Influence of Process Parameters for Electrical Discharge Machine Using Nano Particle and Brass Electrode

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Abstract- Current development in electrical discharge machine with nano particle mixed dielectric fluid has most recent avenues for finishing of hard and brittle materials. In this paper, material removal rate (MRR) and tool wear rate (TWR) on the nano particle mixed electrical discharge machining (NPMEDM) of inconel 718 material using brass electrode. The input parameters like current, pulse on time and pulse off time and titanium carbide nano particle added in to dielectric fluid. The result shows that MRR gets improved and TWR gets reduced. The most significant factors contributing towards MRR and TWR have been identified. The results clearly showed that addition of titanium carbide nano particle has increased the MRR.

Index Terms- Electrical Discharge Machine (EDM), Titanium Carbide Nano Particle, Material Removal Rate (MRR), Tool Wear Rate (TWR).

1. INTRODUCTION

Electrical Discharge Machining is an electro thermal nontraditional machining process, where electrical energy is used to make electrical spark and material removal mainly occurs due to thermal energy of the spark. The new impression of manufacturing use nonconventional energy sources like mechanical, chemical, electrical, electrons. The industrial and hi-tech growth, advance of harder and complicated to machine materials, which locate large application in nuclear engineering, aerospace and additional industries due to their high strength to weight ratio, hardness and heat resistance behavior has been observer. Modern developments in the field of material science have led to new engineering metallic materials, composite materials and modern ceramics having good mechanical properties and thermal characteristics in addition to sufficient electrical conductivity so that they can eagerly be machined by spark erosion. Nontraditional machining has grown out of the need to machine these smart materials. The machining processes are nontraditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. The troubles of high difficulty in shape, size and higher order for product accuracy and surface finish can be solved through nontraditional methods. Currently, nontraditional processes possess virtually unlimited capabilities except for volumetric material removal rates. Used for which large advance have been complete in the history little years to increase the material removal rates. As removal rate increase, the cost efficiency of operations also increases, motivating ever better uses of nontraditional method.

The electrical discharge machining process is functioning widely for make tools, dies and new precision parts [1]. EDM has been replacing grinding, drilling, milling, and other traditional machining operation and is now a fine established machining option in many manufacturing industries throughout the world. The capable of machining geometrically difficult or inflexible material components that are accurate and not easy to machine such as heat treat tool steels, super alloys, composites, ceramics, heat resistant steels etc. Being widely used in die and mold design industries, aeronautics, aerospace and nuclear industries. Electrical discharge machining have been moreover made its being there felt in the new fields such as medical, sports and surgical, instruments, optical, as well as automotive R&D areas. Powder mixed dielectric fluid in electrical discharge machining (PMEDM) is a comparatively newest advance material removal process useful to enlarge the machining efficiency and surface finish. Powder particles mixed dielectric medium the faster sparking and increase thermal conductivity within a discharge arise causing faster erosion from the workpiece surface and thus the material removal rate (MRR) increases [2]. In nano sized powder, suspended SiC and Al_2O_3 in dielectric fluid will change the surface roughness. A powder suspended dielectric is among 14% and 24% of the average surface roughness generated. The addition of nano particle to a dielectric fluid has further benefit in improving surface quality by eliminating micro-cracks. Moreover, the suspension of nanographite powder produced a high sparking gap size [3].

The carbon nano tube (CNT) is mixed with dielectric fluid in AISI D2 tool steel material is very good thermal conductivity, absorb heat and white layer formation is reduced and surface finish can be greater [4]. Inconel 718 has been preferred for the analysis because of its increasing demand in high temperature applications and lack of literature available on electrical discharge machining of this material. In the present paper, a challenge has been made to attain an optimal setting of process parameters, which may yield optimum MRR and TWR.

