International Journal on Emerging Technologies (Special Issue on NCRIET-2015) **6**(2): 274-283(2015)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Material removal rate with powder mixed Dielectric on Electric Discharge Machining

Umakanth Mathapathi
Assistant Professor, Department of Mechanical Engineering,
BKIT Bhalki, Karnataka, INDIA

(Corresponding author: Umakanth Mathapathi)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Electrical discharge machining (EDM) is non-conventional machining process with a large industrial implementation. Its use is particularly intense when very complex shapes on hard Materials with a high geometrical and dimensional accuracy are required. However the technology capability of the process has limited its application when there is a requirement of high surface quality and mirror like characteristics. Its operation is characterized by long machining time, low discharge dispersion, high tool wear and uncertainty in the final finish of the surface. To improve the efficiency and surface finish of the work piece, some suitable material in the powder form is mixed into the dielectric fluid as a suspension at tool-work piece interface. The new process is termed as powder mixed EDM (PMEDM). In this process the added powder into the dielectric fluid facilitate the bridging effect and minimize the insulating strength of the dielectric fluid. As result, the machining becomes more stable and efficient. the aim of this study the effect of powder suspended into the dielectric fluid on the EDM process performance. Graphite and Chromium powders are mixed into the dielectric fluid and performance is measured in terms of material removal rate (MRR), surface roughness (SR) and tool wear rate (TWR).

Keywords: Powder mixed EDM, material removal rate, Dielectric Fluid,

I. INTRODUCTION

Technological developments in the field of new materials and alloys with increasing Strength, hardness, toughness, heat resistance and wear resistance have imposed many problems and difficulties during the machining of these materials by conventional means. Machining of intricate and complicated shapes, thin and fragile components, accurate and economical forming of very hard, high strength materials that are extensively used in aerospace and nuclear industries, have forced the scientists, engineers and technologists to search for new techniques of machining. As a result of research and development since many years, several new methods of machining have emerged. These new methods can be grouped under the name of non conventional machining methods. Non conventional machining methods are classified on the basis of type of fundamental machining energy used which are Mechanical Processes: In mechanical processes metal removal takes place either by the mechanism of simple or by erosion mechanism where high velocity particles are used as transfer media and pneumatic/hydraulic pressure acts as source of energy. It includes abrasive jet machining (AGM0, ultrasonic (USM), and water machining (WJM) etc.

Electrochemical Processes: They involve removal of metal by the mechanism of ion displacement. High current is required as the source of energy and electrolyte acts as transfer media.

It includes electrochemical machining (ECM), and electrochemical grinding (ECG) etc. Chemical Processes: They involve the application of resistantmaterial (acidic nor alkaline in nature) to certain portions of work piece. The desired amount of material is removed from the remaining area of work surface by the subsequent application of an element that converts the work material into a dissolvable metallic salt. It includes Chemical Machining (CHM), and Photochemical Machining (PCM) etc. Thermal Processes: They involve the application of very intense local heat. Here melting or vaporizing small amount of materials from the surface of the work piece. The sources of energy used are amplified light radiation, ionized material and high voltage. It includes Laser Beam Machining (LBM), Ion Beam Machining (IBM), Plasma Arc Machining (PAM) and Electrical Discharge Machining (EDM) etc. Among the various non-conventional machining methods, electrical discharge machining (EDM) is the important manufacturing process for the tool, mould and dies industries for several decades. It has capability to machine very hard materials and to produce complicated profiles automatically. EDM technology is widely used in manufacturing industry. This process enables machining of any materials, which is electrical conductive. Physical and metallurgical properties of the work material such as strength, toughness, microstructure, etc., are no barrier to its application.

