A review: Effect of input parameters on electrical discharge machining

Hira Singh

Assistant Professor in Mechanical Department

Gian Jyoti Group of Instititutions
Shambhu Kalan, Banur.

Mail ID: hira507puri@gmail.com

Abstract: Electrical discharge machining is a non conventional machining process. EDM is very useful for the machining of very hard material. There is no direct contact between the workpiece and tool electrode. This paper shows the effects of input parameters on the response parameters. In other words this shows the effect of the current, voltage, duty factor, etc. on the material removal rate, surface roughness etc.

Keyword: EDM, MRR, TWR, SR

Introduction: Electrical Discharge Machining is a Non-Traditional material removal process. EDM is one of the most popular machining techniques to manufactured dies, press tools, complicated shape of aerospace, automobiles and surgical equipments. Because EDM has capability to produce complicated shapes and machining of very hard materials. The EDM process is applicable for machining where both cutting tool and workpiece are electrically conductive. The process of material removal in EDMing is done by sparks generated between tool electrode and workpiece. EDM process differs from the traditional machining process because there is no direct contact between tool electrode and workpiece. The dielectric fluid is used in EDM machining process for flushing the eroded particles which are removed by the thermal energy of the sparks from the workpiece as well as tool electrode.

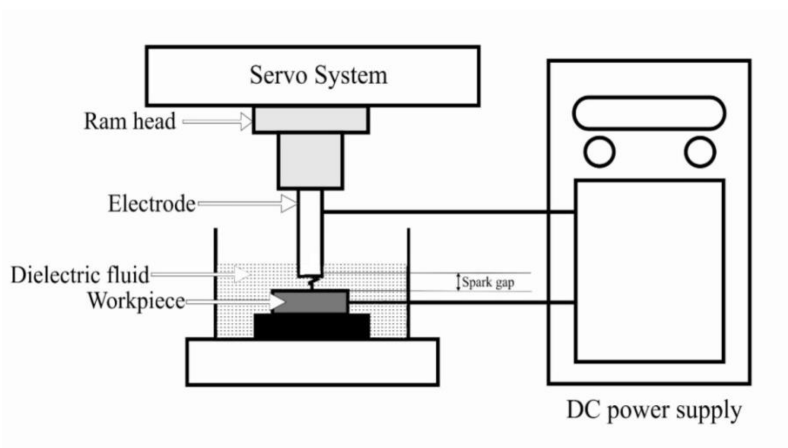

Figure 1 Layout of the EDM process

Principle of EDM: The working principle of electrical discharge machining is based on conversion of electrical energy into thermal energy. In EDM the material removes from the both workpiece and tool electrode due to the sparking produced between the workpiece and tool electrode. A very small gap between workpiece and tool electrode of about 0.02mm to 0.5mm is to be maintained by servo controller system. In EDM both workpiece and tool electrode are submerged in a dielectric fluid. Deionised water, EDM oil and kerosene are few examples of commonly used dielectric fluids. The main function of the dielectric fluid is to provide insulation between workpiece and tool electrode, and the dielectric fluid flush the debris particles which are produced by the sparking effect. Due to the spark produce between the workpiece and tool electrode, the temperature of both materials rise, and the metal evaporate from both workpiece and tool electrode. If the workpiece is at positive terminal (Anode) and tool electrode at negative terminal (Cathode) then the rate of material removal of the workpiece is more than the tool wear rate. Because material removal rate at positive terminal is higher than the negative terminal.

The basic EDM process parameters can be divided into following two categories.

(i) Input parameters

(ii) Output parameters

Input parameters: The input parameters are those types of parameters which are set as per user's requirements and according to machine rating. Input parameters provide excitation to the electrical discharge machine. Some general input parameters are pulse-on time, pulse-off time, supply voltage, polarity, sparking gap, workpiece and electrode materials, flushing pressure, current, duty cycle, etc.

Brief description of these parameters is as follows:

(i) Pulse-on time: It is denoted by $T_{on.}$ The material removal rate is directly proportional to the pulse-on time. When the current starts flowing**,** then the sparking occurs between the workpiece and tool electrode, due to this sparking the material removes from the workpiece as well as tool electrode. The unit which is generally used for pulse-on time is μs.

(ii) Pulse-off time: It is generally denoted by T_{off} and the unit of pulse-off time is μs. The time when the sparks in off mode i.e. when the sparks between the workpiece and tool electrode is not occurs, during this time it allows molten metal to remove from the sparking gap (gap between the workpiece and tool electrode) with the pressure of the dielectric fluid. So the pulse-off time is inversely proportional to the MRR, but if the pulse-off time is too short then the debris particles do not completely removed from the sparking gap.

