CNC Wire EDM: Programming Wire Cuts

Objective

Students will be able to:

- Develop a program and setup the Computer Numerical Control (CNC) Wire Electrical Discharge Machining (EDM) machine
- Analyze the program for errors using the CNC simulator and revise the program as needed
- Operate and setup the CNC Wire machine, this will include wire setup, work piece offsets, program input into the CNC control, and part prove out

Orienting Questions

✓ What is a CNC Wire EDM Machine?
✓ What advantages does CNC Wire EDM machining have over conventional machining?
✓ What are some restrictions to using CNC Wire EDM machining?
4.1 INTRODUCTION TO WIRE EDM MACHINING AND PROGRAMMING

Electric Discharge Machining, also known as EDM, is a machining process using electrical discharges (sparks) with temperatures between 10,000-20,000 degrees C to remove material from the workpiece. Machining is done by rapidly recurring current discharges between the Electrode (wire) and the workpiece causing the material to be eroded and flushed away. The wire (Electrode) does not touch the workpiece, it is separated by a Dielectric Fluid (De-ionized water or mineral oil). The insulating effect of the Dielectric Fluid used in EDM process is very important as it prevents the Electrolysis of the Electrodes during the process.

EDM Machining has been around since World War II for the use of removing broken taps and drills for the workpiece. This process opened the door for sinker, conventional ram, plunge, or diesinker EDM’s. Wire EDM was introduced in the late 1960’s. The advancements in EDM machining has revolutionized the tool and die, mold making industries.

There are two basic types of EDM machines, one is the “Wire-cut EDM” and the other is “Die-sinker EDM”. The wire EDM uses a thin wire being pulled off a spool as the Electrode, the Die-sinker EDM uses a pre shaped Electrode for the EDM process. EDM machining are also referred to in the industry as spark machining, wire erosion, wire burning, die sinking, ram EDM, and spark eroding.

The EDM process is used to produce molds, complex die shapes, machining of hardened materials including carbide, and is becoming a common method of making prototype and production parts. EDM machines can be setup and run unmanned when programmed properly, quite often is not required for the operator to remain at the machine, therefore saving the company money in wages.

EDM machining can be used on materials that are electrically conductive regardless of the hardness of the material. Some materials can be a problem to machine with conventional methods due to material hardness and toughness.

Machining process with EDM will leave a random pattern on the surface rather than tool marks from a mill, lathe, or grinder. EDM machines are capable of doing small parts as well as large, with minimal clamping since the wire/Electrode does not touch the workpiece. EDM’s are able to produce parts of extreme accuracy and very good surface finish.

Wire cut path is programmed very similar to contour milling on a CNC machining center.

This module teaches how to program “Wire EDM” machines. The examples in this module is for the Mitsubishi EDM controls, for other model controls codes may need to be modified.
4.2 CNC WIRE EDM PROGRAM PLANNING AND SOLVING POINT VALUES

In this section we will study the sample print and solve points for writing Wire EDM Operations. The machine to being programmed is a 5 axis Mitsubishi Wire EDM machine.

4.2.1 WIRE PART PRINT

The prints in Figures 1 through 3 will be used in programming the example throughout this module.

Figure 1, 3D model of the finished part
4.2.2 WIRE THREAD LOCATIONS

Holes must be drilled into the work piece at a known location for programming and machining purposes. This location must be programmed in the X and Y axis to thread the wire from the top wire guide to the bottom wire guide. The hole location and size of the hole chosen must not cut into the finish part. The location of the holes is chosen with a machining plan in mind, it must be a good place to start into the part and a good location for the tab.

The tab is the last cut that for each shape that separates the part from the stock. Depending on the tolerance allowed if there is an imperfection caused by cutting through the tab this must be touched up on a surface grinder, so pick a good place that can be reached with a grinding wheel. Some shapes will allow to use the entire last edge to cutoff the part, so the tab would start in one corner and end at the next corner. If possible secured to the part to the work piece when the machine reaches the tab (M00 mandatory machine stop) just before cutting off the part, the imperfection may be eliminated.

