A

Dissertation Report On

"MACHINING PERFORMANCE OF AISI P20 STEEL WITH GRAPHITE AND TUNGUSTEN BASED ELECTRODE ON EDM"

Submitted in Partial Fulfilment of the Requirements for Award of Degree of

Master of Technology

In

Production engineering

By

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CERTIFICATE

This is to be certify that the dissertation report entitled "**Machining Performance of AISI P20 Steel with Graphite and Tungsten Based Electrode on EDM Machine."** Prepared by **ARUN KUMAR (ID 2013PPE5044)** in partial fulfilment for the award o Degree of **Master Of Technology** in **Production Engineering** of Malaviya National Institute Of Technology, Jaipur is bonafide research work carried out by him under my Supervision and guidance.

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CANDIDATE'S DECLARATION

I hereby certify that following work which is being presented in the dissertation entitled **"Machining Performance Of AISI P20 Steel With Graphite And Tungsten Based Electrode On EDM** " in the partial fulfilment of requirement for award of the degree of Master of technology (M.tech) and submitted in **Department of Mechanical Engineering** of Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out by me during a period from July 2014 to June 2015 under the supervision of **AMIT PANCHARYA,** Associate Professor, Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the result my own work and studies carried out and has not been submitted anywhere else.

ARUN KUMAR

2013PPE5044

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ARUN KUMAR

Date - **2013PPE5044**

Place -

Abstract

The selection of manufacturing process mainly depends on the form and accuracy of the desired product. And selection of required manufacturing process is very necessary. To improve the process and manufacturing. EDM machining is also one of the most demanded processes for machining complex shapes regardless of hardness.

Pre-hardened steel AISI P20 is a plastic mold steel usually available in a pre-hardened and tempered condition. Good machine capability, better polishability, which has the status of implementation in plastic molds, plastic frames pressure dies, hydraulic forming tools to the competitive environment.

AISI P20 are classified as hard and difficult to machine materials, have good strength and toughness they are usually for the major challenges for the conventional and non-conventional machining. The process is to find out the performance EDM machining steel AISI P0 using two electrodes, graphite electrode and based tungusten. An experimental scheme was used to reduce the total number of experiments.

ABBREVIATIONS AND SYMBOLS

EDM- Electro discharge machining

RC- Relaxation circuit

MRR- Material removal rate

TWR- Tool wear rate

EDE- Electro discharge erosion

DC- Direct current

SR- Surface roughness

ECDM- Electro chemical discharge machining

RSM- Response surface methodology

SEM- Scanned electron microscope

CBN- Cubic Boron Nitrate

FEM- Finite element method

AISI- American Iron and Steel Institute

WEDM- Wire electrode discharge machining
XRD- X-ray diffraction

V- Voltage

Amp- Ampere

Ip- Input current

SPK- Spark timing

LFT- Lift IB- Bi pulse current

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Chapter 1

Introduction

1.1 Background of EDM

Since early 1770 the process of EDM EDM technique was first it was very difficult in implementing this process .Later studied carefully and came to know about the process and their appropriate uses EDM was known He discovered history of EDM machining techniques go as far as the 1770s when it was discovered by an English scientist. However, the electrical discharge machining full advantage is not taken until 1943 when Russian scientists learned the erosive effects of the art could be controlled and used for machining purposes.

When you originally observed by NI Lazaranko in 1970, EDM Machining was very difficult and full of failures. Progress was made in the mid1970s, wire EDM also came into being as a process developed for machining complex contour shape.

The new method for machining uses electrical energy as a source, who gave a revolution to the new world of demand by producing complex shapes without any mechanical interaction of forces. With the development of new processes for industries that is easy to produce human comfort equipment increasing demand and provide lubricant market.

1.2 Introduction of EDM

The Synod also sent erosion machining or metal process removes from utilizing carefully controlled electrical spark discharge. They say that in the present time, it is a question that many thousand of their choicest repeated could prevail.

The essential process (involving basic relaxation round) .the cutting action is being vaporization, and erosion of the metal. The material parts between work and instrument eroded spark electrically reject the candidate. Usually a liquid dielectric (kerosene, paraffin or light oil) is used to flush the eroded material. Irrespective of the hardness of the material can be machined, and as much as you, provide leads him to electricity.

1.3 Principle of EDM –

IN spark erosion machining process, the tool electrode is connected to the negative terminal of the special electrical dc source and work piece is connected to the positive terminal. When two electrodes are separated by a dielectric and a suitable voltage is applied the dielectric breakdown. The strong electrostatic field produces emission of electrons from the tool face and this causes ionization of the gap. An avalanche of electrons and ions follows, the resistance of the gap drops and the electrical energy is discharged in the gap between tool electrode and work piece. This causes electrical breakdown of dielectric. This phenomenon in few microseconds, shock waves in dielectric is created and impact of electron on work piece material causes transient pressure of about 1000kg/cm2.Due to high temperature of work material reached (1100 C), the metal melts instantaneously and part of it get vaporised. This is being forced into the gap between the tool and the work piece.

The power supply unit know as resistance capacitance circuit, utilizes a high energy discharge at low frequency. This self- oscillating type circuit operates at 70-180 V, with an open circuit voltage up to 300V

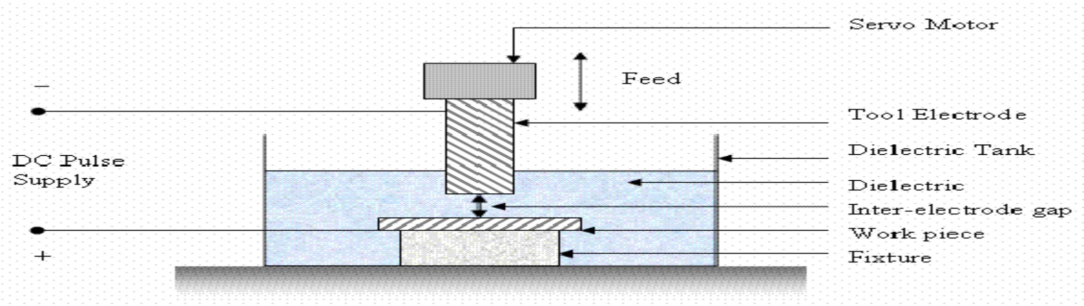

Figure1. 1 Set up of Electric discharge machining

This fig.1.2 is shown the electric setup of the Electric discharge machining. The tool act as a cathode and work piece is anode.

1.4 Types of EDM –

Basically, there are two different types of EDM:

1.4.1) Die-sinking

1.4.2) wire EDM

1.4.1Die-sinking EDM –

In die sinking EDM tool and wok piece are submerged in the electrolyte which is going to be

Machined. IN spark erosion machining process, the tool electrode is connected to the the negative terminal of the DC source and special electrical work piece contiguous to the positive terminal. When the two electrodes are separated by a suitable dielectric and dielectric breakdown voltage is applied. Strong electrostatic field emission of electrons produces a tool face ionization, and this ensures that gaps. Electrons and ions is used and follows the electrical resistance drops away and the gap tool gap between the electrode piece. This makes electrical breakdown dielectric. This phenomenon in a few microseconds, the dielectric is created shock waves in the electron impact on the work pressure, passing the material pieces of about 1000kg / cm2.Due to heat the material reached (1100 100), the metal melts instantly and the vaporised get. By this operation, the gap between the tool and are forced to prevail.

Figure1. 2 Die sinking EDM Machine

1.4.2 Wire-cut EDM –

Wire cut electro discharge machine (Wedmor) is known for its capability. As its work on the same principal but the setup is somehow different from die sinking EDM. Here instead of shaped electrode. A copper or brass wire act as the continuously moving work piece is clamped on to the electrode .The table. The table is moved along x and y axis by the drive units controlled by the NC system. One more important point is to be consider is that, in Wedmor working zone alone is supplied with the dielectric fluid, instead of submerging the whole work piece in the dielectric, the dielectric used is deionised water as compared to the hydrocarbon oil used in conventional EDM .

In Wedmor the wire is passed through a predrilled hole in the work piece. The electrical power is supplied by the electronic pulse generator which applies a potential between wire electrode and work. The table is moved till the wire is very close to the edge of the hole. The drilled hole is supplied with the flow of dielectric fluid. The voltage across the spark gap increases linearly, which set up an electric field across the spark gap. It lead to the breakdown of spark gap. At this instant, the current from the pulse generator flows across the spark gap. The spark energy heats, melts and vaporizes the material of the work piece. After a short time, the current flow through the gap reduces to zero. With water vaporizing action molten material on the work piece is removed.

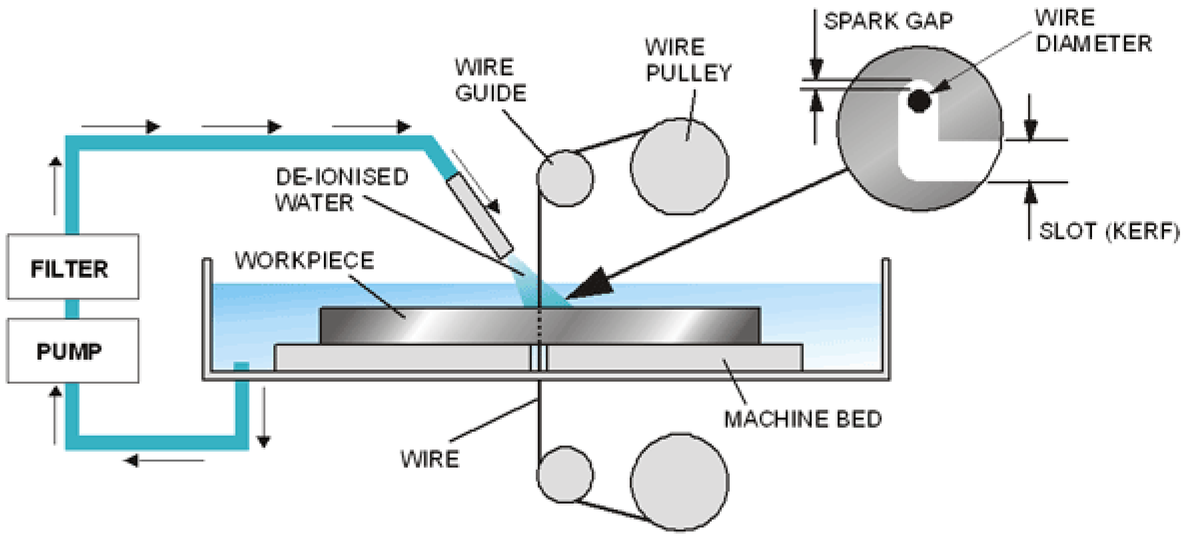

Figure1. 3 wire cut EDM (Manufacturing Technology, M.adithan 212)

1.5 Important parameters of EDM

(a) Spark On-time (pulse time or Ton**):** The duration of time (µs) the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is really controlled by the peak current and the length of the on-time.