During machining, the work piece is not subjected to mechanical deformation, because there is no physical contact between. This makes the process more versatile and can be machined conveniently. Despites its many advantages EDM process is characterized by long machining time, low discharge dispersion, high tool wear and uncertainty in the final finish of the work surface. For the fine finish work piece mechanical polishing after EDM is required. Therefore to improve the efficiency and surface finish of the work piece, some particles in the powder form are mixed into the dielectric fluid of the EDM. These current conducting micro Powders cause electric field aberration in the discharge gap. Under the pressure of gap voltages, lots of positive and negative charges gather respectively at the top and bottom of powders. The nearer the point is to top or bottom the higher is the electric current density. Then at points ‘a’ and ‘b’ between the two nearby powder where the electric field density is the highest, discharge breakdown will firstly occur when the electric field density surpasses the break-down resistant. capability. Discharge breakdown then causes a short circuit between the two powder particles and the redistribution of electric charges. More electric charges then gather at points ‘c’ and ‘d’, which leads to the discharge between these two powder and other powders, resulting in “series discharge” and accordingly the discharge breakdown between the electrode and the work piece. As the distance between the powders become smaller then the discharge gaps and more electric charges gather at the vertexes of the powder then at the other points, “series discharge” occurs easily. Thus electric discharge can easily occur in PMEDM process.

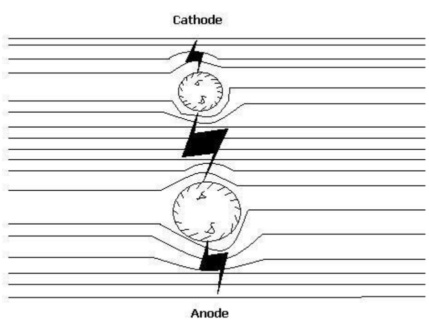


Fig. 1. Schematic Diagram of “Series Discharge” in PMEDM.

Machining may be performed on different materials with different type of powder suspended into dielectric fluid at different process parameters. The appropriate setting of the input process parameters and the correct combination of work piece material and powder characteristics has been found to improve machining efficiency. PMEDM has shorter machining time, and more dispersion of electric discharges.

In 1943, the soviet scientists Lazarenko and Lazarenko announced the construction of the first EDM. They discovered the effect of an electric discharge and developed a controlled method of machining.

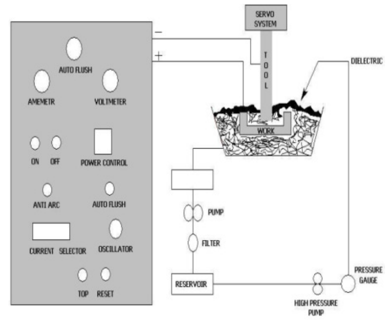


Fig. 2. Schematic Diagram of EDM Process.

In this process the tool electrode is connected to the negative terminal of the special electrical D.C. source and the piece is connected to the positive of the D.C. source. The EDM process can be compared with the conventional cutting process, expect that in this case, a suitably shaped tool electrode, with a precision controlled feed movement is employed in the place of cutting tool, and the cutting energy is provided by means of short duration electrical impulses.

Working principles of EDM. EDM is a thermoelectric process in which heat energy of a park is used to remove material from the work piece. The work piece and the tool should be electrically conductive. A spark is produced between the two electrodes and its location is determined by the narrowest gap between the two. Duration of each spark is very short. The entire cycle time is usually few micro seconds. The frequency of sparking may be high as thousands of sparks per second. The area over which a spark is effective is also very small; however temperature of the area under the spark is very high. As a result the spark energy is capable of partly melting and partly vaporizing material from localized area on both the electrodes i.e. work piece and tool. The material is removed in form of craters which spread over the entire surface of the work piece. Finally the cavity produced in the work piece is approximately the replica of the tool. Particles eroded from the electrodes are known as the debris. Usually the amount of the material eroded from the tool surface is much smaller than that from the work piece surface. A very small gap between the electrodes is maintained to have the spark to occur. For this purpose, a tool driven by the servo system is continuously moved towards the work piece.

