DESIGN AND DEVELOPMENT OF EDM MACHINE

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BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING
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Certificate

This is to certify that the project entitled **“Design and development of EDM machine”** is a bonafide work of “**Aditya Ajitkumar (Roll No. 804), Adnan Aasim Budye (RollNo.818), Febin Biju (RollNo.819), Yash Deshmukh (RollNo.829)”** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of **“Bachelor of technology”** in **“Mechanical Engineering”**.

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Abstract

Electro discharge machining (EDM) process is a non-conventional and non-contact machining operation which is used in industry for high precision products. EDM is known for machining hard and brittle conductive materials since it can melt any electrically conductive material regardless of its hardness. The workpiece machined by EDM depends on thermal conductivity, electrical resistivity, and melting points of the materials. The tool and the workpiece are adequately both immersed in a dielectric medium, such as, kerosene, deionised water or any other suitable fluid. This project provides an important review on design and development of EDM machine.

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Chapter 1

Introduction

1.1 History/Background

Two Soviet scientists, B. R. Lazarenko and N. I. Lazarenko, were tasked in 1943 to investigate ways of preventing the erosion of tungsten electrical contacts due to sparking. They failed in this task but found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid. This led them to invent an EDM machine used for working difficult-to-machine materials such as tungsten. The Lazarenkos' machine is known as an R-C-type machine, after the resistor–capacitor circuit (RC circuit) used to charge the electrodes.

Simultaneously but independently, an American team, Harold Stark, Victor Harding, and Jack Beaver, developed an EDM machine for removing broken drills and taps from aluminium castings. Initially constructing their machines from under-powered electric-etching tools, they were not very successful. But more powerful sparking units, combined with automatic spark repetition and fluid replacement with an electromagnetic interrupter arrangement produced practical machines. Stark, Harding, and Beaver's machines were able to produce 60 sparks per second. Later machines based on their design used vacuum tube circuits that were able to produce thousands of sparks per second, significantly increasing the speed of cutting.

The wire-cut type of machine arose in the 1960s for making tools (dies) from hardened steel. The tool electrode in wire EDM is simply a wire. To avoid the erosion of the wire causing it to break, the wire is wound between two spools so that the active part of the wire is constantly changing. The earliest numerical controlled (NC) machines were conversions of punched-tape vertical milling machines. The first commercially available NC machine built as a wire-cut EDM machine was manufactured in the USSR in 1967. Machines that could optically follow lines on a master drawing were developed by David H. Dulebohn's group in the 1960s at Andrew Engineering Company for milling and grinding machines. Master drawings were later produced by computer numerical controlled (CNC) plotters for greater accuracy. A wire-cut EDM machine using the CNC drawing plotter and optical line follower techniques was produced in 1974. Dulebohn later used the same plotter CNC program to directly control the EDM machine, and the first CNC EDM machine was produced in 1976.

Commercial wire EDM capability and use has advanced substantially during recent decades. Feed rates have increased and surface finish can be finely controlled.

1.2 Motivation

As mechanical engineering students, we were really intrigued by the idea of various types of electro-mechanical processes. We found the EDM machine to be the ideal topic for our final year project through which we can learn about different types of electro-mechanical processes. Since this process also involves the removal of material, we also got the opportunity to learn about subtractive manufacturing. Subtractive manufacturing usually involves the removal of material by a CNC machine. But in the EDM machine, the removal of material takes place because of a spark generation or due to induced electricity. This made us very curious about how this process takes place. This was enough motivation for us to take up the following project.

1.3 Technical Details

Components used for the setup of EDM machine are: -

- ❑ Power Supply (Step down transformer)

A step-down transformer is an electrical device that is used to decrease the voltage level of an alternating current (AC) power signal. It consists of two coils of wire, called the primary and secondary coils, which are wound around a common magnetic core. The primary coil is connected to the input voltage source, and the secondary coil is connected to the load.

The step-down transformer works by using Faraday's law of electromagnetic induction to induce a voltage in the secondary coil that is proportional to the voltage applied to the primary coil. The voltage ratio between the primary and secondary coils is determined by the ratio of the number of turns of wire in each coil.

For example, if a transformer has a 10:1 voltage ratio, and the primary coil is connected to a 120-volt AC power source, the output voltage from the secondary coil would be 12 volts. This is because the number of turns in the secondary coil is one-tenth the number of turns in the primary coil.

Step-down transformers are commonly used in electronic devices to provide low-voltage power for components such as microprocessors, sensors, and other integrated circuits. They are also used in power distribution systems to reduce the voltage of high-voltage power lines to a level that is safe for household and commercial use.

Step-down transformers are also used in power distribution systems to reduce the voltage of high-voltage power lines to a lower voltage that is suitable for consumer use. They can also be used in electronic devices to reduce the voltage of AC power to a level that is safe and compatible with the device.

The primary advantage of using a step-down transformer is that it allows the use of high voltage power sources, while still delivering low voltage power to the device. This helps in reducing power loss over long distances, and also provides a level of safety as lower voltages are less dangerous.

- A step-down transfer was used to reduce the supply voltage and current for suitable working of EDM process.

- The step-down transformer of the conversion capacity of stepping down current input of 230V ac supply to a variable 50-100 volt steady output.

- The transformer used in the setup is used to obtain multiple voltage outputs with ranges of 12-0-12 and 24-0-24 voltages at the output for the steady 230V input.

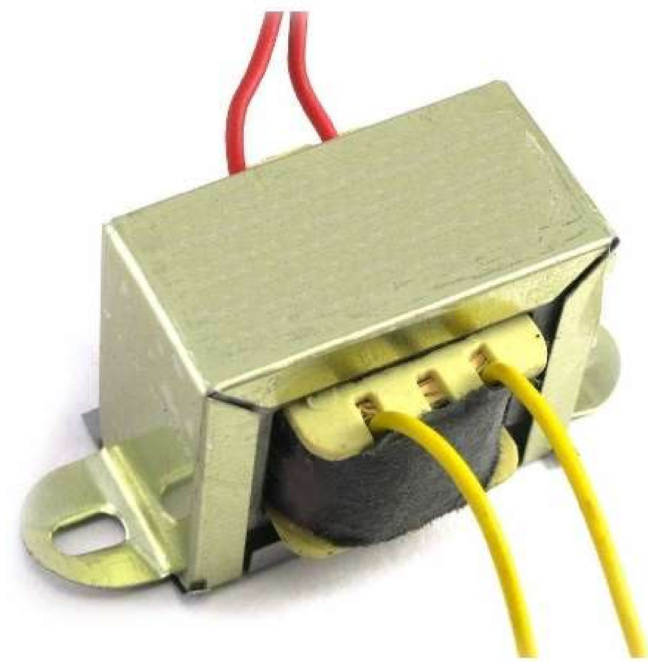


Figure 1.1: 230V Transformer

❑ Bridge rectifier

A bridge rectifier is an electrical circuit that is used to convert an alternating current (AC) signal to a direct current (DC) signal. It is commonly used in power supplies for electronic devices and other applications that require DC power.

