# MACHINING

# Level-III

## Based on October 2023, Curriculum Version II




## Module Title: EDM PLUNGER AND WIRE OPERATION

## Module Code: IND MAC3 06 0223

## Nominal Duration: 60 Hours

**Prepared by: Ministry of Labor and Skill**

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# Acknowledgment

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## Acronym.

ASTM_____ American Society for Testing and Materials

CAD_____ Computer-Aided Design

CAM _____Computer-Aided Manufacturing

CNC _____computer numerical control

CMM_____ coordinate measuring machines

EDM _____Electrical Discharge Machine

LAP _____Learning Activity Performance

NEMA _____National Electrical Manufacturers Association

OHS_____Occupational Health and Safety

TTLM _____Teaching, Training, Learning Materials

TVT _____Technical and Vocational Training

2D_____ Two dimensional

## Introduction to the Module

EDM (Electrical Discharge Machining) is a precision machining process used to shape and cut metal parts with high accuracy. It involves the use of electrical discharges to erode material from the workpiece. EDM can be performed using two main methods: Plunger EDM and Wire EDM. In this module, we will introduce you to the basics of performing EDM operations using both plunger and wire techniques.

1. Plunger EDM: Plunger EDM, also known as Ram EDM or Sinker EDM, uses a precisely controlled vertical ram or plunger to create electrical discharges between the electrode and the workpiece. The electrode, made of a conductive material, is precisely shaped according to the desired part geometry. When the electrode approaches the workpiece, a dielectric fluid is used to flush away the eroded material. Plunger EDM is typically used for small-sized parts or parts with intricate details.

2. Wire EDM: Wire EDM, also known as Wire-Cut EDM or Wire-Cut Electric Discharge Machining, utilizes a thin, electrically conductive wire as the electrode. The wire is fed continuously through the workpiece, while a controlled spark discharge erodes the material. Wire EDM is capable of cutting complex shapes with high precision and is commonly used for parts with tight tolerances, such as molds and dies.

Remember, EDM operations require careful attention to detail and expertise in machine setup and operation. Safety precautions, such as wearing appropriate personal protective equipment, should always be followed.

This introduction provides a general overview of performing EDM plunger and wire operations. For more in-depth knowledge and practical skills, additional training and hands-on experience are recommended.

**This modules cover the unite**

- EDM Plunger and Wire Operations work requirements
- EDM machining operations set up

- Electro-Discharge machining (EDM)
- Check components

**Learning objectives of the modules**

- Determine EDM Plunger and Wire Operations work requirements
- Prepare EDM machining operations set up
- Perform Electro-Discharge machining (EDM)
- Check components for conformance to specification

**Modules learning instruction**

For effective use these modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

## Unit One: Introduction of EDM machine operation

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Safety precaution/OHS/
- Interpret drawings and sequence of operations
- Select correct electrode
- Calculate electrode surface area

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Distinguish safety precaution/OHS/
- Interpret drawings and sequence of operations
- Select correct electrode depending on the job
- Calculate electrode surface area depend on process parameters

## 1.1.EDM Safety precaution and OHS

**Definitions:** A safety precaution means as any action taken before an activity to prevent danger or risk during the activity. An example would be to keep a work area clean at all times to avoid accidents, or to wear protective gloves and glasses when working with hazardous chemicals. It is the steps that you take before you do something to keep bad things from happening.

When we handling a machine, precautions have to be taken in order to secure good result of the work piece and personal safety.

Observing comprehensive Occupational Health and Safety (OHS) procedures is crucial to ensure a safe working environment during EDM operations. Here are some key aspects of OHS procedures to consider:

1. **Risk Assessment**:
   - Conduct a thorough risk assessment specific to the EDM process.
   - Identify potential hazards, such as electrical risks, exposure to hazardous substances, fire hazards, and ergonomic issues.
   - Evaluate the severity and likelihood of each hazard and implement appropriate control measures.
2. **Personal Protective Equipment (PPE):**
   - Determine the necessary PPE based on the identified hazards.
   - Typical PPE for EDM operations may include safety glasses, face shields, gloves, protective clothing, and hearing protection.
   - Ensure that all personnel involved in the process are trained in the proper use and maintenance of PPE.
3. **Machine Safety:**
   - Follow machine manufacturer guidelines for safe operation and maintenance.
   - Ensure that EDM machines are properly installed, grounded, and regularly inspected.
   - Implement lockout/tag out procedures to control hazardous energy sources during maintenance or repair activities.
4. **Electrical Safety:**
   - Adhere to electrical safety standards and regulations.

- Ensure that electrical connections, circuits, and grounding systems are in accordance with applicable codes.
- Inspect and maintain electrical components regularly to prevent electrical hazards.

**5. Fire Safety:**

- Implement fire prevention measures in the EDM work area.
- Maintain clear access to fire extinguishers and other firefighting equipment.
- Regularly inspect and test fire suppression systems, such as sprinklers, if present.

**6. Material Safety:**

- Handle and store dielectric fluids, lubricants, and chemicals according to safety data sheets (SDS) and relevant regulations.
- Implement appropriate ventilation systems to control potential exposure to fumes or vapors.
- Provide training on the safe handling, storage, and disposal of hazardous materials.

**7. Ergonomics:**

- Assess the ergonomic aspects of the workspace to minimize the risk of musculoskeletal injuries.
- Ensure that workstations are properly designed and adjustable to accommodate different operators' needs.
- Promote good ergonomic practices, such as regular breaks, stretching exercises, and proper lifting techniques.

**8. Training and Communication:**

- Provide comprehensive training to all personnel involved in EDM operations.
- Train employees on machine-specific procedures, safe work practices, emergency response, and the proper use of safety equipment.
- Establish clear communication channels for reporting hazards, incidents, and near misses.

**9. Regular Inspections and Audits:**

- Conduct regular inspections and audits to identify potential safety issues.
- Address any identified hazards promptly and document corrective actions.
- Involve employees in safety inspections to encourage their active participation and input.

10. **Continuous Improvement**:

- Foster a culture of continuous improvement in safety.
- Encourage employees to provide feedback and suggestions for enhancing safety procedures.
- Regularly review and update OHS policies and procedures to reflect changing regulations and best practices.

Comprehensive OHS procedures should be developed in consultation with relevant regulatory authorities, industry standards, and the expertise of health and safety professionals. Compliance with these procedures is essential to protect the well-being of employees and maintain a safe working environment.

1,2, Interpret drawings and sequence of operation

When performing EDM (Electrical Discharge Machining) operations, both plunger and wire EDM, it is important to interpret drawings accurately and establish the sequence of operations in accordance with relevant standards. Here's a general outline of the process:

1. Interpretation of Drawings:
    - Carefully review the engineering drawings or blueprints provided.
    - Understand the part's overall shape, dimensions, and features.
    - Identify critical dimensions, tolerances, and any specific surface finish requirements.
    - Note the material type and any special considerations mentioned on the drawing.
2. Identify EDM Operations:
    - Analyze the part geometry and features to determine the required EDM operations.
    - For plunger EDM, identify areas that require specific shapes or profiles.
    - For wire EDM, focus on features such as holes, slots, and intricate contours that need to be machined.
3. Workpiece Preparation:
    - Prepare the workpiece by ensuring it is securely fixtured or clamped in the EDM machine.
    - Take into account any necessary workpiece preparation steps, such as cleaning or pre-machining.
4. Electrode Selection:
    - Select the appropriate electrode material and size for the EDM operation.
    - Consider factors such as material compatibility, electrode wear, and required level of detail.
    - For plunger EDM, design and manufacture shaped electrodes to match the desired part features.
    - For wire EDM, use a continuous wire electrode guided by computer numerical control (CNC) programming.
5. Establish Sequence of Operations:
    - Determine the logical order in which the EDM operations should be performed.

- Start with the operations that are necessary to establish critical references or datum's.
- Consider the accessibility of features and any potential interference between operations.
- Plan the sequence to minimize electrode changes, setups, and overall machining time.

6. EDM Parameters:
    - Set up the EDM machine with appropriate parameters based on the material and electrode being used.
    - Adjust settings such as power, pulse duration, flushing, and electrode wear compensation.
    - Fine-tune the parameters to achieve the desired cutting speed, accuracy, and surface finish.
7. Conduct EDM Operations:
    - Follow the established sequence of operations to perform the EDM machining.
    - Monitor the process closely, ensuring that the electrode and workpiece are adequately submerged in dielectric fluid.
    - Maintain proper electrode alignment and prevent electrode wear or breakage during the operation.
8. EDM Wire cut

There it is safety precautions when handling EDM wire-cut machines as shown below:

I. Make sure there are no leaks in the tank dielectric liquid tank hose and pipe connections.
II. Make sure a fire extinguisher near the machine for use in emergencies.
III. Make sure the materials are installed in areas where the right job.
IV. Make sure the electrodes are not touching the thing work.
V. Make sure the cutting wire is not touching things work.
VI. Make sure each cable there is no leakage.
VII. Clear oily liquid that is in place the working substance during the installation process.
VIII. Clean all dirt in the tank desk and storage tanks.
IX. Wear appropriate clothing while using machines.

9. Quality Control and Inspection:

- Conduct regular inspections during and after EDM operations to ensure dimensional accuracy.
- Measure critical dimensions using appropriate inspection tools, such as micrometers or coordinate measuring machines (CMM).
- Verify surface finish and other specifications against the drawing requirements.

10. Documentation and Reporting:
    - Document the sequence of operations, EDM parameters, and any deviations or adjustments made during the process.
    - Maintain records of inspection results, including dimensional measurements and surface finish analysis.
    - Report any issues or non-conformities identified during the process to relevant personnel or quality control departments.

Throughout the entire process, it is important to follow relevant standards and guidelines specific to EDM operations, such as those provided by organizations like the National Electrical Manufacturers Association (NEMA) or the American Society for Testing and Materials (ASTM). Adhering to these standards ensures consistent and accurate EDM operations while maintaining quality and safety.

### 1.3. Select correct electrode

Selecting the correct electrode is crucial to ensure that the finished component conforms to the specifications outlined in the drawing. Here are some considerations for electrode selection:

1. Material Compatibility:
    - Choose an electrode material that is compatible with both the workpiece material and the machining process.
    - Consider factors such as conductivity, thermal properties, and chemical stability.
    - Common electrode materials include copper, graphite, copper-tungsten alloys, and brass for wire EDM.
2. Electrode Geometry:
    - Design the electrode geometry to match the desired part features and dimensions.

- Ensure that the electrode can accurately reproduce the shape and details specified in the drawing.
- Take into account any draft angles, fillets, or radii required in the part.

