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Study The Effect Variable Indicators When Operating a High-Speed Steel M2 By an Electric Discharge Machine on The Metal Removal Rate and Final Surface

Ahmed Lajili Ahmed[1], Abdulmenam Shaban Alagille[2], Hisham H. Al graiw[3], Fathi Rabee Ashour[4], Ehab Alageli[5]
[1,2,3,4,5] College of Technical Engineering- Janzour

Abstract- EDM is an unconventional electro thermal machining method used for the production of geometrically complicated or hard cloth components which might be extraordinarily difficult to gadget with the aid of using traditional machining method. The method includes a managed erosion of electrically conductive substances with the aid of using the initiation of speedy and repetitive spark discharges among the device and paintings piece separated with the aid of using a small hole of approximately 0.01mm to 0.50mm. This hole is both flooded or immersed in a dielectric fluid. The managed pulsing of direct current among the device and the painting's piece produces the spark discharge. The EDM method that we recognize these days is an end result of numerous researches performed over the years. EDM researchers have explored some of the approaches to enhance the sparking performance with numerous experimental concepts. Despite a variety of various approaches, each new study stocks the equal targets of reaching excessive metallic elimination price with discount in device put on and stepped forward floor first-class. This paper opinions the sizable array of studies paintings performed inside beyond a long time for the improvement of EDM. This observe is in particular targeted on components associated with floor first-class and metallic elimination price which can be the most vital parameters from the factor of view of choosing the applicable method parameters in addition to distinctive warmth remedy method

***Keywords* —Electric discharge, electrode corrosion, material removal rate, surface roughness, high-speed M 2 steel, heat treatment, EDM.**

1. Introduction

The electric discharge machine it works theory is to use electrical energy to generate an electric spark to remove the metal so that it generates heat energy generated by the electric spark that melts the metal to be removed. It is also known that the use of the new concept of non-traditional methods of operation depends on energy sources such as sound, light, mechanical, chemical, electrical, electrons, and ions. Throw industrial progress and technological growth, machines have been developed where they can produce difficult parts that cannot be accomplished by traditional methods of operation, which has contributed to wide applications in aerospace, nuclear engineering, and other industries due to the ratio of strength to weight, hardness and heat resistance. This has seen new developments in the field of materials to produce new. As well as mechanical and thermal properties sufficient electrical conductivity so that it can be easily modulated by Spark corrosion. Unconventional machines have evolved so that they can manufacture complex materials in a geometric shape. That is, they do not use traditional tools to remove metals and instead, they use other forms of energy directly.

It has succeeded in making pieces that are complex in shape and size and this has led to increased demand for a product that enables it to solve precision and finish the surface through unconventional methods. Currently, non-traditional processes have almost unlimited possibilities except for the size of material removal rates, while in the past few years significant progress has been made in the industry, especially by increasing material removal rates. The higher the demoralization rate, the more cost-effective the operational processes are, stimulating the increasing uses of non-traditional processes.

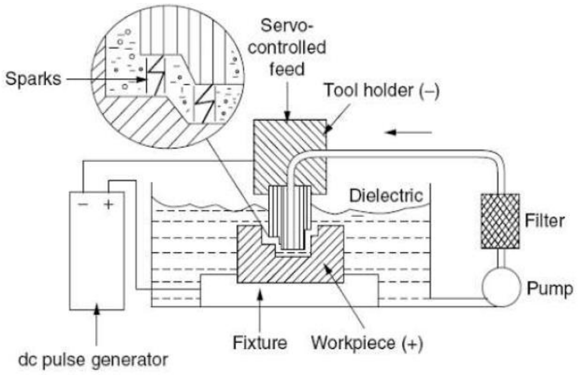

Figure-1
Schematic View of EDM

2. Electric discharge machine EDM

They are widely used for making tools, molds and other precision parts. Previously referred to as a non-traditional machining operation, it is now firmly established as a manufacturing option for many manufacturing industries around the world. It is capable of forming complex engineering pieces or solid material components, which are accurate and difficult to perform using conventional machine such as heat-treated steel, composite engineering materials, alloys, ceramics, carbides, heat-resistant steel etc. where it is widely used in industries such as mold making, aerospace, aerospace, and nuclear industries. The electric vacuum machine is making its presence felt in new fields such as sports, medical, surgical and optical instruments, including automotive and aerospace research and development.