(b) Spark Off-time (pause time or Toff): The duration of time (µs) between the sparks (that is to say, on-time). This time allows the molten material to solidify and to be wash out of the arc gap. This parameter is to affect the speed and the stability of the cut. Thus, if the off-time is too short, it will cause sparks to be unstable.

(c) Arc gap (or gap)**:** The Arc gap is distance between the electrode and work piece during the process of EDM. It may be called as spark gap. Spark gap can be maintained by servo system (fig no.-1).

(d) Discharge current (current Ip**):** Current is measured in amp Allowed to per cycle. Discharge current is directly proportional to the Material removal rate.

(e) Duty cycle (τ)**:** It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the total cycle time (on-time pulse off time).

(f) Voltage (V): It is a potential that can be measure by volt it is also effect to the material removal rate and allowed to per cycle. Voltage is given by in this experiment is 50 V.

1.6 EDM Specification

EDM is specified by working principal, MRR and TWR

Working principal	Controlled erosion (melting and vaporization) through a series of electric spark

Sparking gap	0.010- 0.500 mm
Sparking frequency	50– 500 kHz
Supply voltage	415 V, 59 Hz, 3 Phase 5 Wire System
MRR (max.)	3000 mm^3/min
Connected Load	4 KVA
Dielectric fluid	EDM oil, Kerosene liquid paraffin, silicon oil, deionized water etc.
Electrode material	Copper, Brass, graphite, Ag-W alloys, Cu-Tungsten alloys.
MRR and TWR	0.2-8
Materials that can be machined	All conducting metals and conducting composites.
Shapes	Non regular holes, contour shapes
Limitations	High specific energy consumption, Tool wear and non -conducting materials .

1.7 Dielectric fluid

Common dielectric fluids used are paraffin oil, transformer oil and kerosene. Kerosene is widely used. The dielectric fluid prevents particles from the workpiece to adhere to the electrode tool and increase metal removal rate compared to operation in air. These are fluid hydrocarbons and hydrogen in these fluid provides the deionizing action necessary for the fluid to become an effective insulator after each download t .It remains nonconductive until failure occurs, it decomposes rapidly that the capacitor has discharged . Low viscosity fluids flow easily make.

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1.8. Flushing method-

Flushing is the most important function in any electrical discharge machining operation.
Flushing is the process of introducing clean filtered dielectric fluid into the spark gap.
There are a number of flushing methods used to remove the metal particles efficiently.

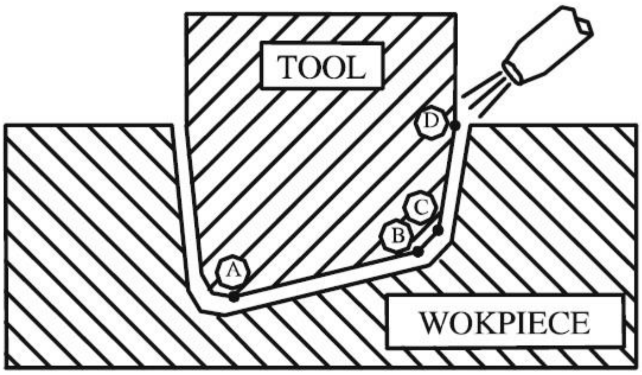


Figure 1. 4 Flushing of graphite electrode

1.9. Tool Material-

Tool that does not matter so much suffering tool wear when hit by positive ions. Thus, localized increased temperature is related to the properties of the pigeon to be too little, or, strictly speaking, the choice of tailoring, or even the temperature increases, there is less fusion. Yes, let the geometric characteristics as iron are readily capable of being embarrassed in the machining down .So the basic electrode materials characteristics are:

1. high electrical conductivity - are cold electrons out of the body with easier and give the amount is less than electric heating.

2. High thermal conductivity - for the same amount of heat, the heat, the temperature rise would be faster due to the less powerful and therefore less than the servant, and being moved to a volume that wear tool.

3. greater density - the same heat load and the weight of the tool wear much less wear volume removal tool and therefore less loss or dimensional inaccuracy.

4. High melting point - the high melting point leads to reduced tool wear due to the lower tool for hot melt material through the same heat load.

5. Easy Manufacturability.

6. Cost - cheaper.

What are the different electrode materials in the following habits:

1. Graphite

2. Copper

3. Tellurium Copper - 99% Cu + 0.5% TELLURIUM

4. Brass

5. Aluminum

In this experiment with graphite and washing tool system based on tungsten it is used.

1.10. Variable design

Parameter design, process parameters and the constant parameters are following ones,

Design parameters -

1. material removal rate.

2. Tool wear rate

3. Surface roughness

Machining parameter -

1. Adoption of the current management (Ip)

2. Pulse time (Ton)

3 spark gap

Constant parameterization

1. Duty cycle

2. Voltage

3. Pressure Flushing

4. Polarity

1.11. Material of the workpiece

It is capable of machining geometrically complex components or hard material, which are difficult to machine accurate, such as heat treated tool steels, composite materials, superalloys, ceramics, carbides, heat resistant steels, etc.

It is capable of machining geometrically complex or difficult materials, such as components that are heat treated tool steels and difficult to machine precise, composed, super alloys, ceramics, carbides, heat resistant steels, etc.

Different types of tool material EDM method is used. And the tool steel contains carbon steels and alloy which are particularly suitable to be turned into tools. Suitability comes from its distinctive hardness, resistance to abrasion, its ability to maintain a cutting edge, and / or resistance to deformation at elevated temperatures (red-hardness). Tool steel is generally used in a heat-treated state. Tool steels to a number of grades are made for different applications. In general, the edge temperature conditions expected in use is a major determinant of both the composition and the required heat treatment. Carbon grades are

Typically it used for such applications as stamping dies, metal cutting tools, etc.

In this experiment they are using P-20 tool steel materials plastic mold prehardened AISI.1.12

Application of EDM –

1. For machining dies for forging, blanking, extrusion, etc.
2. For drilling fine deep hole like in fuel injecting nozzles.
3. Hydraulic valve spools can be machined.
4. It is possible to manufacture fragile components which are difficult to machine through
5. conventional methods because of high tool forces.

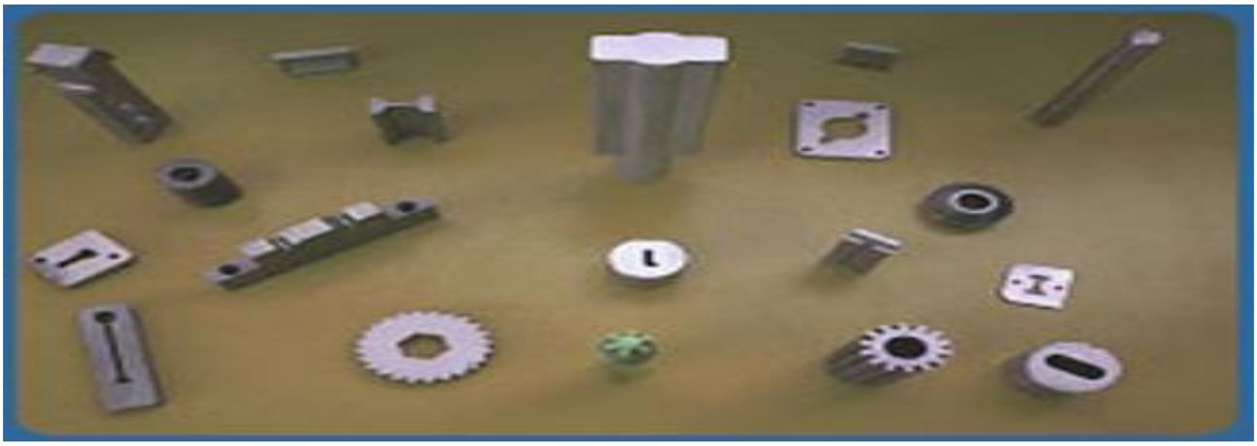


Fig.1.5 Parts produced by EDM

1.13 Advantages of EDM

(a) Complicated geometrical products are easily formed.

(b) Toughness and hardness of the material are of no importance for the metal removal rate.So die can be hardened before being shaped by EDM.

(c) Possibility to do jobs which are impossible by conventional machining methods (including of tungsten carbide, profiling holes for spinning orifices, etc.

1.14 Limitation of EDM –

(a) Tool wear, which leads to use of three per operation, thus resulting in high tool manufacturing cost.

(b) Only electrically conductive materials can be machined.

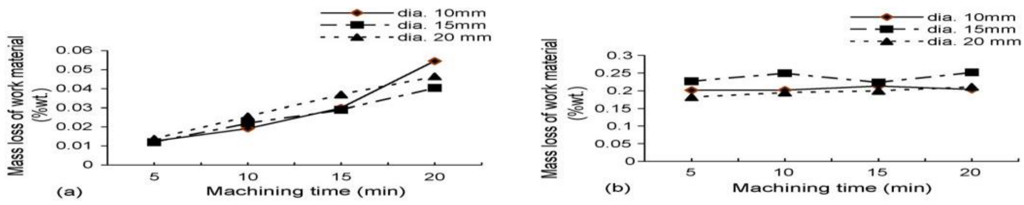
Chapter 2

Literature Survey

In this chapter search few selected research paper related to EDM with effect of metal MRR, Twr, surface roughness (SR) work piece material, we are broadly classified in to five different category all the paper, that is, related to material related paper work piece or tool, tubular electrode, tool design, related to some paper Effect of multiple discharge and rest of the paper related to CNC.

2.1 Work piece and tool material-

Subramanian Gopalakannan, Thiagarajan Senthilvelan [1] evaluates the effect of current (c), of the pulse-on time (p) and the intention of the air gap (5) MRR, Twr, ROC 316 of the gets ahead of it, with the 50 and the stainless steel 17-4 PH steel. Distinguishes between different kinds of electrode materials are machined by eg. Copper alloy, graphite, noted that the output parameter as MRR, electrode wear rate and surface roughness changes desired by increasing pulse current.C.H.Che haron et .al [2] while machining XW42 Tool steel at two current setting(3A and 6A) and three diameter size(10,15,20 mm).The result show that the material removal rate is higher and the electrode wear rate is lower than the graphite electrode and copper electrode. Is the increase in current and electrode diameter reduces tool wear rate as well as material removal rate.



% of mass loss at current 6A

Figure 2.1 Graph between electrode wear rate and machining time

Apiwat Muttamara [3] while using the two kinds of graphite (Poco Edm-3) and air infiltrate graphite electrode used to compare the Edm properties. The experiment showed proof of graphite electrode worn in Ti6AL4V.The (Poco-edm3) has significant giving higher than the MRR Graphite mangers.

versus discharge current. (t_e =200 μs , *DF.* =50 %).