The bridge rectifier consists of four diodes arranged in a bridge configuration, hence the name. The diodes are connected to form a diamond shape, with the AC signal applied to the two AC input terminals of the bridge. The DC output is taken from the two DC output terminals of the bridge.

The operation of the bridge rectifier is based on the fact that a diode allows current to flow in one direction only. When the AC signal is positive, the diodes D1 and D4 are forward-biased, and current flows through the load in the direction of the arrow shown in the diagram. When the AC signal is negative, the diodes D2 and D3 are forward-biased, and current flows in the opposite direction through the load.

As a result, the AC signal is effectively converted to a DC signal, with the negative portions of the AC signal inverted and combined with the positive portions to produce a smooth DC output. The output voltage of the bridge rectifier is approximately equal to the peak value of the AC input voltage minus the voltage drop across the diodes.

Bridge rectifiers are widely used in electronic circuits due to their simplicity and efficiency. They are commonly found in power supplies for computers, audio equipment, and other electronic devices.

In EDM machines, a bridge rectifier is commonly used to convert the AC power supply to DC power that is used to drive the EDM process. The high-frequency electrical discharge requires a stable and precise DC voltage supply to operate properly.

The bridge rectifier in the EDM machine is used to convert the incoming AC power supply to a stable DC voltage. The DC voltage is then fed to a pulse generator that produces a series of high-frequency electrical discharges between the electrode and the workpiece. The pulse generator also controls the duration, frequency, and intensity of the electrical discharges.

The use of a bridge rectifier in the EDM machine ensures that the electrical discharge is generated with a stable and precise voltage, which is critical to achieving accurate and consistent results in the manufacturing process. The bridge rectifier helps to eliminate the AC ripple and provide a smooth and stable DC voltage supply to the pulse generator.

Overall, the bridge rectifier is an essential component in EDM machines, as it plays a critical role in providing a stable and precise DC voltage supply for the electrical discharge process.

Figure 1.2: Bridge Rectifier

❑ Work plate

In Electrical Discharge Machining (EDM), the workpiece is the material that is being machined using electrical discharges. The workpiece can be made of any electrically conductive material, such as metals, alloys, or ceramics.

The EDM process involves using a shaped electrode, usually made of copper or graphite, to create a series of electrical discharges between the electrode and the workpiece. These electrical discharges create a spark that melts and vaporizes the material in a controlled manner, which is then removed from the workpiece as debris.

The shape of the electrode determines the shape of the cavity or feature that is being machined into the workpiece. The electrode is typically held in a CNC machine, which controls the movement of the electrode relative to the workpiece. The CNC machine is programmed to follow a specific path and create the desired shape or feature in the workpiece.

The workpiece is submerged in a dielectric fluid, such as oil or deionized water, which helps to cool the machining area, flush away debris, and provide a path for the electrical discharge. The dielectric fluid also helps to prevent the electrode and workpiece from coming into contact with each other, which would short-circuit the electrical discharge and damage the electrode.

Overall, the workpiece is a critical component of the EDM process, as it is the material that is being machined using the electrical discharges. The selection of the workpiece material, as well as the shape and size of the workpiece, can have a significant impact on the EDM process and the quality of the final product.

The size of the workpiece is limited by the capacity of the EDM machine used for the process. In general, larger workpieces require larger EDM machines with higher power capabilities.

It is important to note that the EDM process can generate a lot of heat, which can cause thermal stress and deformation in the workpiece. Therefore, care must be taken in selecting the appropriate workpiece material and in designing the workpiece to minimize these effects.

- We are using an alloy of copper sheet as our workpiece as copper is good conductor of electricity hence the material removal will be superior.

Figure 1.3: Copper Sheet

- Dielectric medium

In Electrical Discharge Machining (EDM), a dielectric medium is used to help facilitate the electrical discharge between the electrode and the workpiece. The dielectric medium is typically a liquid, such as deionized water, oil, or a synthetic fluid, that is circulated through the machining area.

The main functions of the dielectric medium in EDM are:

Cooling: The electrical discharge generates a significant amount of heat, which can cause the workpiece and the electrode to become too hot and deform or even melt. The dielectric medium helps to cool the machining area, preventing excessive heat buildup and maintaining the temperature within a safe range.

Flushing: The dielectric fluid is circulated through the machining area to flush away the debris created during the machining process. This helps to maintain a clean and clear machining area, ensuring that the electrical discharge is not interrupted by debris.

Insulation: The dielectric medium also helps to insulate the electrode and workpiece, preventing them from coming into direct contact with each other during the electrical discharge. This insulation prevents a short circuit and damage to the electrode.

Ionization: When the electrical discharge occurs, the dielectric fluid undergoes a process called ionization, which creates a conductive path between the electrode and the workpiece. This conductive path allows the electrical discharge to flow, removing material from the workpiece in a controlled manner.

The selection of the dielectric medium is based on several factors, such as the type of material being machined, the electrode material, and the desired surface finish. The dielectric medium should have good electrical and thermal properties, as well as good lubrication properties to reduce tool wear. Additionally, the dielectric fluid should be compatible with the materials being machined and not cause any corrosion or other damage.

We are using Distilled water as the dielectric medium kerosene can also be used as a dielectric medium but we avoided it as it is flammable in nature.

Figure 1.4: Distilled water

❑ Electrode

In Electrical Discharge Machining (EDM), the electrode is a critical component that is used to shape the material being machined. The electrode is usually made of copper or graphite, which are both electrically conductive materials.

During the EDM process, the electrode is held in a CNC machine and positioned above the workpiece. A voltage difference is applied between the electrode and the workpiece, which creates a series of high-frequency electrical discharges between the two components.

The electrical discharges create a spark that melts and vaporizes the material in a controlled manner, which is then removed from the workpiece as debris. The shape of the electrode determines the shape of the cavity or feature that is being machined into the workpiece.