2. LITERATURE SURVEY

It is significant to understand the history and current status of the EDM process to propose future areas of work. Extensive literature survey has been carried out to find the state of art at EDM process. Electrical discharge machining (EDM) provides an efficient manufacturing technique that enables the production of parts made of hard materials with complicated geometry that are difficult to produce by conventional machining process. Its facility to control the process parameters to attain the required dimensional accuracy and surface finish has placed this machining operation in a prominent position in industrial applications. Inconel 718 by creation deep hole drilling with EDM. The parameters like current, pulse on time, duty factor and electrode speed were select input parameters. The output responses were metal removal rate, depth of average surface roughness. The experimented were planned using central composite design. The results revealed that metal removal rate is more influenced by peak current, duty factor and electrode rotation, and MRR is increased with increase in current and duty factor and electrode speed, where as depth of average surface roughness is increased with increase in peak current , electrode speed and pulse on time [5].

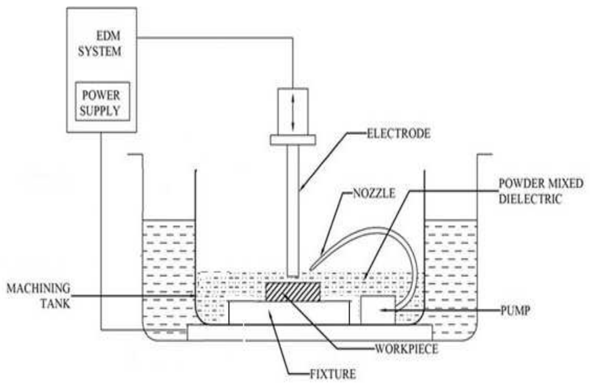

Fig.1. Schematic Diagram of Experimental Setup

Aluminium bronze machined with nickel powder mixed kerosene dielectric fluid has a smaller surface roughness than that in conventional EDM with kerosene. Recast layer restricted nickel richly and the thickness of white layer became larger and uniform with an increase in the concentration of nickel powder. Further, the hardness of the white layer is higher and the surface is smoother than that with pure kerosene [6].

To improve surface roughness, and reduce machining time and tool wear, for that they have used different powder like aluminum, silicon, graphite and carbon nano tube mixed with dielectric fluid and experiment work on NAK 80 steel using copper electrode. They have analyses three different parameters like effect of various powders mixed into dielectric on surface roughness, machining time and also on tool wear. They have concluded that improvement of the machining efficiency and the roughnesses of a machined surface by add CNT powder to the dielectric. The surface roughness of the work piece and the machining efficiency of the EDM with powder mixed into the dielectric were improved by 70% and 66% respectively, compared with conventional EDM. Carbon nano tubes express better achievement than other powder [7]. Nano surface finish has become an important in the optical, semiconductor, electrical and mechanical industries. The materials use in these industries is classifying as complicated to machine materials such as glasses, ceramics and silicon. Machining of these materials up to nano accuracy is a great challenge in the manufacturing industry. Finishing of micro components such as micro lenses, micro moulds and micro holes need different processing technique. Conventional machining method used so far happens to almost impossible or unwieldy. A nano material especially multi wall carbon nano tube is used in the machining process like grinding to improve the surface characteristics from micro to nano level [8].

3. EXPERIMENTAL PROCEDURE

For this conduct experiment the whole work can be along by die sinking Electric Discharge Machine, model ELECTRONICA - M100 MODEL machine. The selected work piece material is inconel 718. The chemical composition of workpiece material in inconel 718 is shown in Table 1.

Table. 1. Chemical composition of inconel 718

Chemical composition	Percentage
Nickel	52.34
Chromium	18.33
Iron	18.59
Niobium	5.16
Molybdenum	3.1
Titanium	0.96
Aluminum	0.5
Cobalt	0.36
Carbon	0.04
Manganese	0.21
Silicon	0.27
Sulfur	0.01
Copper	0.02

The inconel 718 is a high strength temperature resistant (HSTR) nickel based super alloy. It is widely used in aerospace applications such as gas turbines, rocket motors, space crafts, tooling and pumps.

Inconel 718 is difficult to machine, of its poor thermal properties, high hardness, high toughness and high work harden rate so machining conventional process is very difficult. The tool electrode material used is brass.