3. Size and Accuracy:
   - Select an electrode size that allows for the required level of detail and precision.
   - Consider the electrode's dimensions in relation to the part's features and tolerances.
   - Smaller electrodes are suitable for intricate details, while larger electrodes may be used for roughing operations.
4. Wear Resistance:
   - Evaluate the electrode's wear resistance, especially for long-duration machining operations.
   - Some materials, such as graphite, may wear out quickly, requiring frequent electrode changes.
   - Consider using electrode materials with higher wear resistance for extended tool life.
5. EDM Method:
   - Different EDM methods, such as plunger EDM and wire EDM, may require specific types of electrodes.
   - Plunger EDM typically uses shaped electrodes that match the desired part geometry.
   - Wire EDM requires a continuous wire electrode that can be guided through the workpiece.
6. Surface Finish:
   - Consider the desired surface finish specified in the drawing.
   - Some electrode materials, such as graphite, can produce a rougher surface finish compared to copper or fine-grained tungsten.
7. Consultation and Experience:
   - Seek guidance from experienced machinists, EDM operators, or tooling suppliers.
   - They can provide valuable insights into electrode selection based on their expertise and past experience.

Remember, electrode selection is a critical step in achieving the desired accuracy, surface finish, and dimensional conformity specified in the drawing. Regular inspection and maintenance of electrodes are also essential to ensure consistent performance throughout the EDM process.

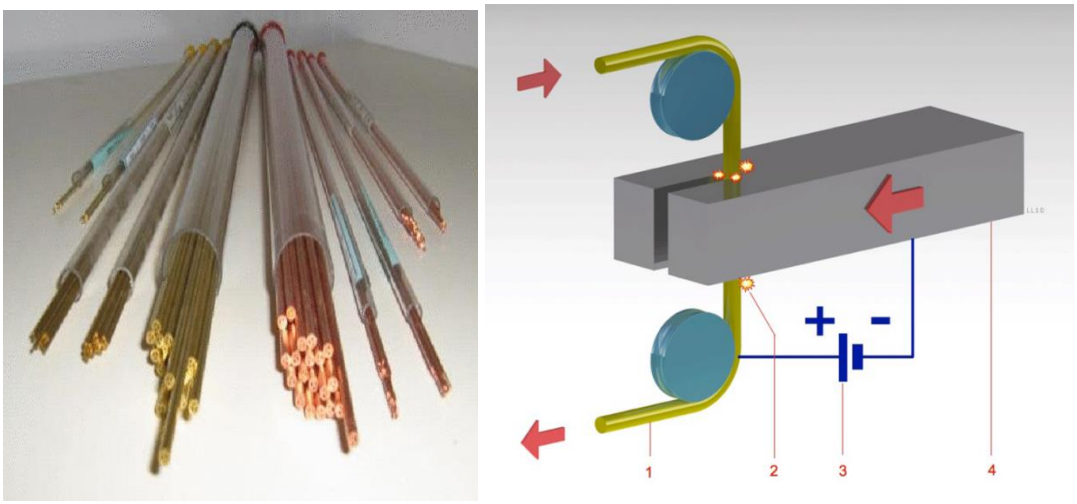



**Figure 1.1 EDM electrode**

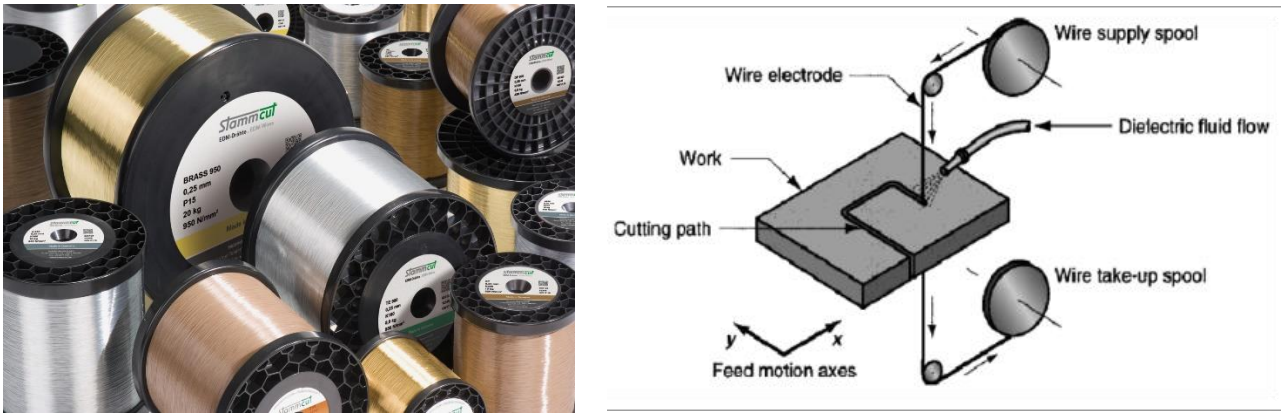



**Figure 1.2 EDM wire**

EDM Electrode Materials



EDM electrodes consist of highly conductive and/or arc erosion-resistant materials such as graphite or copper. EDM is an acronym for electrical discharge machining, a process that uses a controlled electrical spark to erode metal. EDM electrodes include components made from brass, copper and copper alloys, graphite, molybdenum, silver, and tungsten.

Electrical discharge machining (EDM) makes it possible to work with metal for which traditional machining techniques are ineffective. It only works (except by specific design) with materials that are electrically conductive. Using recurring electric discharge, it is possible to cut small, odd-shaped angles and detailed contours or cavities in hardened steel as well as exotic metals such as titanium and carbide.

**Types**

EDM electrode materials need to have properties that easily allow charge and yet resist the erosion that the EDM process encourages and stimulates in the metals it machines. Alloys have properties which provide different advantages based on the needs of the application.

**Brass** is an alloy of copper and zinc. Brass materials are used to form EDM wire and small tubular electrodes. Brass does not resist wear as well as copper or tungsten, but is much easier to machine and can be die-cast or extruded for specialized applications. EDM wire does not need to provide wear or arc erosion resistance since new wire is fed continuously during the EDM wiring cutting process.

**Copper** and copper alloys have better EDM wear resistance than brass, but are more difficult to machine than either brass or graphite. It is also more expensive than graphite. Copper is, however, a common base material because it is highly conductive and strong. It is useful in the EDM machining of tungsten carbide, or in applications requiring a fine finish.

**Copper tungsten** materials are composites of tungsten and copper. They are produced using powder metallurgy processes. Copper tungsten is very expensive compared to other electrode materials, but is useful for making deep slots under poor flushing conditions and in the EDM machining of tungsten carbide. Copper tungsten materials are also used in resistance welding electrodes and some circuit breaker applications.

**Graphite** provides a cleaning action at low speeds. Carbon graphite was one of the first brush material grades developed and is found in many older motors and generators. It has an amorphous structure.

**Molybdenum** is used for making EDM wire. It is the wire of choice for small slot work and for applications requiring exceptionally small corner radii. Molybdenum exhibits high tensile strength and good conductivity, making it ideal where small diameter wire is needed for demanding applications.

**Silver tungsten** material is tungsten carbide particles dispersed in a matrix of silver. Silver offers high electrical conductivity and tungsten provides excellent erosion resistance and good anti-welding characteristics in high-power applications. This composite is thus the perfect choice for EDM electrode applications where maximizing conductivity is crucial.

**Tellurium copper** is useful in EDM machining applications requiring a fine finish. Tellurium copper has a machinability that is similar to brass and better than pure copper.

Specifications

When selecting EDM electrodes, the most important considerations alongside its form and function are the material's conductivity (or resistivity) and it's erosion resistance.

**Conductivity** promotes cutting efficiency, since electric current is the "cutting tool".

**Erosion resistance** (a factor of melting point, hardness, and structural integrity) gives the electrode a longer service life and lowers the frequency of replacement. These properties, which vary almost exclusively by the type of alloy or material used, must be the deciding factors when selecting an electrode.

1.4. Calculate electrode surface area

Calculating the electrode surface area and setting appropriate process parameters are crucial for achieving safe, accurate, and efficient EDM (Electrical Discharge Machining) operations, whether plunger or wire EDM. Here are the key steps involved:

1.4. 1. EDM Electrode Surface Area Calculation

Determine the surface area of the electrode that will come into contact with the workpiece during the EDM operation.

For a plunger EDM electrode, calculate the surface area based on the electrode's shape and dimensions.

For wire EDM, the surface area is typically determined by the cross-sectional area of the wire.

**A. Material and Workpiece Considerations**

Evaluate the material of the electrode and workpiece to understand their compatibility and electrical conductivity.

Consider the hardness and melting point of the workpiece material when selecting the appropriate electrode material.

Ensure that the electrode material can withstand the electrical discharge and thermal loads during the EDM process.

**B. Process Parameter Selection:**

Based on the electrode surface area and material considerations, set the EDM process parameters.

Common process parameters include pulse duration, current, voltage, and electrode wear compensation.

Start with the manufacturers recommended parameters for the specific electrode material and workpiece combination.

Adjust the parameters as needed to achieve the desired cutting speed, accuracy, and surface finish.

**C. Safe Operation:**

Ensure that the selected process parameters prioritize safety during the EDM operation.
Avoid excessively high currents or voltages that could lead to arcing, overheating, or damage to the electrode or workpiece.
Implement appropriate flushing or dielectric fluid circulation to control heat dissipation and prevent excessive electrode wear.

**D. Accuracy and Surface Finish:**

Fine-tune the process parameters to achieve the desired level of accuracy and surface finish specified in the drawing.
Higher pulse durations may result in slower cutting speeds but can offer better accuracy and surface finish.
Lower pulse durations can increase cutting speed but may result in reduced accuracy and surface finish quality.

**E. Efficiency and Productivity:**

Optimize the process parameters to ensure efficient material removal and maximize productivity.
Balance cutting speed with electrode wear and the desired surface finish.
Consider using advanced EDM technologies, such as adaptive control systems, to optimize cutting conditions in real-time.

**F. Monitoring and Adjustment:**

Continuously monitor the EDM process during operation.
Observe the electrode wear and adjust the process parameters if necessary.
Maintain regular inspections to ensure that the electrode wear remains within acceptable limits for accurate and consistent machining.

**G. Documentation and Optimization:**

Document the selected process parameters and any adjustments made during the EDM operation.
Record observations, such as cutting speed, electrode wear rates, and surface finish results.

Use this information for future reference and to optimize the process parameters for similar EDM operations.

It is important to note that the specific process parameters and electrode surface area calculations may vary depending on the EDM machine, electrode material, workpiece material, and desired outcome. Consulting the machine manufacturer's guidelines, expert recommendations, and conducting trial runs can help fine-tune the process parameters for optimal results.