Copper is a popular choice for EDM electrodes because it is a good conductor of electricity, has good wear resistance, and is relatively easy to machine. Graphite electrodes are also commonly used in EDM because they have good thermal conductivity, low electrode wear, and produce a high-quality surface finish.

Tungsten and molybdenum electrodes are typically used for EDM applications that require higher precision and accuracy, as they have high melting points and can maintain their shape under high-temperature conditions.

There are two main types of electrodes used in EDM:

Sinker or Ram Electrodes: These electrodes are used to create cavities or features in the workpiece that are of a specific shape and size. The electrode is shaped to the desired shape of the cavity or feature, and then pressed into the workpiece to create the desired shape.

Wire Electrodes: These electrodes are used to cut complex shapes in the workpiece that cannot be created using a sinker or ram electrode. A thin wire electrode is fed through the workpiece and is continuously moved through the material in a specific pattern, which cuts the material into the desired shape.

The selection of the electrode material depends on several factors, such as the material being machined, the desired surface finish, and the electrode wear rate. Copper electrodes are typically used for rough machining and graphite electrodes are used for finishing and fine detail work.

Overall, the electrode is a critical component in the EDM process, as it determines the shape and accuracy of the final product. The selection of the electrode material and type depends on the specific machining requirements and the desired outcome.

- Copper tool electrode and workpiece will be used as after researching about other materials that could be used before the process.
- Copper was used as EDM tool material by several researcher, due to its good conductivity.

figure 1.5: Copper electrode

Chapter 2

Literature Survey

Over the years, different studies have been conducted on the EDM processes. Some of the research papers related to the applications of these components were studied.

The EDM how to book by Ben Fleming

Some of the topics covered in the book are: -

1.Theory of EDM processes

2.Explanation of circuit operation

3.Building the generator

4.Building of an automatic control system

5.Building of a low cost, gearmotor slide

6.Building a full functioning dielectric tank and filtering system

7.EDM techniques and tooling

The book is laid out to construct the EDM in the following building sequence, though it may be built in any order.

1.Control circuit

2.Generator circuit

3.Servo head

4.Dielectric tank

Electrical Discharge Machining: Types, Technologies and Applications
by M. P. Jahan

Electrical Discharge Machining (EDM) is one of the earliest and most widely used non-conventional machining processes. In recent years, the use of EDM has increased significantly in industries, mainly due to the extensive use of hard and difficult-to-cut materials, i.e. hardened steels, carbides, titanium alloys, nickel super alloys and so on. The EDM process is being used extensively for many important applications in die and mould, aerospace, automotive, micro-electronic and biomedical industries. As a result, extensive research has been carried out on various aspects of EDM. Taking those facts into consideration, this book aims to provide a comprehensive overview of the various types, technologies and applications of EDM. The book starts with chapters on the two major types of EDM: die-sinking EDM and wire-EDM. Subsequently, several EDM-based hybrid machining processes, such as: ultrasonically aided EDM, powder-mixed EDM, and simultaneous micro-EDM/ECM have been discussed in detail. This book includes chapters on the detail of EDM surface and modeling and simulation of the EDM process. This book also contains chapters on the novel and innovative applications of EDM as well as machining of newer materials, such as: shape memory alloy, reaction-bonded silicon carbide, metal matrix composites, silicon-based semiconductors, and non-conducting polymers. It is a useful resource for students and researchers who are planning to start their research on the area of EDM and related processes. It can also serve as a reference for students, academics, researchers, engineers, and working professionals in non-traditional manufacturing processes related industries.

Analysis of Electrical Discharge Machining (EDM) Process: Surface integrity and Energy distribution in Electrical Discharge Machining (EDM) process.
by C. P. Khatter

This book is meant for the students, research scholars and teachers using the EDM process. The author presented a detailed study of Input energy parameters including peak current, pulse duration and polarity. Output in the form of surface integrity has been explained in detail, which includes surface roughness, micro hardness and microstructure. The key interest of scientists and technologists is for the higher rates of metal removal with excellent surface finish and low tool wear. The detailed study on effect of processing parameters, the nature of cracks observed at the surface and on structural features of cermet after EDM is precisely described. In order to improve the technological performance during the EDM process it is essential to understand the formation of cracks, distribution of cracks, size of the cracks, and the structure of cracks to distinguish between fatigue cracks and EDM cracks. The amount of energy available for this process is generated through plasma. Account of the total energy input and output is explained. It is an ideal text book on practical EDM.

Chapter 3

Problem statement

- ## Identification of Problem

After studying and reviewing the various research papers, we found that EDM is a very large and expensive setup. A small experimental set up needs to be developed in a lower budget. The process needs to be the same and the removal of material should take place due a spark generation only.

- ## Objective

1.To learn about the electro-mechanical processes taking place.