Table.2. Chemical composition of brass electrode

Chemical Composition	Percentage
Copper	56.7
Aluminium	0.03
Tin	0.02
Phosphorous	0.02
Lead	3
Iron	0.1
Zinc	39.85
Nickel	0.08

Table. 2 shows the chemical composition of brass electrode. The brass electrode was the negative polarity and the specimen was the positive polarity. The dielectric fluid was mixed in titanium carbide nano particle for kerosene. The separate tank was used for machining with using titanium carbide nano particle mixed dielectric fluid. During EDM, the primary parameters are current, pulse on time, and pulse off time. The machining was generally carried out for a fixed time interval and the amount of MRR and TWR was measured by taking the difference in weights before and after each experiment using an electric balance with a resolution of 0.001mg to determine the value of metal removal rate was measured from the weight loss.

4. EXPERIMENTAL PLAN

Response surface methodology (RSM) approach is the procedure for determining the relationship between various process parameters with the various machining criteria and exploring the effect of these process parameters on the coupled responses [9]. The metal removal rate and tool wear rate. In order to study the effect of the EDM parameters on the above mentioned two most criteria, a second order polynomial response can be fitted into the following equation

$$Y_u = b_o + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k} b_{ii} x^2{}_i + \sum_{j>1}^{k} b_{ij} x_i x_j \quad \text{------ (1)}$$

Where Y_U is response and the $x_{i\ (1,2,\ldots,k)}$ are coded level of k quantitative variables. The coefficient b_0 is the constant term, the coefficients b_i are the linear terms, b_{ii} are the quadratic terms and b_{ij} are the interaction terms. The relevant process parameters selected for the present investigation are current, pulse on time and pulse off time on the metal removal rate (MRR) and tool wear rate (TWR) during the EDM process.

Table.3. Process parameters and their levels

Parameters	Levels		
	1	2	3
Current, amp (A)	5	10	15
Pulse on time, µs (B)	200	500	1000
Pulse off time, µs (C)	100	200	500

For the three variables the design required 20 experiments with 8 factorial points, 6 axial points to form face centred composite design with α = 1 and 6 centre points for replication to estimate the experimental error. The design was generated and analyzed using MINITAB 14.0 statistical package. The levels of each factor were chosen as -1, 0, 1, in closed form to have a rotatable design. Table 3 shows the factors and their levels in coded and actual values. The experimentation has been carried out according to the central composite second order rotatable design.

5. MATHEMATICAL MODELING

The relationship between the factors and the performance measure was modeled by multiple linear regressions. Mathematical models based on second order polynomial equations were developed for MRR and TWR using the experimental results and are as follows:

MRR = 0.028100 - 0.000505 A + 0.000020 B - 0.000264 C + 0.000286 A^2 + 0.000001C^2 - 0.000010 A*C ------ (2)
TWR = 0.009787 + 0.004242 A + 0.000007 B - 0.000186 C - 0.000113 A^2 - 0.000001 A*B - 0.000002A*C ------ (3)

6. RESULT AND DISCUSSION

6.1 Effects of current with MRR and TWR

The parameter analysis has been carried out to study the influences of the input process parameters such as

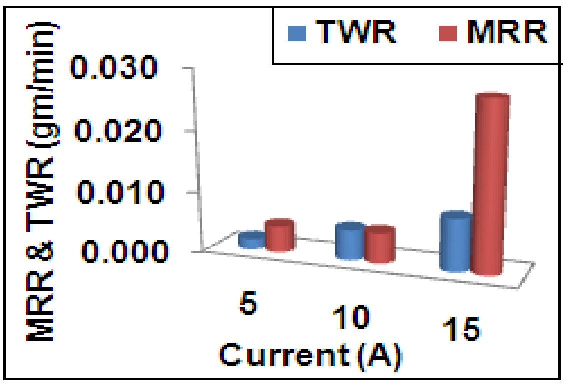

Fig. 2: Variation of Current with MRR and TWR

current, pulse on time and pulse off time on the process responses, such as material removal rate and tool wear rate were analyzed in during in titanium carbide nano powder mixed EDM die sinking process. The Variation of the current with material removal rate and tool wear rate are shown in fig.2. The maximum MRR is obtained for value of current 15 amps with TWR rate increases with an increase in the current. This may be due to reason that with high current 15 amps more material gets melted at the tool and work piece interface. The compare MRR and TWR with MRR slightly increased up to 5 - 10 amps.

