

# A Review – An Experimental Effect of Electrode Material on Overcut, MRR, TWR and Surface Roughness of AISI 304 Stainless Steel in EDM

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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). Electrical Discharge Machining performance is generally evaluated on the basis of Overcut (OC), Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR). The important EDM machining parameters affecting to the performance measures of the process are discharge current, pulse on time, pulse off time, arc gap, and duty cycle. Several approaches are proposed in the literature to solve the problems related with optimization of these parameters. It is felt that a review of the various approaches developed would help to compare their main features and their relative advantages or limitations to allow choose the most suitable approach for a particular application and also throw light on aspects that needs further attention. In view of above, this paper presents a review of Effect of Electrode Material on Overcut, MRR, TWR and Surface Roughness of AISI 304 Stainless Steel in EDM.

**Key words:** ANN, Electrical Discharge Machining, GA, GRA, MRR, OC, RSM, SR, TWR

## I. INTRODUCTION

Electrical Discharge Machining (EDM) is an important manufacturing process for machining hard metals and alloys. This process is widely used for producing dies, molds, and finishing parts for aerospace, automotive, and surgical components. The process is capable of getting required dimensional accuracy and surface finish by controlling the process parameters. EDM performance is generally evaluated on the basis of Overcut (OC), Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR).

The important EDM parameters affecting to the performance measures of the process are discharge current, pulse on time, pulse off time, arc gap, and duty cycle. In EDM, for optimum machining performance measures, it is an important task to select proper combination of machining parameters. Generally, the machining parameters are selected on the basis of operator's experience or data provided by the EDM manufactures. When such information is used during Electrical Discharge Machining, the machining performance is not consistent. For these materials, Experimental optimization of performance measures is essential. Optimization of EDM process parameters becomes difficult due to more number of machining variables and slight changes in a single parameter significantly affect the process. Optimization of EDM process parameters becomes difficult due to more number of machining variables and slight changes in a single parameter significantly affect the process. Thus, it is essential to understand the influence of various factors on EDM process.

Analytical and statistical methods are used to select best combination of process parameters for an optimum machining performance. Different author use different combination of process parameters. They analyze the experimental data by plotting Interaction graphs, Residual plots for accuracy and Response curves. Some other methods used by different author for analysis of data related to Electrical Discharge Machining (EDM) are Regression analysis, Response Surface Methodology (RSM), Central Composite Design (CCD), Grey Relational Analysis (GRA), Genetic Algorithm (GA), Fuzzy clustering, Artificial Neural Network (ANN) etc. Most of the author used L9 & L27 Orthogonal Array. Generally the effect of Pulse ON time, Pulse OFF time, Spark gap set Voltage, Peak current on the Material Removal Rate, Surface Roughness, Overcut, Tool Wear Rate is investigated.

## II. PRINCIPLE OF EDM

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system shown in fig 1. Both tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/de-ionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases. Basically, there are two different types of EDM: Die-sinking EDM & Wire-cut EDM. A EDM system has four major Components: (1) Computerized Numerical Control (CNC), (2) Power Supply, (3) Mechanical Section: Worktable, work stand, taper unit etc., (4) Dielectric System.

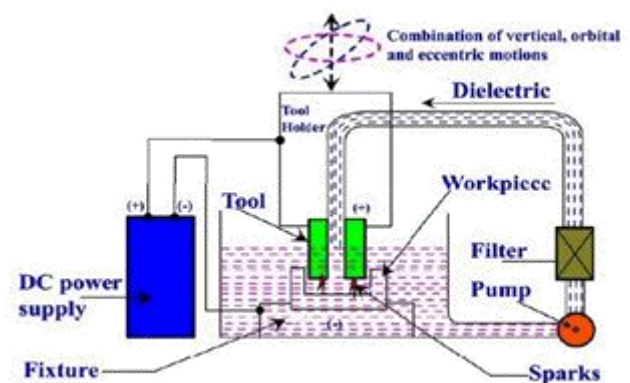


Fig. 1: Setup of EDM

## III. EXISTING RESEARCH EFFORTS

S.H.Tomadi et. al. [2] evaluate that the influence of operating parameters of tungsten carbide on the machining characteristics such as surface quality, material removal rate and electrode wear. The effectiveness of EDM process with tungsten carbide, WC-Co is evaluated in terms of the material removal rate, the relative wear ratio and the surface