**EDM working process**

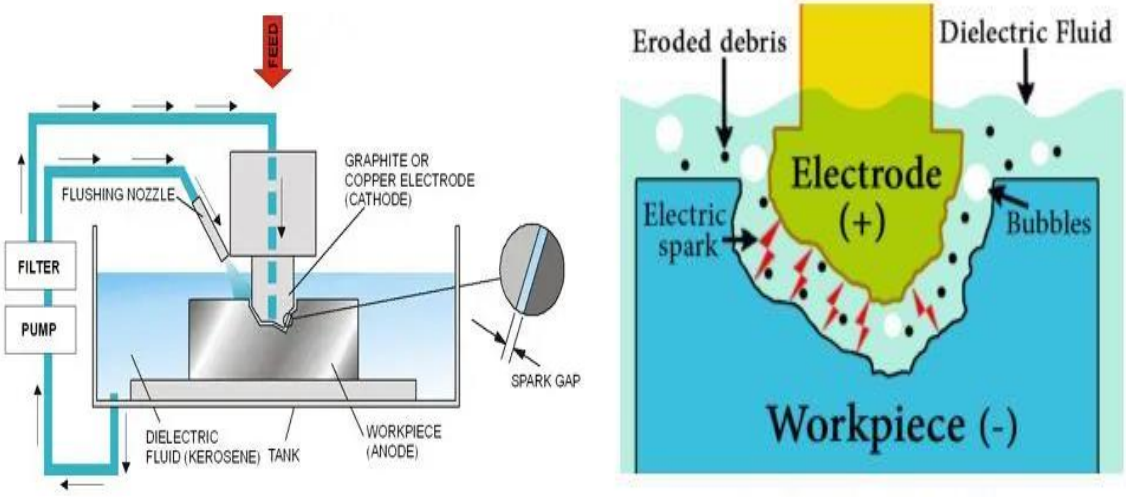



Figure 1.3 working principle EDM

**Advantages of EDM**

The main advantages of EDM are:

• By this process, materials of any hardness can be machined.

• No burrs are left in machined surface.

• One of the main advantages of this process is that thin and fragile/brittle components can be machined without distortion.

• Complex internal shapes can be machined.

**Limitations of EDM**

The main limitations of this process are:

• This process can only be employed in electrically conductive materials.

• Material removal rate is low and the process overall is slow compared to conventional machining processes.

• Unwanted erosion and over cutting of material can occur.

• Rough surface finish when at high rates of material removal.

**Dielectric fluids**

Dielectric fluids used in EDM process are hydrocarbon oils, kerosene and deionised water.

The functions of the dielectric fluid are to:

• Act as an insulator between the tool and the workpiece.

• Act as coolant.

• Act as a flushing medium for the removal of the chips.

Self-check 1.1

**Instruction1- Say True or Fouls to the following questions.**

1. EDM (Electrical Discharge Machining) is a precision machining process used to shape and cut metal parts with high accuracy.
2. Safety glasses, face shields, gloves, protective clothing, and hearing protection are the typical PPE for EDM.
3. Drawing interpretation is not important to determine the EDM work requirement.
4. Selecting the correct electrode is crucial for EDM work.

**Instruction1I- Choose the best answer from the given alternatives.**

1. Which of the following is a key aspect of OHS procedures for EDM operations?
   a) Risk assessment
   b) Material compatibility
   c) Electrode selection
   d) Cross-sectional area calculation
2. What is the purpose of conducting a risk assessment for EDM operations?
   a) To select the appropriate electrode material
   b) To establish the sequence of operations
   c) To identify potential hazards
   d) To calculate the electrode surface area
3. Which of the following is an example of personal protective equipment (PPE) for EDM operations?
   a) EDM machine guidelines
   b) Lockout/tag out procedures
   c) Safety glasses
   d) Sprinkler systems
4. Which safety measure should be followed to control hazardous energy sources during EDM machine maintenance?
   a) Maintaining clear access to fire extinguishers
   b) Proper installation and grounding of EDM machines
   c) Using appropriate ventilation systems
   d) Implementing lockout/tag out procedures
5. What should be considered when handling and storing hazardous materials in EDM operations?

a) Ergonomic aspects of the workspace
b) Compatibility of electrode and workpiece materials
c) Proper ventilation systems
d) Safety data sheets (SDS) and relevant regulations

6. What is the purpose of conducting regular inspections and audits in EDM operations?
   a) To establish the sequence of operations
   b) To identify potential safety issues
   c) To select the appropriate electrode material
   d) To calculate the electrode surface area
7. What should be done to foster a culture of continuous improvement in safety?
   a) Establish clear communication channels
   b) Conduct regular inspections and audits
   c) Provide comprehensive training to personnel
   d) Encourage feedback and suggestions from employees
8. What is the first step in interpreting drawings for EDM operations?
   a) Identifying critical dimensions and tolerances
   b) Reviewing engineering drawings or blueprints
   c) Determining the necessary PPE
   d) Assessing the ergonomic aspects of the workspace
9. Which EDM method requires continuous wire electrodes guided by CNC programming?
   a) Plunger EDM
   b) Wire EDM
   c) Material compatibility
   d) Electrode geometry
10. Why is electrode selection important in EDM operations?
    a) To identify potential hazards
    b) To establish the sequence of operations
    c) To achieve the desired accuracy and surface finish
    d) To calculate the electrode surface area

**Instruction III- Briefly answer the following questions**

1. Why calculating electrode surface area for EDM?

2. Why is electrode selection important in EDM operations?
3. What is drawing interpretation in EDM

## Unit Two: EDM Machining Operations Set up

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Setting up Parameters
- Accessories and work-holding fixtures
- Machines and work piece
- Program 2D elements and machine code functions

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this unit, you will be able to:

- Ensure accessories and work-holding fixtures
- Align machine and work piece
- Define program 2D elements and machine code functions

## 2.1 Setting up Parameters

When setting up EDM (Electrical Discharge Machining) operations, several factors need to be considered and optimized for successful and efficient machining. Here's a breakdown of each factor and its significance:

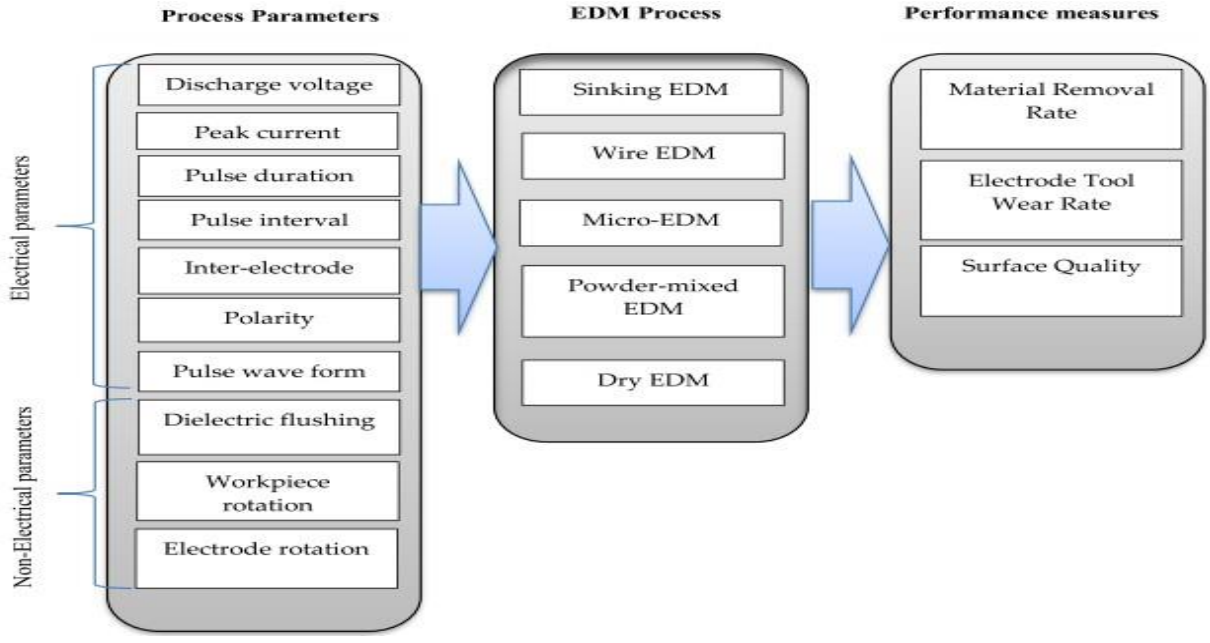
1. Power Settings:
   - Power settings refer to the electrical parameters applied during EDM, such as current, voltage, and pulse duration.
   - These parameters directly affect the intensity of the electrical discharge and the rate of material removal.
   - Adjusting the power settings allows control over the cutting speed and accuracy of the machining process.
2. Surface Finish:
   - Surface finish refers to the quality and smoothness of the machined surface.
   - It is influenced by factors such as the power settings, electrode material, flushing rate, and machining conditions.
   - Finer surface finishes may require lower power settings, shorter pulse durations, and improved dielectric flushing.
3. Metal Removal Rate:
   - Metal removal rate, also known as cutting speed, is the rate at which material is removed during EDM.
   - It depends on factors like power settings, electrode material, workpiece conductivity, and flushing effectiveness.
   - Balancing metal removal rate with surface finish requirements helps achieve efficient machining without compromising quality.
4. Workpiece Material:
   - The workpiece material plays a crucial role in determining the EDM process parameters.
   - Different materials exhibit varying levels of electrical conductivity, hardness, and melting points.

- Consider the workpiece material's properties to select appropriate power settings, electrode materials, and machining strategies.

5. Electrode Material and Wear:
   - The electrode material should be chosen based on its compatibility with the workpiece material and desired machining results.
   - Factors like electrode wear resistance, electrical conductivity, and thermal properties influence material selection.
   - Monitoring and managing electrode wear is essential to maintain dimensional accuracy and prevent excessive tooling costs.
6. Selection of Dielectric:
   - The dielectric fluid serves several purposes, including electrical insulation, cooling, and flushing away debris.
   - The dielectric fluid should have good electrical properties, thermal stability, and appropriate viscosity for effective flushing.
   - The selection of dielectric depends on factors like workpiece material, electrode material, surface finish requirements, and environmental considerations.
7. Flushing Rate and Method:
   - Proper dielectric flushing is crucial for effective debris removal, heat dissipation, and maintaining stable machining conditions.
   - Adjusting the flushing rate and method, such as through nozzles or submerging the workpiece, helps optimize debris removal and cooling.
   - Insufficient flushing may result in poor surface finish, increased tool wear, or electrode breakage, while excessive flushing can lead to decreased cutting speed and energy efficiency.
8. Spark Gap:
   - The spark gap is the distance between the electrode and the workpiece during EDM.
   - It affects the intensity and stability of the electrical discharge.
   - Optimizing the spark gap based on the workpiece material and electrode wear helps maintain consistent machining conditions.

9. Depth to be Machined:
    - The desired depth of cut influences the machining strategy and considerations for electrode wear and tool life.
    - Deeper cuts may require adjustments in power settings, flushing, and electrode wear compensation strategies.
10. Feed Rate and Wire Speed (for Wire EDM):
    - Feed rate and wire speed determine the rate at which the wire electrode moves through the workpiece during Wire EDM operations.
    - Proper feed rate and wire speed settings affect cutting speed, accuracy, and surface finish.
    - Consider the workpiece material, wire diameter, and desired outcome to optimize feed rate and wire speed.

Optimizing these factors in EDM operations requires a balance between achieving the desired results (such as surface finish and metal removal rate) while considering the limitations of the workpiece material, electrode wear, and machine capabilities. It is important to refer to the manufacturer's guidelines, conduct test cuts, and make iterative adjustments to achieve the best possible outcomes.