2.1. Its working principle

In this process the metal is removed from the workpiece by corrosion by rapidly repeated spark discharge between the tool and the workpiece. Figure (1) above shows the file of mechanical and electrical installations and electrical circuits for the generation of electrical discharges. A thin gap of about 0.025 mm is maintained between the tool and the workpiece by an automatic control system. Both of the tool and the workpiece are immersed in an electrolytic insulating liquid such as kerosene or deionized water, a very common type of insulating liquid.

2.2. Methodology of its work

The tool is represented by the cathode and the workpiece are represented by the anode. When the voltage across the gap becomes high enough, it is generated through the gap in the form of a spark at intervals of up to 10 microseconds. Which accelerates positive ions and electrons, resulting in a discharge channel that becomes conductive. Just at this point the spark jumps and causes a collision between ions and electrons and creates a plasma channel with a sudden drop in electrical resistance to the previous channel allows the current density to reach high values producing an increase in ionization and creating a strong magnetic field. Spark moment a sufficiently developed pressure occurs between the work and the tool as a result of which a very high temperature is reached and at such a high pressure and temperature that some metals melt and corrosion occurs in the metal. This localized extreme rise in temperature causes the material to be removed. Removal of substances occurs immediately in the evaporation of the substance as well as due to melting. The molten metal is not removed completely but only partially. The potential difference (plasma channel) is also drawn. When the plasma channel collapses, pressure or shock waves are generated that discharge the molten material forming a hole of the removed material around the spark site.

2.3. Metal removal mechanism

The mechanism of material removal is carried out by converting electrical energy into thermal energy. During the manufacturing process sparks are produced between the workpiece and the tool. Thus, each spark produces a small crater, forming a crater shown in Figure 2 in the material along the cutting path by melting and evaporation, thus eroding the workpiece into a tool shape. He is known and described by many researchers in EDM, the mechanism of material removal in this process (Material Removal Mechanism 'MRM') is the process of converting physical elements between the workpiece and the electrode so that it is the transfer of knowledge in solid, liquid, or gas.

3. Important indicators in EDM

- **On-time or pulse time:** It is the duration of time (μs) for which the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time.
- **Off-time or Pause time:** It is the duration of time between the sparks. This time allows the molten material to solidity and to be wash out of the arc gap.
- **Arc Gap:** It is the distance between the electrode and the workpiece during the process of EDM. Also called the spark gap.
- **Duty Cycle:** It is the percentage of on-time relative to total cycle time. Which calculated by this equation:

  $$Duty\ Cycle = \frac{on\ time}{total\ cycle\ time} \Longrightarrow$$ total cycle time = on-time + off-time

  If multiply Duty Cycle by 100 it's efficiency
- **Intensity:** It points out different levels of power supplied by the generator of the EDM machine.
- **Voltage (V):** It is a potential that is measured by volt, also its effect to the material removal rate and allowed to per cycle. It is approximately 50 volts.

4. The effect of different indicators on MMR and surface finish SR

- **Effect of peak current:** to achieve the peak current effect of metal removal rate (MMR) and surface roughness (SR), pulse-on time is varied while keeping other indicators like pulse-off time, servo voltage, wire feed rate constant. At low pulse duration, the metal removal rate is low and nearly constant as low discharge energy is produced between the working gap due to insufficient heating of workpiece and pulse duration. While when the pulse duration is high, the rate of removal of the metal increases initially with increase in peak current because of the sufficient availability of discharge energy and heating of the workpiece material. The small increase in cutting speed at high value of peak current to insufficient cooling of the work material. The surface roughness (SR) is function of two parameters, peak current and pulse-on time, both are function of power supply. A surface roughness is produced at high peak current and/or pulse-on time. A finer surface texture is produced at low value of peak current and/or pulse duration and vice versa, so pulse energy per discharge can expressed as:

  $$E = u(t).i(t)dt$$

  Where:

$u(t)$is the discharge duration, $i(t)$ is the discharge current, and E is the pulse energy per discharge.

- **Effect of pulse on time:** to observe the effect of pulse-on time on material remove rate and surface roughness value of peak current is varied while keeping the other indicators such as pulse-off time, servo voltage, wire feed rate fixed. The material removal rate increases with an increase in pulse duration at all values of peak current. The material removal rate is a function of pulse duration but at the low value of peak current, also it is low due to the insufficient heating of the material and after pulse duration, the material removal rate increases less as of insufficient clearing of debris from the gap due to insufficient pulse interval. Surface roughness increase with an increase in pulse duration at different value of peak current but it is observed that surface roughness at