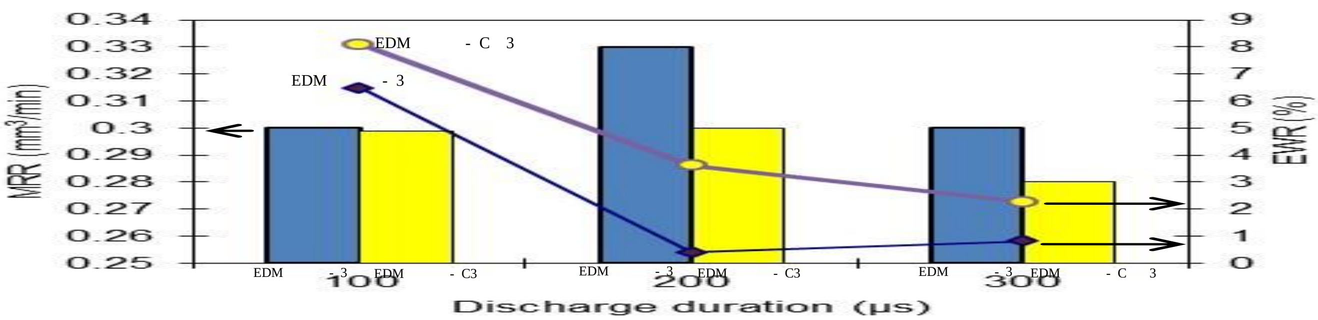


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Fig.2.3 (Relationship of material removal rate and electrode wear ratio)

Khalid Hussain Syed, Kuppan palaniyandi [4] uses aluminum metal powder to the dielectric fluid in the electric discharge machine. Investigation was done on the day of W-300 steel and copper. Result indicates that polarity affect the machining performance

K.S.Banker et al. [5] investigate the result using three different types of electrode copper brass and aluminum on AISI 304L, have the results show that the copper electrode By the maximum MRR, aluminum brass and finally, the results can also be concluded that the surface of the air has a good finish, but from blackness in it's affordable, too, shalt not wear a rate it is wont to use Edm.

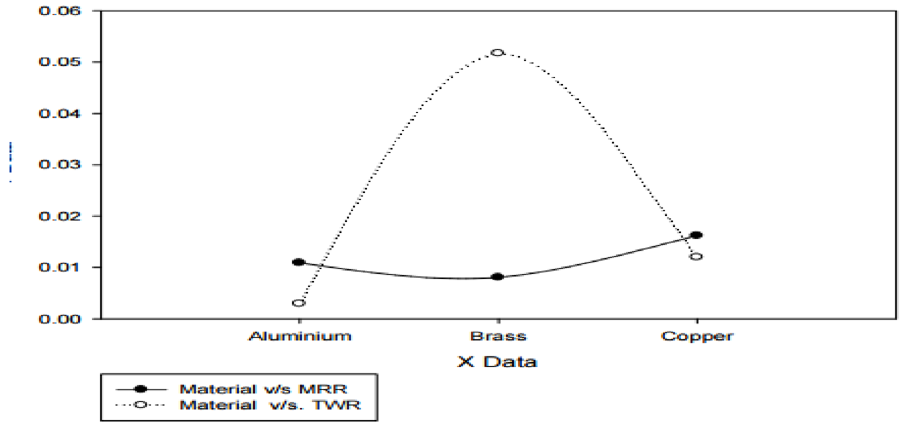

Fig.2.4 Work Material V/s. MRR, TWR

Aluminium and copper are found to equally capable of in term of MRR, TWR and SR. They are also similar in availability and cost.

Emre unseset al. [6] using graphite powder in electrolyte when machining Ti-6Al-4V the, which comes under the category of difficult preparations. Experiment has shown significant results, which increases the machining parameters or that MRR and good surface finish.

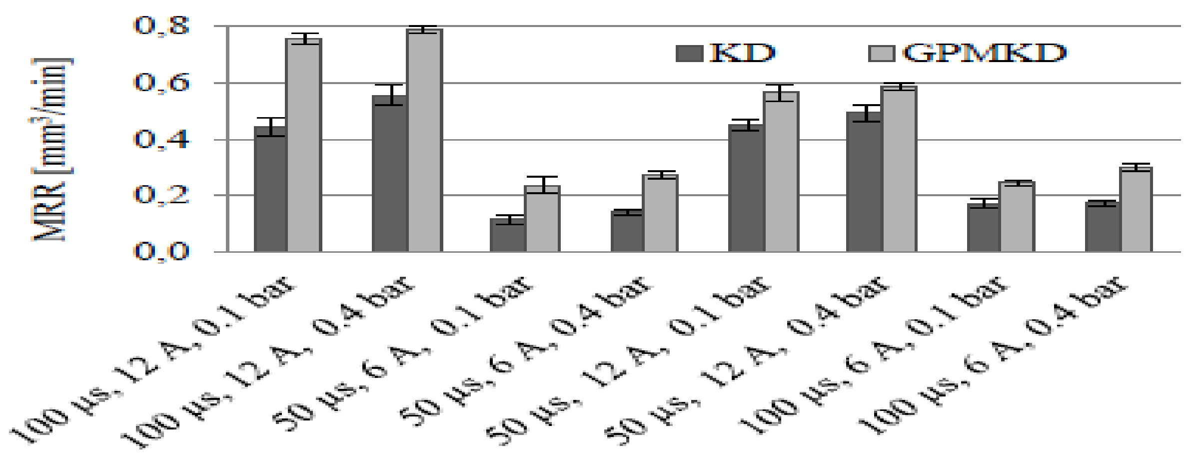

Fig.2.5

Biing Hwa et al. [9] has discuss the investigates the feasibility and optimization of a rotary EDM with ball burnishing for inspecting the machinability of Al_2O_3/6061Al composite using the Taguchi method. Three ZrO_2 balls attached as additional components behind the electrode tool offer immediate burnishing following EDM. Three observed values machining rate, surface roughness and improvement of surface roughness are adopted to verify the optimization of the machining technique. Design of tool electrode is Cupper ring shaped BEDM as shown in Fig 2.4. This B-EDM process approaches both a higher machining rate and a finer surface roughness. Furthermore, the B-EDM process can achieve an approximately constant machining rate.

Yan-Cherng Lin et al. [10] has reported that Electrical Discharge Energy on Machining of Cemented Tungsten Carbide using an electrolytic copper electrode. The machining parameters of EDM were varied to explore the effects of electrical discharge energy on the machining characteristics, such as MRR, EWR, and surface roughness. Moreover, the effects of the electrical discharge energy on heat-affected layers, surface cracks and machining debris were also determined. The experimental results show that the MRR increased with the density of the electrical discharge energy. The EWR and diameter of the machining debris were also related to the density of the electrical discharge energy. When the amount of electrical discharge energy was set to a high level, serious surface cracks on the machined surface of the cemented tungsten carbides caused by EDM were evident

Lee and X.P.Li [11] showed the effect of the machining parameter in EDM of tungsten carbide on the machining charatercteristics. The EDM process with tungsten carbide better machining performances is obtaining generally with the electrode as the cathode and the workpiece is anode. Tool with negative polarity give the higher material removal rate, lower tool wear and better surface finish. High open circuit voltage is necessary for tungsten carbide due to its high malting point and high hardness value and cupper tungsten as the tool electrode material with tool electrode material with negative polarity. This study confirms that there exists an optimum condition for precision machining of tungsten carbide although the condition may vary with the composing of martial, the accuracy of the machine and other other external factor.

Zuyuan yu et al. [12] in this paper effect of machining parameter is considered on EDM. Experiments shows that machining performance has close relationship with pulse energy, MRR, TWR and surface roughness increases with increase in pulse energy.

Wang and Lin [13] discuss the optimization of W/Cu composite martial are used the Taguchi method. W/Cu composites are a type of cooling material highly resistant to heat corrosion produced through powder metallurgy. The Taguchi method and L18 orthogonal array to obtain the polarity, peak current, pulse duration, duty factor, rotary electrode rotational speed, and gap load voltage in order to explore the material removal rate, electrode wear rate, and surface roughness. The influenced of each variable and optimal processing parameter will be obtained through ANOVA analysis through experimentation to improve the process.

Tsai et al [14] have working martial of graphite, copper and copper alloys are widely using EDM because these materials have high melting temperature, and excellent electrical and thermal conductivity. The electrodes made by using powder metallurgy technology from special powders have been used to modify EDM surfaces in recent years, to improve wear and corrosion resistance. Electrodes are made at low pressure (20 MPa) and temperature (200 °C) in a hot mounting machine According to the experimental results, a mixing ratio of Cu–0wt%Cr and a sinter pressure of 20 MPa obtained an excellent MRR. Moreover, this work also reveals that the composite electrodes obtained a higher MRR than Cu metal electrodes. The recast layer was thinner and fewer cracks were present on the machined

Study of parameter in EDM by using the RSM, the parameter like MRR, TWR, gap size and SR and relevant experimental data were obtained through experimentation by Sameh S. Habib[15]. They are using Al/Sic composites material and shown the correlations between the cutting rates, the surface finish and the physical material parameters of this process made it difficult to use. Optimal combination of these parameters was obtained for achieving controlled EDM of the workpiece and finding the MRR increases with an increase of pulse on time, peak current and gap voltage and MRR decreases with increasing of Sic%.

Saha and Choudhury [16] Study the process of dry EDM with tubular copper tool electrode and mild steel workpiece. Experiments have been conducted using air and study the effect of gap voltage discharge current, pulse-on time, duty factor, air pressure and spindle speed on MRR, surface roughness (Ra) and TWR. Empirical models for MRR, Ra and TWR have then been developed by performing a designed experiment based on the central composite design of experiments. Response surface analysis has been done using the developed models. ANOVA tests were performed to identify the significant parameters. The dry EDM attachment has shown the experimental result in Fig 2.5, and finding the Flow characteristic of air in the inter-electrode gap affects the MRR and the surface roughness (Ra). There exists an optimum number of airflow holes (in the tool) for which the MRR is highest and the Ra is lowest.

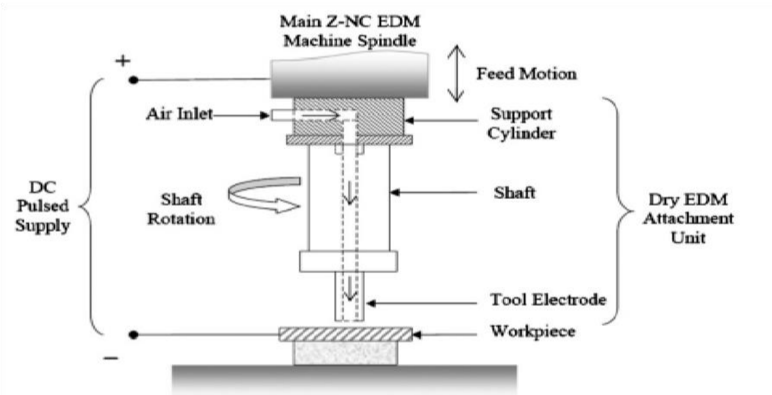

Fig 2.5 Experimental set-up

2.2 EDM tool design –

Sohani et al. [20] discuss the sink EDM effect tool shape and size factor will be considered in the process by using RSM process parameters such as discharge current, pulse time, pulse off time and tools area. The mathematical models based on MRR and TWR RSM have been developed using data obtained through the central composite design. Analysis of variance was applied to verify the lack of adjustment and adaptation of the developed models. Investigations revealed that the best tool for greater MRR and lower TWR is circular, followed by triangular, rectangular and square cross sections. From the parametric analysis, it is also observed that the effect of the interaction of the discharge current and pulse time is highly significant in MRR and TWR, while the main factors such as pulse out of time and area tools are statistically significant in MRR and TWR.