Mechanism of EDM process. During EDM, pulsed D.C. voltage of 80-100 V at approximately 5 KHz is passed through the electrodes. It results in the intense electric field at location where surface irregularity provides the narrowest gap. Negatively charged particles loose from the cathode surface and move towards the anode under the influence of electric field forces. During this movement in the inter electrode gap(IEG). The electrons collide with the neutral molecules of dielectric. In this process electrons are also detached from these neutral molecules of the dielectric resulting in still more ionization. The ionization soon becomes so intense that a very narrow channel of continuous conductivity is established. In this channel there is a continuous flow considerable number of electrons towards the anode and that of ions towards the cathode. There kinetic energy (K.E.) is converted into heat energy, hence heating of anode due to bombardment of electrons and heating of cathode due to bombardment of ions, takes place. Thus, it ends up in a momentary current impulse resulting in a discharge, which may be an arc or a spark. The spark energy raises the localized temperature of the tool and work piece to such a high value that it results either in melting, or melting as well as vaporization of small amount of material from the surface of both electrodes at the point of spark contact. In fact due to evaporation of dielectric the pressure in the plasma channel raises to a very high value and it prevents the evaporation of superheated metal. As soon as the off time of the pulse starts, the pressure drops instantaneously allowing the superheated metal to evaporate. The amount of the material eroded from the work piece and the tool will depend on the contributions of the electrons and ions respectively. A servomechanism controls the movement of tool electrode towards the work piece. The sparking takes place over the entire surface of the work piece hence the replica of the tool is produced on the work piece. The polarity normally used is straight (or normal polarity).

Parameter of EDM process. The different process parameters that affect the machining characteristics of the EDM process are:-

1. Peak current (A) 2. Pulse on time (usec)3. Pulse off time (usec) 4. Duty factor5. Spark voltage or Breakdown voltage (V)6. Electrode Polarity7. Frequency (Hz) 8. Flushing

1. Peak Current Peak current is the function of energy. An increase in peak current will result in increased energy per spark. Consequently material removal rate (MRR) will increase, resulting in bigger craters on the work surface, and hence increased value of surface roughness (SR).

2. Pulse on time. Pulse on time is the time during which the machining is performed. The longer spark is sustained; more will material rate (MRR). Consequently the resulting craters will be broader and deeps; therefore, SR increases.

3. Pulse off time. During pulse off time, the pulse rests and reionization of the dielectric takes place. More is pulse off time greater will be the machining time. But this is integral part of EDM process and must exist. Pulse off time also governs the stability of the process.

4. Duty factor. This is an important parameter in the EDM process. This is ratio of pulse on time to the total time (Pulse on time + Pulse off time). If there is a high duty factor, then the flushing time is very less and this might lead to the short circuit condition. A small duty factor indicates a high pulse off time and low machining rate. Therefore there has to be a compromise between the two depending upon tool used and the work piece and the conditions prevailing.

5. Voltage. The voltage determines the width of the spark gap between the leading edge of the electrodeand the work piece. High voltage settings increase the gap and hence flushing and machining.

6. Electrode polarity. Polarity refers to the electric condition determining the direction of the current flow relative to the electrode. The polarity of the electrodes can be either straight or reverse depending on the application. The polarity normally used is straight in which the tool electrode is connected to the positive terminal of D.C. source and the work piece to the negative terminal of the D.C. source, while in reverse polarity the tool electrode is connected to the negative terminal of the D.C. source and the work piece to the positive terminal of the D.C. source. Some electrode/work metal give better result when polarity is changed.

7. Spark frequency. This is the measure the number of time the current is turned on and off. An increase in spark frequency results in an improved SR. since the energy available for materials removal during a given period of time is shared by a large number of sparks, the size of the crater is reduced with increase in frequency, thus SR decreases.

8. Flushing. Flushing is defined as the correct circulation of dielectric fluid between the tool electrode and the work piece. Proper flushing of dielectric fluid removes by product from the discharge gap. Hence the flushing is decisive for process efficiency and product quality. The effective flushing may increase MRR and lowers SR. Poor flushing ends up with stagnation of dielectric fluid and builds up of machining residues, which apart from low MRR also leads to short circuits and arcing.

II. LITERATURE REVIEW

The detailed literature survey conducted related to this problem is given as under: *Erden & Bilgin* studied the effect of powders suspended into the dielectric fluid on EDM process.