1.5. Electro -discharge machining process, process parameters and performance measures

2.2. Accessories and work-holding fixtures

To ensure the required position and stability of the workpiece during EDM (Electrical Discharge Machining) operations, various accessories and work-holding fixtures can be installed. The specific choice of accessories and fixtures will depend on the workpiece's size, shape, and material. Here are some commonly used options:

1. Vises:
    - Vises are widely used for holding smaller workpieces securely during EDM operations.
    - They provide adjustable clamping force and allow for precise positioning and alignment.
    - Different types of vises, such as jaw vises or precision vises, can be used based on the workpiece requirements.
2. Clamps and Hold-Downs:
    - Clamps and hold-downs are versatile fixtures used to secure workpieces of various shapes and sizes.
    - They can be used in combination with T-slots, fixture plates, or machine tables to provide stability.
    - Different clamping mechanisms, such as toggle clamps or screw clamps, can be employed depending on the application.
3. Fixture Plates and Tooling Blocks:
    - Fixture plates and tooling blocks are flat, rigid surfaces with drilled and tapped holes for mounting workpieces or additional fixtures.
    - They provide an adaptable and repeatable setup for holding workpieces during EDM operations.
    - Fixture plates and tooling blocks can be customized with specific hole patterns to accommodate various workpiece configurations.
4. Electrode Holders and Chucks:
    - Electrode holders and chucks are used to secure the electrodes during EDM machining.

- They provide a means of aligning and clamping the electrodes in the desired position.
- Depending on the EDM machine and electrode type, specific holders or chucks may be required for proper electrode stability.

5. Rotary Tables and Indexing Heads:
   - Rotary tables or indexing heads are utilized when machining features at specific angles or when performing multi-sided operations.
   - They enable precise rotation and indexing of the workpiece, allowing for machining on multiple faces without the need for repositioning.
   - Rotary tables and indexing heads are commonly used in applications such as gear machining or machining complex contours.
6. Custom Fixtures and Jigs:
   - For complex workpieces or unique machining requirements, custom fixtures and jigs may be designed and fabricated.
   - These fixtures are tailored to the specific workpiece, ensuring optimal positioning and stability during EDM operations.
   - Custom fixtures and jigs can be made from materials such as steel, aluminum, or plastic, depending on the application.
7. Alignment and Positioning Tools:
   - Various alignment and positioning tools, such as edge finders, dial indicators, or coordinate measuring machines (CMM), can be employed to ensure accurate positioning of the workpiece.
   - These tools help align the workpiece with the machine's coordinate system and verify its position before starting the EDM operation.
8. Pallet Systems:
   - Pallet systems are used for efficient and rapid workpiece changeovers in high-production EDM environments.
   - Workpieces are mounted on individual pallets, allowing for quick swapping and setup between different jobs.

- Pallet systems minimize machine downtime and facilitate streamlined production processes.

When selecting and installing accessories and work-holding fixtures, it is important to consider factors such as workpiece accessibility, interference with the EDM machine components, and the stability required for precise machining. Following the guidelines provided by the EDM machine manufacturer and considering industry best practices will help ensure proper installation and reliable workpiece positioning during EDM operations.

2.2.1 Electrical Discharge Machines (EDM) Machines and work piece

Wire EDM machines utilize a very thin wire (.0008 to .012 in.) as an electrode. The wire is stretched between diamond guides and carbide that conduct current to the wire and cuts the part like a band saw.

Material is removed by the erosion caused by a spark that moves horizontally with the wire.




Figure 1.6. Electrical Discharge Machines (EDM)

**Types of EDM Processes**

**A. Die-Sinking EDM**

In the die-sinking EDM process, the workpiece is machined by a controlled electrical spark generated in the gap between the electrode tool and the workpiece. Sparking is repeated until the electrode tool shape is replicated in the workpiece surface facing the electrode tool. The heat produced by the electrical spark causes a sharp temperature rise in the area to be machined (i.e., 8000 to 12,000 °C). EDM machines contain a unit that controls and monitors the machining variables, such as the gap and axis movements. Furthermore, this system shows the process execution sequence.

Normally, copper or graphite is used as the electrode tool material in this process with hydrocarbon dielectric because of its positive effect on the SR and EWR (Electrode tool Wear Rate). The dielectric flows through the cooling system, carrying the debris and eroded material with it, is filtered to remove the suspended particles and is returned to the system. In the die-sinking EDM process, the electrode should be re-shaped to carry out the finishing operations. Figure 3 shows a schematic diagram of the die-sinking EDM.

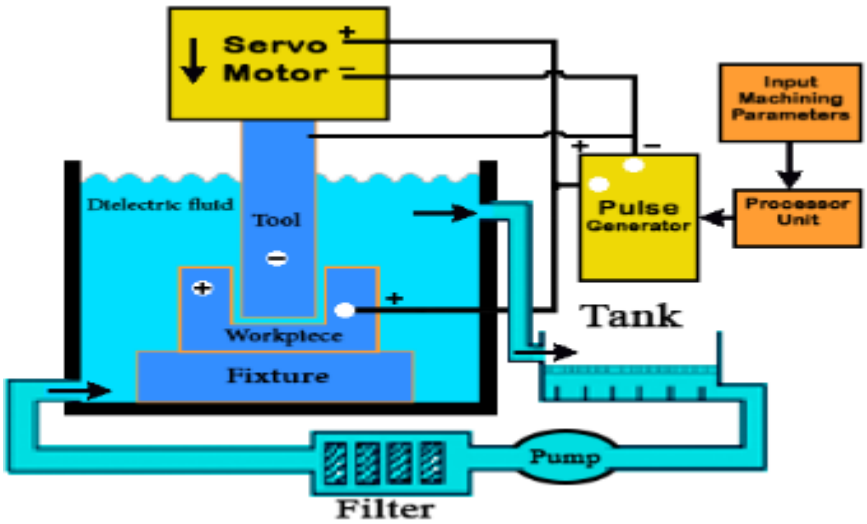



**Figure 1.7 schematic diagram of the die-sinking EDM**

**Typical Parts Die-Sinking EDM**

1. Injection Molds

2. Dies
3. Complex shapes

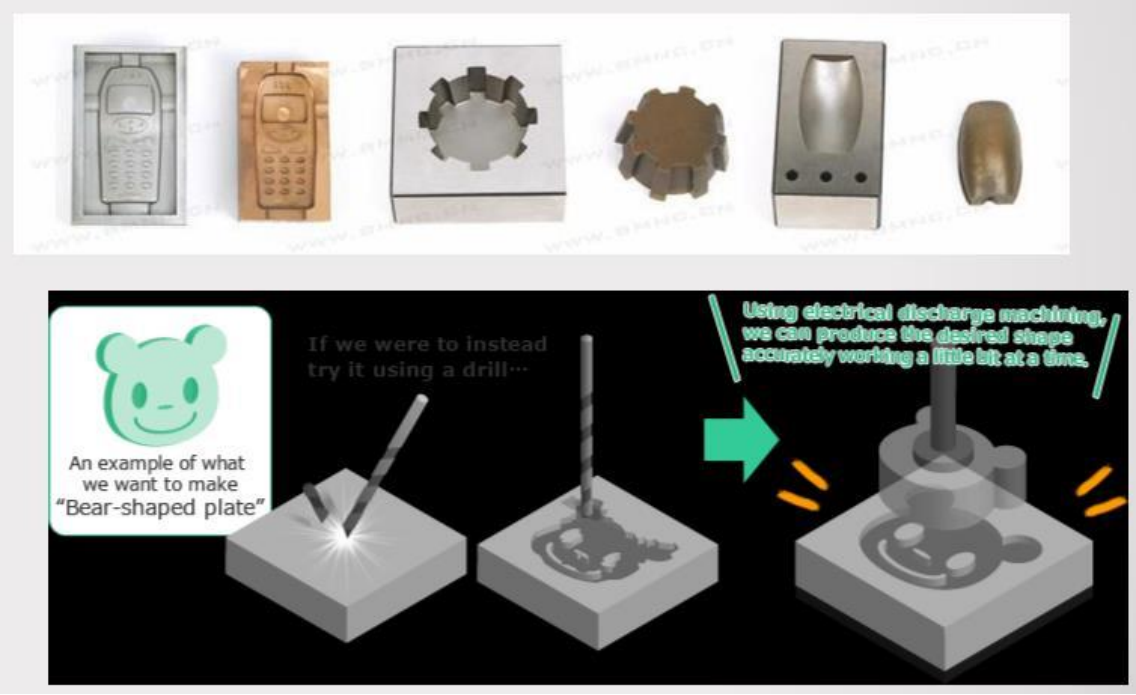



**Figure 1.8 Typical Parts Die-Sinking EDM**

**Wire EDM**

In the wire EDM, a metallic thin wire is used to cut the workpiece along a well-defined path. Discrete sparks between the wire and the workpiece cause eroding in the machined area. The wire used is usually thin, the standard EDM wire is 0.25 mm. Micro-wires dimeter can range from 0.020 mm to 0.15 mm and is normally copper, brass or coated steel materials. As with the die-sinking EDM, the wire and the workpiece do not have any contact during machining and both should be immersed in a dielectric fluid. A high peak current of short duration is applied in this process. The machining variables and the movement of the worktable that holds the workpiece are controlled by the control units. Thus, complicated shapes can be produced using this process. The control unit contains a microprocessor to maintain the gap between the wire and the workpiece in a suitable range, normally between 25 µm and 50 µm. In addition, the unit controls the feeding of the wire through the workpiece at a suitable speed that produces surfaces with very high accuracy. De-ionized water is a common dielectric fluid used in this process. The wire EDM process has a wide range of applications, such as in die making, electronics and

automotive industries. Closed operations, which do not start from the edges of the workpiece, require the drilling of a full-depth hole to start the machining process. Figure 4 shows a schematic diagram of the wire EDM.