Zhong and Han [21] worked on the EDM servo system, adaptive control of a new self-regulating adaptive EDM control system that automatically regulates direct and spin tool down time has been developed. On the basis of the estimated real-time model of EDM process, by using the control strategy of minimum variance parameters process controller, a self-tuning controller was designed to control the machining process so that the states gap state are specified separation. With a properly selected states specified Gap, this adaptive system improves machining rate approximately 100% and in the meantime achieved a more robust and stable than normal machining adaptive control machining. This adaptive control system helps to gain the expected goal of optimum machining performance.

2.3 **Effect of multiple discharges of EDM-**

EDM and work piece generated by overlapping multiple downloads, as during an actual operation EDM, Izquierdo et al. [22] diameter of the discharge channel and the efficiency of material removal can be estimated using the inverse identification from the results of numerical model. An original numerical model for simulating the EDM process has been presented. EDM surface model generated by calculating the fields of temperature inside the work piece using a finite differences approach, taking into account the effect of successive discharges.

Bin Wei et al. [23] has study of electrical discharge machining multiple holes in a work piece electrically conductive, includes an electrical discharge machine for rotating the assembly of a first electrode, and at least one electrical discharge unit for rotate ably mounting at least one second electrode. The electric discharge machine includes a controller and a controller, the controller is desirably coupled to the electric discharge machine and electrical discharge unit for rotating the first electrode and the at least one second electrode, and the controller is coupled desirably the electric discharge machine and drive at least one electric discharge for controlling a supply of electrical energy from the first electrode and the second electrode to the work piece.

Kunge et al. [24] the effect of evolution EWR MRR and study on the mixed powder of electrical discharge machining (PMEDM) of cobalt-bonded tungsten carbide (WC-Co) was carried out. In PMEDM process, the aluminum powder particle in suspension in the dielectric fluid dispersed and uniform dispersion causes the discharge energy; It shows multiple effects of discharge within a single input pulse. This study was done to the finishing steps only and has been carried out taking into account the four processing parameters: discharge current, pulse time, grain size and concentration of particles of aluminum powder for evaluation MRO machinability and EWR. The RSM is used to plan and analyze experiments. Note that waste generally fall in a straight line implying that the errors are normally distributed. Moreover, this supports the suitability of the least squares fit. The MRR generally increases with increasing concentration of aluminum powder.

2.4 CNC **Electric discharge machining-**

Ding and Jiang [25] presented work on CNC EDM machining of freeform surfaces required tool paths that are different from those used in the mechanical grinding although the geometry of the two processes are described by the similar pattern of intersection between the tool rotation and work piece. Special requirements regarding the direction demanded by EDM CNC machining are studied and a method of generating tool path in two phases to 4-axis EDM hard CNC milling with a cylindrical electrode develops tools. The solid model of the workpiece and the interface between the electrodes. And find compensation discharge gap, the electrode wear compensation and many other factors have to be considered in the process of generating toolpath.

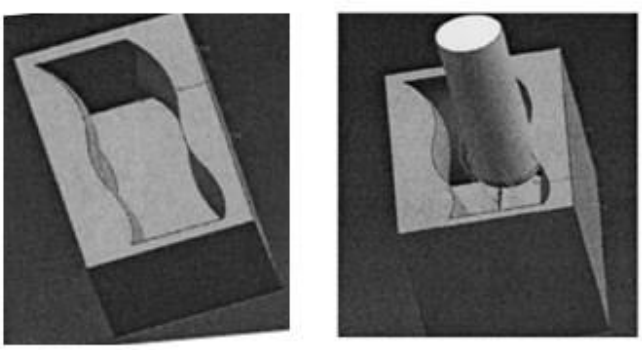

Figure 2.6 Solid model of work piece and interference between work and tool

Bleys et al. [26] have to discuss the outline CNC EDM with a rotating cylinder electrode tubular necessary compensation electrode wear CNC milling tool is based on off-line simulation tool wear prior to machining. Therefore, tool wear can be compensated in one dimension, the tool continuously moving downward, online estimation tool wear is used to combine the anticipated compensation compensated in real time. This extends the reach of EDM milling machining of blanks of which is not known accurately beforehand.

Study on Variable system structure (VSS) with large proportional gains may contain suddenly the electrode in position he was in Fang Chang [27] for the design process of the VSS is presented in accordance with a practical control system a gap of EDM. This advantage can provide a high performance, variable nonlinear time gap condition during the erosion process. The practical experimental results with a VSS controller EDM show a decrease in machining time compared to the time required by the conventional controlled proportional EDM. And experimental results obtained indicate commercial CNC EDM fastest speed EDM erosion control with VSS that the speed control system of the force P.

Chang and Chiu [28] presented compensation electrode wear EDM scanning process using control robust gap is applied to compensate for wear of the electrodes in a scanning electric discharge (ED-Scanning) process. This control compensates for wear without reference to the ratio of electrode wear. As the tool moves horizontally from part (a) to part (b) as shown in the figure, compensation for wear are hollow discharge occur, and the material is then removed .The electrode should be moved from Z1 and Z2 to maintain the depth of removal of a layer. Finally During scanning the robust controller can compensate for wear on the bottom electrode

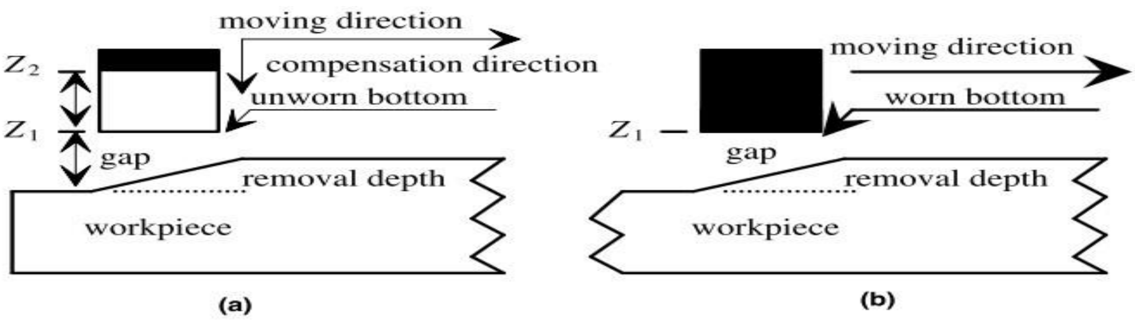

Fig 2.7 Compensation for wear during scanning of a layer

Ziada and Koshy [29] Study on the process of EDM tools Rotation curvilinear polygonal shapes with sharp corners, Flushing gap between electrodes is critical in conducting operations sinking of electric shock. When the arrangement of the holes cleaning tool or the workpiece is impractical, effective cleaning is best accomplished by inducing a relative movement between the electrodes. This innovative scheme allows machining regular and non-regular polygonal shapes with sharp corners. Experimental results of the application of this concept in a 4-axis machine tool CNC EDM are presented.

Study on reducing errors contour CNC EDM was shown by Shieh and Lee [30] control proposed, the scheme consists of three parts. First, the control step performs position loop controller for each individual axis. Secondly, error calculations appropriate control for the analysis and design of control systems, and the third control cross coupling is used is used to control contour error. Under the proposed control system, system stability is studied for both linear and circular paths. Experimental results of a CNC EDM show that the proposed scheme is effective in improving performance contour and ready for practical implementation.

2.5 Research Gap and Objective of the present work-

• Going through the research work most of the research in the EDM is observed refers to the use of the tool of 3D shape. Alternative types of tools such as frame type and plate type are yet to be judged by more interfaces work tool.

• copper electrode has been frequently used as electrode material ultrasonic vibration assisted EDM. Other electrode materials should be thoroughly investigated.

• Very less work has been reported in the improvement MRR using powders important alloying elements such as chromium and vanadium. In addition, many materials such as hardened steel water given tool steel high speed molybdenum have not been tested as working material mixed powder electrical discharge machining.

The same can be judged in the future worksthat little work has been done in EDM in the material such as mild steel, D2 steel, chromium steel, using different types of electrodes eg .Graphite, Brass, etc. The review is that many works were done using different tools and different material MRR, TWR, but no gap tungsten electrodes used as material based tool and see the behavior of surface roughness of AISI stainless P20.

• The aim of this study is to see the effect of graphite and tungsten tool based tool mold steel AISI P20 and observe: -

to. Material removal rate

b. Tool wear rate

c. Surface roughness

By varying the input parameter such as current, spark, pulse in time and compare the results using both the tool. Select the best tool for machining steel AISI P20.

Chapter 3

In this chapter we discuss the experimental work being consists on the formation of L-16 orthogonal array design based on Taguchi, orthogonal matrix total is reduced in the experiment, this experiment 32run total. And Experimental set, the selection of the workpiece, tool design, and taking all the value and calculation of MRR, TWR, and surface finish.

3.1 Experimental set

For this joint experiment of the work can be down by the electric discharge machine, model PS Electrónica- ELECTRAPULS 50ZNC (type die-sinking) with servo-head (constant gap) and positive polarity electrode is used to carry out the experiments . Commercial EDM grade oil (specific gravity = 0.763, freezing point = 94 ° C) was used as dielectric fluid. With .Experiments were carried out with the positive electrode polarity. The discharge current pulse was applied in several steps in a positive way.

The EDM is to follow important part as shown in the Appendix chapter (Fig 5.1)

3.1 (a) dielectric, tank, pump and circulation system.

3.1 (b) power generator and the control unit.

3.1 (c) the dielectric tank work holding device.

3.1 (d) XY table accommodating the workbench.

3.1 (e) The head of the fastening tool

3.1 (f) servo mechanism to feed the tool.

3.1.1 dielectric tank, pump and circulation system - reservoirs and dielectric strength of the oil pump EDM for each run of the experiment and the oil filter is also used EDM. Dielectric reservoir tank shown in Figure 3.1.

Experiment setup

Figure 3.1 Dielectric reservoir

3.3

Figure 3.3 Tool holder with Workpiece and tool

3.2 Selection of the work piece-

It is capable of machining hard material component, such as heat treated tool steels, composite materials, superalloys, ceramics, carbides, heat resistant steels, etc. The higher carbon grades are typically used for applications such as stamping dies, tools of metal cutting, etc. AISI grade tool steel is the most common scale used to identify the different grades of steel for tools. Individual alloys within a grade are given a number; eg A2, O1, D2, P20, etc.

