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Study and Analysis of Temperature Distribution on AlSiC machining on EDM

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Abstract: **-- In die sinking electric discharge machining manufacturing conditions are most important aspects to be considered as these conditions are very important to determine output parameters. Aluminium silicon carbide that are widely used automotive, defence and automotive industries possess a very mechanical and physical properties is used in this study to find the temperature distribution on its surface by using current , discharge voltage and pulse on time as input process parameters. A number of combinations were prepared with the help of Taguchi L9 Orthogonal Array and analysis is done using minitab 18 software.**

Keywords— Electric Discharge Machine, temperature distribution, AlSiC composites, regression modelling

1. INTRODUCTION

One of the non-conventional manufacturing processes, Electric Discharge Machining (EDM) is based on the principle of erosion of metal by discharge of electric spark. Two electrodes (the harder one is called tool material and the softer one work material) and series of electric discharges between them are responsible for erosion of work material. As the work gets eroded, it gets the replica of shape of tool material and hence this machining is suitable for making dyes. Very complicated contours and delicate cavities which cannot be produced by conventional methods in short time can be manufactured using EDM. As electric discharge to happen between electrodes, both the electrodes should be made of electrically conductive materials.

The working principle of electric discharge machining is based on the thermoelectric energy. Series of sparks are created between tool material and work material by this thermoelectric energy in presence of a dielectric and hence study the temperature distribution in the work material in this process has become an important and relevant area for the researchers in the machining using EDM. Even though, aluminium is conductive material and has very wide applications in industry, of late, composites of aluminium are developed in order to increase the strength and hardness of the resultant composite. Out of these composites, aluminium silicon carbide is the latest which has attracted the researchers for further study as it has very wide applications in aerospace and automobile industries. As aluminium is electrically conductive where as silicon carbide is not, machining of this material using EDM is a great challenge if quality of the surface is important. At the same time, study of the temperature distribution along the work piece should be taken care of, while machining this composite.

In this paper, the machining of AlSiC composite is performed using EDM and the temperature distribution along the material at selected distance values from the machining point are considered as one of the process variables. The introduction is given first and it is followed by a section on literature review which covers the work of previous researchers in this area. The methodology and experimentation are explained in this third section and the results and analysis are given the fourth section. It is followed by meaningful conclusions about the work.

2. LITERATURE REVIEW

In this section, the works of earlier researchers related to machining of composites on EDM and the input/response variables taken into consideration are reviewed. M. Uthyakumar et al. [3] in this work, has taken AlSic-functionally graded aluminium metal matrix composite and they machined it using EDM by taking pulse on time, pulse current etc., as input parameters and surface roughness, electrode wear rate and power consumption as output parameters. For optimization of output variables, they used gray relational analysis. Chen et al. [2] in his work of optimization of the EDM process parameters of A6061-T6 aluminium alloy used Taguchi methodology for experimentation. They have taken peak current, duty cycle, and pulse on time and machining duration as input variables and surface roughness as output variable. He used ANOVA and analysis of means (ANOM) for analysing the experimental outcome, and optimized parameters and their effect on the surface roughness.

Hung et al.[1] used EDM for machining cast aluminium metal matrix composites reinforced with SiC particles. They developed the statistical models to predict the effect of input

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process parameters on surface finish, metal removal rate and re-cast layer. Bhuyan et al. [4] investigated for the optimization of EDM process parameters of Al-SiC metal matrix composites (AMMC). The process parameters taken by them include peak current, flushing pressure and pulse on time and they studied response parameters like tool wear rate, material removal rate and surface roughness. Seo et al. [5] used EDM for machining aluminium composites and concluded that metal removal rate increases with increase in pulse on time and current up to a limit and then decreases with increase in pulse on time. In their case, for metal matrix composites, high value of pulse on time and current resulted in greater tool wear and increased average diameter error.
Velmurugan et al. [6] investigated the effect of process parameters like discharge current, pulse on time, flushing pressure and voltage etc. From experimental values obtained, they have concluded that, with increase in discharge current, flushing pressure and pulse on time, the material removal rate has increased while it decreased with increase in voltage. Nakagawa et. al. [7] has taken working gap control as input variable in high-speed electrical discharge machining (EDM) milling. From this literature, it may be concluded that EDM milling does not need complex electrode fabrication and it is necessary to improve the removal rate in EDM milling. Very few researchers have taken temperature distribution as one of output parameters and it is important to study this as lot of heat is generated while machining takes place.

3. METHODOLOGY AND EXPERIMENTATION

The main purpose of the research is to identify the temperature distribution on AlSiC using current, pulse on time, voltage and length as input parameters. This experimentation contains four independent factors each at three levels. These factors are used in Taguchi L9 array and nine different combinations are made and experiments are conducted using these combinations. Model development and analysis of input and output parameters is carried out using the MITITAB software.

3.1 Selection of Tool and Work Material

AlSiC (200× 50× 20) composite has been chosen as work piece for study purpose. This composite is casted by combining 90% of aluminium and 10% of silicon in a furnace as shown in Table-1. The testing of the material reveals that it possesses superior physical and mechanical properties like low density, greater strength to wear ratio.