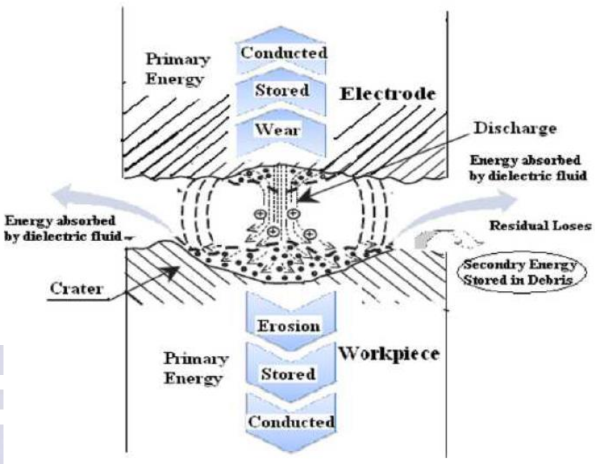

Figure-2
Mechanism of MRR

low value of pulse duration and high value of peak current is less than the high value of pulse duration and low value of peak current. on the other hand, long pulse duration removes material mainly by melting and forms craters with melting morphology due to low value on peak current and heat flux in the ionized channel, which prevents the temperature of the workpiece from reaching a high value it is in agreement with the work carried by others.

- **Effect of pulse-off time:** The metal removal rate MRR decreases when the pulse time is increased, as is the case with the long pulse time. The insulating fluid has a cooling effect on the electrode wire and work materials and thus reduces the cutting speed. It was observed that the surface roughness slightly changed despite the change of pulse time corresponding to a small value of pulse over time. Mainly the surface roughness improved with increasing pulse time. The surface roughness will be high at the low value of the pulse time, since with a very short pulse time there is not enough time to remove small solute particles from the gap between the tool electrode and the work piece and also there is not enough time to remove ions from the dielectric: then the surface will be rougher.

5. Research Review

Stated researcher Vineet Srivastava et al [3]. During their study of ultrasonic development with the help of a cryogenic electrode and performed the experiment on a high-speed steel material of grade M 2. The researcher took the study of electrode corrosion ratio (EWR), material removal rate (MRR) and surface roughness (SR) as performance coefficient. The indicator of the controllable process was taken as the discharge current, the pulse on time, the duty cycle and the alternating voltage. The result was compared to the ordinary electrode by the method of cooling and ultrasonic cryogenic with the help of cryogenic electrode. Experiments have been studying M2 grade HSS electrode with dimensions of 15mm*15mm*15mm. Work piece hardness 35 HRC. The tool electrode is selected as copper material with a diameter of 7 mm and a length of 70 mm. Kerosene oil was used as an insulating medium. The processing time was appropriately selected and kept for 25 minutes for all trial. Figure 3 shows the experimental setup developed by the researcher. The schematic presentation of the UACEDM is as under the results of the experiment were compared to the normal EDM, CEDM and UACEDM for the specified performance coefficient.

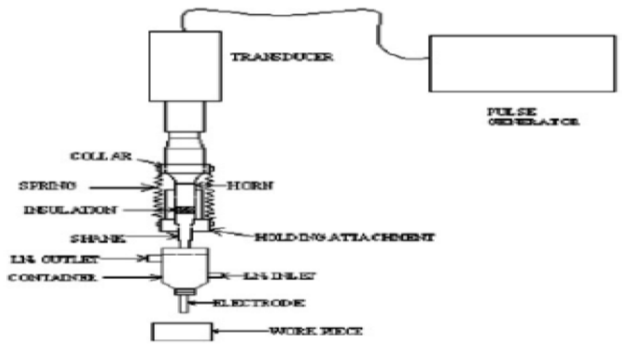

Figure-3
Experimental Setup

Vineet Srivastava et al [4]. Their study foxed on the development of an ultrasonic cryogenic cooled EDM process using (Cu-TiC) toolip. Where the researcher developed a sintered copper (Cu) - with an electrode tip of titanium carbide (TiC) in the UACEDM. Performance indicators in this experiment were electrode corrosion ratio (EWR), material removal rate (MRR), surface roughness (SR), roundness and surface integrity. Operation the indicator was taken as discharge current, pulse on time, due cycle, and voltage gape. The electrode was then manufactured by either rapid prototyping technique or powder metallurgy technique. In the experimental work four controllable variables were considered discharge current, pulse on time, duty cycle, voltage gap. Experiments on these process indicators were conducted at different levels. After performing the test file, they found a result m in terms of as shown in Figure 4.