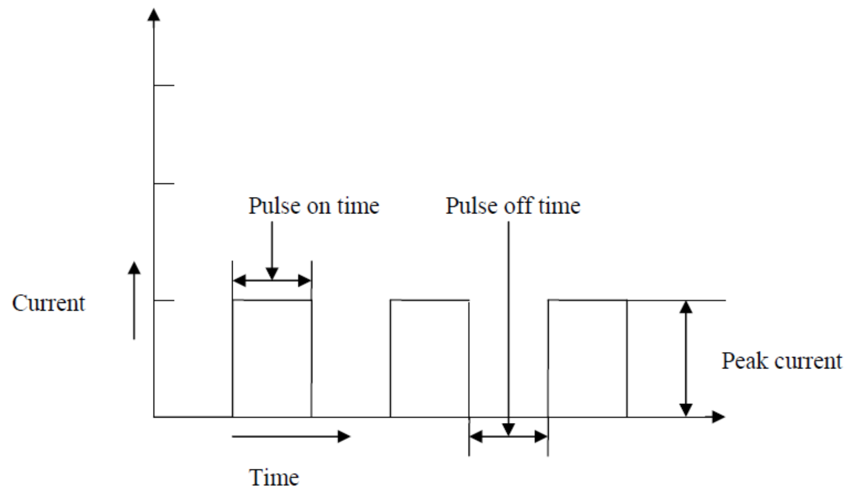

Figure 2 Pulse wave form of controlled pulse generator [5]

(iii) Supply voltage: The supply voltage is measured in Volts, and denoted by V. It also affects the material removal rate of the both workpiece and tool electrode. MRR, TWR and surface roughness are increased by increasing supply voltage.

(iv) Polarity: The polarity of the workpiece can either be positive or negative. In the positive polarity (straight polarity), the workpiece connected with the positive terminal and tool electrode with the negative terminal, while in the negative polarity (reverse polarity) the workpiece is connected with the negative terminal and tool electrode is connected with the positive terminal. The research shows that the MRR and TWR are higher with the straight polarity but finishing is better with the reverse polarity.

(v) Sparking gap: Sparking gap is the gap between the workpiece and tool electrode. It is also called spark gap or electrode gap. Generally sparking gap varies from $0.01mm$ to $0.5mm$, and this gap is maintained by the servo system of EDM.

(vi) Workpiece and tool electrode material: The material of the both workpiece and tool electrode affects EDM parameters such as MRR, TWR, SR, etc. In the EDM the material of workpiece and tool electrode must be electrically conducting, because electrically insulating material cannot be machined by the EDM.

(vii) Current: Current is defined as rate of flow of charge and flows opposite to the flow of electrons. It is the most important machining parameter in EDM. Current is measure in term of the Ampere (A). The MRR, TWR and SR are directly proportional to the current.

(viii) Duty factor: It is defined as the percentage of the pulse-on time to the total cycle time. The research shows that the increases in duty factor increases MRR. Duty factor is often defined in percentage. The mathematically expressions of the duty factor is given below:

$$Duty\ Factor = \frac{T_{on}}{T_{total}} \times 100$$

$$T_{total} = T_{on} + T_{off}$$

$$\therefore Duty\ Factor = \frac{T_{on}}{T_{on} + T_{off}} \times 100$$

Output parameters: The output parameters are the response of the EDM to input parameters. The output parameters depend upon the input parameters and working conditions. Some main output parameters are given below:

(i) MRR: The rate of removal of material per unit time is known as material removal rate and is denoted by MRR. MRR is directly proportional to the current, supply voltage and pulse-on time and is inversely proportional to the pulse-off time.

(ii) TWR: The rate of wear of tool electrode per unit time is known as tool wear rate and is denoted by TWR. TWR is also directly proportional to the current, supply voltage and pulse-on time and is inversely proportional to the pulse-off time.