In this experiment using AISI P20 pre-hardened tool steel is used, which is further heat treated to the desired property

Plastic steel mold (P-20 tool steel) supplied usually a hardened and tempered condition. Good machine capacity, better nail capacity compared with DIN 1.2312 (AISI P20 + S). Plastic mold steel wider range of plastic mold frames for plastic pressure dies, hydro forming tools increasingly being used. And the composition of the tool shown in this table: 3.1, 3.2, 3.3 and 3.4.Table 3.1 Composition of AISI P-20 tool steel material

Elements	Weight limit %	Actual weight %
C	0.27-0.60	0.45
Mn	0.70-1.30	0.90
Si	0.30-0.90	0.50
Cr	1.50-2.5	1.30
Mo	0.40-0.6	0.40
Cu	0.35	0.30
P	0.033	0.04
S	0.035	0.04

Table 3.2 AISI P20 tool steel categories

Category	Steel
Class	Tool steel
Type	General mold steel
Designations	Germany : DIN 1.2330 United States : ASTM A681 , UNS T51620

Table 3.3 Mechanical properties of AISI P20 steel

Properties		Conditions T (°C)
Density	7.86x1000 kg/m^3	30
Poisson's Ratio	0.26-0.30	30
Elastic Modulus	180-210Gpa	30

Table 3.4 Thermal Properties of AISI P20 tool steel material

Properties		Conditions T (°C)
Thermal Expansion (10^{-6}/°C)	13.8	30-425 more

AISI P20 tool steel material and after machining work piece and the cu-tungsten tool. As showing Fig 3.4 and the work piece shows 18 total no. of experiments doing in this job.

Figure 3.4 P-20 workpiece before and after machining with tool.

3.3 Mechanism of MRR

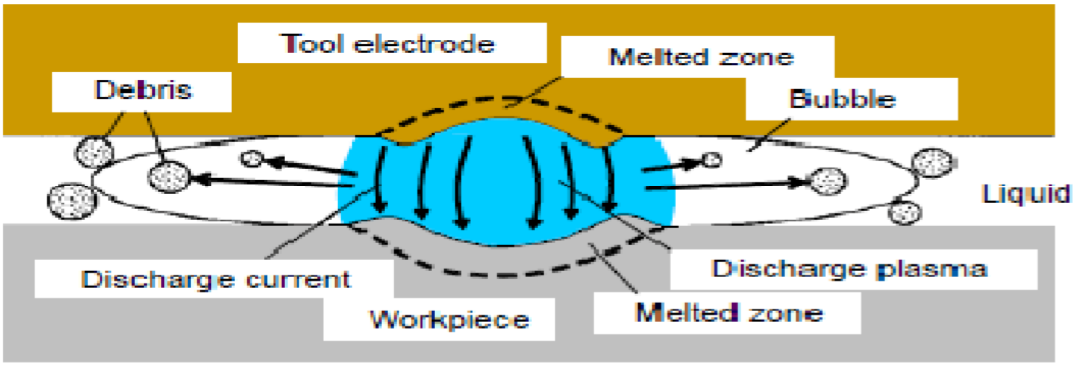

Figure 3.7 Crater formation in EDM process

3.3.1 Evaluation of MRR-

The material MRR is expressed as the ratio of the difference of weight of the workpiece before and after machining to the machining time and density of the material.

$$MRR(mm^3/min) = \frac{\text{(Work piece weight loss (gm.) *1000)}}{\text{Density(gm/cm}^3\text{)*(Machining time in minute}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

ρ= Density of AISI P20 steel material =7.80gm/cm^3

3.4 Mechanism of Tool wears-

Tool wear is an important parameter to be taken into consideration, in order to make the components of desired shape. Mohri et al. explain the mechanism of tool wear is due to the failure of carbon to precipate and difficult to reach the electrode. Tool wear is due to the melting point of the electrode

3.4.1 Evaluation of tool wear rate

TWR is expressed as the ratio of the difference of weight of the tool before and after machining to the machining time. That can be explain this equations

$$TWR(mm^3/min) = \frac{\text{(Electrode weight loss (gm.) *1000)}}{\text{Density (gm/cm}^3\text{)*(Machining time in minute)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.3.2$$

Whereas Wtb = Weight of the tool before machining.

Wta = Weight of the tool after machining.

t = Machining time (In this experiment the machining time is one hour).

3.5 Measurement of surface roughness-

Surface roughness measurement is done by equipment which calculate the machined surface. It becomes important when close tolerance components are required to be produced for space application and also in tools, dies and moulds for press work.

3.6 Taguchi design

Dr. Genichi Taguchi is regarded as the main advocate of robust design parameter, which is an engineering method for the product or process design focuses on minimizing variation and / or sensitivity to noise. When used properly, Taguchi designs provide a powerful and effective product design to constantly and optimally on a variety of operating conditions method. Taguchi proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." These methods use two, three, four, five, and fractional factorial designs mixed level. Taguchi experimental design refers to as "quality control offline", as it is a method to ensure good performance in the design stage of products or processes.

3.7 Taguchi design experiments in MINITAB

Minitab offers both static and dynamic experiments response in a static response experiment; the quality characteristic of interest has a fixed level. The aim of robust experimentation is to find an optimal combination of settings of the control factors that achieve robustness (insensitivity) noise factors. MINITAB calculates and generates response tables main and interaction effects for plots: -

Signal to noise ratio (S / N) vs. relations control factors.

Media (static design) vs. control factors.

Taguchi design or an orthogonal matrix method is designing the experimental procedure using different types of similar design, two, three, four, five, and mixed level. In the study, a level of three factors mixed configuration is chosen for a total of eighteen numbers of experiments was carried out and therefore L16 OA was chosen. This design would allow interactions of the two factors to evaluate. As few more factors have to be added for further study with the same kind of material, we decided to use the L16setup, which in turn would reduce the number of experiments in the later stage. Furthermore, comparison of the results would be simpler.

Levels experiment parameters of sparks in the spark time (Ton) and the discharge current (IP) is shown in Table 3.5 and the design matrix shown in Table 3.6.

Table 3.5 Machining parameters and their level

Machining parameter	Symbol	Unit	Level

			Level 1	Level 2	Level 3	Level 4
Spark Gap	(L)	mm	4	6	8	10
Spark on time	(Ton)	µs	50	100	500	1000
Discharge current	(Ip)	A	5	10	15	20

3.8 Conduct of Experiment –

Tool steel AISI P20 material was using tungsten particles and graphite tool with 4 mm diameter and 6 mm. And the ELEKTRA 50ZNC (type die-sinking) EDM machine used. Commercial EDM grade oil (specific gravity = 0.763, freezing point = 90 ° C) was used as dielectric fluid. Tungsten and graphite wash tool was used to wash away the eroded material in the area of sparks. In this cycle of tension and duty experiment remains constant is 50 v. For a factor of three dealt with a total of 16 experiments carried out in EDM.

Calculating the rate of material removal and the rate of tool wear by using electronic balance weight machine as shown in Figure 5.2. This capability of the machine is 300 grams and precision is 0.001 gram. Profile and surface roughness meter. Its accuracy is 0.01 micro meter.

3.9 Design matrix and Observation table

Table 3.6 Design matrix and Observation table

TUNGUSTEN ALLOY ELECTRODE

Run	Spark Gap(mm)	Ip (A)	Ton (µs)	Wt of Workpiece (gm)		Wt. of Tool (gm)		
				Wjb	Wja	Wtb	Wta	Machining time
1	0.04	5	50	266.510	266.220	96.970	96.873	3.23
2	0.04	5	100	266.220	265.897	96.973	96.778	3.28

3	0.04	5	500	265.897	265.397	96.778	96.686	3.33
4	0.04	5	1000	265.397	264.941	96.686	96.595	3.45
5	0.06	10	50	264.941	264.446	96.595	96.410	2.53
6	0.06	10	100	264.446	263.951	96.410	96.301	2.57
7	0.06	10	500	262.883	262.382	96.301	96.220	2.59
8	0.06	10	1000	262.382	261.882	96.220	96.070	3.11
9	0.08	15	50	261.882	261.382	96.070	95.097	2.58
10	0.08	15	100	261.382	260.886	95.097	95.00	3.01
11	0.08	15	500	270.922	270.423	95.00	94.900	3.04
12	0.08	15	1000	270.423	269.912	94.900	94.803	3.16
13	0.10	20	50	269.912	269.400	94.803	94.609	2.47
14	0.10	20	100	269.400	268.899	94.609	94.434	2.33
15	0.10	20	500	268.899	268.301	94.434	94.279	2.53
16	0.10	20	1000	268.301	267.801	94.279	94.133	3.14

Table 3.7 Design matrix and Observation table.

GRAPHITE ELECTRODE

Run	Spark Gap(mm)	Ip (A)	Ton (µs)	Wt of Workpiece (gm)		Wt. of Tool (gm)		
				Wjb	Wja	Wtb	Wta	Machining time(min)
1	0.04	5	50	267.590	267.189	55.976	55.920	3.16
2	0.04	5	100	267.189	266.766	55.920	55.858	3.10

3	0.04	5	500	266.766	266.311	55.858	55.774	3.20
4	0.04	5	1000	266.311	265.886	55.774	55.678	3.50
5	0.06	10	50	265.886	265.441	55.678	55.600	2.18
6	0.06	10	100	265.441	265.001	55.600	18.512	2.05
7	0.06	10	500	265.001	264.558	55.512	55.408	2.25
8	0.06	10	1000	264.558	264.129	55.408	55.289	2.40
9	0.08	15	50	264.129	263.684	55.289	55.205	2.20
10	0.08	15	100	263.684	263.244	55.205	55.137	2.02
11	0.08	15	500	263.244	262.804	55.137	55.087	2.23
12	0.08	15	1000	262.804	262.345	55.087	55.020	2.33
13	0.10	20	50	267.341	266.901	55.020	54.910	1.53
14	0.10	20	100	266.901	266.461	54.910	54.822	1.45
15	0.10	20	500	266.461	266.021	54.822	54.767	1.57
16	0.10	20	1000	266.021	265.576	54.767	54.745	2.04

Chapter 4

Result and Discussion

In This chapter are related about influences of MRR, TWR, and Surface finishand finding the result which factors discharge current , pulse duration, spark gap , is most important with help of Taguchi method.