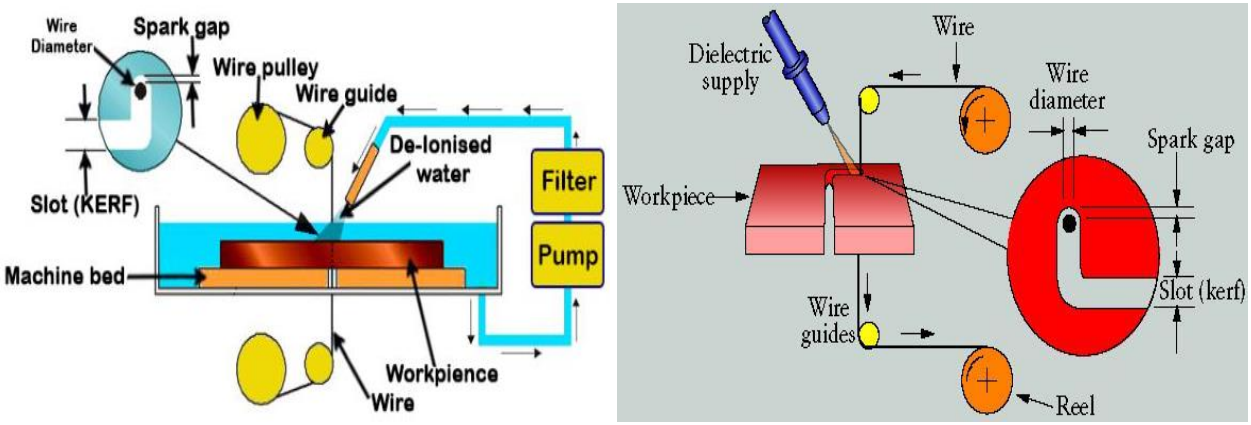
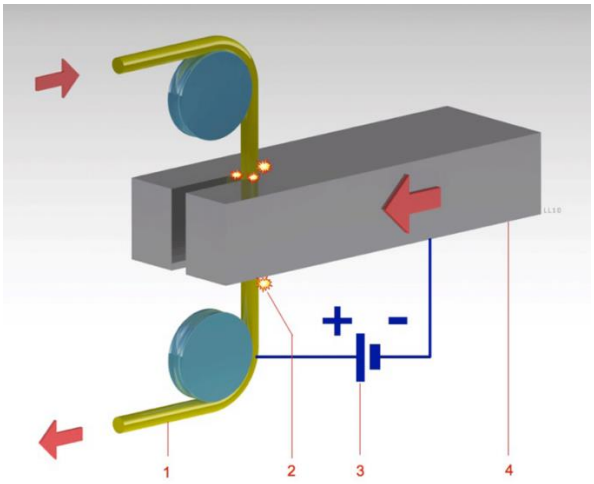



**Figure 1.9 Schematic Diagram of the wire EDM**




1. Wire.
2. Electrical discharge erosion (Electric arc).
3. Electrical potential.
4. Workpiece.

**Motion or Wire & Workpiece:** Wire EDM 4-axis motion possible

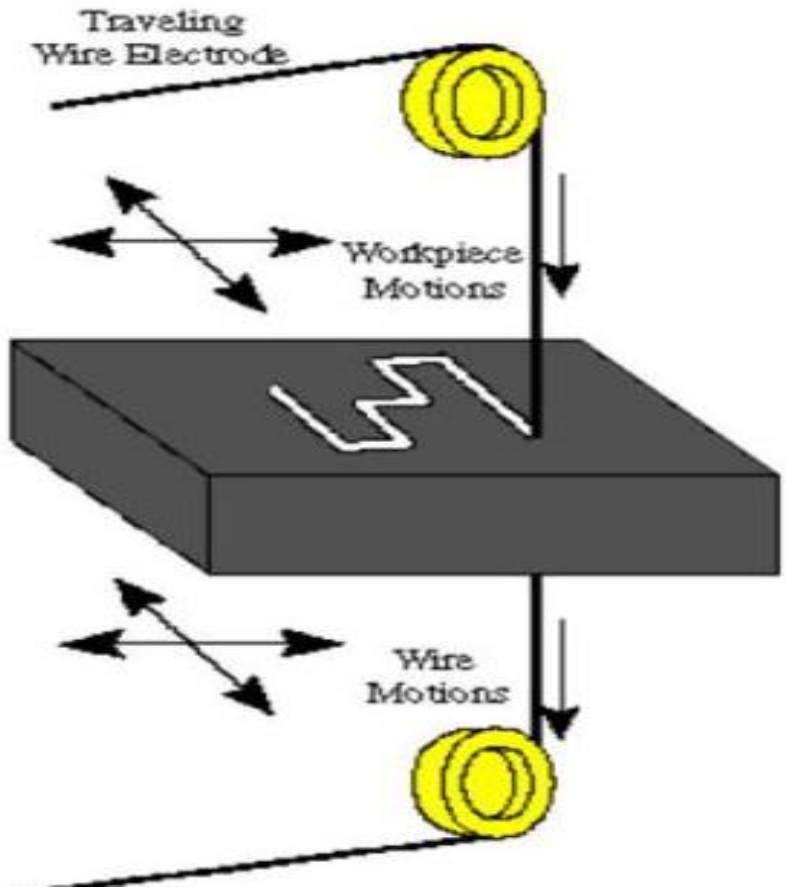



**Figure 1.10 Wire EDM 4-axis motion**

**4-axis Motion**

- With the 4-axis Wire EDM
- Different shapes can be produced on top and bottom of a workpiece




**Figure 1.11 Different shapes produced by 4-axis motion EDM**

## 1. Micro EDM

The micro-EDM is a machining process that follows the same principles as the die-sinking EDM and wire EDM. The process removes material at the micro-scale for components smaller than 100 µm, including micro-holes, micro-shafts and 3D micro-cavities. The only principled difference from the other EDM processes is the power involved. The MRR will be in Nano meters because the machine part is at the micro level and the required voltage and current will be several times less than those used in the die-sinking EDM or any other normal-level EDM process. This process can produce a hole or shaft diameters of only 5 µm, while holes of up to 70 µm and 40 µm can be produced by drilling and laser machining, respectively. EDM at the microscale level is available in many machining processes, such as die-sinking micro-EDM, microware EDM, micro-EDM drilling and micro-EDM milling. In the micro-wire EDM, a wire with a diameter less than 20 µm is used. The minimum machinability of cavities in other micro-EDM processes have diameters of 5 µm. The grain sizes of workpiece materials have significant impact on the characteristics of micro EDM. The MRR for micro-EDM has a direct relationship with the grain size of the machined workpiece because the effective thermal conductivity and local effective melting point of polycrystalline materials vary with grain sizes of these materials since the grain boundary volume fractions change. It is worth emphasizing that the material microstructure of the processed workpiece plays a significant role in the performance of the micro EDM process. In particular, the refined material microstructure can give a better surface quality when compared with the results for the course grained microstructure of the same material. This conclusion is explained by the heterogeneity of the course grained material microstructure that normally leads to more anisotropic behavior of the microstructure and the more homogenous response of the refined microstructure that results in more isotropic/consistence behavior.

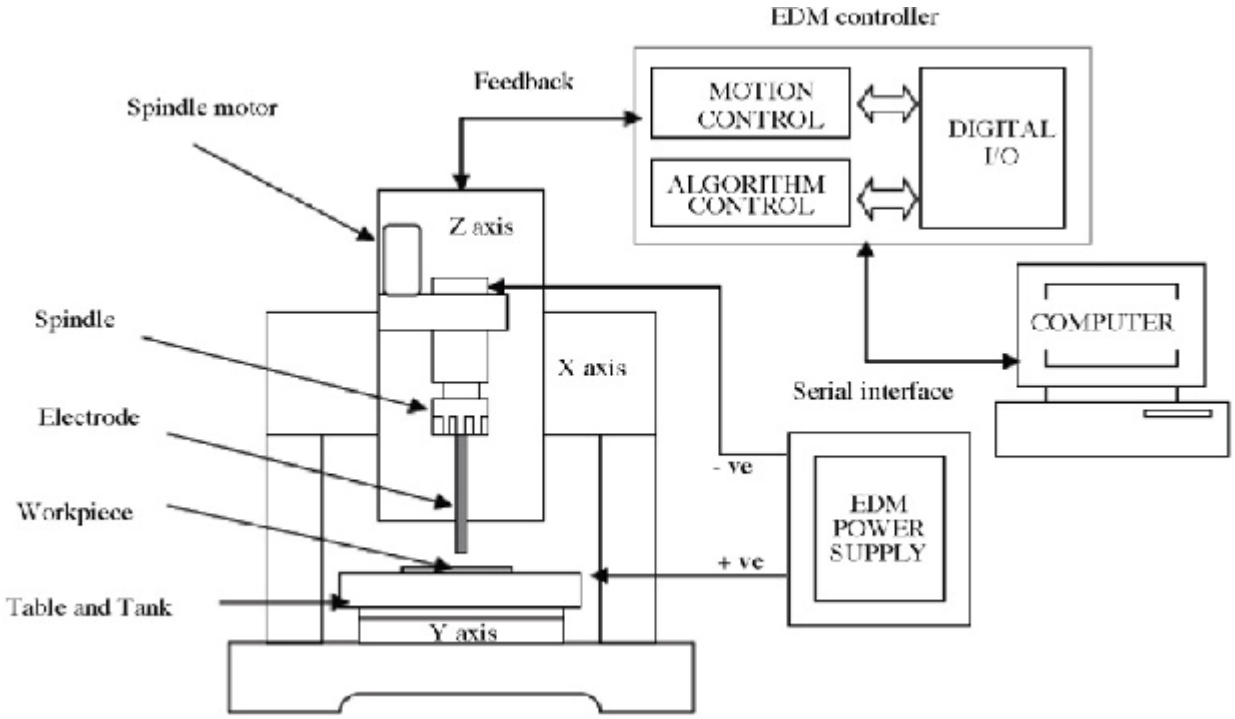



**Figure 1.12 Schematic diagram of micro-EDM**

### A. Powder-Mixed EDM

As the name implies, powder of a suitable material, such as nickel, is mixed with the dielectric fluid. The presence of this powder makes the process mechanism substantially different from the conventional EDM process. The powder particles fill the gap between the electrode tool and the workpiece when a voltage is applied during machining. This particle aggregation forces the electrode tool and the workpiece to move a small distance further apart by an amount equal to the gap filled by the powder particles. The gap between the electrode tool and the workpiece can increase by 100% to 300% (from 25–50 μm to 50–150 μm). The presence of the powder particles between the electrode tool and the workpiece leads to earlier and faster sparking, which causes a higher erosion rate.

### B. Dry EDM

The dry EDM uses dielectric high-pressure gas instead of dielectric liquid.

Here, the electrode tool is in the form of a thin-walled pipe through which high-pressure gas or air is supplied. The pressurized gases flow outwards through the gap between electrode tool and machined surface and carry away the debris being formed. The gases also reduce the machining area temperature. Using gas instead of fluid in this process can reduce harmful environmental effects. Most notably the dielectric fluid and the powder-mixed dielectrics in the EDM processes

are associated with evaporation from the fluid surface during machining. Utilizing gas an also decrease the cost of managing the debris waste and enhance the machining performance and the environment as regards worker health. From this point of view, this process could be named as the “Green EDM.” The dry EDM process positively influences the MRR and reduces the EWR. Under ideal conditions, this process allows to obtain very good accuracy and surface layer quality.

In addition to the previous main types of EDM, there are other types such as EDM milling, in this type the final shape is obtained using a simple electrode tool which is moved in a 3D path along several directions and may also subject to rotations.

A combination of the two cutting systems can also be applied. Also, EDM grinding, when the electrode tool design as a rotating disk.

**Mathematical Modeling of the Thermos-Physical Phenomenon in EDM**

EDM involves removal of material from the workpiece due to heat generated from electric discharge in the inter-electrode gap. Plethora of research study and analyses this phenomenon; mathematical models are developed to provide better understanding of the EDM process. A quasi-static model is proposed by, the model computes the material removal rate based on predicted distribution of the temperature in the workpiece. Equation of transient heat conduction is employed to predict the distribution. The model assumes Gaussian heat flux since it gives better results as demonstrated by. Finite element method is used to solve the model and obtain the results, which show significant closeness to the experimental results.