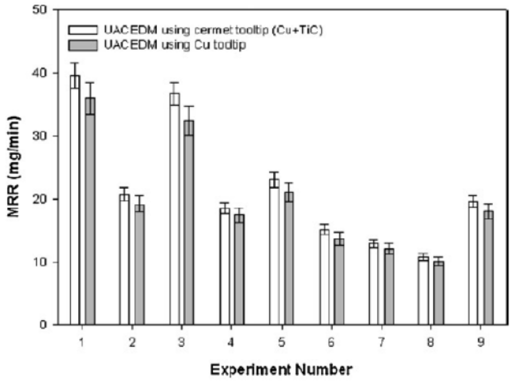

Figure-4

Animesh Prakesh et al [5]. Their development study summarized a hybrid manufacturing process using gas and kerosene as an insulating medium to study the effect of material removal rate (MRR) and electrode wear ratio (EWR). The researchers validated the experiment data by Taguchi's method of designing the experiment. Work the piece was taken as a square block of HSS which having size 1.5 cm material and the electrode is made up of a copper tube with a thin wall 0.5 mm thick hollow to allow the passage of compressed air. The controllable indicator is discharge current, pulse on time, and voltage gap. The researchers work with two cases in which at first the state of its performance when kerosene was used only as an electrical insulator in the intermediate state and in the second case both are used as a medium insulator. The result was different when only kerosene performed it and when both performed it. From the diagram, we understand that when compressed air was used at the time, the material removal rate was increased and the tool wear rate was reduced. Similarly, the voltage Gap Index is the most important indicator when using both liquid as insulation compared to the discharge current and the discharge current was the most important indicator when using only kerosene as an insulator. After experimental work and validation with the Taguchi method, the researcher succeeded in developing a hybrid manufacturing process on EDM. Successful completion of this work opens new horizons for further investigation of the effect of the use of gaseous semen insulators in the manufacture of electrical discharges. The concept can be applied to know the different work and Tool material response to the hybrid process. Other design indicators such as tool rotation speed and gas pressure can be varied to study the effects on response variables.

Yeh-Fung Zeng et al [6]. It has been studied to develop powder circulation technology to improve process stability and machine accuracy. The researcher used a die-sinking EDM with the help of SHOMOS type dielectric oil which an effective light hydrocarbon oil. For better manufacturing process and improve process stability use Al powder during the manufacturing process to improve circulation Al the cylindrical powder tank and new filtration system are designed for use throughout the experiment. This self-designed filter system was developed by the researcher which is shown in Figure 5.

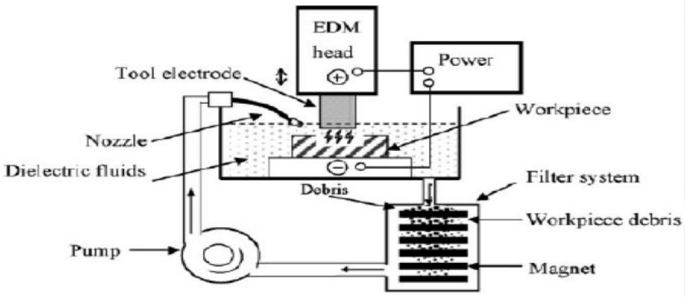

Figure-5
Diagram of a self-designed filter for the EDM

B. Mohan et al [7]. They studied for the development of machining the process of Al-Sic metal matrix composition using rotary tube electrode. The researcher used SiC/6025 Al composite material as a workpiece and brass was used as an electrode tool for the manufacturing process. They observed the value of the material removal rate (MRR), the electrode wear ration (EWR), and the surface roughness (SR) are evaluated the machine ability. Peak current, polarity, volume fraction of SiC reinforced particles, pulse duration, tube electrode hole diameter, pole rotation speed as input variables to evaluate mechanism. The researcher used metal matrix compounds (MMC) to perform the workpiece experiment. The goal of the researcher was to study the effect of the diameter of the hole of the electrode and the effect of the rotation speed of the tube electrode in the MRR, EWR and SR. They also optimize the cutting condition or maximum MRR, minimum EWR and surface roughness is better using genetic algorithm. Al-20 % SiC and Al-25 % SiC composites were machined with brass electrodes having eccentric holes with a diameter of 1.5, 2.5 and 3.5 mm. The effect of tube electrode in the manufacture of the above compounds was tested by measuring MRR, EWR and SR while varying the input variables. This input variables have been selected in this case are discharge current, polarity, SiC volume, pulse duration, hole diameter of the tube electrode and speed rotation of the electrode. The result that researchers got from this experimental the hole diameter of the electrode is significantly affects the MRR, EWR and SR. The decrease in hole diameter has produced a better MRR, SR and higher EWR. Volume percentage of SiC increased in MRR, SR in decrease and EWR increase. Also, the increase in rotation speed of the tube electrode has been produce higher MRR, EWR and better SR.

