voltage	45 V
Powder concentration	5g/L
Peak current	8,10 12,
Pulse on time	6 7,8 µs
Pulse offTime	6,7,8 µs
Machining depth	1.0mm

M. Durairaj[5] et.al were analyzed Surface roughness and kerf width are of crucial importance in the field of machining processes. This paper summarizes the Grey relational theory and Taguchi optimization technique, in order to optimize the cutting parameters in Wire EDM for SS304. The objective of optimization is to attain the minimum kerf width and the best surface quality simultaneously and separately. In this present study stainless steel 304 is used as a work piece, brass wire of 0.25mm diameter used as a tool anddistilledwtater is used as a dielectric fluid .For experimentation Taguchi's L;16, orthogonal array has been used. The input parameters selected for optimization are gap voltage, wire feed, pulse on time, and pulse off time. Dielectric fluid pressure, wire speed, wire tension, resistance and cutting length are taken as fixed parameters. For each experiment surface roughness and kerf width was determined by using contact type surf coder and video measuring system respectively. By using multi objective optimization technique grey relational theory, the optimal value is obtained for surface roughness and kerf width and by using Taguchi optimization technique, optimized value is obtained separately. Additionally, the analysis of variance (ANOVA) is toouseful to identify the most important factor.

Y.H. Guu[6] et.al were analyzed surface morphology, surface roughness and micro-crack of AISI D2 tool steel machined by the electrical discharge machining (EDM) process were analyzed by means of the atomic force microscopy (AFM) technique. Experimental results mindicate that the surface texture after EDM is determined by the discharge energy during processing. An excellent machined finish can be obtained by setting the machine parameters at a low pulse energy. The surface roughness and the depth of the microcracks were proportional to the power input. Furthermore, the AFM application yielded information about the depth of the micro-cracks is particularly important in the post treatment of AISI D2 tool steel machined by EDM.

III. EXPERIMENTAL TAGUCHI DESIGN

1) TAGUCHI DESIGN

Basically, experimental design methods were developed original fisher. However 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. There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems. The formulae for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic. They are

1. Smaller-The-Better,
2. Larger-The-Better,
3. Nominal is Best.

1) SMALLER IS BETTER

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the smaller-is-better S/N ratio using base 10 log is: S/N = -10*log(S (Y2)/n) Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

2) LARGER IS BETTER

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the larger-is-better S/N ratio using base 10 log is: S/N = -10*log(S(1/Y2)/n) Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

3) NOMINAL IS BEST

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the nominal-is-best I S/N ratio using base 10 log is: S/N = -10*log (s2) Where s = standard deviation

IV. RESULT

The various parameters have to be selected for EDM machining. The work piece will be machined with various parameters like Pulse on time pulse off time Gap current (ampere). In order to achieve to high degree surface finish aswellasminimum cycle timing. Along with that compare the process parameter optimization of material in next phase.

Proposed work status

The following proposed work has been completed as

phase – 1

- Objective (selection)
- Collection of information
- Aluminium metal matrix volume Ratio calculation and casting
- Method for conduct of machining on sample work piece.
- Conducting the machining operation.

In phase – II

- Analyzing the experiment details.
- Optimize the parameter
- Conclusion.
- Scope for future work.

REFERENCES

[1] Vijaykumar S. Jatti *, ShivrajBagane, Thermo-electric modelling, simulation and experimental validation of powder mixed electric discharge machining (PMEDM) of BeCu alloys, Alexandria Engineering Journal

[2] Chethan Roya*, Khalid Hussain Syeda, KuppanP.a, machinablity of AL/ 10%SIC/ 2.5%TIB2 metal matrix composite with powder-mixed electrical discharge machning, Procedia Technology 25 (2016) 1056 – 1063

[3] RyotaToshimitsua, Akira Okadaa,*, RyojiKitadab and Yasuhiro Okamotoa, Improvement in Surface Characteristics by EDM with Chromium Powder Mixed Fluid, Procedia CIRP 42 (2016) 231 – 235

[4] Jagdeep Singh*, Rajiv Kumar Sharma*,Implementation of Taguchi method withhybrid decision making tools for predictionof surface characteristics for powder-mixedEDM of WC _,Perspectives in Science (2016) 8, 455—458

[5] S. Tripathy a, D.K. Tripathy b,*, Multi-attribute optimization of machining process parameters in powder mixed electro-discharge machining using TOPSIS and grey relational analysis,

[6] GangadharuduTalla a, Deepak Kumar Sahoo a, S. Gangopadhyay a, *, C.K. Biswas b, Modeling and multi-objective optimization of powder mixed electric discharge

machining process of aluminum/alumina metal matrix composite, Engineering Science and Technology, an International Journal 18 (2015) 369e373

[7] GangadharuduTalla, SoumyaGangopadhyay, Chandan Kumar Biswas,multi response optimization of powder mixed electric discharge machining of aluminum alumina metal matrix composite using grey relation analysis,Procedia Materials Science 5 (2014) 1633 – 1639

[8] F.Q. Hua*, F.Y. Caob, B.Y. Songa, P.J. Houa, Y. Zhanga, K. Chena, J.Q. Weia, Surface properties of SiCp/Al composite by powder-mixed EDM, Procedia CIRP 6 (2013) 101 – 106

[9] Ahmed Al-Khazraji a, Samir Ali Amin a, Saad Mahmood Ali b,*, The effect of SiC powder mixing electrical discharge machining on white layer thickness, heat flux and fatigue life of AISI D2 die steel, Engineering Science and Technology, an International Journal.19 (2016) 1400–1415

[10] H.K. Kansala,_, SehijpalSinghb, Pradeep Kumarc, Numerical simulation of powder mixed electric discharge machining (PMEDM) using finite element method, Mathematical and Computer Modelling 47 (2008) 1217–1237