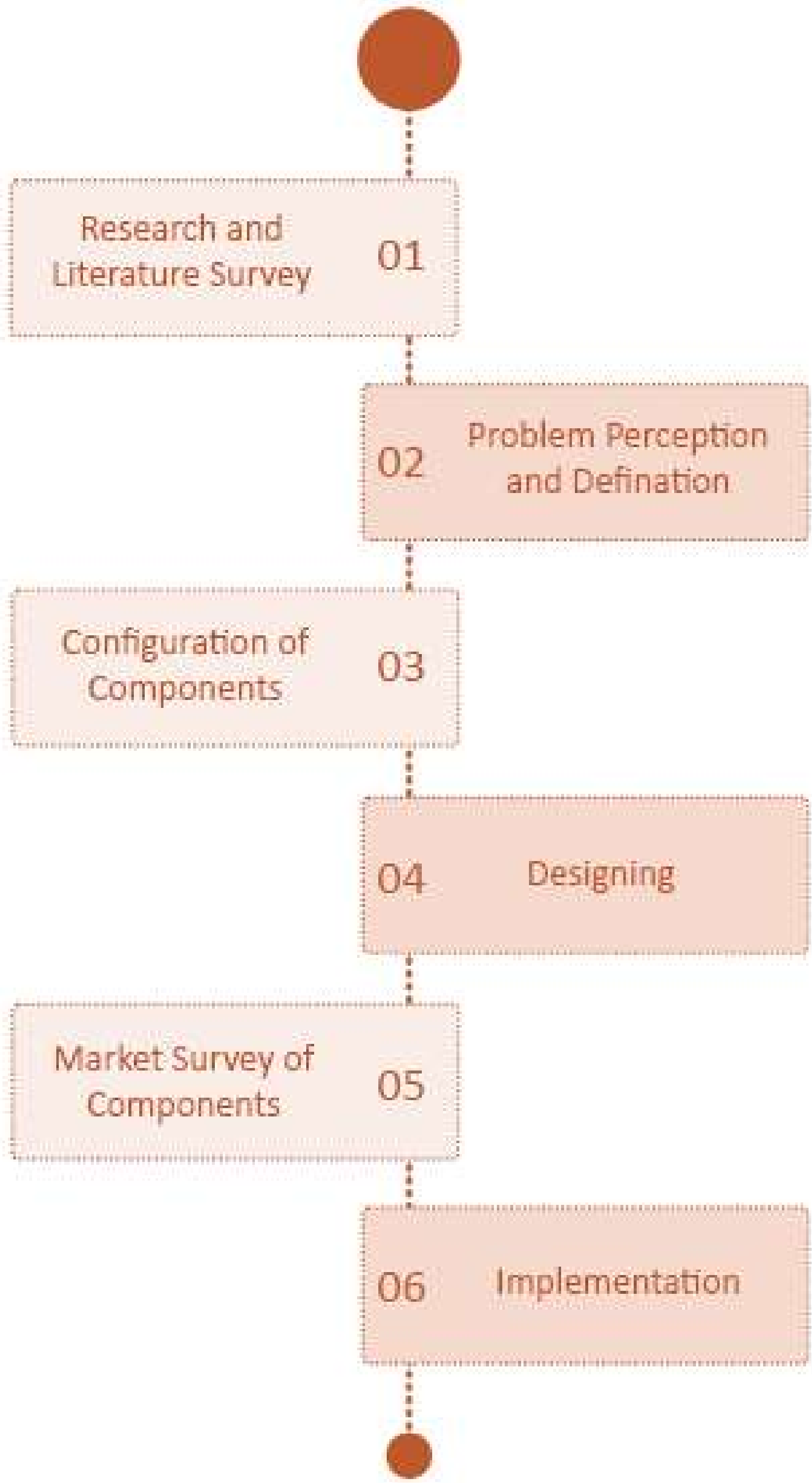
2.To design and develop a small scale EDM machine setup at a lower budget.

3.To learn about the subject of subtractive manufacturing.

4. To explore the various applications of EDM machines in the industries

Chapter 4

Methodology



Chapter 5

Design

In EDM, the voltage supplied is approximately 50 to 300 volts because higher voltage is not suitable for high precision machining. Therefore, EDM discharge gap is about **5 - 10.mm**.

To calculate the Electro Discharge Machining
Electro Discharge Machining = Voltage* (1-e^ (-Time/ (Resistance*Capacitance)))

The potential difference obtained by the formula is used to generate spark for carrying out the following process

We have chosen the following dimensions and materials to make our setup

- ❑ Electrode – Copper (35 to 70mm)
- ❑ Dielectric Fluid – Distilled water
- ❑ Size of tub – 60x30 cm
- ❑ Workpiece - Steel sheet
- ❑ The tool will be cathode and workpiece will be anode.

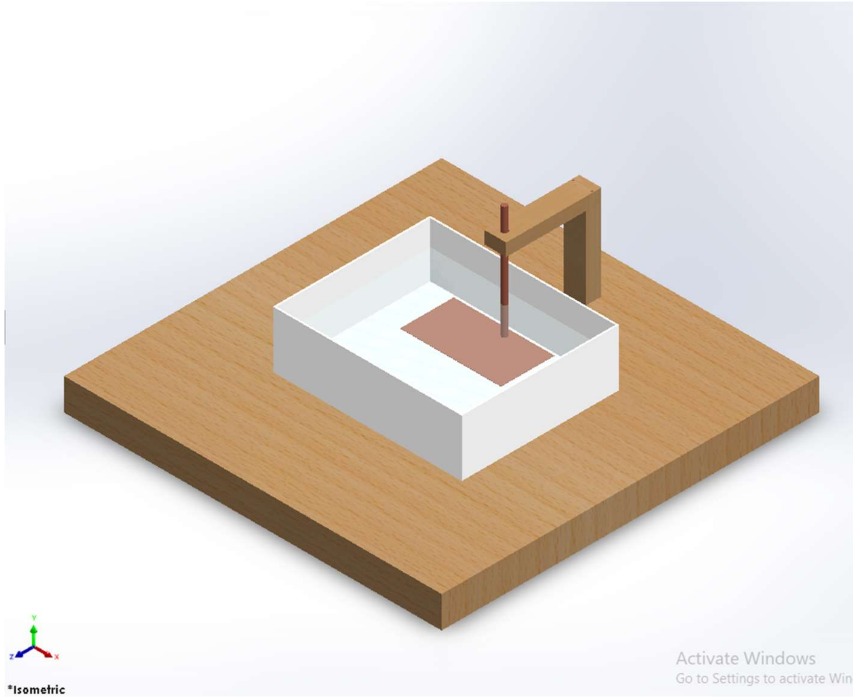


figure 5.1: Model with dielectric fluid

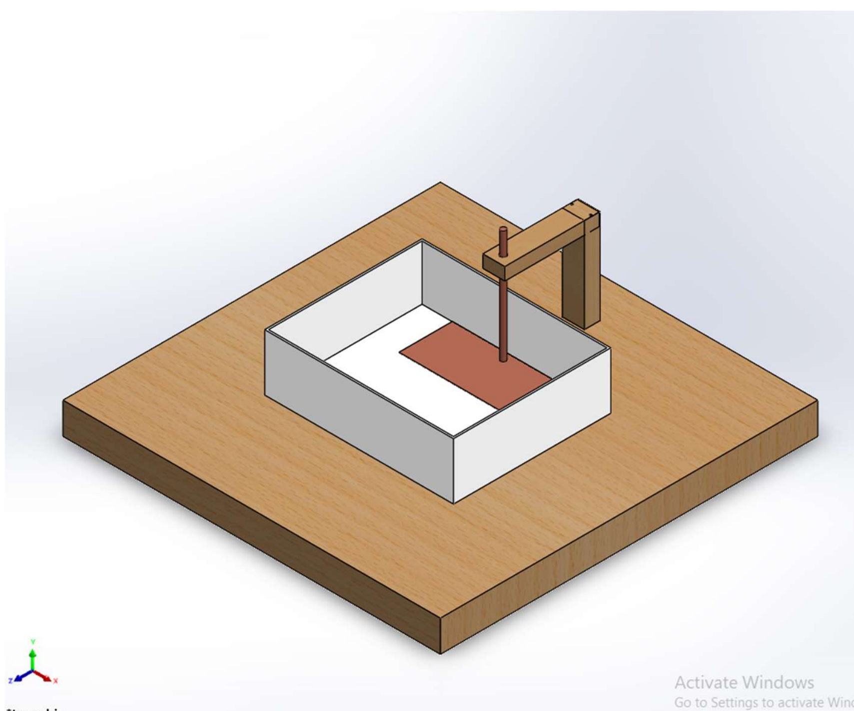


figure 5.2: Model without dielectric fluid

Design parameters while fabricating an EDM machine.