Study the print in Figure 1 through 3, that will be used in the programming the examples throughout this module.
Considering Figure 3, explain why the wire threads are placed in that particular location.

4.2.3 PRAGRAMMING POINT IDENTIFICATION

Study the drawing in Figure 4 below that will be used to reference to the point chart, in Figure 5, with X and Y location values that will be used in programming.
**4.2.4 SOLVING PROGRAMMING POINT VALUES, ACTIVITY 1**

Using Figures 1-5, fill in the values in the point chart below, see 4.9.1 for answers.

<table>
<thead>
<tr>
<th>EDM Points</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Point #</td>
<td>X Value</td>
<td>Y Value</td>
<td>R Value</td>
</tr>
</tbody>
</table>

Figure 4, Point identification used to fill in point chart, and used to aid in programming
4.3 CNC WIRE EDM: PROGRAMMING WIRE CUT OPERATIONS

In this section we will look at codes used, and write the program for the Wire EDM. The machine to be programmed is a 5 axis Mitsubishi Wire EDM machine. The list of codes below, are for a reference until you learn the codes through repeated use.
4.3.1 G-CODES USED IN PROGRAMMING THE WIRE EDM MACHINE

The following G codes are available for the Mitsubishi Wire EDM. We will use these codes to write a CNC program in section, 4.3.4

G00 Rapid Positioning -XYUVZ
G01 Location Linear movement - XYUVZ Location
G02 Circular Interpolation CW- IJK Circle Center R Circle Radius
G02.1 Helical Interpolation CW- IJK Circle Center
G03 Circular Interpolation CCW- IJK Circle Center R Circle Radius
G03.1 Helical Interpolation CCW- IJK Circle Center
G04 Dwell- X Dwell Time in (.001 Sec)
G05 Coordinate Rotation (Angle K)
G06 Coordinate Rotation Off - None
G14 Set Information to Variables- XYZC Variable # to set Value P0. Program Pos. 1. Machine Pos. 5. Start Time
G22 Sub program Call- L Sub program to Call H Sequence Number to Call P Times to Repeat Sub
G23 Sub Program End - None
G27 Zero Pt Verification Memory Type
G28 Zero Pt Return - XYUVZ Axis to Zero Pt
G29 Edge Positioning Call – XY Direction Rapid Move R Rot. Angle P Edge Speed, R Tolerance Q. Variable for Results
G30 Hole Positioning- XY Direction IJ Rapid Move R Rot. Angle P Edge Speed, R Tolerance Q. Variable for Results
G40 Wire Offset Cancel - None
G41 Wire Offset Left - None
G42 Wire Offset Right - None
G43 Transfer ATC & WKPC offset- XYZC Variable Value to Transfer P Tool number of Comp (no P sets work offset)
G43.1 Transfer Time Data- X Variable # to store.
G44 Write a value to Variables P Value Q is Variable
G44.1 Time Data Variable
G46 Micro Joint Function used with H40
G48 No.2 to No. 4 Zero Pt. Return XYUVZ Axis to Zero Pt
G50 Mirror Image OFF- XYZC Designates Axis to Cancel Mirror Function
G50.1 Figure Scale Cancel
G51 Figure Scale setting