SEM Images

Before machining After machining

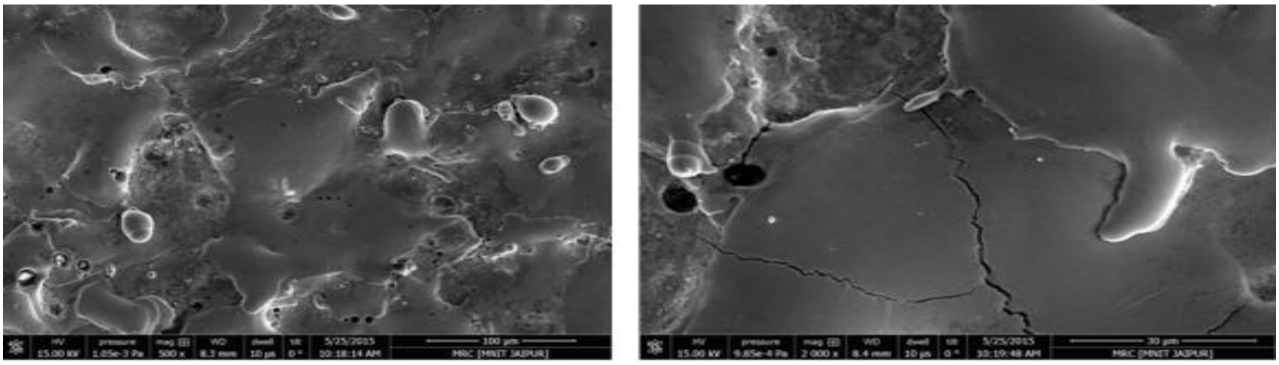

Fig 4.1Tungsten too

Before machining After machining

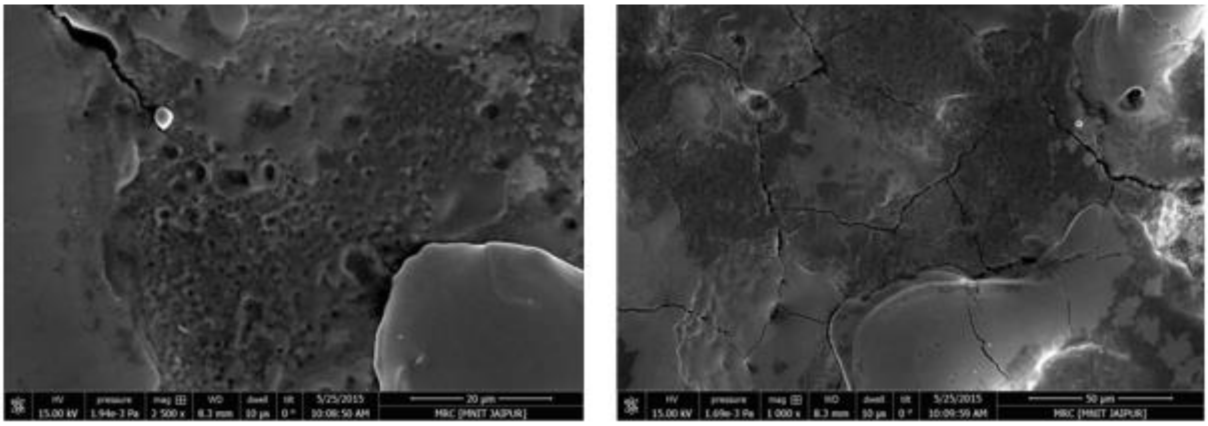

Fig 4.2Graphite electrode

4.1 Response table –

The response table for MRR, TWR and Surface finish are shown in

Table 4.1 along with the input

Table 4.1 Response table

TUNGSTEN ELECTRODE

Run	Spk (mm)	Ip (A)	Ton (μs)	MRR (mm^3/min)	TWR (gm/min)	Surface Finish(μm)

1	0.04	5	50	11.510	1.9762	3.868
2	0.04	10	100	12.4355	1.9654	3.675
3	0.04	15	500	19.250	1.9587	3.060
4	0.04	20	1000	16.5453	1.8976	2.930
5	0.06	5	100	25.0836	2.5687	2.647
6	0.06	10	50	24.6932	2.5436	2.876
7	0.06	15	1000	24.799	2.5323	2.320
8	0.06	20	500	20.611	2.5176	2.101
9	0.06		50	24.845	5.6547	3.121
10	0.08	10	100	21.126	5.6435	2.394
11	0.08	15	500	21.0441	5.6345	2.445
12	0.08	20	1000	20.7319	5.6123	3.030
13	0.10	5	50	26.753	4.9876	3.567
14	0.10	10	100	27.566	4.8765	3.030
15	0.10	15	500	30.303	4.7654	4.876
16	0.10	20	1000	20.414	4.6754	3.654

GRAPHITE ELECTRODE

Run	Spk (mm)	Ip (A)	Ton (µs)	MRR (mm^3/min)	TWR (gm/min)	Surface Finish(µm)
1	0.04	5	50	16.269	0.5647	3.868
2	0.04	5	100	17.493	0.5546	3.675
3	0.04	5	500	16.908	0.5463	3.060
4	0.04	5	1000	15.567	0.5345	2.930
5	0.06	10	50	26.170	1.2675	2.647

6	0.06	10	100	27.517	1.2428	2.876
7	0.06	10	500	25.242	1.2276	2.320
8	0.06	10	1000	22.916	1.2067	2.101
9	0.08	15	50	25.932	2.7634	3.121
10	0.08	15	100	27.925	2.6758	2.394
11	0.08	15	500	25.960	2.5643	2.445
12	0.08	15	1000	25.800	2.4654	3.030
13	0.10	20	50	36.869	3.6543	3.567
14	0.10	20	100	38.903	3.5436	3.030
15	0.10	20	500	35.930	3.4345	4.876
16	0.10	20	1000	27.966	3.3876	3.654

4.2 Influences on MRR

Table 4.2 Response for S/N Rations Larger is better (MRR)

Level	Spk	Ip	Ton
1	23.29	26.42	25.43
2	27.50	26.26	26.46
3	26.80	27.42	27.17
4	28.30	25.80	26.83
Delta	5.00	1.62	1.74
Rank	1	3	2

Tungsten based Electro

Level	Spk	Ip	Ton
1	24.37	28.05	27.56
2	28.10	28.59	28.14
3	28.43	28.00	27.96
4	30.79	27.05	28.03
Delta	6.42	1.54	0.58
Rank	1	2	3

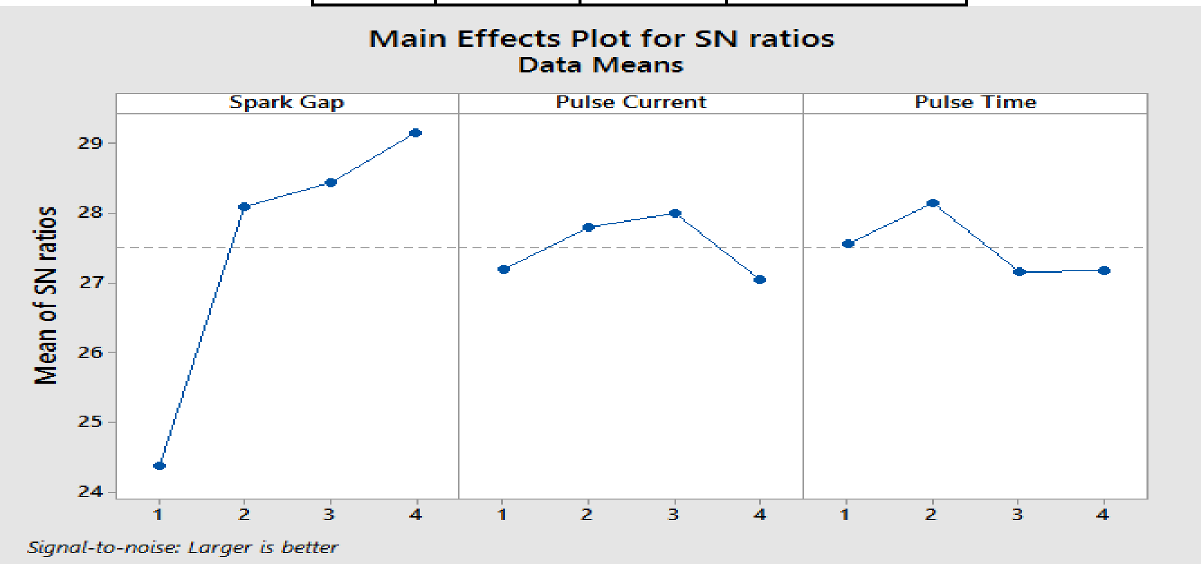

Figure 4.1 Main effect plot for Means of SN ratios (MRR)

Table 4.3 Response for S/N Rations Larger is better (MRR)

Graphite Electrode

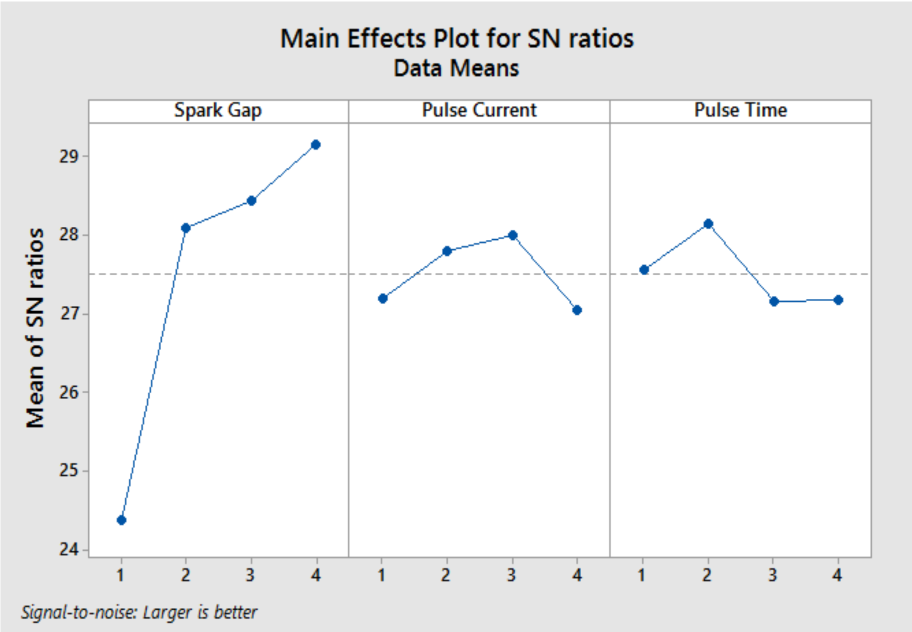

Figure 4.2 Main effect plot for Means of SN ratios (MRR)

During electrical discharge machining, the influence of various machining parameters as Ip, Ton and spark gap tool has a significant effect on MRO, as shown in effect main argument for the S / N ratio MRR in Figure 4.1. The discharge current (Ip) is directly proportional to MRR in the range of 5 to 15A. This is expected due to an increase in pulse current produces strong spark, which produces the highest temperature, causing more material to melt and erode the work piece. Furthermore, it is clearly evident that the other factor influencing not much compared to Ip and similar findings were shown by Ghoreishi and Tabari [34]. But, with increasing discharge current of 10A to 13 MRR increases slightly. However, MRR decreases monotonically with increasing pulse time.