Electric discharge machines (EDM) are complex machines that use electrical discharges to erode a material and create a desired shape. There are different types of EDM machines, such as wire EDM, sinker EDM, and small hole EDM, but they generally consist of the following components:

Power supply: This component provides the electrical energy needed for the EDM process. It delivers a high voltage, high frequency current to the electrodes.

Electrodes: EDM machines use two types of electrodes: the tool electrode and the workpiece electrode. The tool electrode is usually made of copper or graphite and is used to shape the workpiece. The workpiece electrode is usually made of the material being machined and is the object that the tool electrode shapes.

Dielectric fluid: EDM machines require a dielectric fluid, such as deionized water, to prevent arcing between the electrodes and to flush away the eroded material. The dielectric fluid also helps to cool the electrodes and workpiece.

Control system: The control system is the brain of the EDM machine. It regulates the electrical parameters, such as voltage, current, and frequency, as well as the movement of the electrodes.

Worktable: The worktable is where the workpiece is mounted and held in place during the EDM process.

Machining chamber: The machining chamber is the enclosed area where the EDM process takes place. It is filled with the dielectric fluid and is designed to contain any sparks or debris generated during the process.

The design of an EDM machine is critical to its performance and accuracy. Engineers must consider factors such as the type of material being machined, the desired level of precision, and the complexity of the part being produced. Additionally, safety features, such as emergency stops and automatic shut-offs, must be incorporated into the design to prevent accidents.

TYPE OF EDM MACHINE SELECTED

- With the different types of EDM available in the market, we have decided to go with the fabrication of a sinker EDM machine.
- In this type of EDM machining, an electrode is used to remove material from the workpiece.
- A wire EDM machine is more complex in nature and the construction of this type of EDM requires industrial equipment.
- The research conducted by us resulted in us finding out that it is rather easy to fabricate a sinker EDM machine rather than a wire one.
- We have focused ourselves on building this machine with the materials and equipment present around us.
- Before the actual fabrication of the machine, a solid works model was created to give us a general census of what we want to build.
- The design of the CAD model was kept as simple as possible with only necessary elements kept in mind to complete the process.
- Calculations were being carried out side by side by the adequate parameters in mind to find out the voltage, current, capacitance and energy released.
- It is also called as DIE sinker EDM process.

DIE SINKER EDM PROCESS

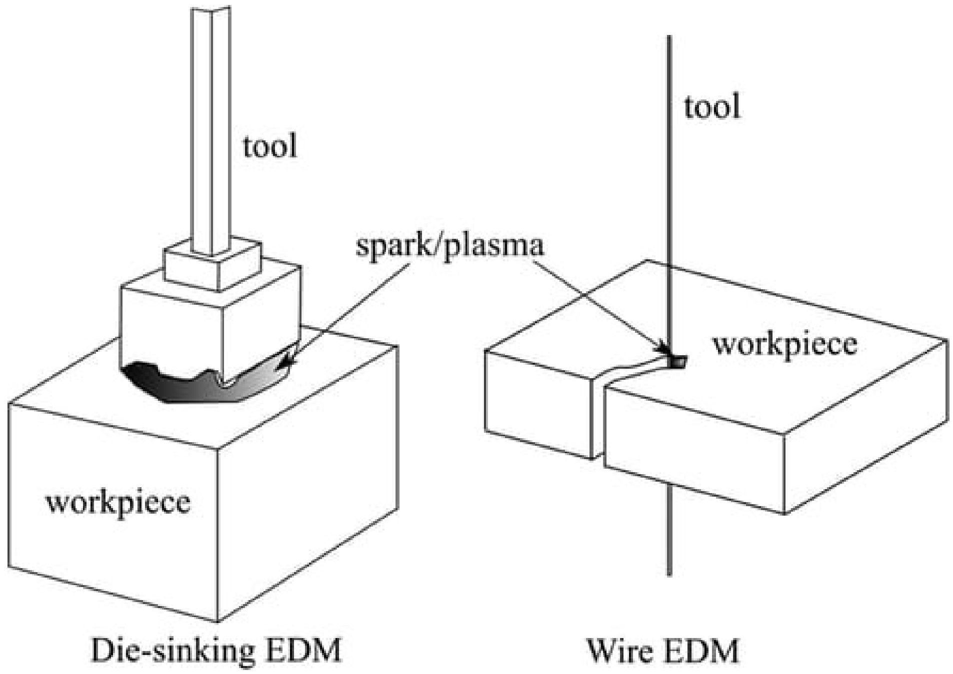


figure 5.3: Die Sinker and wire edm process

- The electrode (tool (Cathode) in your machine is connected to the negative terminal and the work-piece (anode) to the positive terminal of the DC power supply; an electrical potential is generated between the electrode (tool) and the work-piece.

- Both electrode and the workpiece of your machine are completely submerged in the dielectric fluid and the surfaces of the tool and the workpiece are separated by the spark gap.

- As the electrode of your machine approaches the work-piece, at a certain point, the intensity of the electric field in the spark-gap area exceeds the strength of the dielectric fluid; the dielectric fluid breaks down and allows the current to pass from the electrode (tool) to the work-piece in the form of a spark.

- Sparking results in the generation of extreme electro-thermal heat in the spark-gap zone and leads to melting and vaporizing a portion of material from the work-piece surface (spark erosion).

- DC of your machine momentarily pauses the flow of current, and the continuously flowing dielectric fluid flushes away the minute EDM chips and fills the spark-gap zone with fresh clean dielectric fluid (with original properties).

- The dielectric fluid of your machine helps the concentration of spark energy to a small area (where the gap between the electrode and the workpiece is the least).

- This cycle is repeated continuously.