Vaporization of workpiece and tool materials is studied by. The model is used to predict the aerosol emission of EDM process. 70% of the aerosol is found to be vaporized material from the workpiece and the tool, the rest comes from the dielectric fluid. The electric field generated in the interelectrode gap is modelled by. The model represents the electric field at two stages. First; before-discharge stage, where Laplace equation is used to model the electrostatic field. Second; during–discharge state, where Poisson equation is used to model the spatial discharge from electrode and particles of the dielectric fluid. Fluid flow in the interelectrode gap is modelled by. The model attempts to study the motion of the debris particle as well as the drag force between the particles and the dielectric fluid. The purpose is to improve the removal of debris from the machining zone. Fluent software is used to build 3D model of drilling high aspect ratio of a hole.

The effect of incorporating ultrasonic vibration is verified using the proposed model; optimal amplitudes and frequencies are determined using the model based on a set of process parameters.

**Machine and work piece aligned procedures**

Aligning the machine and workpiece to specified datum points is an important step in ensuring accurate and consistent machining results. The alignment process typically follows standard procedures to maintain consistency and repeatability. Here's an overview of the alignment process:

1. Understand Datum Points:
    - Datum points are reference points used to establish a coordinate system for the machining process.
    - These points are predetermined and specified in the design or manufacturing documentation.
    - Study the workpiece drawings or specifications to identify the relevant datum points and their locations.
2. Machine Preparation:
    - Before aligning the workpiece, ensure that the machine is properly set up and calibrated.
    - Verify that the machine's axes are correctly aligned and perpendicular to each other, ensuring the machine's geometric accuracy.
    - Check for any mechanical issues or misalignments in the machine that could affect the machining process.
3. Workpiece Preparation:
    - Prepare the workpiece by cleaning it and removing any burrs or contaminants that could interfere with the alignment process.
    - Identify the surface or feature on the workpiece that corresponds to the specified datum points.
    - Ensure that the workpiece is securely clamped or fixtured in place to prevent movement during alignment and machining.
4. Establish Rough Alignment:
    - Use manual or automated methods to position the workpiece in the approximate location relative to the machine's axes.

- Rough alignment can be achieved by visual inspection, manual manipulation, or using alignment tools such as edge finders or dial indicators.
- Align the workpiece to the machine's reference surfaces or fixtures to establish a preliminary alignment.

5. Fine Alignment:
   - With the workpiece roughly aligned, proceed to the fine alignment stage.
   - Utilize precision measurement tools such as dial indicators, height gauges, laser alignment systems, or coordinate measuring machines (CMM) to achieve precise alignment.
   - Measure the distances, angles, and offsets between the workpiece's specified datum points and reference features on the machine.
   - Make necessary adjustments to position the workpiece accurately in relation to the machine's coordinate system.
6. Verification and Adjustment:
   - Once the alignment is completed, verify the alignment accuracy using appropriate measurement techniques.
   - Inspect the alignment of additional features or surfaces on the workpiece to ensure overall alignment consistency.
   - If any discrepancies are found, make necessary adjustments to correct the alignment by readjusting the workpiece position or machine setup.
7. Documentation:
   - Maintain proper documentation of the alignment process, including the specified datum points, measurement results, and any adjustments made.
   - Documenting the alignment process helps ensure repeatability and facilitates troubleshooting or future reference.

It is crucial to follow the standard procedures established by the worksite or industry to ensure consistent and accurate alignment. Adhering to these procedures helps minimize errors, reduces setup time, and ensures that the machining process is performed within the desired tolerances and specifications.

2.2. Program 2D elements and machine code functions

In EDM (Electrical Discharge Machining) operations, programming 2D elements and generating machine code functions are crucial steps to define the machining process and ensure that the specifications are met. Here's an overview of the process:

1. CAD/CAM Software:
   - Utilize Computer-Aided Design (CAD) software to create or import the 2D geometry of the workpiece or desired features.
   - CAD software allows you to define the shape, dimensions, and tolerances of the elements to be machined.
2. Programming 2D Elements:
   - In the CAD software, define the 2D elements that need to be machined using appropriate drawing and modeling tools.
   - Create geometrical entities such as lines, arcs, circles, rectangles, or custom profiles to represent the desired features.
   - Apply necessary constraints, dimensions, and tolerances to ensure the elements meet the required specifications.
3. Tool Path Generation:
   - Use Computer-Aided Manufacturing (CAM) software to generate tool paths based on the defined 2D elements.
   - CAM software allows you to select machining strategies, such as roughing, semi-finishing, or finishing, and specify parameters like stepover, feed rate, and cutting direction.
   - The software calculates the tool paths based on the geometry, machining strategy, and desired surface finish.
4. Machine Code Functions:
   - Once the tool paths are generated, the CAM software converts the tool paths into machine-readable code, often in G-code format.
   - The machine code functions include commands that instruct the EDM machine on how to move the tool electrode and control the machining parameters.
   - Machine code functions encompass commands for tool positioning, electrode movement, power settings, flushing, and other relevant parameters.

5. Post-Processing:
    - After generating the machine code functions, perform post-processing to review and optimize the code if necessary.
    - Check for any errors, collisions, or inconsistencies in the tool paths or machine code functions.
    - Make adjustments to the code as needed to ensure it aligns with the machine's capabilities and the desired machining specifications.
6. Machine Setup:
    - Transfer the generated machine code functions to the EDM machine.
    - Set up the workpiece, tool electrode, and necessary auxiliary equipment based on the programming and machining requirements.
    - Ensure the machine parameters, such as power settings, flushing rate, and electrode wear compensation, are properly configured to match the programmed specifications.
7. Machining Operations:
    - Initiate the machining process on the EDM machine, following standard operating procedures and safety guidelines.
    - The machine reads the machine code functions and executes the programmed tool paths, controlling the electrical discharges and other machining parameters.
    - Monitor the machining process, make adjustments if necessary, and perform quality checks to verify that the specifications are being met.

By programming 2D elements and defining machine code functions, you can precisely control the EDM machining process and ensure that the workpiece is machined according to the specified geometry, tolerances, and surface finish requirements. The CAD/CAM software, along with post-processing and machine setup, play crucial roles in translating the design intent into machine-readable instructions for EDM operations.

**CNC programming**

When programming 2D elements and machine code functions for EDM machining operations, there are two primary environments where you can work: using a simulator or directly on the machine tool. Here's an explanation of each option:

1. **Simulator:**

- Many CAD/CAM software packages provide simulation capabilities that allow you to visualize and verify the machining process virtually.
- In the simulator, you can load the 2D elements, generate tool paths, and simulate the tool movement and material removal.
- The simulator provides a 3D representation of the machining process, allowing you to check for any collisions, verify the tool paths, and optimize the programming before executing it on the actual machine.
- By utilizing a simulator, you can reduce the risk of errors, optimize machining strategies, and ensure that the programmed specifications are met without the need for physical trial and error.

**2. On Machine Tool:**

- Alternatively, you can program the 2D elements and machine code functions directly on the EDM machine tool.
- Some EDM machines are equipped with built-in programming interfaces that allow you to input the commands and parameters directly.
- This approach requires a good understanding of the machine's programming language and syntax, as well as the ability to visualize the machining process without a simulator.
- On-machine programming is suitable for simpler part geometries or when immediate adjustments or modifications are required during the machining process.
- However, it carries the risk of errors or collisions that may require manual adjustments or reprogramming.

The choice between using a simulator or programming on the machine tool depends on factors such as the complexity of the part geometry, the availability of simulation capabilities, the level of confidence in the programming, and the specific features and capabilities of the EDM machine. In general, utilizing a simulator provides a safer and more efficient way to program and optimize the machining process before physically executing it on the machine tool.

Self-check 2.1

**Instruction I- Choose the best answer from the given alternatives.**

1. Which factor directly affects the intensity of the electrical discharge and the rate of material removal in EDM?
   a. Surface finish
   b. Metal removal rate
   c. Power settings
   d. Workpiece material
2. What does surface finish refer to in EDM?
   a. The quality and smoothness of the machined surface
   b. The rate at which material is removed during EDM
   c. The distance between the electrode and the workpiece
   d. The conductivity and hardness of the workpiece material
3. What is the purpose of selecting an appropriate electrode material in EDM?
   a. To improve dielectric flushing
   b. To achieve efficient machining without compromising quality
   c. To maintain dimensional accuracy and prevent excessive tooling costs
   d. To balance metal removal rate with surface finish requirements
4. Which factor should be considered when selecting a dielectric fluid for EDM?
   a. Workpiece material
   b. Electrode wear resistance
   c. Power settings
   d. Flushing rate and method
5. What is the significance of adjusting the flushing rate and method in EDM?
   a. To optimize debris removal and cooling
   b. To maintain consistent machining conditions
   c. To achieve a deeper cut
   d. To improve surface finish
6. How does the spark gap affect EDM?
   a. It determines the rate at which the wire electrode moves through the workpiece.
   b. It influences the intensity and stability of the electrical discharge.

c. It affects the cutting speed, accuracy, and surface finish.

d. It helps maintain consistent machining conditions.

7. What is the role of accessories and work-holding fixtures in EDM?

   a. To control the power settings during machining

   b. To optimize the selection of dielectric fluid

   c. To ensure the required position and stability of the workpiece

   d. To increase the metal removal rate

8. Which accessory is commonly used for holding smaller workpieces securely during EDM operations?

   a. Fixture plates

   b. Electrode holders

   c. Rotary tables

   d. Vises

9. What is the purpose of using electrode holders and chucks in EDM?

   a. To secure the electrodes during machining

   b. To align and clamp the workpiece in the desired position

   c. To rotate and index the workpiece for multi-sided operations

   d. To design and fabricate custom fixtures and jigs

10. How do pallet systems contribute to efficient workpiece changeovers in EDM?

    a. They ensure accurate positioning of the workpiece.

    b. They facilitate streamlined production processes.

    c. They provide stability during machining operations.

    d. They minimize machine downtime.

11. Which EDM process involves machining the workpiece using a controlled electrical spark generated in the gap between the electrode tool and the workpiece?

    a) Die-Sinking EDM

    b) Wire EDM

    c) Micro EDM

    d) Powder-Mixed EDM

12. What material is commonly used as the electrode tool in the die-sinking EDM process?

    a) Copper

b) Graphite

c) Steel

d) Nickel

13. In which EDM process do the wire and the workpiece not have any contact during machining?

a) Die-Sinking EDM

b) Wire EDM

c) Micro EDM

d) Powder-Mixed EDM

14. What is the typical diameter of the standard EDM wire used in the wire EDM process?

a) 0.25 mm

b) 0.5 mm

c) 1 mm

d) 2 mm

15. The micro-EDM process is used for machining components smaller than:

a) 1 mm

b) 10 µm

c) 100 µm

d) 1 mm

16. What is the main difference between the powder-mixed EDM process and the conventional EDM process?

a) The use of a different dielectric fluid

b) The presence of powder particles between the electrode tool and the workpiece

c) The absence of sparks during machining

d) The use of high-pressure gas instead of a dielectric fluid

17. The dry EDM process uses which substance instead of a dielectric liquid?

a) Water

b) Oil

c) Gas

d) Powder

18. What is the advantage of using gas instead of fluid in the dry EDM process?
    a) Reduced machining area temperature
    b) Higher erosion rate
    c) Environmental friendliness
    d) Improved surface layer quality
19. Which type of EDM involves using a rotating disk as the electrode tool?
    a) EDM milling
    b) EDM grinding
    c) Die-Sinking EDM
    d) Wire EDM
20. Mathematical models in EDM are developed to:
    a) Predict the distribution of temperature in the workpiece
    b) Study the motion of debris particles in the dielectric fluid
    c) Determine optimal amplitudes and frequencies for ultrasonic vibration
    d) Align the machine and workpiece to specified datum points
21. When establishing a coordinate system for the machining process, datum points are:
    a) Predetermined reference points specified in the design or manufacturing documentation.
    b) Points that indicate the start and end of the machining process.
    c) Randomly selected reference points on the workpiece.
    d) Points used to measure the temperature of the workpiece during machining.
22. Before aligning the workpiece, it is important to ensure that:
    a) The workpiece is securely clamped or fixtured in place.
    b) The machine's axes are parallel to each other.
    c) The workpiece is cleaned and free of burrs.
    d) The machine's geometric accuracy is not necessary.
23. Rough alignment of the workpiece can be achieved by:
    a) Using precision measurement tools.
    b) Visual inspection and manual manipulation.
    c) Checking for mechanical issues in the machine.
    d) Aligning the workpiece to the reference surfaces of the machine.