finish quality of the workpiece produced. It is observed that copper tungsten is most suitable for use as the tool electrode in EDM of WC-Co. Better machining performance is obtained generally with the electrode as the cathode and the workpiece as an anode. In this paper, a study was carried out on the influence of the parameters such peak current, power supply voltage, pulse on time and pulse off time. The surface quality that was investigated in this experiment was surface roughness using perthometer machine. Material removal rate (MRR) and electrode wear (EW) in this experiment was calculated by using mathematical method. The result of the experiment then was collected and analyzed using STATISTICA software. This was done by using the design of experiments (DOE) technique and ANOVA analysis.

**Othman Belgassim et. al. [41]** used L9 orthogonal array based on Taguchi method to conduct a series of experiments to optimize the EDM parameters. Experimental data were evaluated statistically by analysis of variance (ANOVA). The EDM parameters are Pulse current ( $I_p$ ), Pulse –on- time ( $T_{on}$ ), Pulse –off- time ( $T_{off}$ ), and the Gap voltage ( $V_g$ ) , while the machining responses in concern are the surface roughness of the machined surface and the over-cut. The experimental results have given optimal combination of input parameters which give the optimum surface finish of the EDM surface.

**Shankar Singh et. al. [22]** reports the results of a experimental investigation carried out to study the effects of machining parameters such as pulsed current o material removal rate, diameter overcut, electrode wear, and surface roughness in electric discharge machining of E 31 tool steel (IS designation: T105 Cr 1 Mn 60) hardened and tempered to 55 HRC. The work material was ED machined with copper, copper tungsten, brass and aluminum electrodes by varying the pulsed current at reverse polarity. Investigations indicate that the output.

Parameters of EDM increase with the increase in pulsed current and the best machining rates are achieved with copper and aluminum electrodes.

**Subramanian Gopalakannan et. al. [25]** study the effect of pulsed current on material removal rate, electrode wear, surface roughness and diameter overcut in corrosion resistant stainless steels viz., 316 L and 17-4 PH. The materials used for the work were machined with different electrode materials such as copper, cop-per-tungsten and graphite. It is observed that the output parameters such as material removal rate, electrode wear and surface roughness of EDM increase with increase in pulsed current. The results reveal that high material removal rate have been achieved with copper electrode whereas copper-tungsten yielded lower electrode wear, smooth surface finish and good dimensional accuracy.

**V.Balasubramaniam et. al. [31]** used different electrode materials namely copper, brass and tungsten while EDM of Al-SiCp Metal Matrix Composite. Material Removal Rate (MRR), Electrode Wear Rate (EWR) and Circularity (CIR) are considered as the performance measures. Artificial Neural Network is used for optimization of the machining parameters such as current, pulse on time and flushing pressure. Investigations indicate that the current is the most significant parameter. Among the three electrodes copper

yields better performances. Machining time is reduced with better performances.

**Praveen Kumar Singh et. al. [40]** focused on the effect of Copper and Brass electrodes on material removal rate (MRR) and tool wear rate (TWR) for AISI D2 tool steel by using Die- Sinker EDM. The current was varied from 4 to 10 amp, the voltage and flushing pressure were constant, the MRR for copper electrode was in the range of 4.8139 - 22.6580 mm<sup>3</sup>/min whereas the range of MRR for brass electrode was 7.2213-9.8203 gm/min. The trend of TWR as shown in results increases with current for both the electrodes. The effect of voltage on MRR and TWR for both the electrodes was analyzed. The MRR for copper electrode was continuously decreasing with voltage whereas MRR for brass don't follow any specific trend. The TWR for both the electrodes decreases with voltage. It has been observed that copper electrode is the best for machining AISI D2 tool steel by using Die- Sinker EDM.