Continued

G51.1 Mirror Image ON XYZC Value given is location at which to Mirror Axis
G52 Local Offset Setting
G53 Used with G92 to activate work offsets
G54 Sets to Active Work Coordinate.
G54.1 Set Work Numb as Work Pos P designates Work Number to Use (00-99)
G55 Sets G55 to Active Work Coordinate.
G56 Sets G56 to Active Work Coordinate.
G57 Sets G57 to Active Work Coordinate.
G58 Sets G58 to Active Work Coordinate.
G59 Sets G59 to Active Work Coordinate.
G60 Dog Type Zero Pt Return - XYZVU Axis to Zero Pt
G62 G command Mirror Image XYZC Mirror ON/OFF 1. ON 0. OFF
G63 Soft Limit Activation H## -1st# 1-5 Soft limit to activate 2nd# 0. Outside 1. inside
G64 Soft Limit Invalid H## 1-5
G65 Macro Simple Call- L Program Number P Number of Repeats A-Z Local Variables (see back of page)
G66 Macro Modal access A-L Program Number P Number of Repeats A-Z Local Variables (see back of page)
G66.1 Macro Modal access B-L Program Number P Number of Repeats A-Z Local Variables (see back of page)
G67 Macro Modal Cancel
G69 Clear Circle End Point Error
G70 Inch Command - None
G71 Metric Command - None
G72 Absolute Value Command - None
G78 Automatic Wire Alignment- XY Direction to do wire alignment
G87 Creates a constant radius in a tapered part (used on G2 or G3 Line)
G88 Automatically put radius equal offset into punch or undercuts die
G89 Default Corner mode in the machine
G90 Absolute Positioning Mode
G91 Incremental Positioning Mode
G92 Program Position Setting
G101 A = B
G102 A = B + C
G103 A = B - C
G104 A = B * C
G105 A = B / C
G106 A = SQRT(B2 + C2)
G107 A = B * SIN (C)
G108 A = B * COS (C)
G109 A=TAN (B/C)
G110 A = SQRT(B2 - C2)
G111 3PT Center Find- A B 1st XY loc. C D 2nd XY 3rd XY X Var. of X center Y Var. of Y center R Var. of Radius

Continued

G112 Tangent Function
G200 Uncondition Branch-A N number to branch too
G201 Zero Condition Branching-A N number to branch BC Values are compared if equal machine branches
G202 Negative Condition Branching-A N number to branch B is less than machine branches
G203 Bit Test

### 4.3.2 M-CODES USED IN PROGRAMMING THE WIRE EDM MACHINE

The following M codes are available for the Mitsubishi Wire EDM. We will use these codes to write a CNC program in section, 4.3.4

- M00 Program Stop
- M01 Optional Stop
- M02 Optional Stop
- M03 **Electrode** Rotation ON
- M05 **Electrode** Rotation OFF
- M20 Wire Insert
- M21 Wire Cut
- M22 AWF Test
- M23 AWF Reset
- M24 AEC Wire Set 1
- M25 AEC Wire Set 2
- M30 Program End
- M32 Tank Circulation ON
- M33 Tank Circulation OFF
- M46 Initial Hole Compensation 1
- M47 Initial Hole Compensation 2
- M48 Initial Hole Compensation 3
- M49 Initial Hole Compensation 4
- M58 Drain to Table Level
- M60 External Signal Output 1 ON
- M61 External Signal Output 1 OFF
- M62 External Signal Output 2 ON
- M63 External Signal Output 2 OFF
- M64 External Signal Output 3 ON
- M65 External Signal Output 3 OFF
- M66 External Signal Output 4 ON
- M67 External Signal Output 4 OFF
- M68 External Signal Output 5 ON
- M69 External Signal Output 5 OFF

Continued

- M70 Initial Hole Mode ON
M71 Initial Hole Mode OFF  
M74 Filter Pump ON  
M75 Filter Pump OFF  
M76 Fluid Cycle ON  
M77 Fluid Cycle OFF  
M78 Rapid Fill (submerged)  
M80 Fluid ON  
M81 Fluid OFF  
M82 Wire ON  
M83 Wire OFF  
M84 Machining ON  
M85 Machining OFF  
M88 Fluid Weak  
M89 Fluid Full  
M90 Adaptive Control ON  
M91 Adaptive Control OFF  
M93 All Stop  
M96 Programmable Function ON  
M97 Programmable Function OFF  
M101 Power Master OFF

4.3.3 OTHER CODES USED IN PROGRAMMING THE WIRE EDM MACHINE

The following other codes are available for the Mitsubishi Wire EDM. We will use these codes to write a CNC program in the next section, 4.3.4

**Axis designations:**
X, Y, and Z axis are the three major axis that are used very similar to the CNC Machining center. X and Y are table movements, X axis left and right motion, Y axis is perpendicular to the X axis and moves back and forth. The Z axis is programmable but is recommended to not program the Z axis but to place the Z axis at the machining height before starting the cut.
U and V axis are used to tilt the wire at an angle for tapper cuts and 4 axis machining. U and V axis will move the upper head similar to the X and Y axis, causing the wire to be at an angle between the top guide and the lower guide.