Chinmaya bi Mohanty et al [8]. They were studied for the development of Structural Thermal analysis of treated electric discharge machines. The researchers analyse the process indicators and their impact on three important responses such as material removal rate, tool wear rate, and residual stress on the work piece in the process. Design Box for response surface methodology is adopted to collect data for analysis. The process indicators such as voltage, current and pulse on time would be used to calculate the transient temperature distribution, the transformation of liquid and solid materials, and residual pressures. The researcher was taken M2 steel as a workpiece and the brass material was used as an electrode. And then has determined that the power distribution is 2% - 5% and 4% - 8% recommended for the tool and workpiece respectively. They got result of MRR, TWR and residual stress with respect to pulse on time and current with the help of graphical representation as show in figure 6.

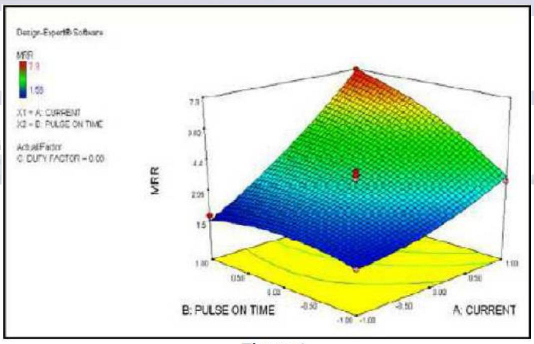

Figure-6
Surface plot of MRR with current vs. Pulse-on-time

V. Firouzdor et al [9]. This is to examine the outcomes of deep cryogenic remedy on put on resistance and device lifestyles of M2 HSS material. Deep cryogenic remedy consisted of slowly cooling to approximately −196ºC and maintaining at this low temperature for 24h and regularly bringing the specimens back to room temperature. In order to keep away from thermal shocks from fast cooling and heating, the specimens have been cooled down and heated up slowly, to and from the cryogenic temperature (−196ºC), over an 8h duration with the temperature being monitored through a thermocouple connected to the specimen. This offers a mean heating/cooling fee of 0.5ºC/min. Three styles of the device have been tested, reference tools (R) without an extra remedy, cryogenic-dealt with tools (CT), and cryogenic with a 1h mood at 200ºC dealt with tools (CTT). In these studies, it was determined that diffusion put on mechanism caused the motion of alloying factors from the floor of rake to chip and therefore weaken the rake face and plastic deformation occurs. Cryogenic remedy impacts the complete phase of the element not like coatings; consequently, comparable lives can be anticipated after every regrinding.

Sameh S. Habib et al [10]. have studied to the improvement of a complete mathematical version for correlating the interactive and better order impacts of diverse electrical discharge machining parameters thru the top present-day, average hole voltage. In fact, the metallic elimination charge will increase with a growth of pulse on time, top present-day and comparatively with hole voltage. Metal elimination charge decreases with the growth of SiC percent. Electrode put on ratio will increase with a growth of each pulse on time and top present-day and reduces with the growth of each of SiC percent and hole voltage. The hole length decreases with the growth of SiC percent and will increase with the growth of pulse on time, top present-day and hole voltage. Finally, the floor roughness will increase with the growth of pulse on time, SiC percent, top present-day, and hole voltage. The primary goal of the paintings become to illustrate the mathematical version of the MRR, TWR, GS, and Ra by the usage of a mathematical equation and discovered EDM parametric have an impact on of all layout parameter that is as under. remedy, cryogenic-handled tools (CT), and cryogenic with a 1h mood at 200ºC handled tools (CTT). In these studies, it becomes discovered that diffusion put on mechanism brought about the motion of alloying factors from the floor of rake to chip and therefore, weaken the rake face and plastic deformation occur. Cryogenic remedy influences the whole phase of the element not like coatings; consequently, comparable lives can be anticipated after every regrinding.

6. Conclusion

The above literature survey infers that there's a want to study the impact of all procedure parameters in detail. The quantity of Discharge current, hole voltage, pulse on time, pulse off time, exceptional warmness remedy procedure like warmness remedy, cryogenic remedy on workpiece dictates a a success procedure which is affected to fabric elimination rate, device put on rate, floor finish, microstructure of the workpiece and electrode. Parameters like discharge current, gape voltage, pulse on time, pulse off time, energy intensity, amplitude, overcut, dielectric fluid are having an effect on in electro discharge machining procedure at once or indirectly.

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