- Continuous spark discharge in your Sinker-EDM, between the tool and the work-piece surface, removes uniform material from the work-piece surface forming a cavity that is the exact (negative) replica of the electrode (tool) profile.

- A tiny portion of the tool is also eroded due to the spark discharge.

EDM ELECTRODE MATERIAL

What are EDM electrodes made of?
Even though you may use any electrically conductive material for the electrode (tool), it is important to consider the following qualities (in addition to good electrical conductivity, availability, and cost). The electrode material should be able to:

Transfer the electric pulses to the work-piece surface for effective spark erosion, with minimum erosion of the electrode.

Adoptability for processes like casting and machining.
Resist the tool wear and have a good surface finish in machining (electrodes with good surface finish produce components with a better surface finish in EDM).
Ensure a high metal removal rate.
Keeping the above in view, the electrodes of your Sinker-EDM are generally made from copper, brass, graphite, tungsten, copper-tungsten, carbides, copper-graphite, etc.

You can machine graphite electrodes easily and it has high material removal capability with minimum thermal effect (heat affected zone) on the work-piece surface; also, the melting point of graphite is much higher than copper and brass, which makes it superior in wear resistance. However, graphite is a costly material.

Copper is the most commonly used electrode material in your Sinker-EDM because of its superior conductivity and ability to produce a fairly good surface finish; the negative points of copper are :-

(1)-it is ductile and difficult to machine.

(2)-low wear resistance due to its low melting point.

SPARK GAP

The electrode (tool (cathode)) and the workpiece (anode) in your Sinker-EDM are always separated by a small gap and this gap is called spark-gap.

The electrode and the workpiece in your Sinker-EDM are submerged in a dielectric fluid and the spark gap between them is always flooded with the continuously flowing dielectric fluid.

The spark-gap in your Sinker-EDM is designed to allow the spark to happen between the two electrically conductive materials (electrode and the work-piece) for removal of material from the work-piece surface by spark erosion.

The dielectric fluid of your Sinker-EDM is an insulating material and offers resistance for the flow of electricity from the electrode to the work-piece; however, at a certain spark-gap, the applied voltage exceeds the strength of the dielectric fluid and the dielectric fluid breaks down to allow the current to pass through in the form of a spark.

The process of sparking in your Sinker-EDM happens in pulses by the pulse generator and there is a continuous spark on and spark off in the form of a square wave.

Accuracy of Sinker-EDM

You can achieve a tolerance of ±0.05 mm in your Sinker-EDM process and higher accuracy of ±0.004 mm can be possible by proper selection of electrode material and close monitoring of discharge current and its frequency.

Further, the material removal in your Sinker-EDM is due to the continuous sparking between the external surface of the electrode (tool) and the work-piece surface; due to this, the cavity formed on the work-piece is marginally bigger than the electrode and space between the internal edge of the cavity (on the work-piece surface) and the external edge of the electrode is called overcut.

You have to consider this overcut while designing the electrode; overcut exists all over the surface of the cavity formed in the Sinker-EDM process. Your Sinker-EDM manufacturer may give the expected overcut details under various working conditions (depending on the roughing or finishing operation, the overcut can be 5 to 100 microns).

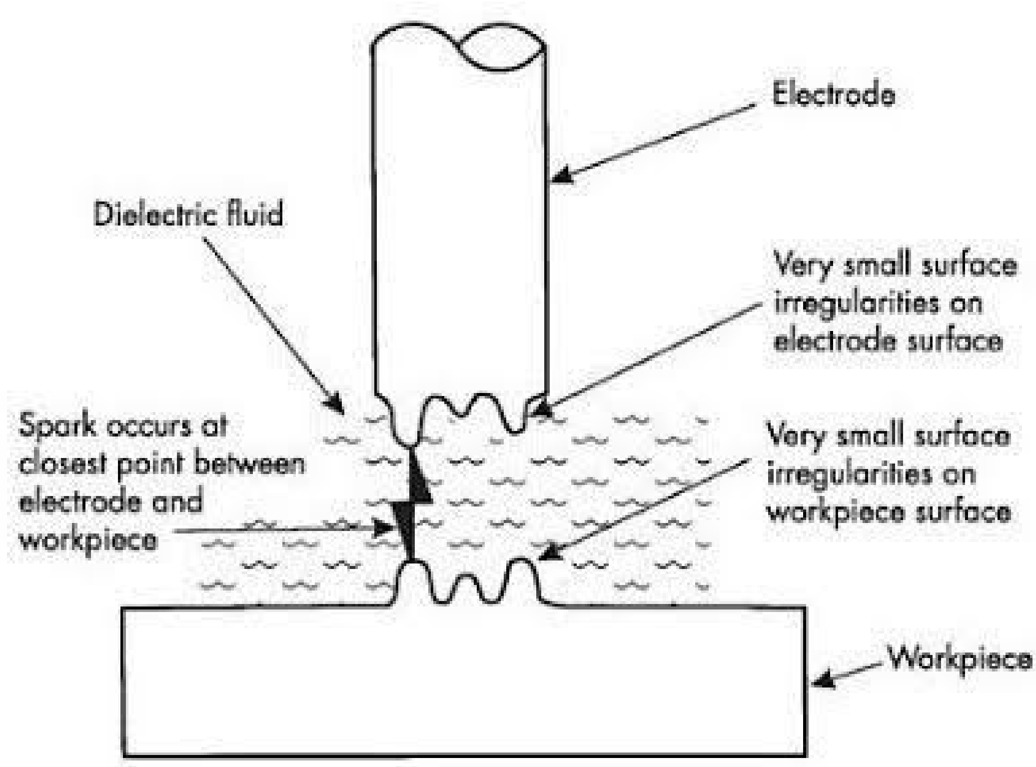


figure 5.4: Spark gap

EDM SURFACE FINISH

The surface finish obtained in your Sinker-EDM depends on variants like material used for the electrode, surface finish of the machined electrode, spark-gap dimension, discharge current and its frequency, efficiency of the dielectric fluid system and the machine type; high frequency and low discharge current gives the best surface finish.

In your Sinker-EDM process, each spark discharge across the spark-gap forms a spherical crater on the work-piece surface; the depth of this crater is an indicator of the surface finish, more the depth, and rougher is the surface finish.

Unlike in conventional machines, your Sinker-EDM process does not leave tool marks on the work-piece surface and this will help in improving the surface finish by secondary operations like polishing to remove recast layer and other surface defects.

