# A REVIEW ON MODELLING TECHNIQUES OF ELECTRICAL DISCHARGE MACHINING PROCESS

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## Abstract

*Modelling helps to carry out the research work to identify the action of work without the requirement of real time experimentation. It saves time and resources. Modelling can be done in different ways by considering thermal, physical, mechanical, electrical and energy properties of the system. Nowadays designing of experiments has also been modelled to reduce the complexity in experimental work. In this paper, the review of modelling of EDM process parameters has been studied.*

***Keywords** - EDM modelling, EDM.*

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## ABBREVIATIONS

FEM - Finite-element method
GPR - Gaussian process regression
EDM - Electrical discharge machining
MRR - Material removal rate (mm3/min)
EWR - Electrode wear ratio
SR / $R_a$ - Surface roughness (µm)

## 1. INTRODUCTION

The experiment has been modelled to understand the basic occurrence of the process. Depending upon the type of process viz., thermal, electrical, chemical, physical, energy and fluid flow process, the event has been modelled using different techniques. EDM is an Electrical Discharge Machining where erosion of material taken place by melting and evaporation of cathode (workpiece) without touching the anode (tool) due to continuous sparks discharges between the electrodes. Since EDM is a multiphysics, electrical process, the modelling of such a machine has been developed using variety of techniques and the influence of process parameters has been studied. This paper reviews about the mathematical and software modelling of EDM process parameters.

## 2. LITERATURE REVIEW

Tang et al. [1] modelled the formation process of discharge crater in EDM. They have analysed the temperature, velocity and acceleration distribution at the heated zone. The kerf loss is an important factor in slicing of silicon ingots in photo voltaic industries. The crack free silicon wafers has been achieved by non conventional machining like wire EDM. Joshi et al [5] developed the numerical modeling for predicting the erosion rate of silicon wafer in wire EDM. They have calculated the number of sparks at the starting of the wire to the starting of the workpiece. They have evaluated the erosion rate by splitting the wire in equal lengths. They have developed the mathematical model for the plasma temperature. They have followed a new technique by considering the plasma flushing efficiency. As per the fact that the erosion rate is proportional to the crater depth, they have achieved increase in erosion rate with increase in voltage. They have also concluded that there is decrease in erosion rate with increase in wire diameter. By analyzing the plasma heating phase and bubble collapsing phase Tao et al. [3] developed a model for formation of discharge crater. Hoang et al. [17] developed an electro thermal model for µ EDM to calculate the fraction of energy distributed to the electrodes. They have used the single discharge erosion model to calculate the discharge crater radius. They have discovered that the distribution of energy to electrodes depends on the workpiece thermal conductivity and the dielectric density.

Zahiruddin and Kunieda [4] estimated the temperature distribution in the electrodes by solving the heat transfer equations. Ghiculescu et al. [6] studied the microgeometrical behaviour of thermal attack produced by the discharges under ultrasonic vibrations of electrode tool in EDM. The cumulative microjets improve the machining rate upto 500% and the surface roughness upto 50% by removing the melted material during discharging in solid state as well as liquid state and by orienting the cumulative micro jets parallel to the machined surface. Iuras [7] established a mathematical model for the relation between tool electrode wear with other EDM parameters using taguchi method. Maity and Mishra [8] carriedout artificial neural network modelling to predict the material removal rate, overcut effect and recast layer thickness of micro EDM for the fabrication of micro holes. Chung et al. [9] investigated the electrolytic corrosion of micro EDM using deionized water and modeled the prevention of it by giving narrow positive pulse to the workpiece . They have fabricated micro holes and 3D structures in WC–Co workpiece without corrosion.

Somashekhar et al. [10] used finite volume method to predict the effect of spark ratio on the the temperature distribution in the material. Numerical simulation of multi spark discharges in μ EDM has been modeled with heat equations with proper boundary conditions on machining of AISI316L. They have realized that temperature oscillation is needed extra in the case of less spark ratio time. The temperature at the spark on time increases along the axial and normal directions of the workpiece. Similarly, the surface convection affects the faster decrease in temperature at spark off time. Ming et al. [2] developed a hybrid intelligent model for latent heat, heat distribution coefficient of cathode, Plasma Flushing efficiency (PFE) to calculate the MRR and surface roughness using FEM and the relationship between the input parameters and the output performance have been established using GPR model.

Sanchez et al. [11] constructed an inversion model based on least squares theory to estimate the values of EDM input parameters to fulfill the MRR, SR, EWR. Izquierdo et al. [13] predicted a thermal model for heat affected zone and recast layer by considering multiple discharges in EDM for AISI D2 tool steel. They have considered the effect of interaction between successive discharges and the presence of bubbles and debris which other authors have not considered in single discharges. They have also derived the relationship between the radiuses of the plasma channel with percentage of heat transferred to the workpiece. Prediction of convection coefficient has also been encountered. Zhou et al. [12] derived a predictive model of gap states which gives out the link between internal and external factors and the characteristics of timely varying gap states.

Das and Joshi [14] developed an analytical model to predict the cathode erosion rate for single and multi spark in micro wire EDM process with vibration effects by taking in to account the moving heat source phenomena and the time variant heat source. They have concluded that the erosion rate of workpiece is directly related to the plasma temperature but not on the wire velocity. Erosion rate increases step by step with pulse on time and decreases by the vibration effects. They have achieved an erosion rate of $3.25\times10^{-11}m^3/s$ and $9.1\times10^{-10}m^3/s$ for single and multiple spark erosion. To increase the process productivity and finishing ability Joshi and Pande [15] developed the intelligent model for single spark EDM process. They have derived the shape of the crater cavity, MRR and tool wear rate using Finite Element Method (FEM) and Artificial Neural Network (ANN). Salonitis et al. [16] formulated the theoretical thermal model for the die sinking EDM process. They have derived the MRR and surface roughness in terms of arc voltage, current and sparking time.

Çaydaş & Ahmet Hasçalik [18] modelled the electrode wear and white layer thickness in die sinking EDM. They have used Graphite and Titanium (Ti) alloy as a tool and workpiece. They have found that the pulse current has major effect on the electrode wear and recast layer while the pulse off time has no effect on both performance. Valentinčič and Junkar [19] modelled the current signal in the discharge gap using inductive machine learning. The current signal in the gap depends upon the size of the eroding surface which in terms determines the surface power density. In this regard the author specifies six tasks on the current signal of the electric discharge. The average pulse current at the discharge, variation of average pulse current of the succession discharge plays a major role on attributes. Bobbili et al [20] established the relation between the input variables and the performance measures with the dependence of thermo physical properties on MRR and SR of armour materials. They have derived the mathematical model for MRR and SR by using buckingham pi theorem on wire EDM. Due to the thermal properties of WEDM, the MRR is high for low melting temperature materials. Shao and Rajurkar [21] simulated the crater development process using electro-thermal model of micro EDM. The energy distribution to the electrodes has been calculated by using the heat transfer equation and dimensions of crater formed.

## 3. CONCLUSION

This paper reviews about modeling of process parameters of EDM using numerical and software solutions. The researchers developed the model using different techniques to analyze the action and its influence on the process parameters. It reveals that the modeling techniques ease the experimentation work and also used to compare the results of it.

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