With addition of copper, aluminium and iron powder into the dielectric fluid of EDM process, it was found thatmachining rate generally increases with increase in concentration of the powder. However at high concentration machining becomes unstable, which attributed to frequent shoring of the electrode. However, they have not considered other machining parameters such as peak current, voltage and spark frequencies. M.L. Jeswani carried out work using graphite powder on the EDM. It is observed that the MRR is increased by 60% and TWR is reduced by 15%. In 1988 Mohri *et.al*. produced very fine finish machined surfaces by mixing of silicon powder into dielectric of the EDM process. Silicon powder of 10-30 um particle sizes was mixed uniformly with the working oil produced surfaces of fine finish under controlled working conditions of low discharge current and pulse duration. However, they have not studied the effect of silicon powder on MRR and PWR. A new method of EDM, in which oxygen is supplied into the discharge gap, was proposed by *Kuniedo* et.al. The experiments were performed on makino ED 22 EDM machine with the generator GPC 30 P. the machining is performed by using graphite electrode, carbon steel work piece (S 45 C) in water based dielectric fluid. All the experiments were conducted by setting the positively polarity. The oxygen gas was premixed with the dielectric fluid and supplied into the discharge gap through a small hole of the graphite electrode. Supplied oxygen gas reacts not only with iron, but also cracked gases such as hydrogen, carbon monoxide and hydro carbon. The rate of heat generation through reactions of supplied oxygen is about 5.6% of the power from the pulse generator. The additional power is helpful for melting work piece and increasing explosive force to remove the molten material. The diameter of eroded particles with the oxygen assisted EDM is larger than that of the convectional EDM. Therefore the increased gap distance causes the increased gap impendence then, the decreased leak current during the discharge delay time brings about the increased open gap voltage, because the specific resistance of the water- based dielectric is not infinite compared with kerosene. In this way the occurrence of discharge becomes more frequent. It is found that the MRR is increased due to enlarged volume of discharged crater and more frequent occurrence of discharge. It seems that too much of oxygen is harmful to the stability of discharges, since the gap becomes to be dry. But they have not included the other machining characteristic such as TWR and SR. they only made comparison between conventional EDM in terms of MRR, discharge frequency and remove volume per pulse. However, they have not studied the effect of other machining parameters such as pulse on time, and pulse off time etc on MRR, TWR and

III. PRESENT WORK

A. Problem formulation

EDM has been recognized as an excellent technology to achieve highly accurate complex shapes on a wide range of conductive and even non-conductive materials. EDM has been generally used in the process of tool, mould and die manufacturing for several decades. However, its lowmanufacturing efficiency and poor surface finish have been the key problems restricting its further development. Therefore, it is of great importance to improve the machining efficiency and surface quality of EDM technology.

To overcome all these difficulties, an innovative new strategy proposed in these days powder mixed electric discharge machining (PMEDM). In PMEDM, some suitable material in the powder form is mixed into the dielectric fluid as a suspension at the tool work piece interface during machining. The added powder into the dielectric fluid enlarged and widened the gap. This is because the added powders facilitate the bridging effect and insulating the strength of the dielectric fluid, thus a discharge channel is easily formed. The relative movement between the tool electrode and the work piece or the flowing of dielectric fluid may disturb the added powder in the gap and eliminate both the discharge channel and the transient bridging effect. Then the insulating status inside the dielectric fluids refreshed again. The flowing powder inside the dielectric fluid creates another discharging channel, and the gap voltage between the electrode and the work piece is obviously decreased. However, the discharging channel is then corrupted again. The formation of a discharge channel, the creation of discharging, the elimination of discharge channel and the corruption of discharge are created repeatedly until the end of the pulse duration of single discharging. The different discrete discharging pulses created in one single discharging period can effectively separate the discharging energy into several increments and help in minimizing the debris and increasing MRR. At the same time, both wider discharge channel and larger impact area on the work piece on the work piece generate a lower impact force on the melted material of the surface craters. Within these conditions, shallow craters are formed. It improves the SR.

Objectives of proposed study

To achieve these research gaps following objectives are carried out

- Analysis by addition of various powders into the dielectric Fluid of EDM in the process, and output variables such as MRR compared with traditional EDM processAnalysis the effect of concentration of added powder on PMEDM process Performance.
- Analysis on Surface roughness(Ra).
- Analysis of Tool Wear Rate(TWR).
- To establish the relationship between various input parameters (pulse on time, pulse off , Time, current, concentration of powder etc.) and output characteristics (MRR).