#### IV. OBJECTIVE

Encouraging for the use of AISI 304 Stainless Steel due to its good weldability, resistance against corrosion & chemicals, good machinability, and good heat resistance. Finding out the best suitable electrode material for machining AISI 304 Stainless Steel depending upon requirements such as Overcut, SR, MRR & TWR which directly affects quality of machining and machining time. Also finding out optimum value and effect of input variable parameters such as Current, Pulse on time, Pulse off time on Overcut, Surface Roughness, Material Removal Rate and Tool Wear Rate.

#### V. EXPERIMENTAL SETUP

Material to be used as workpiece- AISI304 Stainless Steel  
Electrode to be used- Copper, Graphite, Silver, all of have 10.00 mm diameter.

Variable Input Parameters- Current, Pulse on time, Pulse off time.

Constant Input Parameter- Voltage, Flushing Pressure  
Depth of Cut- 3 mm

Square work piece has to be machined with each side of 25 mm & 20 mm Thickness.

Experiment has to be done at Jayvir Engineering, Ahmadabad.

DOE Adopted : Taguchi L9 Orthogonal Array

	Level 1	Level 2	Level 3
Current	4	8	15
Pulse on Time	5	6	7
Pulse off Time	4	5	6

Table 1: Factors with Levels

Experiment No.	Current	Pulse on Time	Pulse off Time
1.	4	5	4
2.	4	6	5
3.	4	7	6
4.	8	5	5
5.	8	6	6

6.	8	7	4
7.	15	5	6
8.	15	6	4
9.	15	7	5

Table 2: DOE – L9 Orthogonal Array

From above experiment effect on output parameter- Overcut, MRR, SR and TWR will be found.

## VI. CONCLUSION

From Existing Research Efforts-

- (a) The Input Parameters in EDM Process are Polarity, Pulse on time, Pulse off time, Peak Current, Gap Voltage, Duty cycle.
- (b) The Output Parameters in EDM process are Material Removal Rate, Surface Roughness, Tool Wear Rate, Over cut.
- (c) The DOE Techniques which used for process parameter optimization work in EDM are Taguchi Orthogonal array, Response Surface method.
- (d) The Optimization Techniques which used for process Parameter optimization work in EDM are Taguchi S/N ratio analysis, Response Surface Method, Genetic Algorithm. MATLAB is a program which can be useful as a soft computing tool for Genetic Algorithm.
- (e) List of Workpiece which are used in EDM- EN31 Tool Steel, Tungsten-Carbided, V Composite, Al 7075 B4C MMC, AISI 202 SS, AISI D3 Tool Steel, H-11 Steel, H-13 Tool Steel, Hastelloy Steel, Mild Steel, AISI 1040 Medium Carbon Steel, EN19, EN9, AISI 316-L SS, NiTi60-SMA, AISI D2 Tool Steel, Ai-SiCP MMC, AISI P20 Tool Steel, Silver Steel, W300 Die Steel, AISI 4340 Steel, Titanium Super Alloy.
- (f) List of Tool Material which are used in EDM- Copper, Graphite, Brass, Silver, Tungsten, Copper Tungsten, Silver Tungsten, Tungsten Carbide, Aluminum.
- (g) The performance is affected by discharge current, pulse on time, pulse off time, voltage, arc gap, duty cycle, and flushing pressure.
- (h) When current increases, the MRR also increases. The higher the current, intensity of spark is increased and results in high metal removal rate. When the current is increased, surface roughness is also increased.
- (i) When pulse-on-time increases, the MRR is decreased. The higher the pulse-on-time, intensity of spark decreases due to expansion of plasma channel and results in less metal removal. When Pulse-on-time is increased, surface roughness is decreased.
- (j) With increase in pulse-off time, the MRR increases as with long pulse off time the dielectric fluid produces the cooling effect on electrode and work material, decreasing the cutting speed. Surface Roughness improves with increase in pulse-off time.

## VII. FUTURE SCOPE

For researchers there is wide scope for analyzing and developing new technology. Many different types of tool material can be used for machining on a particular material and optimum parameters can be obtained. Also many different work piece materials that can be used for research. Thus the best tool material with optimum parameters can be selected to obtain satisfying results for efficient and effective processing.

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