**E and F codes:**
E-pack (E###) and Feed Rate (F##) codes are used in programming to set machining conditions, the proper E-pack numbers and feed rates are listed in the Mitsubishi book and at the control. The proper E-pack is determined by: wire material, wire diameter, material type, and material thickness. Code Example: E952 or E1231

**H codes/variables:**
H (H##) codes/variables are used to define a variable amount used in wire compensation. The value to assign is also found in the Mitsubishi book with the E-packs. In our program example the H = ##### is the
amount of the radius the wire burns into the part. The wire we will use measures .010 inch diameter, however the arc from the wire to the material being cut causes the wire to burn larger than the wire measures. The wire does not ever touch the workpiece, the H value will be larger than the radius of the wire.

LEARNING ACTIVITY OTHER CODES

Match the following characteristics with the correct codes.

- **H codes/variables**: three major axis that are used very similar to the CNC Machining center.
- **E and F codes**: available for the Mitsubishi Wire EDM and are used to write a CNC program.
- **Axis designations**: used in programming to set machining conditions.
- **M and G codes**: used to define a variable amount used in wire compensation.

4.3.4 WRITING THE PROGRAM FOR THE WIRE EDM

USING THE POINTS FROM 4.2.4, WE WRITE A CNC PROGRAM FOR THE WIRE EDM, SEE BELOW.

Writing the Wire EDM Star project.

% L57/MTT 253 STAR PROGRAM
H01=0.00680 (WIRE RADIUS OFFSET- GET FROM E-PACK BOOK)
G62 X0. Y0. (MIRROR IMAGE OFF)
G70 (INCH)
G90 (ABSOLUTE)
G92 X0 Y-.152 Z0. (SET COORDINATE SYSTEM, THIS IS THE CURRENT LOCATION FROM THE ORIGIN)
M91 (ADAPTIVE CONTROL OFF)
M20 (THREAD WIRE)
M78 (FILL TANK FIRST STAGE)
M78 (FILL TANK SECOND STAGE SAFETY FEATURE)
E952 F.04 M90 (STARTUP E-PACK-GET FROM E-PACK BOOK, AND ADAPTIVE CONTROL ON)
M80 (FLUID ON)
M82 (WIRE ON)
M84 (MACHINING ON)
G92 X0 Y.152 Z0. (VERIFY-SET COODINATE SYSTEM)
G01 G41 Y.3516 H01 (COMPENSATION ON TO THE LEFT USING OFFSET H01) (POINT 2)
E1231 F.12 (NORMAL E-PACK AND FEEDRATE- GET BOTH FROM E-PACK BOOK)
X.203 (POINT 3)
X.4059 Y0 (POINT 4)
X.203 Y-.3516 (POINT 5)
X-.203 (POINT 6)
X-.4059 Y0 (POINT 7)
X-.203 Y.3516 (POINT 8, STOP HERE, THIS WILL BE THE TAB LOCATION)
M00 (MANDATORY STOP)