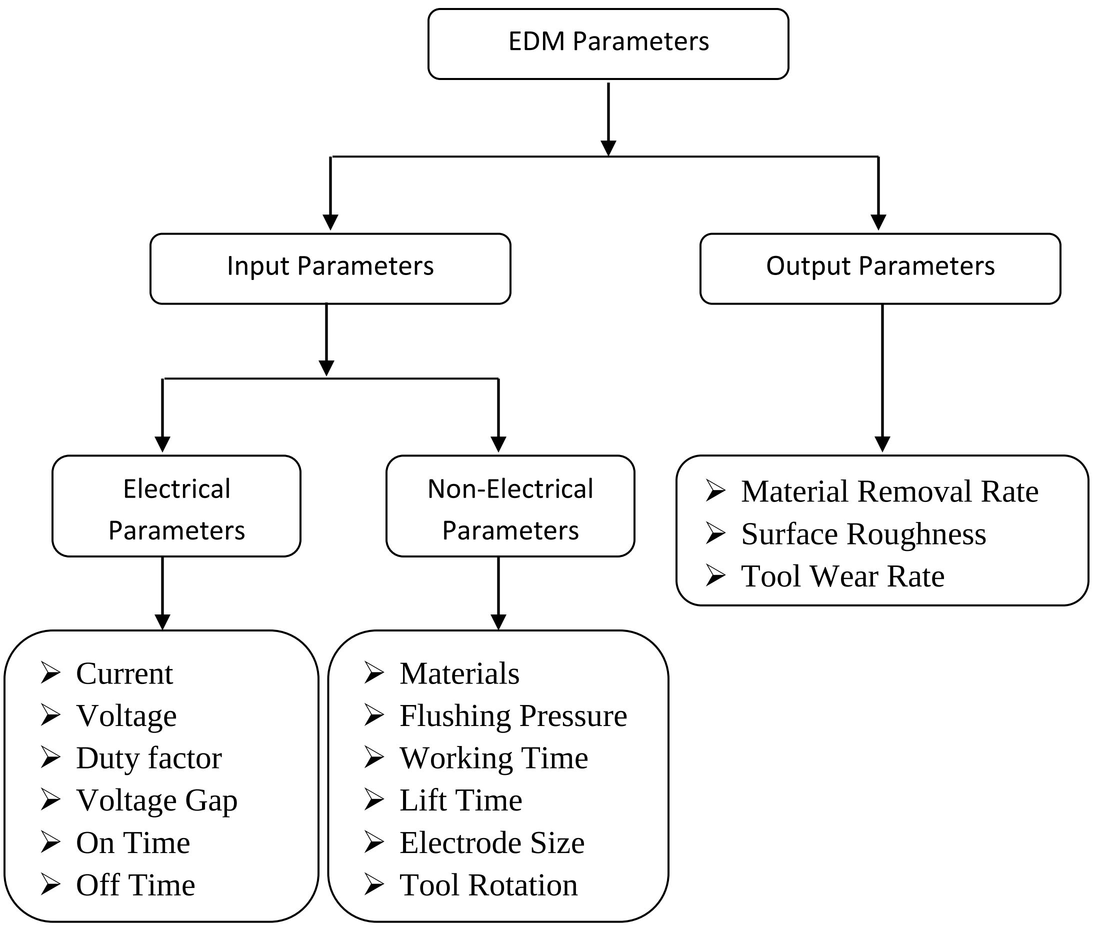

Fig.3 Parameters of EDM

(iii) Surface roughness (SR): Surface roughness is also an output parameters and it is measure with the surface roughness tester. The value of the surface roughness is generally increased with the increase in current. The higher value of the surface roughness implies the machining surface of the workpiece to be very rough. But rough surface is generally not required, hence to overcome this problem the value of current should be kept to optimum value. This yields researcher to develop new material for tool electrode. For example the brass tool electrode gives betters surface finishing as compare to copper tool electrode.

(iv) Surface integrity: Surface integrity includes surface roughness, thickness of the recast layer, microstructures of the grains, etc. These all surface integrity characters depend upon the input parameters which are used for machining of workpiece in EDM.

Literature Review: Raghuraman et al. [6] investigated machining effect on mild steel IS 2026 using copper tool electrode using Taguchi method. During this experimental work they found that MRR and TWR are directly proportional to current and pulse on time. They also found that the Taguchi Grey relational Analysis is being effective technique to optimize the machining parameters for EDM process. **Srivastava and Pandey [7]** compared the machining effect of conventional EDM and cryogenic assisted EDM using copper electrode for machining of high speed steel (M2 grade). From this study, found that the EWR increases with increase in discharge current and duty cycle for both conventional and cryogenic EDM and also found that the EWR and SR are lower in cryogenic EDM as compare conventional EDM process. **Khan and Hammedullah [8]** investigated the effect of electrical discharge machining polarity with straight polarity and reverse polarity using workpiece as a silver steel of 28 grade with copper tool electrode has centre flushing system for higher MRR and lower SR. This study shows that the higher metal removal rate and lower electrode wear is achieved with the straight polarity. Lower SR is obtained by reverse polarity. **Reza et al. [9]** analysed the effect of machining polarity on Alloy Steel (AISI P20 GRADE 1.2738) using copper electrode by DOE using L18 orthogonal array. The results of this study show that, the positive polarity gives optimum result for material removal rate, tool wear rate and surface roughness. **Yan et al. [10]** machined tungsten carbide (P10 and K10) using electrolytic copper electrode with negative polarity EDM. This study reveals that MRR and EWR increased with increase in discharge energy for both workpiece (K10 and P10). The debris diameter also increased with the increase in electrical discharge energy. The heat affected zone is softer than the base metal with the higher discharge energy. **Yan et al. [11]** investigated the effect of electrical discharge energy on machining performance of the cemented tungsten carbide (K10 and P10) with electrolytic copper electrode using reverse polarity. This study reveals that the MRR is increase with the increase in electrical discharge energy but the surface finishing and bending strength of the cemented tungsten carbide decrease with the increase in discharge energy.

Conclusions: This review paper shows following conclusions:

1. Material removal rate is directly proportional to the current.
2. Material removal rate is directly proportional to the pulse on time.
3. Tool wear rate is directly proportional to current and pulse on time.
4. Surface roughness is inversely proportional to the current.

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