Table-1 Chemical composition of AlSiC

S.No.	Material	Percentage
1.	Aluminium	90%
2.	Silicon carbide	10%

In this study, pure copper in cylindrical shape has been used as tool electrode. Selection of tool material depends on the various factors such as electrical conductivity as the tool and work piece should conduct electricity.

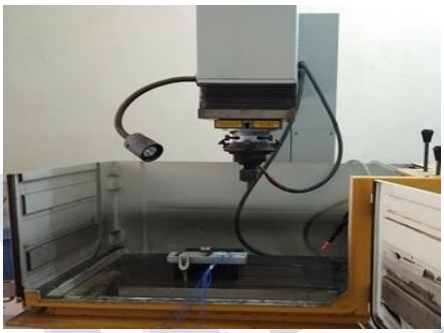

Figure-1. Die sinker EDM

In this study experiments were carried out in computer aided manufacturing laboratory of the institute, on a die-sinker EDM (Smart CNC S50) of Electronica Machine tools Ltd, Pune, India (shown in Figure-1). In this research, the work piece AlSiC composite is used with a pattern of thermocouples kept at regular distance from the place where machining is to be done.

3.2 Process Parameters and their Levels

Four input process parameters, viz., current, discharge voltage, pulse on time and length (the distance between place of machining and the thermocouples), have been taken. The details are given in the Table-2.

3.3 Output Process Parameters

Temperature is taken as output parameter and it is defined as the warmth or coldness of an object with reference to some standard value. It is measured by using thermocouples located at pre defined distance values.

Table-2 Process Parameters and their Levels

S. No.	Input Parameters	Level 1	Level 2	Level 3
1.	Current (Ampere)	10	12	15
2	Discharge voltage(volt)	40	50	55
3	Pulse-on-time	150	200	300
4	Length(cm)	15	25	35

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3.4 Temperature Measurement

Experiments are carried out on Die-sinking EDM using pure cylindrical copper as tool electrode and AlSic as workpiece with 10% of SiC. Workpiece is made with a proper arrangement of themocouples on its surface. Each thermocouple is placed at distance of 10mm from the other, a total number of three thermocouples were placed lengthwise and another three were placed width wise as shown in Figure-2.

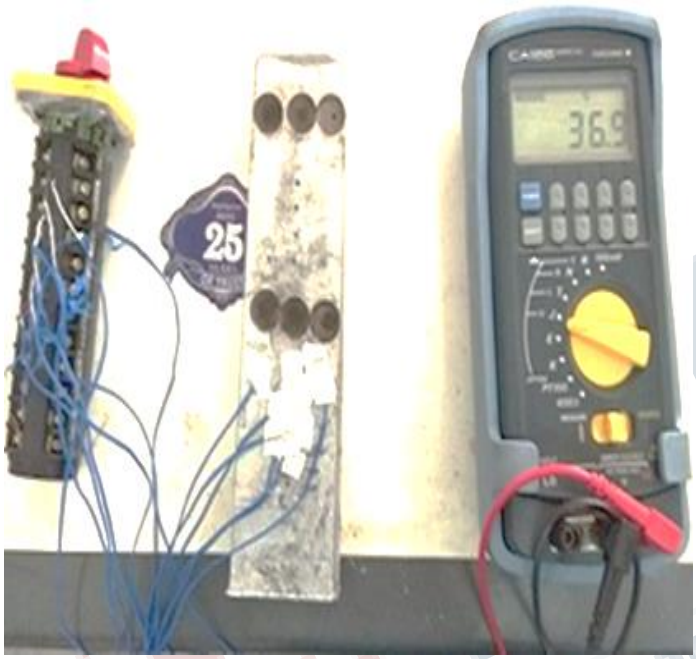

Figure-2: Thermocouple arrangement

Temperature was measured with the help of thermocouple and temperature calibrator with the help of selector switch, result obtained are given in Table-3.

Table-3 Experimental data of AlSiC

S. No	Current (A)	Voltage V)	TON	Length cm)	Temperature (ºC)
1	10	40	150	1.5	41.1
2	10	50	200	2.5	41.6
3	10	55	300	3.5	43.9
4	12	40	200	3.5	38.8
5	12	50	300	1.5	43.9
6	12	55	150	2.5	42.8
7	15	40	300	2.5	38.9
8	15	50	150	3.5	38.7
9	15	55	200	1.5	42.4

4. RESULT AND ANALYSIS

In this section, effect of input process parameters i.e. input current (IP), discharge voltage (V), pulse on time (Ton), and length (L) on temperature distribution is analysed. Temperature distribution is used to develop a linear regression analysis model with the help of MINITAB18 software. The Regression equation obtained is given in Eq-1.

Temperature = 36.3-0.454I +0.2219V+0.00967Ton- 1.000L ….. (1)

From the above model, it may be observed that temperature is inversely proportional to current and length and directly proportional to voltage and Ton time.

5. CONCLUSION

The above research and experimentation shows that temperature distribution is an important parameter to study in the case of EDM machining of aluminium silicon carbide composites and its distribution depends on the factors like current, discharge voltage, pulse on time and the distance from the point where machining is done. The value of temperature obtained is higher or higher value of current, pulse on time and discharge voltage, also value of temperature is low for lower value of discharge voltage.

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