Continued

X.01 (POINT 2) (CUT PAST POINT 2 BY THE WIRE DIAMETER)
G40 X0 Y.152 (COMP OFF) (POINT 1)
G04 X5.0 (DWELL OF 5 SECONDS)
M85 M83 M81 (MACHINING-WIRE-FLUID OFF)
M21 (CUT WIRE)
M01 (OPTIONAL STOP)
G0 X.862 Y-.669 (POINT 9)
H01=0.00680 (WIRE RADIUS OFFSET- GET FROM E-PACK BOOK)
G62 X0 Y.0. (MIRROR IMAGE OFF)
G70 (INCH)
G90 (ABSOLUTE)
G92 X.862 Y-.669 Z0. (SET COORDINATE SYSTEM, THIS IS THE CURRENT LOCATION FROM THE ORIGIN)
M91 (ADAPTIVE CONTROL OFF)
M20 (THREAD WIRE)
M78 (FILL TANK FIRST STAGE)
M78 (FILL TANK SECOND STAGE SAFETY FEATULRE)
E952 F.04 M90 (STARTUP E-PACK-GET FROM E-PACK BOOK, AND ADAPTIVE CONTROL ON)
M80 (FLUID ON)
M82 (WIRE ON)
M84 (MACHINING ON)
G92 X.862 Y-.669 Z0. (VERIFY-SET COODINATE SYSTEM)
G01 G42 X.8119 Y-.4687 H01 (COMPENSATION ON TO THE RIGHT USING OFFSET H01) (POINT 10)
E1231 F.12 (NORMAL E-PACK AND FEEDRATE- GET BOTH FROM E-PACK BOOK)
X.5413 Y0 (POINT 11)
X.8119 Y.4688 (POINT 12)
X.2706 (POINT 13)
X0 Y .9375 (POINT 14)
X-.2706 Y.4687 (POINT 15)
X-.8119 (POINT 16)
X-.5413 Y0 (POINT 17)
X-.8119 Y-.4687 (POINT 18)
X-.2706 (POINT 19)
X0 Y-.9375 (POINT 20)
X.2706 Y-.4688 (POINT 21)
X.5413 (POINT 22, TAB LOCATION)
M00 (MANDATORY STOP)
X.8219 (POINT 10) (CUT PAST POINT 10 BY THE WIRE DIAMETER)
G40 X.8119 Y-.669 (POINT 9)
G04 X5.0 (DWELL OF 5 SECONDS)
M85 M83 M81 (MACHINING-WIRE-FLUID OFF)
M21 (CUT WIRE)
M58 (DRAIN TANK)
G23 (SUB PROGRAM END)
M02 (PROGRAM END)
%

**LEARNING ACTIVITY 4.3.5**

Briefly describe the differences and similarities between Milling, Turning, and EDM programs.

**4.4 PROGRAM SIMULATION FROM CAD/CAM SOFTWARE**

In this section video simulations of the part being machined using CAD/CAM software.

I was not able to include an actual video of the part being cut at the machine due to the fact that while machining is taking place, the part is submerged in water, a video would not be able to show the machining taking place.
4.4.1 WIRE EDM WIRE PATH SIMULATION

Click the YouTube links below to watch video simulations of the wire cutting path. Simulation video 1 shows the wire guides with transparency setting in the CAM software turned on, look for the wire inside the wire guide. Simulation video 2 the wire guide has been hidden in the CAM software so you can better see the wire in the simulation moving around the shape.

Simulation video 1 (with wire guide visible)
Simulation video 2 (with wire guide hidden from view)

VIDEO ACTIVITY

In Simulation videos 1 and 2, briefly describe the process of cutting the shape using wire edm. What is the “tab” that is described in the video?

In both simulation videos, a “M00” command is used in the programming. Why would this function be required during the process?

4.5 OVERVIEW OF EDM MACHINE

In this section there is photos of the Wire EDM machine we will be programming, and video simulations of the part being machined. I was not able to include an actual video of the part being cut at the machine due to the fact that while machining is taking place, the part is submerged in the tank of water, a video would not be able to show the machining taking place.

4.5.1 WIRE EDM MACHINE
Figure 5, this is the Mitsubishi FA-10S- Advanced Wire EDM machine that we will be programming.

Figure 5, Wire EDM Machine

4.5.2 WIRE EDM MACHINE, MITSUBISHI CONTROL
Figure 6, Mitsubishi FA-10S- Advanced Wire EDM machine control.

Figure 6, Wire EDM Machine Control

4.5.3 WIRE EDM MACHINE, MITSUBISHI CONTROL E-PACK
Figure 7 below, this is the Mitsubishi FA-10S- Advanced Wire EDM E-Pack setting screen. The values in this chart must be adjusted for material type, thickness, wire diameter, wire speed, feed rate, and amount of power to use for the machining process. These setting are taken from a chart provided by the machine manufacturer, they may be tweaked by the operator during the machining operation or before the start of the cut.

**Figure 7, Wire EDM E-Pack settings**

**DESCRIPTION OF E-PACK SETTINGS AS FOLLOWS:**
**Vo Open Voltage** - (1-16) 65 to 150 Volts-Voltage to initiate spark. Higher Voltage- More Spark Intensity, Faster Burn time. Lower Voltage- Spark spreads out, used to help stabilize.

