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A Review on Process Parameter Optimization in EDM

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***Abstract*- electrical discharge machining performance is generally evaluated on the basis of material removal rate (mrr), tool wear rate (twr), relative wear ratio (rwr) 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 [9]. a considerable amount of work has been reported by the researchers on the measurement of edm performance on the basis of mrr, twr, rwr, and sr for various materials. 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 development done in the optimization of edm related process parameters.**

***Keywords*- edm, taguchi method, optimization, anova**

I. INTRODUCTION

The extraction of reliable information from aerial EDM or electric discharge machining is achieved when a discharge take place between two points of the anode and cathode, the intense heat is generated near the zone melts and evaporates the materials in the sparking zone. For improving the effectiveness of the process, the workpiece and the tool are submerged in a dielectric fluid (hydrocarbon or mineral oils). It is found that if the materials of electrodes are same and when it is connected to positive terminal, it erodes fastly. Due to this reason, workpiece is generally made the anode.

Also some gap is kept in between tool and workpiece surfaces which are called as spark gap. In this process this spark occurs continuously at the spot where tool and workpiece surfaces are come closest, however the spot changes after each spark in the form of material removal after each continuous spark, the spark travels all over the surface. This causes uniform material removal over the surface; hence workpiece conforms to tool surface. For hard metals which are unable to machining using conventional methods, EDM proves beneficial means it is easily machine able with EDM process.

It is commonly used for complex type contours or cavities cutting that are difficult to create with conventional machining methods. However EDM process has limitation too, i.e. it only works with conductive materials. Some common materials which are machined by this method are nickel-based alloys (aerospace materials), very hard tool steels, High speed steels, conductive composites, conductive ceramics, etc.

We can say that EDM is usually an electro-thermal non-traditional type material removal process which is extensively used to produce complicated cuts for aerospace and automotive industry, nozzles, machining of ceramics and composites and surgical components. The basic working principle of EDM process is centred on thermoelectric energy. This energy is produce between a work piece and an electrode which is submerged in a dielectric fluid with the passageway of electric current.

However for producing a discharge, the ionization of dielectric is required. Suitable voltage is applied and intensity of dielectric field between them builds up. The electrons break loose from the surface of cathode and are impelled towards the anode under field forces. While moving, the electrons collide with the neutral molecules of dielectric and causes ionization. When this happens, there is an avalanche of electrons flowing towards anode, resulting in a discharge of energy which is seen as spark.

The discharge leads to the generation of extremely high temperature causing fusion of the metal and the dielectric fluid at the point of discharge. The metal in the form of liquid drops is dispersed into space surrounding the electrodes by the explosive pressure of gaseous product in the discharge. The continuous flushing of the dielectric is necessary for efficient removal of debris. The material removal takes place due to localized heating and then vaporization of material during machining when the distance between the tool electrode and the work piece electrode is maintained as electrostatic field of sufficient strength is established, causing cold emission of electrons from tool electrode. These liberated electrons accelerate towards the anode. After gaining sufficient velocity, the electrons collide with the molecules of dielectric fluid breaking them into electrons and positive ions. The electrons so produced also accelerate and may ultimately dislodge to other electrons from the dielectric fluid molecules. Ultimately a series of narrow columns of ionized dielectric fluid molecules is established, connecting two electrodes causing an avalanche of electrons since the conductivity of the ionized column is very large which is normally seen as a spark. Thus a very high temperature is developed on the electrodes. This causes the melting and vaporization of the electrode materials and the molten metals are evacuated by a mechanical blast, resulting in a small crater on both the electrodes.

II. EDM PRINCIPLE

EDM is carried out in a liquid medium, the machine's automatic feed adjustment device to the work piece and the tool electrode discharge gap between the right, when the tool is applied between the electrode and the work piece strong pulse voltage (up to the gap in the media breakdown voltage) when the lowest breakdown strength of dielectric insulation, as shown. The discharge area is small, the discharge time is very short, so a high concentration℃ of energy, so that the instantaneous temperature of the discharge area of up to 10000-12000, and tools for surface partial melting of the metal electrode surface, or even vaporized.

Partial melting and vaporization of metal under the action of the explosive thrown into the working fluid, small particles of metal was cooling, and then quickly washed away by the working fluid work area, so that the surface to form a small pit. One discharge, the medium dielectric strength recovery waiting for the next discharge. This is repeated continuously so that the surface ablation, and copy the tool electrode on the work piece shape, so as to achieve the purpose of forming. EDM metal ablation is constantly discharging process. Although a pulse discharge time is very short, but it is electromagnetism, thermodynamics and fluid mechanics combined effects of such a process is quite complex. Taken together, the first pulse discharge can be divided into the following phases.