Work justification

Due to demand of machining of hard and brittle materials. EDM process has the ability to produce geometrically complex shapes. It does not induce mechanical stresses into the work piece during machining. Although the EDM process has many advantages but it is a much slower process as compared to the machining processes. The question arises that how to develop an EDM process with the capability of high speed machining, high accuracy and precision without any major alterations to the EDM system. To overcome all these difficulties, recently the introduction of some metallic powder into the dielectric fluid of EDM has been reported. The added powder facilitates the discharge into number of small trajectories, as a result, the MRR increases. At the same time, the discharge is uniformly distributed over the whole surface under the electrode that produces small and shadow crater. It improves the SR. However very little research has been reported on PMEDM.

Methodology

First of all, High carbon high chromium (HCHCr) die steel work pieces as per the dimensions (90 cm X 65 cm X 10 cm) are prepared. After treatment, the hardness of the work piece is in the order of HRc 54-58. Before experimentation, all the undesirable particles like foreign material, oil, scale, rust grease etc is removed from work piece with the help of cleaning and grinding process. Then the powders are added into the kerosene dielectric fluid of EDM. Machining is performed according to the decided parameters on a locally designed EDM machine. (ELECTRONICA 400-250) on HCHCr die steel work piece with the help of copper tool electrode.

Parameters of PMEDM process

Along with conventional EDM parameters, the other factors accounted for PMEDM processes,which affect the output characteristics is:-

1. Type of the powder
2. Concentration of the added powder (gm/lit.)
3. Mesh size (degree of purity) of the powder
4. Electrical properties of the powder

1. Type of powder

The powder added into the dielectric fluid could increase the MRR and decrease the tool wearrate (TWR) and improve the surface quality of the work quite clearly. But the different powderswould have different impact on the output characteristics of the EDM process. Some kinds ofinorganic oxide powders cannot disperse uniformly and persistently in kerosene, concentrate andprecipitate quickly, so they do not play a good role in improving the MRR, decreasing the SRand TWR.

A powder which can be suspended into dielectric fluid of EDM must have following properties:-

· It should be electrical conductive in nature.
· It must be non-magnetic in nature.
· It must have good suspension capabilities.
· It should have good thermal conductivities.
· It should be in toxic and odorless.

2. Concentration of added powder

Addition of appropriate amount of powder into dielectric fluid plays a very important role onMRR, TWR and SR. The material removal depth reached the maximum value at appropriateconcentration. Further increase or decrease in the concentration of the added powder woulddecrease the MRR.

3. Mesh size of powders

The size of the powder particles affects the PMEDM performance. A large diameter of thepowder particle increases the gap but simultaneously decreases the MRR and then increases theSR.

4. Electrical properties of powders

The electrical conductivity of the addedPowder directly affects EDM performance. This is because the added powder increases theConductivity of the dielectric fluid and results in the extension of the gap distance.

Output parameters

The following output parameters have been studied during the course of this experimentation:-

1. Material removal rate (MRR)
2. Surface roughness (SR)
3. Tool wear rate (TWR)

1. Material removal rate (MRR)

The quantity of the material removed from the work piece in each experiment was known from the change in the weight of the work piece. When divided by the density of the work piece material. It gives the volume of the material removed. The density of the work piece material (HACHCr) was taken as 7.85 gm/mm^3. the MRR (mm^3/min) is calculated as:

(wt. loss in gm of work piece)
mm^3/min
MRR= Density (gm/mm^3) X machining time (min)
Density of material of W/P X machining time (min.)

Work Piece Material

The work piece material taken for this study is high carbon high chromium non-shrinking disteel. Its AISI name is D3. Its chemical composition is given as:- Table of chemical composition of HCHC

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	6	100	25	3	1.5	0.69
2	6	100	25	4	1.5	0.56
3	6	100	25	5	1.5	0.44
4	6	100	25	6	1.5	0.41

%C	%SI	%MN	%CR
1.83	.25	.61	12.45

Tool Material. The tool electrode material selected for this investigation is Copper. The tool electrode is inthe form of circular rod of Φ20 mm. The properties are given in table

Table Properties of Copper

Density	Electrical Resistivity	Purity	Melting Point
8.9 kg/dm³	0.0167 Ωmm²/m	99.8%	1083°C

Dielectric Fluid. The dielectric fluid selected for the experimentation is commercial grade kerosene oil. The properties of erosene oil are given in table.