**IP Intensity of Pulse** - (1-18) Combination of Amperage and Spark Duration 4 to 18 - Rough settings or Initial Skim 1 to 3 - Lower Power settings used for finishing Skims

**OFF Off Time** - (1-16) Pause Time between sparks AE power supply changes, Off time automatically with IP above 4

**SA Stabilizer A** - (1-8) Sets Intensity of Secondary Spark usually set by diameter of wire at IP 4 and above sets power level of spark when instability is measured with IP spark. At IP 3 or Lower sets Ontime of individual power spike.

- .004 - 1
- .006 - 2 to 3
- .008 – 3 to 5
- .010 – 4 to 6
- .012 – 4 to 8
- .014 – 5 to 8

**SB Stabilizer B** - (1-16) Sets Time between SA pulses, Higher the setting the more Off time between SA pulses, Good Adjustment because doesn’t effect size or Finish

**WS Wire Speed** - (1-16) The higher the Value the faster the Wire travels. Don’t lower if higher accuracy is needed.

**WT Wire Tension** - (100 to 2500) Tension of Wire in grams. Lowered for high speed cuts but will cause wire to trail behind, Raise Tension to increase accuracy

**PT Pre-Tension** - (1-16) 50 to 300 grams, Amount of tension applied by wire spool, set by spool size

- Spool Size Pre Tension
  - P1 3..5 Lb 10
  - P3 6..6 Lb 10
  - P5 11 Lb 14

**LQ Liquid Quantity** - (1 or 2) Controls use of high or low pressure

- 1 - Low pressure- used during finishing, reduces
- 2 - High pressure- used for roughing

**LR Liquid Resistivity** - (1-9) Sets conductivity of fluid, Higher settings cause more conductive fluid

**VG Voltage Gap** - (1-150 Volts) Sets Target Voltage for machine to Maintain

Used with adaptive control (M90) Increase VG increases gap width which improves flushing
Decreasing VG will increase burn speed with good flush, Material less than .075 thick should not use Adaptive Control (M90).
Briefly describe the difference between (1) Stabilizer A and Stabilizer B, and (2) Wire Speed and Wire Tension.

**4.5.4 WIRE EDM MACHINE, AUTOMATIC THREADING DEVICE**

*Figure 8*, Mitsubishi FA-10S- Advanced Wire EDM “AT Device” automatic threading unit.

*Figure 8*, Wire EDM Automatic Threading Device (AT)

**4.5.5 WIRE EDM MACHINE, WIRE THREAD PATH**

*Figure 9*, Mitsubishi FA-10S- Advanced Wire EDM “AT Device” automatic threading unit. (Continued) The wire spool is the large spool located on the left in the picture. The wire then is threaded around a series of
rollers, then goes into the AT device, shown with the cover off, to be threaded through the upper and lower wire guides.

**Figure 9**, Wire EDM Automatic Threading Device (AT)

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**4.5.6 WIRE EDM MACHINE, AUTOMATIC THREADING DEVICE**

**Figure 10**, Mitsubishi FA-10S- Advanced Wire EDM “AT Device” automatic threading unit. (Continued) This close up view of the AT device without the cover shows how intricate of a device this really is. If you
look closely you should be able to see the .001 diameter wire as it enters from the top, and goes through the pinch rollers first, then it is threaded on through the device and wire guides.

Figure 10, Wire EDM Automatic Threading Device (AT)

4.5.7 WIRE EDM MACHINE, WIRE AND UPPER AND LOWER FLUSH CUPS
Figure 11, Mitsubishi FA-10S- Advanced Wire EDM, at the top you can see the black flush cup with the wire coming through and going into the lower white flush cup. The upper and lower wire guide is inside the flush cup, you cannot see the actual wire guides.

Figure 11, Wire EDM Flush Cup and Wire Threaded

4.5.8 WIRE EDM MACHINE, WIRE AND LOWER FLUSH CUP
Figure 12 below, this is the Mitsubishi FA-10S- Advanced Wire EDM, wire and lower white flush cup.