24. Fine alignment of the workpiece involves:
    a) Cleaning the workpiece and removing contaminants.
    b) Using precision measurement tools to achieve precise alignment.
    c) Verifying the alignment accuracy using appropriate techniques.
    d) Roughly aligning the workpiece using manual methods.
25. The purpose of documenting the alignment process is to:
    a) Troubleshoot any issues during machining.
    b) Maintain a record of the specified datum points.
    c) Ensure repeatability and future reference.
    d) Reduce setup time for future alignments.
26. In the EDM process, CAD software is used for:
    a) Generating tool paths based on the defined 2D elements.
    b) Defining the shape and dimensions of the workpiece.
    c) Cleaning the workpiece and removing burrs.
    d) Setting up the EDM machine.
27. CAM software is used for:
    a) Creating or importing the 2D geometry of the workpiece.
    b) Checking for errors and collisions in the tool paths.
    c) Converting tool paths into machine-readable code.
    d) Aligning the workpiece to the machine's reference surfaces.
28. Machine code functions in EDM refer to:
    a) Commands that instruct the EDM machine on tool movement and machining parameters.
    b) Commands for cleaning and maintaining the EDM machine.
    c) Commands for adjusting the alignment of the workpiece.
    d) Commands for generating tool paths in CAM software.
29. Post-processing in EDM involves:
    a) Cleaning the workpiece after machining.
    b) Optimizing the machine code functions for better performance.
    c) Reviewing and optimizing the generated machine code.
    d) Inspecting the alignment of additional features on the workpiece.

30. When programming 2D elements and machine code functions, using a simulator allows you to:

    a) Visualize and verify the machining process virtually.

    b) Directly input commands and parameters on the machine tool.

    c) Check for errors and collisions without physical trial and error.

    d) Modify the machine's programming language and syntax.

## Unit Three: Electro-Discharge Machining (EDM)

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Electro-discharge machine Operation
- Machine Cleaning and dispose waste material

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this unit, you will be able to:

- Operate electro-discharge machine
- Clean Machine and dispose waste material

3.1. Electro-Discharge Machine Operation

To operate an Electrical Discharge Machine (EDM) to produce components to drawing specifications, you would typically follow these steps:

1. Review the Drawing Specifications:
   - Carefully study the engineering drawing provided, which includes dimensions, tolerances, surface finishes, and any additional specifications.
   - Understand the required features, such as holes, pockets, slots, or complex geometries.
2. Select the Workpiece Material:
   - Identify the material specified on the drawing and ensure you have the appropriate stock material available.
   - Consider the material's electrical conductivity and other properties that may affect the EDM process.
3. Set Up the EDM Machine:
   - Prepare the EDM machine for the specific operation.
   - Mount the workpiece securely using clamps, vises, or fixtures.
   - Install the appropriate tool electrode (made of copper, graphite, etc.) based on the shape and requirements of the component.
4. Prepare the EDM Machine Parameters:
   - Configure the EDM machine settings for the specific job.
   - Set the appropriate power settings, pulse duration, discharge current, and electrode wear compensation.
   - Adjust the dielectric fluid level, flushing rate, and any other relevant parameters.
5. Load the CNC Program:
   - Generate or load the CNC program specific to the component and EDM operation.
   - Ensure the program includes the necessary tool paths, electrode movements, machining depths, and any specific instructions.
6. Run the CNC Program:
   - Load the CNC program into the EDM machine's controller.
   - Execute the program and monitor the machine's operation.
   - Ensure the EDM machine follows the programmed tool paths and performs the required machining operations.

7. Inspect and Measure the Machined Component:
   - Once the machining process is complete, remove the component from the EDM machine.
   - Inspect the machined features to ensure they meet the drawing specifications.
   - Use measuring tools such as calipers, micrometers, or CMM (Coordinate Measuring Machine) to verify dimensions and tolerances.
8. Make Adjustments if Necessary:
   - If the machined component does not meet the drawing specifications, analyze the discrepancies.
   - Determine if adjustments are required in the EDM machine parameters, tooling, or programming.
   - Modify the appropriate settings and rerun the machining process if needed.
9. Repeat for Additional Components:
   - If multiple components need to be produced, repeat the above steps for each component, ensuring consistency and accuracy.

Throughout the process, it's crucial to maintain a clean EDM machine, monitor the electrode wear, and ensure proper dielectric fluid conditions. Regular machine maintenance, tool electrode replacement, and periodic calibration checks are also essential to maintain the quality and accuracy of the produced components.

**Application of EDM**

The EDM process has the ability to machine hard, difficult-to-machine materials. Parts with complex, precise and irregular shapes for forging, press tools, extrusion dies, difficult internal shapes for aerospace and medical applications can be made by EDM process. Some of the shapes made by EDM process are shown in Figure



**Figure 3.1 deferent internal parts made by EDM process**

3.2. Machine Cleaning and Dispose Waste Material

In EDM machining operations, it is important to maintain cleanliness and dispose of waste material properly. Here are some guidelines for cleaning the machine and disposing of waste material in accordance with worksite procedures:

1. Cleaning the EDM Machine:
   - Follow the manufacturer's guidelines for cleaning and maintenance of the specific EDM machine.
   - Regularly clean the work area, removing debris, chips, and swarf generated during machining.
   - Use appropriate cleaning tools such as brushes, vacuum cleaners, or compressed air to remove residual material from the machine, workpiece, and work holding fixtures.
   - Pay special attention to cleaning the dielectric fluid reservoir, filters, and flushing systems to ensure optimal performance.
2. Waste Material Disposal:
   - Determine the type of waste generated during EDM machining, such as metal chips, debris, used dielectric fluid, or spent electrodes.
   - Follow worksite procedures and local regulations for waste management and disposal.
   - Segregate different types of waste into separate containers or designated areas to facilitate proper disposal.
   - Consult with your worksite's waste management team or designated personnel to ensure compliance with the established protocols.
3. Metal Chips and Debris:

- Collect metal chips and debris generated during the EDM process.
- Place them in designated containers or bins specifically allocated for metal waste.
- Ensure that metal chips are not mixed with other types of waste that require separate disposal.

4. Used Dielectric Fluid:
    - Dielectric fluid used in EDM machines may become contaminated during machining operations.
    - Follow worksite procedures for the proper handling and disposal of used dielectric fluid.
    - Store used dielectric fluid in designated containers provided by the worksite.
    - Coordinate with the appropriate personnel or waste management team to arrange for the proper disposal or recycling of the used dielectric fluid.
5. Spent Electrodes and Consumables:
    - Spent electrodes and other consumables, such as worn-out tooling or worn-out filters, should be collected separately.
    - Place them in designated containers or bins specifically allocated for disposal of such items.
    - Follow the worksite's procedures for the safe disposal or recycling of spent electrodes and consumables.

Always prioritize safety when handling waste materials and adhere to the specific regulations and guidelines provided by your worksite or local authorities. Proper waste management and disposal not only contribute to a clean and organized work environment but also help protect the environment and ensure compliance with legal requirements.

Self-check 3.1

**Instruction1- Say True or False s to the following questions.**

1. Reviewing the drawing specifications is not necessary when operating an EDM machine.
2. The selection of workpiece material does not impact the EDM process.
3. Setting up the EDM machine involves securely mounting the workpiece.
4. EDM machine parameters do not need to be adjusted before starting the machining process.
5. Loading the CNC program into the EDM machine is not required.
6. After running the CNC program, there is no need to inspect the machined component.
7. Adjustments are not necessary if the machined component does not meet the drawing specifications.
8. The EDM process is not suitable for machining hard, difficult-to-machine materials.
9. Cleaning the EDM machine and disposing of waste material are not important in EDM operations.
10. Used dielectric fluid should be stored in regular containers for disposal.

**Instruction1I- Choose the best answer from the given alternatives.**

1. What is the first step in operating an EDM machine?
   a. Set up the EDM machine
   b. Review the drawing specifications
   c. Load the CNC program
   d. Inspect and measure the machined component
2. What should be considered when selecting the workpiece material for EDM?
   a. Electrical conductivity
   b. Surface finish
   c. Dielectric fluid level
   d. Flushing rate
3. How should the workpiece be mounted on the EDM machine?
   a. Using clamps, vises, or fixtures
   b. Placing it directly on the machine bed
   c. Attaching it with adhesive
   d. Using magnets to hold it in place

4. What is adjusted in the EDM machine parameters?
   a. Workpiece material
   b. Power settings and pulse duration
   c. Flushing rate and dielectric fluid level
   d. Tool electrode material
5. What is the purpose of loading the CNC program?
   a. To review the drawing specifications
   b. To inspect the machined component
   c. To set up the EDM machine
   d. To execute the machining operations
6. What should be done after running the CNC program?
   a. Review the drawing specifications
   b. Inspect and measure the machined component
   c. Adjust the EDM machine parameters
   d. Select the workpiece material
7. How can the dimensions and tolerances of the machined component be verified?
   a. By reviewing the drawing specifications
   b. By adjusting the EDM machine parameters
   c. By inspecting and measuring the component
   d. By repeating the machining process
8. What should be done if the machined component does not meet the drawing specifications?
   a. Repeat the machining process
   b. Adjust the EDM machine parameters
   c. Select a different workpiece material
   d. Load a new CNC program
9. Which of the following is an application of EDM?
   a. Machining soft materials
   b. Creating simple geometric shapes
   c. Producing components with complex shapes
   d. Fabricating plastic parts

10. What is an important aspect of machine cleaning in EDM operations?
    a. Removing debris and chips generated during machining
    b. Adjusting the dielectric fluid level
    c. Disposing of spent electrodes properly
    d. Reviewing the drawing specifications
11. How should metal chips and debris generated during EDM machining be handled?
    a. Mix them with other types of waste for disposal
    b. Dispose of them in regular trash bins
    c. Collect them in designated containers for metal waste
    d. Use them as raw materials in the manufacturing process
12. What should be done with used dielectric fluid in EDM machines?
    a. Store it in regular containers for disposal
    b. Dispose of it in regular trash bins
    c. Recycle it for future use
    d. Store it in designated containers for proper disposal or recycling
13. How should spent electrodes and consumables be handled?
    a. Dispose of them in regular trash bins
    b. Mix them with metal chips for disposal
    c. Store them in designated containers for disposal or recycling
    d. Reuse them in future machining operations
14. What is the purpose of proper waste material disposal in EDM operations?
    a. To reduce the machine cleaning time
    b. To comply with worksite regulations
    c. To increase the electrical conductivity of the workpiece
    d. To improve the surface finish of the machined component
15. What are the key benefits of maintaining cleanliness and proper waste disposal in EDM operations?
    a. Improved machine performance and accuracy
    b. Reduced tool electrode wear
    c. Faster machining times
    d. Lower dielectric fluid consumption

**Direction III: Short answer items**

**Instruction III- Briefly answer the following questions**

1. What should you review before operating an EDM machine?
2. How does the selection of workpiece material impact the EDM process?
3. What are the steps involved in setting up an EDM machine?
4. What parameters need to be adjusted in the EDM machine before starting the machining process?
5. Why is it important to load the CNC program into the EDM machine?
6. What should you do after running the CNC program on the EDM machine?
7. How can you verify if the machined component meets the drawing specifications?
8. What should be done if the machined component does not meet the drawing specifications?
9. What are some applications of EDM?
10. Why is machine cleaning and proper waste disposal important in EDM operations?