Table Properties of kerosene oil

Surface tension	Density (kg/m3)	Thermal Conductivity	Dynamic Viscosity
0.028	820	0.15	2400

Powder Used for Experimentation

The chromium and the dielectric powder are mixed into the dielectric fluid of EDM process. the particle size of the powders used is 15-20 um. The various properties of the

Table Properties of Graphite Powder

Melting Point(ºC)	Boiling Point(ºC)	Density (gm/cm³)	Thermal Conductivity
3600	4200	2.25	1.50

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	6	50	25	6	1.5	0.41
2	6	100	25	6	1.5	0.42
3	6	150	25	6	1.5	0.43
4	6	200	25	6	1.5	0.45

Table Properties of Graphite Powder

Melting Point(ºC)	Boiling Point(ºC)	Density (gm/cm³)	Thermal Conductivity
3600	4200	2.25	1.50

Table Properties of Chromium Powder

Melting Point(ºC)	Boiling Point(ºC)	Density (gm/cm³)	Thermal Conductivity
1857	2672	7.18	0.939

IV. RESULT AND DISCUSSION

The experiments were carried out on a locally designed EDM machine (ELECTRONICA 400-250) according to the chosen parameters tabulated in Tables for Graphite PMEDM , Chromium PMEDM and Aluminium Oxide PMEDM respectively.

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	6	100	25	6	1.5	0.42
2	6	100	50	6	1.5	0.42
3	6	100	75	6	1.5	0.41
4	06	100	100	06	1.5	0.04

Fig. shows the various holes produced by suspending the Graphite powder into the 1 litre kerosene oil.

Machining with Graphite Powder Effect of concentration on Graphite PMEDM process characteristic

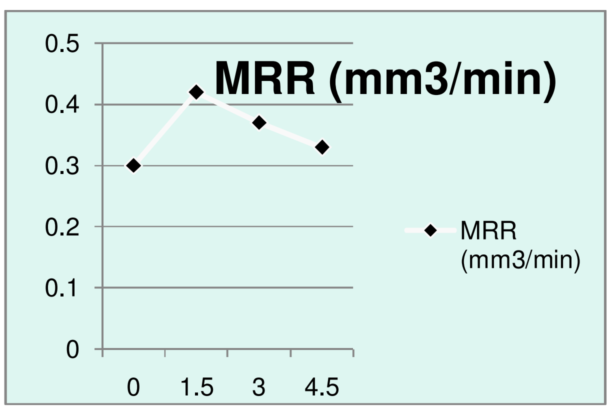
The effect of adding concentration of Graphite.

Powder into the dielectric fluid of EDM was investigated. Table shows the different results produced in terms of MRR (Material Removal Rate) produced at different levels of concentration of Graphite Powder. From this Table, it is cleared that the best result for the MRR (Material Removal Rate) is obtained at 1.5 gm/litconcentration of Graphite Powder. Beyond this concentration, the results obtained are not encouraging. Further increase in the concentration would decrease the MRR. This might be due to short circuiting of the discharge gap between both the electrodes.

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	3	100	25	6	1.5	0.30
2	6	100	25	6	1.5	0.44
3	9	100	25	6	1.5	0.95
4	12	100	25	6	1.5	3.04

Table

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	6	100	25	6	00	0.30
2	6	100	25	6	1.5	0.42
3	6	100	25	6	03	0.37
4	6	100	25	6	4.5	0.33



Concentration (gm/lit)

Effect of Pulse on Time on Graphite PMEDM Process Characteristics

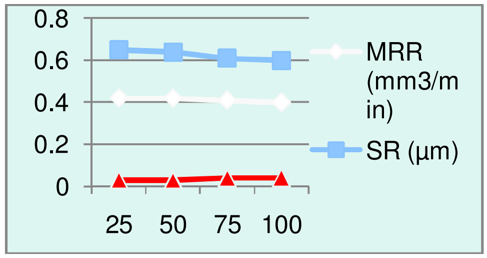
The effect of pulse on time on Graphite PMEDM Process show in table at various output parameters

T-on (µsec) →

Effect of Pulse off Time on Graphite PMEDM Process Characteristics

The effect of pulse off time on Graphite PMEDM Process show in table at various output parameters