Figure 12, Wire EDM Lower Flush Cup and Wire Threaded

4.5.9 WIRE EDM MACHINE, WIRE AND UPPER FLUSH CUP
Figure 13 Mitsubishi FA-10S- Advanced Wire EDM, wire and upper black flush cup.

Figure 13, Wire EDM Upper Flush Cup and Wire Threaded

MAJOR CONCEPTS
KEY CONCEPTS WHEN USING WIRE EDM CNC MACHINES

- The operation and setup the CNC wire machine includes wire setup, work piece offsets, program input into the CNC control, and part prove out.
- Wire EDM Machining can be used to machine parts that can conduct electrical current to remove and cut material. Many times EDM machining process are used because the machines can run parts without an operator present at the machine. This process must be analyzed for errors using the CNC simulator and revised if necessary. EDM machining is capable of cutting hard materials that otherwise would have to be machines with slow grinding processes such as hardened tool steel, or carbide.
- Many times EDM machining can eliminate final grinding process, therefore saving time.
- EDM Electrodes are able to create very tight corners in parts that may not be possible by other machining processes.

KEY TERMS

**De-ionized water** – Water that is no longer conductive of electricity. Water is circulated through special filters at the machine to remove the ions from the water, making it non-conductive.

**Dielectric Fluid** – De-ionized water or mineral oil is used as an insulator and as coolant for the burning process. The fluid is used to fill and submerge the workpiece, and is forced through the flush cup around the wire as a jet stream of water, this helps cool the wire, and remove the particles of material from the area where electrical arcs are being created for machining.

**EDM** - is short for Electrical Discharge Machining. Machining is achieved by means of non-contact machining. An electrode and electrical current is used for the removal of material. Small arcs are created when the electrode is close to the workpiece but not touching the workpiece. Each small arc will cause a breakdown of the material being machined and particles are removed by flushing.

**Electrode** – electrically conductive material used for the positive current, which allows arcing to take place at the point of machining. This process will erode the material from the part and will also erode the material being used as an electrode. Electrodes for wire EDM machining are generally made from Brass of steel. Electrodes for sinker type EDM are made from graphite or a mixture of graphite and brass or bronze.

**Electrolysis** – is the decomposition of the water (H₂O) into oxygen (O₂) and hydrogen gas (H₂). This is due to the electric current being passed through the water during machining. This helps to keep from breaking down the Electrode (wire).
PHYSICAL LAB USING THE MITSUBISHI FA10S ADVANCED WIRE EDM MACHINE

-Introduction: Lab project, using the print in Figure 14 below, study the print, solve the point values and record them in a blank point chart. This part is similar to the one used in this lesson, write a program for the wire EDM before your lab appointment.

-Materials and methods: Use the program presented in this lesson as a guide for writing a program for this lab project.

-Requirements for successful lab completion: The following is necessary to complete the lab project.
  1. Study the print
  2. Identify points, solve and fill in the point chart.
  3. Write a workable CNC wire EDM program.
  4. Make an appointment with your instructor and attend the lab to prove out your program.
ASSESSMENT

TEST 1, ANSWERS TO FOLLOW

Multiple Choice: Read the following questions or statements and select the best answer.

1. When programming the Mitsubishi Wire EDM, how do I determine the burn settings?
   a. By the weight of the material being cut, the machine will adjust for conditions
   b. The machine will determine settings when the wire touches the part
   c. E-pack settings are determined by wire diameter, material type, and thickness
   d. None of the above

2. For machining to take place on any type of EDM machine, what is required?
   a. The material must not conduct electrical current
   b. When cutting plastics a ground strap must be connected
   c. The material must be electrically conductive
3. What is the purpose of dielectric fluid in the machining area?
   a. It keeps the wire cool so it will not break
   b. It prevents the Electrolysis of the Electrodes
   c. To keep the particles flushed away at the point of machining
   d. All of the above

4. Wire EDM machine removes material from the workpiece by cutting with:
   a. very small saw teeth on the wire.
   b. friction and heat buildup.
   c. electrical current arcing to the workpiece.
   d. None of the above.