EDM Machine manufacturers claim a surface finish of 0.29 μRa in large CNC Controlled Sinker-EDM and 0.8 μRa for small machines; the said surface finish can be achieved under the specified parameters.

Formation of Heat affected zone including white (recast) layer affects the surface finish in your Sinker-EDM process.

To achieve the combined goal of higher material removal rate and accuracy with a good surface finish, you can plan the Sinker-EDM process in two setups, roughing and finishing.

You can do roughing with a roughing electrode where your objective is to remove maximum material in minimum time adopting parameters for a higher material removal rate.

You can plan the finishing with an electrode having the final profile and adopting parameters for accuracy and high surface finish.

The shape and material of your roughing electrode will be different from that of the finishing electrode.

EDM FLUID USED IN THE PROCESS

The dielectric fluid used in your Sinker-EDM generally acts as an insulator and does not allow the current to pass from the electrode (tool) to the work-piece; however, under some conditions and in the area of the spark-gap it becomes conductive and allows the current to pass in the form of a spark.

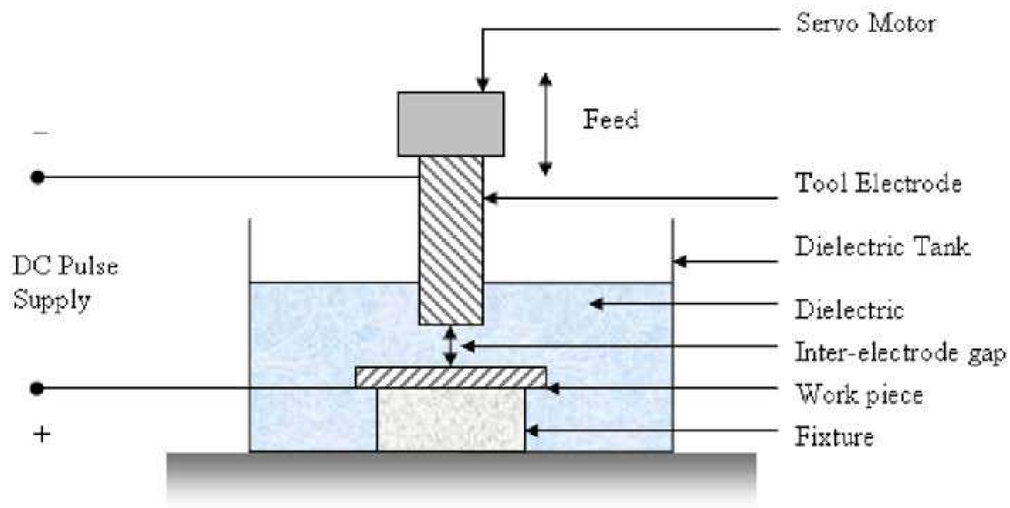


figure 5.5: Electrode and fluid

Some of the desired qualities of the dielectric fluid for your Sinker-EDM are (i) sufficient and stable dielectric strength (ii) low viscosity for better flow (iii) chemically neutral to the materials it comes in contact (iv) sufficiently high flash point (v) not harmful to the operator skin and (vi) no emission of toxic vapors.

Generally used dielectric fluids in your Sinker-EDM process are hydrocarbon oils like transformer oil, paraffin oil, kerosene, and lubricating oil.

Kerosene is a preferred dielectric fluid in your Sinker-EDM because (i) it helps to increase the material removal rate (ii) it aids low wear of the electrode (iii) it does not corrode the work-piece (iv)it does not need deionization and (v) it has a sufficiently high flash point.

The dielectric fluid of your Sinker-EDM helps concentrate the sparking between the electrode and the work-piece surface at the minimum gap area and cools the electrode and the work-piece; further, it flushes away the tiny chips formed during the process and fills the area with the fresh clean dielectric fluid. This is very important since the next spark in your Sinker-EDM can happen only after the chips are completely flushed out and the spark-gap area is filled with clean dielectric fluid with the original strength.

The negative points of kerosene are it needs special disposal methods and it may give out slightly unpleasant fumes during the process (good ventilation is required).

MATERIALS THAT CAN BE EDMed

SR NO	TYPES OF MATERIALS
1.	Inconel
2.	Aluminium
3.	Vasconel 300
4.	Tool steels 01, A2, D2, S7
5.	Aluminium bronze
6.	PCD diamond
7.	Carbide
8.	Copper
9.	Nitronic
1O.	Ferro-Tic
11.	Brass
12.	Beryllium Copper
13.	CPM 10v
14.	Cold Roll Steel
15.	Hot Rolled Steel
16.	Stellite

table 5.1: Material list

ADVANTAGES OF SINKER EDM MACHINE

Sinker EDM (Electric Discharge Die-Sinking) is a specialized machining process that offers several advantages over other types of machining processes. Here are some of the advantages of using a sinker EDM machine:

1. Precision machining: Sinker EDM is a highly precise machining method that can produce intricate and complex shapes with high accuracy. The electrical discharge process used in sinker EDM enables it to machine parts with tolerances of a few microns.

2. Versatile: Sinker EDM is suitable for machining a wide range of conductive materials, including hard and tough-to-machine alloys like titanium and tungsten. It can also machine complex shapes, cavities, and contours with ease, making it ideal for creating complex components like molds, dies, and prototypes.

3. Minimal tool wear: The electrode used in sinker EDM is made of non-conductive materials like copper or graphite, which are not subject to wear and tear during the machining process. This reduces the need for frequent replacement of tooling and minimizes the cost of maintenance.

4. Low heat input: The electrical discharge machining process used in sinker EDM produces a controlled and localized heat input to the material being machined. This reduces the risk of distortion or damage to the workpiece due to excessive heat exposure, making it suitable for machining delicate or heat-sensitive materials.

5. Automation: Sinker EDM machines can be programmed to run unattended, reducing the need for manual intervention and increasing the efficiency of the machining process.

6. Cost-effective: Sinker EDM is a cost-effective method of machining for high precision and complex parts, especially when compared to other processes like CNC milling, which can be more expensive due to the need for specialized tooling and programming.

Overall, sinker EDM is a highly precise and versatile machining process that offers several advantages over other machining methods. It is a suitable choice for manufacturing precision parts with complex geometries and difficult-to-machine materials.