## Unit Four: EDM Machine Product Quality

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Check Components
- Record measurements

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this unit, you will be able to:

- Check manufactured Components
- Record measurements depend on instructions

## 4.1. Check Components

When checking components produced through EDM machining operations for conformance to specifications, it is crucial to use appropriate techniques, tools, and equipment. Here are some guidelines specifically for EDM machining operations:

1. Understand the Drawing Specifications:

- Review the engineering drawing that outlines the specifications for the components.
- Pay attention to dimensions, tolerances, surface finishes, and any other critical requirements specified.

2. Select Suitable Inspection Techniques:
    - Choose inspection techniques that are appropriate for EDM machined components, considering their unique characteristics.
    - Common techniques include dimensional measurement, surface roughness measurement, hardness testing, and visual inspection.
3. Gather the Required Tools and Equipment:
    - Identify and gather the necessary inspection tools and equipment specific to EDM machining operations.
    - This may include calipers, micrometers, height gauges, CMMs, surface roughness testers, hardness testers, and visual inspection tools.
4. Perform Dimensional Measurement:
    - Use precision measuring tools like calipers, micrometers, or CMMs to measure critical dimensions of the components.
    - Pay close attention to the dimensions specified on the engineering drawing, ensuring they fall within the specified tolerances.
5. Measure Surface Roughness:
    - Utilize a surface roughness tester to measure the surface finish of EDM machined surfaces.
    - Follow the appropriate technique and traverse the stylus or sensor across representative areas to obtain accurate roughness values.
    - Compare the measured roughness values with the specified surface finish requirements.
6. Conduct Hardness Testing:
    - Perform hardness testing on the machined components, especially if hardness requirements are specified.
    - Use a hardness tester and follow the appropriate test method (e.g., Rockwell, Brinell) based on the material and requirements.
    - Compare the measured hardness values with the specified hardness range.

7. Perform Visual Inspection:
    - Conduct a thorough visual inspection of the components to identify any visible defects or irregularities.
    - Examine the surfaces, edges, and features of the components, ensuring they meet the specified requirements.
    - Look for surface cracks, burns, burrs, or other anomalies that may affect the component's quality.
8. Record and Document Inspection Results:
    - Record all inspection results, including dimensional measurements, surface roughness values, hardness readings, and visual inspection findings.
    - Document any non-conformities or deviations from the specified requirements.
    - Maintain proper inspection records for traceability and quality control purposes.

Always ensure that your inspection tools are well-maintained, calibrated, and suitable for the specific requirements of EDM machining. Follow the established worksite procedures and consult with your worksite's quality assurance department or designated personnel to ensure compliance with the inspection protocols and standards in EDM machining operations.

4.2. Record measurements

Recording measurements in accordance with worksite procedures is essential for maintaining accurate and organized documentation in EDM machining operations. Here are some guidelines to follow when recording measurements:

1. Understand the Worksite Procedures:
    - Familiarize yourself with the specific worksite procedures and protocols for recording measurements.
    - Review any documentation or guidelines provided by your worksite regarding measurement recording.
2. Use Standard Measurement Units:
    - Ensure that all measurements are recorded using standard units of measurement, such as millimeters (mm), micrometers (μm), or inches (in).

- Avoid mixing different units of measurement in the same record to maintain consistency.

3. Select the Appropriate Measurement Tools:
   - Use the appropriate measurement tools and instruments for the specific dimensions being measured.
   - Calipers, micrometers, CMMs, or other precision measuring devices may be used depending on the requirements.
4. Follow the Measurement Technique:
   - Adhere to the specified measurement technique outlined in the worksite procedures or the relevant industry standards.
   - Follow the correct procedure for each measurement, ensuring accuracy and repeatability.
5. Record Measurements Promptly:
   - Record the measurements promptly after they are taken to minimize the risk of errors or omissions.
   - Avoid relying solely on memory and ensure that measurements are recorded soon after they are obtained.
6. Include Relevant Information:
   - In addition to the measured values, include any relevant information that may be specified in the worksite procedures.
   - This may include the date and time of measurement, the specific location or feature being measured, and any associated identification numbers.
7. Use Clear and Legible Format:
   - Record measurements in a clear and legible format to ensure readability and ease of interpretation.
   - Use standardized forms, digital spreadsheets, or other approved formats recommended by your worksite.

8. Sign and Date the Record:
    - Sign and date the measurement record to indicate the person responsible for taking the measurements.
    - This helps establish accountability and provides a reference for future inquiries or audits.
9. Maintain Proper Documentation:
    - Ensure that all measurement records are organized and stored securely as per worksite procedures.
    - Follow any specific guidelines for retention periods, archiving, or digital storage of measurement records.
10. Communicate Any Deviations or Non-Conformities:
    - If any measurements deviate from the specified tolerances or requirements, report them promptly to the appropriate personnel.
    - Follow the worksite protocols for documenting non-conformities and initiating corrective actions if necessary.

Remember to consult with your worksite's quality assurance department or designated personnel for any specific guidelines or procedures regarding measurement recording in EDM machining operations. Adhering to the established worksite procedures ensures consistency, accuracy, and traceability of measurement data.

Self-check 4.1

**Instruction1- Say True or False to the following questions.**

1. When checking components produced through EDM machining operations, it is crucial to review the engineering drawing for dimensions, tolerances, and surface finishes.

2. Magnetic particle testing is a suitable inspection technique for EDM machined components.
3. Surface roughness testers may be necessary tools for inspecting EDM machined components.
4. Utilizing a CMM is a suitable method for measuring critical dimensions of EDM machined components.
5. Surface roughness measurement is important for evaluating the surface finish of EDM machined components.
6. Rockwell testing may be used as a method for hardness testing on EDM machined components.
7. Visual inspection of EDM machined components involves examining the components' surface defects and irregularities.

**Instruction1I- Choose the best answer from the given alternatives.**

1. When checking components produced through EDM machining operations, it is crucial to:
   a) Review the engineering drawing for dimensions, tolerances, and surface finishes.
   b) Use any inspection techniques without considering the component's characteristics.
   c) Inspect the components visually without referring to the specifications.
   d) Gather tools and equipment unrelated to EDM machining operations.
2. Which of the following inspection techniques may be suitable for EDM machined components?
   a) Magnetic particle testing.
   b) Ultrasonic testing.
   c) Dimensional measurement.
   d) X-ray inspection.
3. Which of the following tools may be necessary for inspecting EDM machined components?
   a) Welding machine.
   b) Surface roughness tester.
   c) Welding helmet.
   d) Soldering iron.

4. What should be done to measure critical dimensions of EDM machined components?
   a) Use a surface roughness tester.
   b) Perform hardness testing.
   c) Utilize a CMM.
   d) Conduct visual inspection.
5. Surface roughness measurement is important for evaluating:
   a) The component's weight.
   b) The component's color.
   c) The component's surface finish.
   d) The component's electrical conductivity.
6. When conducting hardness testing on EDM machined components, which test method may be used?
   a) Tensile testing.
   b) Impact testing.
   c) Rockwell testing.
   d) Creep testing.
7. Visual inspection of EDM machined components involves examining:
   a) The internal structure of the components.
   b) The components' weight.
   c) The components' surface defects and irregularities.
   d) The chemical composition of the components.
8. Why is it important to record and document inspection results?
   a) To demonstrate proficiency in measurement techniques.
   b) To maintain accurate and organized documentation.
   c) To avoid using measurement tools.
   d) To reduce the need for quality control.
9. When recording measurements, it is essential to:
   a) Mix different units of measurement in the same record.
   b) Use non-standardized forms for documentation.
   c) Record measurements promptly after they are taken.
   d) Exclude any relevant information specified in the worksite procedures.

10. Proper documentation of measurement records includes:
    a) Storing records in an unsecured location.
    b) Using an illegible format.
    c) Signing and dating the record.
    d) Ignoring any deviations or non-conformities.

**Direction III: Short answer items**

**Instruction III- Briefly answer the following questions**

1. What are some of the key specifications to pay attention to when reviewing the engineering drawing for EDM machined components?
2. Name four common inspection techniques suitable for EDM machined components.
3. List some of the inspection tools and equipment specific to EDM machining operations.
4. What types of precision measuring tools can be used for dimensional measurement of EDM machined components?
5. How can surface roughness be measured on EDM machined surfaces?
6. What is the purpose of conducting hardness testing on EDM machined components?
7. What are some visible defects or irregularities that should be checked during visual inspection of EDM machined components?
8. Why is it important to record and document inspection results for EDM machining operations?

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## Developers profile

| No | Name | Qualification (Level) | Field of Study | Organization/ Institution | Mobile No. | E-mail |
|---|---|---|---|---|---|---|
| **1** | Tsegaye Mulat | A | Manufacturing Technology | A.A T/ P/T/C | 0910411511 | ttshgm97@gmail .com |
| **1.** | Abebe Hailay | A | Manufacturing Technology | M/G/M/B/P/T/college | 0913175634 | aabebe52@gmail.com |
| **2.** | Mesret woldemariam | A | Manufacturing Technology | W/P/T/college | 912117416 | bmesi2007@gmail.com |
| **3.** | Boka Terefe | A | Manufacturing Technology | Ambo/P/T/college | 0917038870 | bokaterefe@gmail.com |
| **4.** | Mesay Teshome | B | Manufacturing Technology | Hawassa P/T/college | 0905456888 | mesayy2018@gmail.com |
| **5.** | Mohammed Bedri | A | Manufacturing Technology | Robe/P/T/college | 0913897297 | |
| **6.** | Mohammed Abdela | A | Manufacturing Technology | Ethio italy poly technic college | 0907755560 | Mahammedabdella49@gmail. |