5. Surface finish created by cutting with a Wire EDM machine can be improved by:
   a. programming skim cuts
   b. increasing the feed rate
   c. leaving material for milling operation
   d. All of the above

TEST 2, ANSWERS TO FOLLOW

Instructions: Check Yes or No.

1. Can a Wire EDM machine cut soft and hard materials?
   [ ] Yes
   [ ] No

2. Are EDM machines able to cut a counter bore in a hole?
   [ ] Yes
   [ ] No

3. Is programming a cut path on a Wire EDM similar to turning on a CNC Lathe?
4. Was the EDM technology first created for the removal of broken taps in parts?

☐ Yes  ☐ No

5. Can multiple wire cuts be machined in one operation?

☐ Yes  ☐ No

CRITICAL THINKING

Choose one or two formative assessments to include here:

- **One Sentence Summary:** Describe in 1 sentence, how the EDM removes material being machined. Be sure to include answers to some of the following questions in your sentence; “Who does what to whom, when, where, how, and why?”

- **Sequencing Events:** Describe how to determine the order of cuts to be made on a part that has multiple contour shapes to be machined in one operation.

ANSWERS TO ACTIVITIES

4.2.4 ANSWER

The location of the holes is chosen with a machining plan in mind because it must be a good place to start into the part and a good location for the tab.

4.3.5 ANSWER

G-code translates seamlessly between CNC equipment in reference to programming. Ex. G01 – Linear interpolation, moves in a straight line regardless of machine type. The difference may be found in function, M-code. Ex. M06 – Tool change is required to change a tool in a milling program, but not a turning or EDM program.
VIDEO ACTIVITY ANSWERS

Answer: The wire is entering the cut and following a programmed path on both shapes. A M00 code is used after the tab is cut before it performs a rapid move to start the next shape. The tab is used so that the part does not just fall in the tank of the EDM machine because the contoured shape is being cut from a bigger piece of material.

In both simulation videos, a “M00” command is used in the programming. Why would this function be required during the process?

Answer: The M00 code is used to stop the machine which will give the operator time to evaluate the progress of the program and assess the features for variations. In the case of using an EDM it may give the operator a chance to thread the wire to start the next cut.

4.5.4 ACTIVITY ANSWER

Stabilizer A sets the intensity of the secondary spark. Stabilizer B sets the time between SA pulses, Wire Speed is higher if the value is faster than the wire travel and should not be lowered if higher accuracy is needed. Wire Tension is measured in grams and can be raised to increase accuracy.

OTHER CODES ANSWER

Below are the correct answers

H codes/variables used to define a variable amount used in wire compensation
E and F codes used in programming to set machining conditions
Axis designations three major axis that are used very similar to the CNC Machining center.
M and G codes available for the Mitsubishi Wire EDM and are used to write a CNC program

4.9.1 ANSWERS TO POINT CHART
**EDM Points- Answers**

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**ANSWERS TO TEST 1 AND 2**
Answer Key

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Figure 17, Answers

**ANSWERS TO CRITICAL THINKING QUESTION**

- One Sentence Summary: EDM removes material being machined. Be sure to include answers to some of the following questions in your sentence; “Who does what to whom, when, where, how, and why?”

Electric Discharge Machining, also known as EDM, is a machining process using rapidly recurring current discharges with temperatures between 10,000-20,000 degrees C between the Electrode (wire) and the workpiece causing the material to be eroded and flushed away.

- Sequencing Events: Describe how to determine the order of cuts to be made on a part that has multiple contour shapes to be machined in one operation.

The order of cuts to be made on a part is determined by origin (the location where the x, y and z positions originate.)

**FURTHER STUDY**

The video links below show some related EDM machining operations and EDM technology.

https://www.youtube.com/watch?v=pBueWfzb7P0

https://www.youtube.com/watch?v=eaeEn1Gs4aQ

https://www.youtube.com/watch?v=W1YFP8bmEKY

https://www.youtube.com/watch?v=q4FinKsDfww
https://www.youtube.com/watch?v=aWQsEX1TrSI

## ATTRIBUTION TABLE

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