1. Between the medium polar ionization, breakdown and formation of the discharge channel. When the pulse voltage is applied between the tool electrode and the work piece, there is immediate formation of an electric field between the two poles. Electric field strength and voltage proportional to the distance is inversely proportional to the voltage between with the distances between the increase or decrease of the electric field strength between the pole with the increase. Because the micro tool electrode and the work piece surface is uneven, distances between very small, and thus between the electric field strength is very uneven, the nearest between the poles of the salient points or tip is generally the maximum electric field strength. When the field intensity increases to a certain number, the media, the breakdown, the discharge gap resistance decreases rapidly from the insulating state to a fraction of the ohms, the current rapid increase in the gap to the maximum. The channel diameter is small, so a high current density in the channel. Gap voltage by the breakdown voltage decreased rapidly to spark sustaining voltage (usually about 20 ~ 30V), current from 0 up to a peak current.

2. Medium thermal decomposition, electrode material melting, vaporization and thermal expansion. Once the ionized medium between poles, breakdown, the formation of the discharge channel, the pulse power to the electronic speed toward the channel between the cathode, positive ions toward the negative. Energy into kinetic energy, kinetic energy into heat energy through the collision and so in the channel, respectively, as positive and negative instantaneous surface heat source, reached a high temperature. Channel high-temperature vaporization of the working fluid medium, thereby split decomposition heat of vaporization. The vaporized working fluid and metal vapor, instant volume soared to become the bubbles in the discharge gap, the rapid thermal expansion and has explosive characteristics. Observing the EDM process, you can see the discharge gap between the emitting bubbles, working solution gradually darkened, and hear the crisp sound of minor explosions.

3.Electrode material thrown channel and the positive and negative surface discharge point of the instantaneous vaporization of high temperature so that the working fluid and metal melting, vaporization, thermal expansion produces a high transient pressure. The highest channel center of pressure, so that the gas vaporized continuously outward expansion, the pressure height of the molten metal liquid and vapor to be excluded, thrown out and into the work solution. As the role of surface tension and cohesion, so that the material thrown out with the minimum surface area, condensation particles together into small balls. Melting and vaporization of the metal electrode surface in the far better, to the splash, in addition to most of the cast into the working solution and forced into small particles, there is a small splash, plating, adsorption on the opposite side of the electrode surface.

Between the media very deionization- With the end of pulse voltage, pulse current is rapidly reduced to zero, but after the interval should have a period of time to allow the gap deionization media, that charged particles in the discharge channel complex as neutral particles, recovery of this discharge channel at the media dielectric

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strength, and reduce the temperature of the electrode surface so as to avoid duplication in the same place the next place is always a result of the discharge arc discharge, in order to ensure the polarization resistance between the nearest or the formation of the next smallest at the breakdown discharge channel. Thus, in order to ensure the EDM process normally carried out between the two pulse discharge generally have enough time between pulses. Furthermore, it should leave room for the breakdown, the discharge point spread, transfer, or only at a point near the discharge, easy to form the arc.

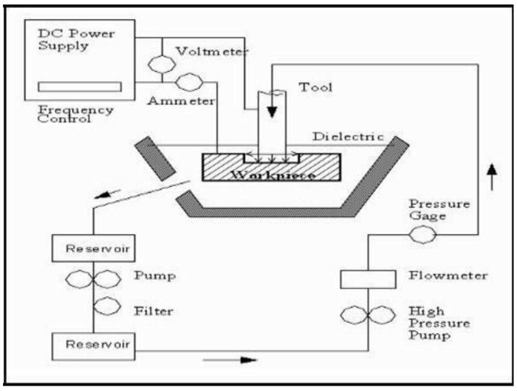

Fig. 1: Electro-Discharge Machine Setup.

III. LITERATURE REVIEW

Electrical discharge machining (EDM) is the non-contact machining technique has been continuously evolving from a mere manufacturing geometrically complex or hard material parts and die making process to a micro scale application machining alternative attracting a significant amount of research interests. In recent years, EDM researches have explored a number of ways to improve the sparking efficiency including some unique experimental concept that depart fro
m the EDM traditional sparking phenomenon.

Gopalakannan and Thiagarajan Senthilvelan [1] to find the effect of pulsed current on material removal rate, electrode wear, surface roughness and diameteral 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, copper-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.

Pravin R. Kubade and V. S. Jadhav [2] investigated the influence of EDM parameters on EWR, MRR and ROC while machining of AISI D3 material with a copper electrode. The parameters considered were pulse-on time (Ton), peak current (Ip), duty factor (t) and gap voltage (Vg). It is found that the MRR is mainly influenced by peak current where as other factors have very less effect on material removal rate. Electrode wear rate is mainly influenced by peak current and pulse on time, duty cycle and gap voltage has very less effect on electrode wear rate. Peak current has the most influence on radial overcut then followed by duty cycle and pulse on time with almost very less influence by gap voltage. The study the influence of process parameters and electrode shape configuration on the machining characteristics such as surface quality, material removal rate and electrode wear.

Shishir Mohan. Shrivastava and A.K. Sarathe [3] conducted experiments and found better machining performance was obtained generally with the electrode as the cathode and the work- piece as an anode and it was observe that for high MRR main process parameters are peak current, pulse on time, pulse off time, whereas for electrode wear were mainly influenced by peak current and pulse on time. Surface quality was mainly influenced by peak current. As far as tool shape configuration concerned best tool shape for higher MRR and lower TWR is circular, followed by square, triangular, rectangular, and diamond cross sections.