It is well known that spark energy increases with Ton and therefore increases with Ton MRR in the range of 300 to 400 mu s. MRR usually increases with Ton to a maximum after which it begins to decrease. This is due to the fact that with greater Ton, the plasma formed between the electrodes Inter separation (IEG) actually hinders the transfer of energy and therefore reduces MRR. In this experiment, the value of pulse durations are 50, 500 and 1,000 missing at maximum mu s. Thus, the graph plotted vs. pulse duration MRR, as shown only decreasing trend.

4.2.1 Graphical Analysis of MRR

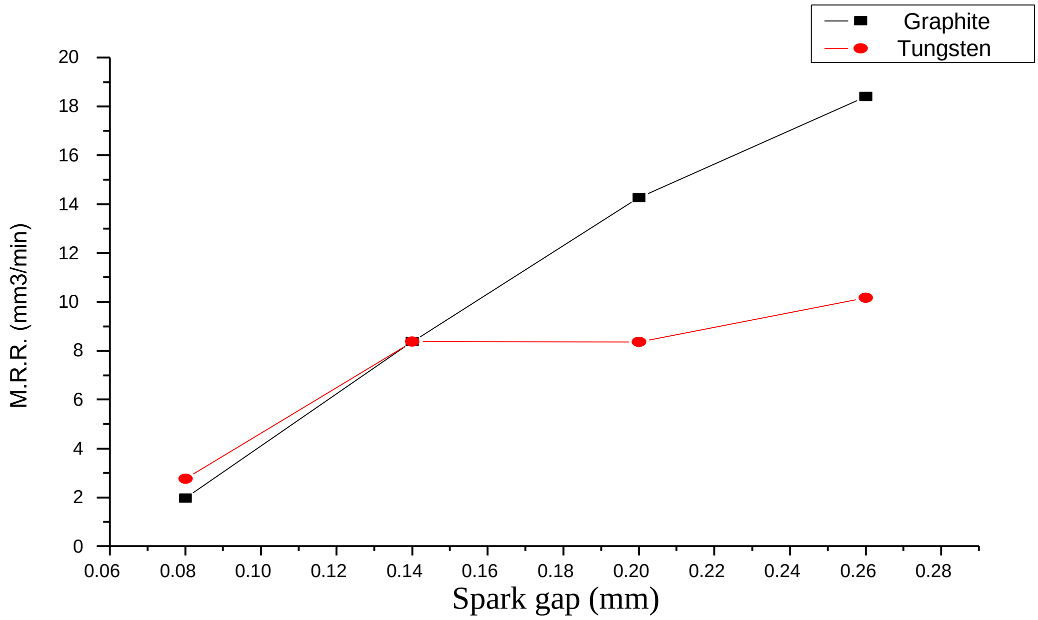

Fig 4.3

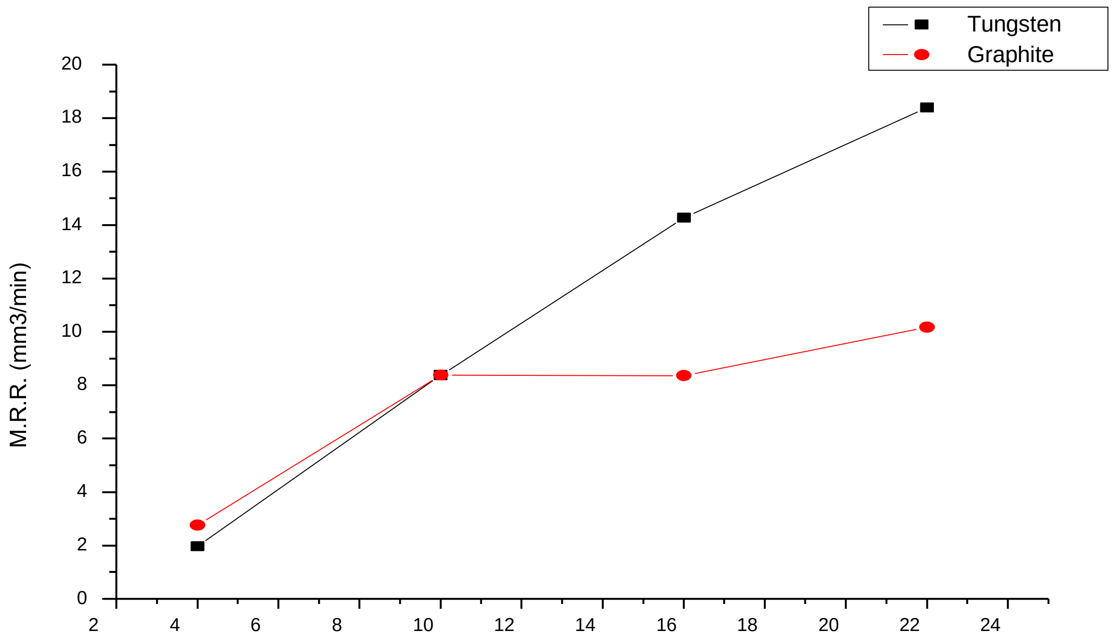

Fig 4.4 Current (amps)

4.3 Influences on TWR

Table 4.4 Variance for TWR

Level	Spk	Ip	Ton
1	-5.797	-10.779	-10.610
2	-8.98	-10.698	-10.652
3	-15.020	-10.622	-10.667
4	-13.670	-10.491	-10.656
Delta	9.22	0.288	0.058
Rank	1	2	3

Tungsten based Electrode

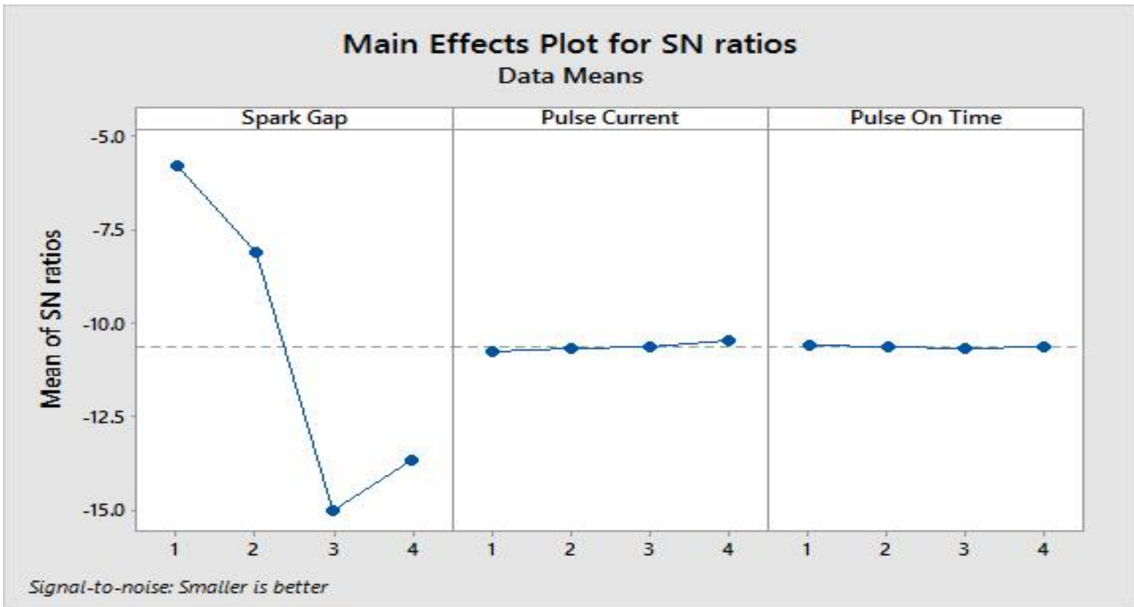

Fig 4.5 Response Table for Signal to Noise Ratios Smaller is better (TWR)

Table 4.5 Analysis of Variance for TWR

Level	Spk	Ip	Ton
1	5.194	-4.295	-3.925
2	-1.840	-4.076	-3.873
3	-8.349	-3.857	-4.050
4	-10.890	-3.657	-4.036
Delta	16.084	0.638	0,176
Rank	1	2	3

Graphite Electrode

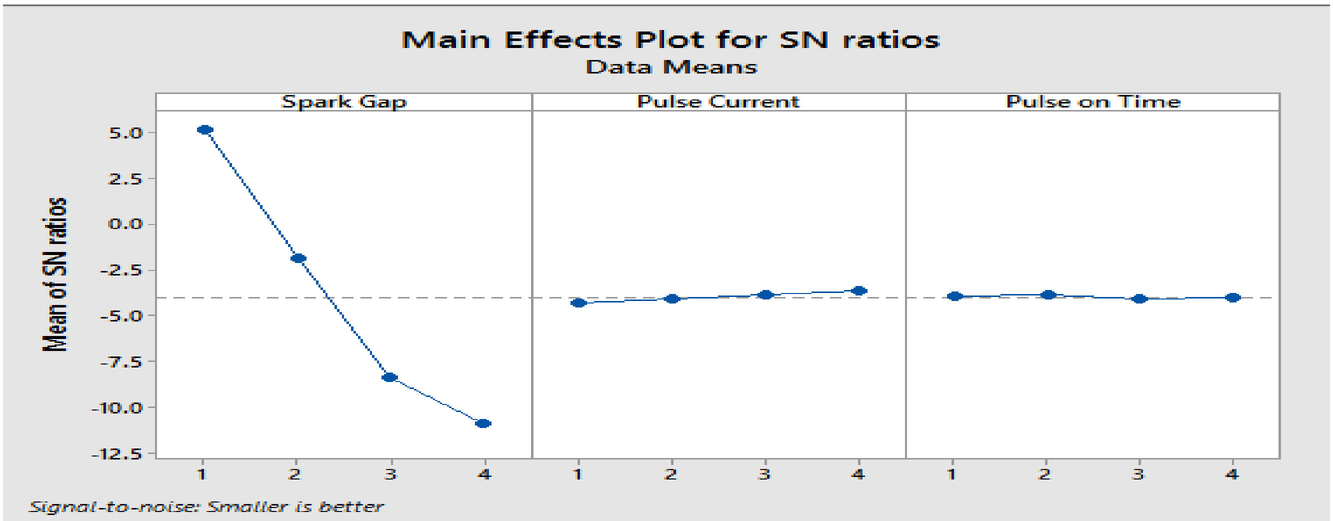

Fig 4.6 Response Table for Signal to Noise Ratios Smaller is better (TWR)

During the EDM process, the influence of various machining parameters as Ip, Ton and tool diameter has significant effect on the TWR, as shown in effect main argument for the S / N ratio of TWR in Figure 4.4. The increase in the discharge current of 1 to 3 A rate of tool wear is decreasing, but the discharge current in the range of 3 to 5 at the rate of tool wear is increasing. Because Ip increases the pulse energy increases and thus more thermal energy is produced in the interface of the work piece of the tool it leads to increase the melting point and evaporation of the electrode. It can be interpreted that Ip has a significant direct impact on TWR by Dhar and Purohit [1]. And the pulse time is directly proportional to the rate of tool wear. And the diameter of the tool has no significant effect on the TWR. TWR interaction plot shown in figure 4.5, where each plot shows the interaction of three different machining parameters such as Ip and Ton day. tool. This implies that the effect of a factor dependent on another factor.