Chapter 6

ACTUAL SETUP

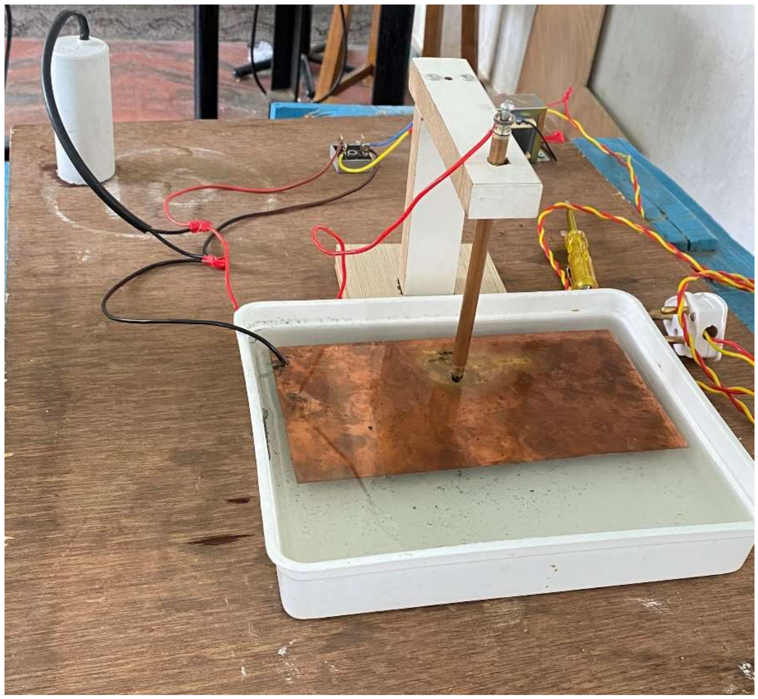


figure 6.1: setup

Chapter 7

CALCULATIONS

While developing an EDM machine, there are some calculations that need to be made while designing the given equipment. The following parameters need to be kept in mind:-

1. Gap voltage
2. Spark voltage
3. Discharge voltage

To find the current flowing through the whole circuit-
This can be found out by using the ohms law which states that the voltage is directly proportional to the current flowing through the circuit.

V=IR

V= voltage
I= current flowing through the circuit
R= resistance offered

We know that for a normal output, V=230v and I= 5A. Therefore, we can find the resistance.

V=IR

230= 5* R

R1=230/5

R1= **26 ohm**

We find that the resistance offered by the circuit is 26 ohm. The resistance offered by the capacitor can also be found out by

R2=V/I

R2=450/5

R2= **90 ohm**

Therefore, total resistance is R1+R2 = 26+90= **116 ohm**

The resistance offered by the transformer and bridge rectifier is negligible therefore we take it as zer0.

To find the spark voltage: -

Electro Discharge Machining = Voltage*(1-e^(-Time/(Resistance*Capacitance)))

EDM (spark voltage) = V*(1-e^(-T/(R*C)))

Where-
V=474v
e= Napier's constant=2.7182649
T= time(seconds)= 60
R= 116 ohm
C= 4.8 capacitance

After solving the following equation, we get the spark voltage as ***48.42 V***

We know that, Vgap= Vdischarge- Vspark

Vgap= 230-48.42 = **181.58 V**

The electro machining to take place, the gap voltage should be between 90 – 300V. More the voltage, the rougher will the surface finish. The gap voltage that we got is **181.58V**

Power consumed by the setup:-

In regard to Voltage and current, it is articulated as

P = V×I
P= 474*5
P= 2370 watts

As during our first run we did the machining for 2 hrs, we can find the energy by: -
The energy E in kilowatt-hours (kWh) is equal to the power P in watts (W),
times the time period t in hours (hr) divided by 1000:

E(kWh) = P(W) × t(hr) / 1000
E(kWh)= 2370* 2/ 1000
E(kWh)= 4.74 kWh

Chapter 8

Cost of Components

Materials	Market value (Rs)
Electrode	400/-
Dielectric medium	1 Liter- 320/-
Transformer (230 volts)	300\-
Bridge rectifier (50 A)	181\-
Copper plate	200/-
Capacitor	260/-
Wires & Miscellaneous	100/-

table 7.1: Cost of components

Chapter 9

FUTURE SCOPE

EDM (electrical discharge machining) is a technology that has been around for decades, and there are still many opportunities for future advancements in this field. Here are some possible future scopes for EDM machines:

Improved precision: EDM machines already offer high precision, but there is always room for improvement. By refining the software algorithms and improving the mechanical design of the machines, it may be possible to achieve even greater accuracy and consistency.

Increased speed: While EDM machines are known for their accuracy, they can be relatively slow compared to other machining methods. By optimizing the process and developing new technologies, it may be possible to increase the speed of EDM machines, making them more competitive in the manufacturing industry.

Enhanced automation: EDM machines are already highly automated, but there is still room for improvement. By incorporating advanced robotics and artificial intelligence, it may be possible to create machines that require even less human intervention, improving efficiency and reducing costs.

Expanded capabilities: EDM machines are currently used primarily for cutting metal, but there may be opportunities to expand their capabilities. For example, by using different types of electrical discharges or adjusting the frequency and intensity of the current, it may be possible to machine new materials or create more complex shapes.

Improved sustainability: As the world becomes more focused on sustainability, there may be opportunities to develop EDM machines that are more environmentally friendly. For example, by using renewable energy sources or developing processes that produce less waste, EDM machines could become more sustainable and appealing to environmentally conscious manufacturers.

Chapter 10

CONCLUSION

In conclusion, EDM (electrical discharge machining) is a well-established technology that has been used for decades to shape and cut metal. However, there are still many opportunities for future advancements in this field.

EDM is a highly accurate and precise machining technology that has been in use for many years. Despite its relatively slow speed compared to other machining methods, it offers numerous benefits such as the ability to cut hard and complex materials with great accuracy.

Some of the possible future scopes for EDM machines include improved precision, increased speed, enhanced automation, expanded capabilities, and improved sustainability. By refining the software algorithms, improving the mechanical design, incorporating advanced robotics and artificial intelligence, and using different types of electrical discharges or adjusting the frequency and intensity of the current, it may be possible to achieve these goals.

Overall, EDM remains a valuable and important technology in the manufacturing industry, and continued research and development in this field will likely lead to even greater advancements and benefits in the future and will continue to play a significant role in the production of high-quality parts and components in the future.

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We are grateful for the opportunity to have worked on such an exciting project, and we believe that the edm machine will have a positive impact on the machining technology and help to have a complete overview and knowledge on the electro discharge machining process.