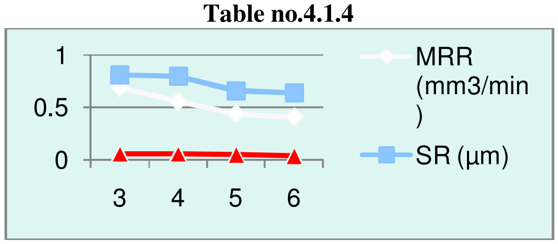
Effect of Tool Electrode lift time on Graphite PMEDM process characteristics The effect of Tool Electrode lift time on Graphite PMEDM Process show in table at various output parameters



T-off (μsec) →

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	06	100	25	06	00	0.36
2	06	100	25	06	1.5	0.48
3	06	100	25	06	03	0.35
4	06	100	25	06	4.4	0.30

Table no.4.1.4



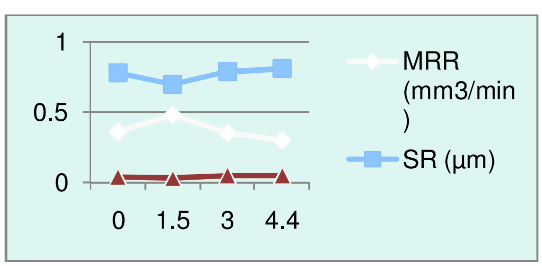
Effect of Peak Current on Graphite PMEDM Process Characteristic

The effect of peak current on Graphite PMEDM Process show in table at various output parameters

Machining with Chromium PowderEffect of concentration on Chromium Powder PMEDM process characteristic

The effect of adding concentration of Chromium Powder into the dielectric fluid of EDM was Investigated. Table shows the different results produced in terms of MRR (Material Removal Rate) produced at different levels of concentration of Chromium powder. From this Table, it is cleared that the best result for the MRR obtained at 3.0 Gms. / lit. Concentration of chromium powder. Beyond this concentration, the results obtained are not encouraging. Further increase in the concentration would decrease the MRR. This might be due to short circuiting of the discharge gap between both the electrodes.

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	6	100	25	03	1.5	0.65
2	6	100	25	04	1.5	0.57
3	6	100	25	05	1.5	0.46
4	6	100	25	06	1.5	0.44

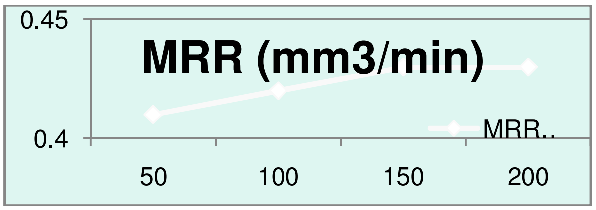


Concentration (gm/lit)

Effect of pulse on time chromium Powder on PMEDM Process Characteristics. The effect of onchromium Powder opulse on time n PMEDM Process show in table at various output parameters

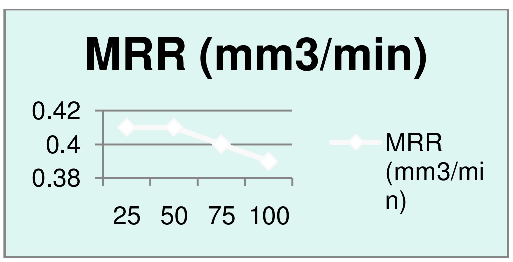
S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	06	50	25	06	1.5	0.41
2	06	100	25	06	1.5	0.42
3	06	150	25	06	1.5	0.43
4	06	200	25	06	1.5	0.43

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	06	100	25	6	1.5	0.41
2	06	100	50	6	1.5	0.41
3	06	100	75	6	1.5	0.40
4	06	100	100	06	1.5	0.39



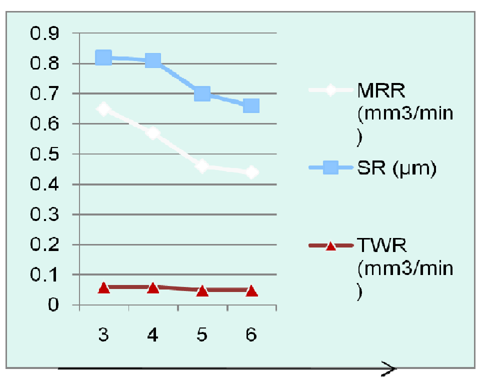
Effect of Pulse off time on Chromium Powder on PMEDM Process

The effect of Pulse off timeon chromium Powder o pulse on time n PMEDM Process show in table at various output parameters



Effect of Tool Electrode Lift time on Chromium Powder on PMEDM Process Characteristics.