6.2 Effects of pulse on time with MRR and TWR

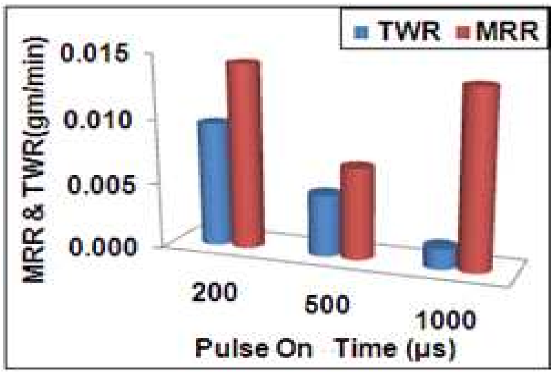

Fig. 3: Variation of pulse on time with MRR and TWR

The influences of pulse on time with material removal rate and tool wear rate are shown in fig.3. The variation of pulse on time MRR with TWR discussed here. For pulse on time the MRR first increased till 200 µs and then decreased in 500 µs. This can be practiced to the fact that very short pulse duration imparts a lesser amount of energy which causes less vaporization on the surface of workpiece resulting in low MRR. The maximum value of MRR is obtained at pulse on time of 1000 µs. Tool wear rate is decreased with increase in pulse on time. These factors result in higher thermal loading on both electrodes (tool and work piece) followed by higher amount of material being removed.

6.3 Effects of pulse off time with MRR and TWR

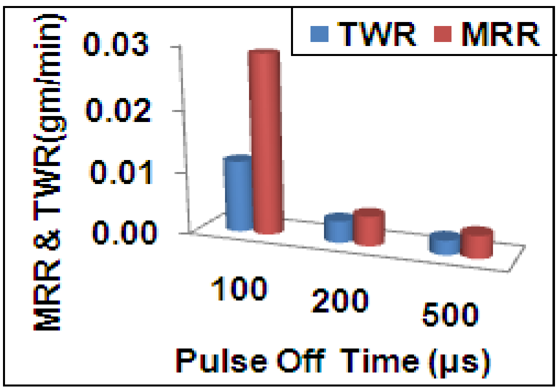

Fig. 4: Variation of pulse off time with MRR and TWR

Fig.4. shows the relationship between pulse off time with material removal rate and tool wear rate. It can be concluded that tool wear rate decrease proportionally with increases in pulse off time. The reasons being due to increase in pulse off time, spark energy decreases and due to this smaller amount vaporization on the face of workpiece resulting in little MRR. For increase in pulse off time MRR increased up to 100 µs and then there was no significant increase. In case MRR first increased up to 80% and then started to decrease.

7. CONCLUSION

In this paper, an experimental investigation of PMEDM with titanium carbide nano particle into suspended at this moment kerosene as a dielectric fluid was performed on inconel 718. MRR and TWR was analysed for effects of different input parameters. The following conclusions have been found out from the experimentation and analysis:

- The current increases in material removal rate increase.
- The maximum material removal rate is increased with increase in current 15 amps.
- With discharge current 5 A the tool wear rate is decreasing, but increase discharge current in the range of 10 to 15 A the tool wear rate is increasing.
- The pulse on time has through effect on the material removal rate.
- MRR first slightly increases as pulse on time 200 µs and then decreases in a similar mode till 500 µs. For higher material removal rate in the surface pulse on time 1000 µs.
- Tool removal rate is decreased with increase in pulse on time.
- With increase in current and pulse on time, the spark discharge energy is increased to facilitate the action of melting and vaporization and advancing the large impulsive force in the spark gap, thereby increasing the material removal rate.
- When the pulse off time is increased the material removal rate and tool wear rate decreases.
- Maximum MRR is obtained with pulse off time 100 µs.

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