4.4 **Variation of Surface roughness –**

Table 4.6 Analysis of Variance for Surface roughness

Level	Spk	Ip	Ton
1	-10.527	-10.284	-9.987

2	-7.847	-9.423	-10.788
3	-8.716	-9.638	-8.919
4	-11.423		-0.1555
Delta			
Rank	1	3	2

Tungsten based Electrode

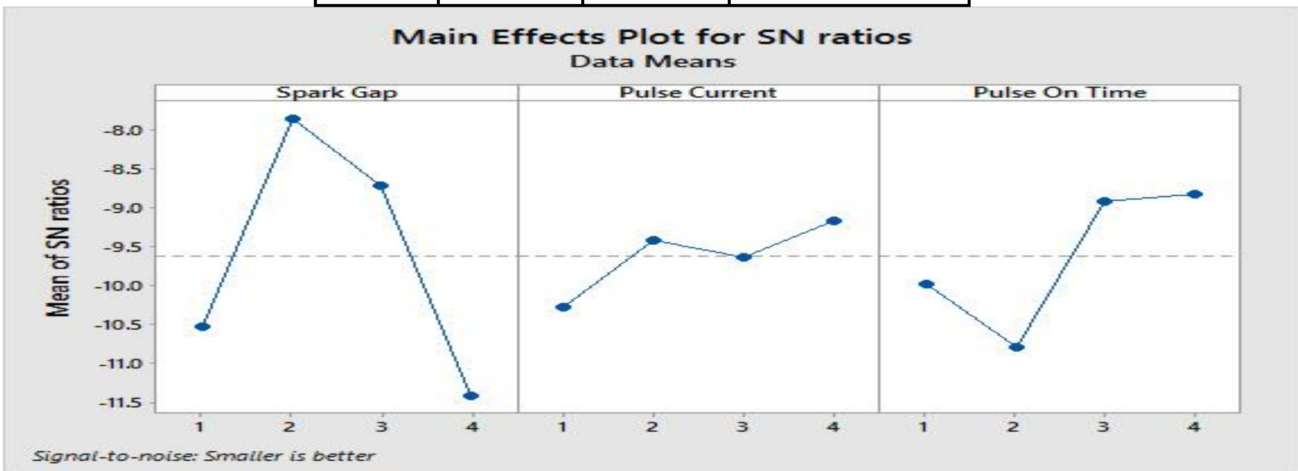

Fig 4.7 Response for Signal to Noise Ratios Smaller is better (Surface Roughness)

Table 4.7 Analysis of Variance for Surface roughness

Level	Spk	Ip	Ton
1	-10.527	-10.284	-9.987
2	-7.847	-9.423	-10.788
3	-8.716	-9.638	-8.919
4	-11.423		-0.1555
Delta	3.576	1.117	1.969
Rank	1	3	2

Graphite Electrode

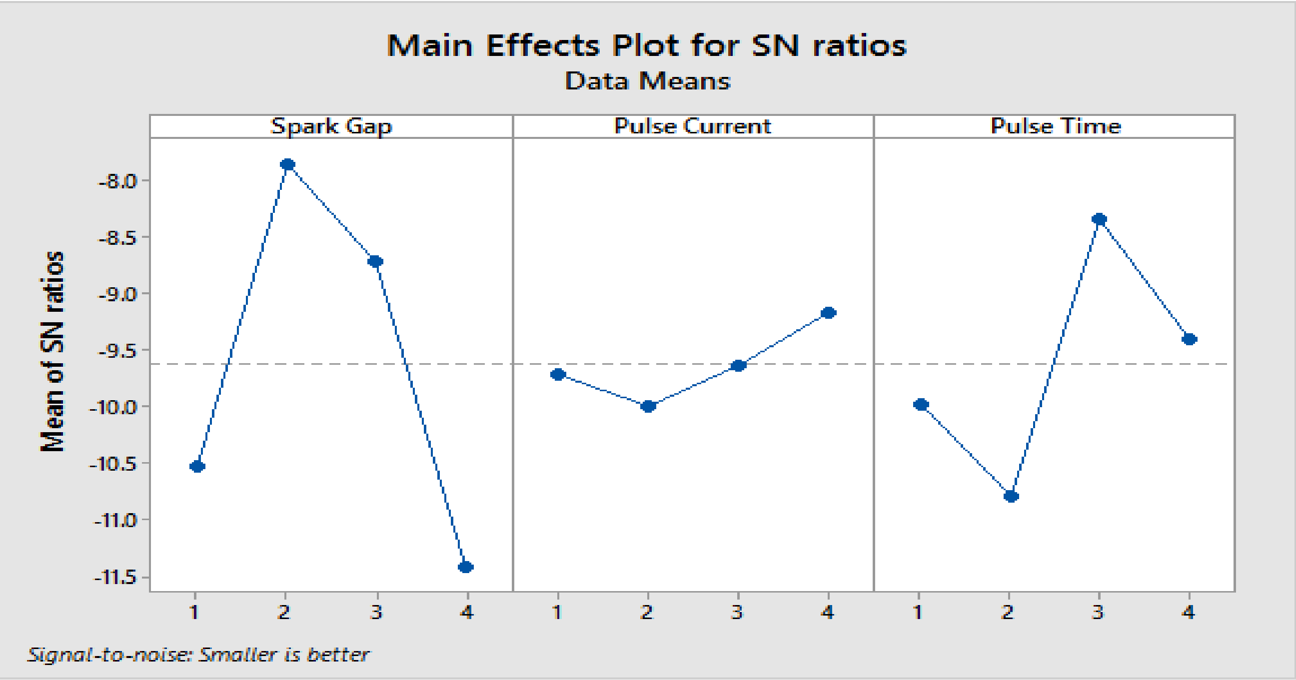

Fig 4.8 Response for Signal to Noise Ratios Smaller is better (Surface Roughness)

Graphical analysis of surface roughness

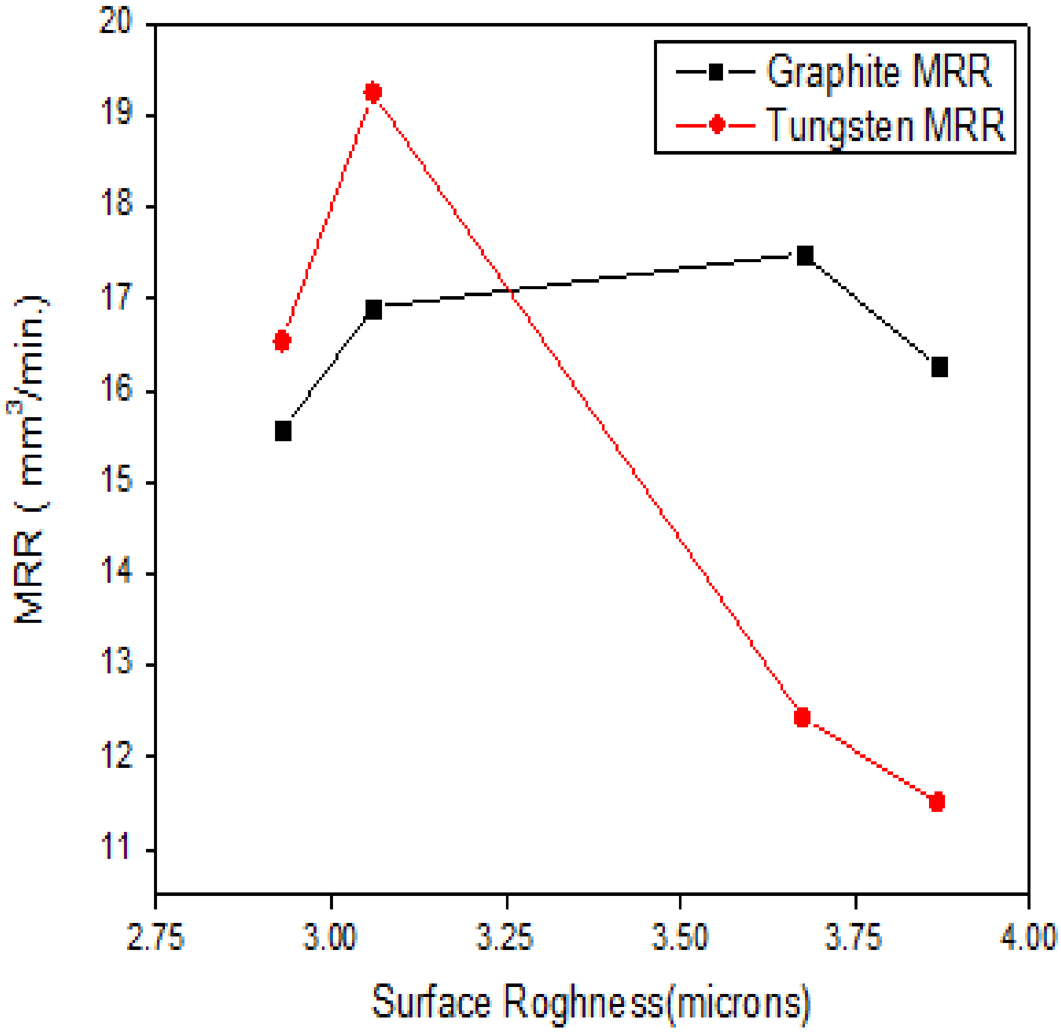

Fig. 4.9

Chapter 5

Conclusion

In the present study the effect of machining answers are MRR and TWR area Roughnessof plastic mold steel AISI P20 component with the function w- cu discharge system have been investigated for the EDM process. The experiments were conducted under various settings discharge current (Ip), Pulse On-Time (Ton), the spark gap. L-16 OA based on Taguchi design was performed to Minitab software was used to analyze the results and thesis answers were partially validated experimentally.

(1) From the above analysis experiment clearly shows that the current Ip is the parameter most influencing both for the tool, then after Ton and spark gap.

(2) A little observation shows that both the tool MRR somehow are not very different,

But the tungsten electrode based MMR is having less compared to graphite.

(3) Speaking of the end surface with the tungsten electrode base is pretty good.

(4) Despite all this the TWR is good for tungsten electrode based

(5) As the current increases MRR is increased up to a point, then decreases

(6) Spark gap somehow influsing parameter.

Chapter 6

Machine and Equipment

This Electrical discharge machine (EDM) was used to machine on for conducting the Experiments. This machine model ELECTRONICA- ELECTRAPULS PS 50ZNC (die-sinking type) with servo-head (variable gap).

Figure 5.1 Die Sinker EDM Model: PS 50ZNC

Weighing machine

Precision balance was used to measure the weight of the work piece and tool. This machine capacity is 300 gram and accuracy is 0.001 gram and Brand: SHINKOO DENSHI Co. LTD, JAPAN, and Model: DJ 301S.

Fig5.2 Electronic Balance weight machine

Surface Roughness measurement device

Fig 5.3

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