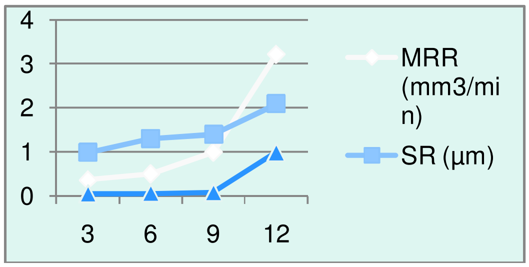
The effect of Tool Electrode Lift time on chromium Powder o pulse on time n PMEDM Process show in table at various output parameters



Effect of peak current on chromium Powder on PMEDM Process Characteristics

The effect of peak current on chromium Powder o pulse on time n PMEDM Process show in table at various output parameters

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	3	100	25	6	1.5	0.37
2	6	100	25	6	1.5	0.51
3	9	100	25	6	1.5	1.0
4	12	100	25	6	1.5	3.22



Machining with Aluminium Oxide Powder

The effect of adding concentration of Aluminium Oxide Powder into the dielectric fluid of EDM was investigated. Table shows the different results produced in terms of MRR Material Removal Rate) produced at different levels of concentration of Aluminium Oxide Powder. From this Table, it is cleared that the best result for the MRR is obtained at 1.5 Gm/lit concentration of Aluminium Oxide Powder. Beyond this concentration, the results obtained are not encouraging. Further increase in the concentration would decrease the MRR. This might be due to short circuiting of the discharge gap between both the electrodes.

S.No.	I_P	T ON	T off	Lift time	Conc. (gm/lit)	MRR (mm3/min)
1	5	150	250	00	3	0
2	5	150	250	06	3.953	1.5
3	5	150	250	09	3.218	3.0
4	5	150	250	12	3.243	4.5

CONCLUSION

The material removal rate increased by mixing powder in the dielectric fluid as compared with conventional EDM process

• Tool wear rate in PMEDM is smaller as compared with the conventional EDM.

• Material removal rate has increased by adding the powder in dielectric fluid as compared with conventional EDM.

• Material removal rate is maximum effected by the increase of peak current.

• Material Removal Rate has been decreased by increasing the pulse off time.

• As the tool electrode lift time has increased, the Material Removal Rate.

REFERENCES

[1]. Devdat R.Vhatkar, B.R. Jadhav Rajarambapu Institute of Technology Sakharale India. "An Experimental Study on Parametric Optimization of HighCarbonSteel(EN-31) Mixed Dielectric EDMProcess"

[2]. Singh, H. and R. Garg, 2009. Effects of process parameters on material removal rate in WEDM. J. Achiev. Mater. Manuf. Eng., 32: 70-74.

[3]. Kuldeep Ojha A,*, R. K. Garg A, K. K. Singh B Experimental Investigation and Modeling of PMEDM Process with Chromium Powder Suspended Dielectric

[4]. Zhao, W.S. Meng, Q.G. Wang, Z.L.(2002). "The application of research on powder mixed EDM in rough machining" ,International journal of materials processing technology,vol.129, pp 30-33

[5]. Pecas, P. Henriques, E. (2003) "Influence of silicon powder mixed dielectric on conventional electric discharge machining", International journal of machine tool & manufacture,vol.43,pp 1465-1471

[6]. Furutani, K. Saneto A. Takezawa, H. Mohri, N. Miyake, H. (2001) "Accretion of titanium carbide by EDM with powder suspended in working fluid", International journal of societies for orecession engineering and nanotechnology,vol.25, pp136-144

[7]. Mohri, N. Satio, N. Suzuki, M. Takawashi, T. Kobayashi, K T. Kobayashi, K.(1988) "Surface modification by EDM – an innovation in EDM with semi conducting electrode", proceeding winter Ann Meet, ASME 34, pp21-30.