Abhishek Gaikwad, Amit Tiwari, Amit Kumar and Dhananjay Singh [4] studied the effect of control factors (i.e., current, pulse on time, pulse off time, fluid pressure) for maximum material removal rate (MRR) and minimum electrode wear rate (EWR) for EDM of hard material Stainless steel 316 with copper as cutting tool electrode. In this paper both the electrical factors and non-electrical factors has been focused which governs MRR and EWR. Paper is based on Design of experiment and optimization of EDM process parameters. The technique used is Taguchi technique which is a statistical decision making tool helps in minimizing the number of experiments and the error associated with it. The research showed that the Pulse off time, Current has significant effect on material removal rate and electrode wear rate respectively.

Y. H. Guu [5] of surface characteristics of Fe-Mn-Al alloy analysed by means of the atomic force microscopy (AFM) technique and concluded that the higher discharge energy caused more frequent melting expulsions, leads to deep and large crater formation on surface of work, resulting in a poor surface finish.

George et al [6] optimized the machining parameters in the EDM machining of C-C composite using Taguchi method. The process variables affects electrode wear rate and MRR, according to their relative significance, are gap voltage, peak current and pulse on time respectively.

C.H. Cheron [7] machined XW42 tool steel and concluded that material removal rate with Cu electrode is greater than graphite electrode. He also concluded that Cu is suitable for roughing surface while graphite is suitable for finishing surface.

Ahmet Hascalk and Ulas¸ Caydas [8] using parameters such as pulse current and pulse duration and concluded that electrode material has an obvious effect on the white layer thickness, the material removal rate, surface roughness and electrode wear are increasing with process parameters.

S. Ben Salem et al [9] conducted experiments by experimental design methodology and found that a fewer number of experiments are required to find optimum result and the surface roughness equation shows that the current intensity is the main influencing factor on roughness. In a research carried out by **V.**

Chandrasekaran et al [10] on WC/5ni Composites Using Response Surface Methodology concluded that the MRR is maximum for all compositions. As the percentage of nickel increases the thermal conductivity of the composition increases since the nickel material is easily removed from the surface of the parent material. So the MRR increases with percentage of nickel. The surface roughness increases with increase in current and flushing pressure irrespective of %Ni. The optimum Ra values decreased with increasing electrode rotation.

Francesco Modica et al [11] aimed of investigation to shed a light on the relation and dependence between the material removal process, identified in the evaluation of material removal rate (MRR) and tool wear ratio (TWR), and some of the most important technological parameters (i.e., open voltage, discharge current, pulse width and frequency), in order to experimentally quantify the material waste produced and optimize the technological process in order to decrease it.
Kumar Sandeep [12] studied aspects related to surface quality and metal removal rate which are the most important parameters from the point of view of selecting the optimum condition of processes as well as economical aspects. It reported the research trends in EDM.

Lau et al [13] stated the feasibility of using Electrical Discharge Machining (EDM) as a means of machining carbon fiber composite materials. Machining was performed at various currents, pulse durations and with different tool materials and polarities and they concluded that it is entirely feasible machine carbon fiber composite materials by EDM process. Copper electrodes prove to be better than graphite electrodes in terms of tool wear and surface finish. Positive polarity should be used for machining carbon fiber composite materials in order to achieve a low tool wear ratio.

Amoljit S Gill et al [14] carried experiment on En31with Cu-Cr-Ni Powder Metallurgy Tool and found that peak current is the most contributing parameter towards surface roughness.

Navdeep Malhotra et al [15] surface roughness of EN-31 Die Steel found that the current and pulse on time have maximum influence on surface roughness. Lower the value of current better the surface finish and same effect in case of pulse on time.

H.T. Lee [16] found the relationship between the EDM parameters and surface cracks formation on the basis of discharge current and pulse on time parameters for EDM machining of D2 and H13 tool steel and concluded that surface roughness increases when pulse on time and pulse current increases. He also found that increased pulse-on duration will increase both the average white layer thickness and also the induced stress. These two conditions tend to promote crack formation.

Rajesha S et al [17] studied surface roughness on AL-7075 metal matrix composite and concluded that the Surface Roughness initially increases rapidly with an increase in pulse off-time and then decreases slowly with an increase in pulse off-time.

IV. CONCLUSIONS

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. A considerable amount of work has been reported by the researchers on the measurement of EDM performance on the basis of MRR, TWR, RWR, and SR for various materials. 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 development done in the optimization of EDM related process parameters.It was observed that the Taguchi's parameter is a simple, systematic, reliable and more efficient tool for optimation of the machining parameters. The effect of various parameters such as tool dia, peak current, pulse on time, and pulse off time on the machining of EN36C STEEL has been workout. It is observed that consider parameter namely tool diameter and pulse off time have significant effect on performance parameters and it was also justified by ANOVA analysis.

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