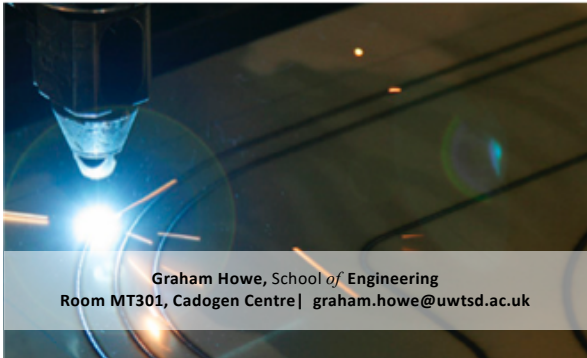


Non-Traditional Machining



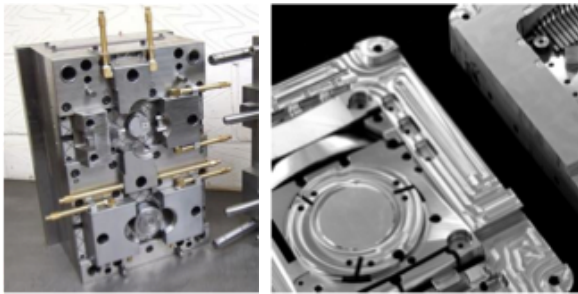
Graham Howe, School of Engineering
Room MT301, Cadogan Centre | graham.howe@uwtsd.ac.uk

1

What we will look at today



- How are plastic injection mould tools made?



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Objectives for today



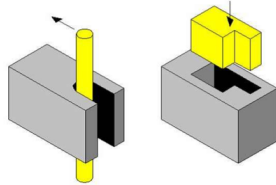
- Review the reasons why we use Non-Traditional Machining.
- Review Electro Discharge Machining (EDM)
- Calculate some machining times for EDM

3

Electrical Discharge Machining



- During the 1770s Joseph Priestly discovered the erosive effect of electrical discharges.
- 1970's onwards saw it's development with machine tools.
- Essentially 2 types of EDM;
 - Ram Machining
 - Wire Machining



What made it interesting?



- The efficiency of chip removing operations is limited;
 - By the mechanical properties of the material being machined.
 - By complicated geometrical workpiece shapes.
- The characteristics of chip removing processes make them wholly unsuitable for the production of certain cavities.
- Deep cavities and sharp inner edges are impossible to produce.
- 2 factors; the form and the material were the reasons for the development and use of a series of manufacturing techniques under the heading "material removal machining operations"



Manufacturing Technology



Electrical Discharge Material Removal

- Electrical Discharge Machining (EDM) is a reproductive forming technique in which the tool electrode reproduces itself in the workpiece electrode.
- In this tool electrode wear does occur.
- In contrast to Electro Chemical Machining



Electrical Discharge Machining



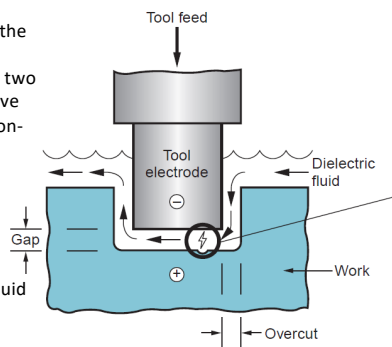
- In basic terms, EDM consists of the following 4 elements;
 - Generator
 - Control System
 - Machine
 - Unit for the working medium

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Electrical Discharge Machining



- Material removal is the result of electrical discharges between two electrically conductive materials under a non-conductive fluid.
- Series of rapidly recurring charges
- Electroerosion
- Remove excess by fluid flow

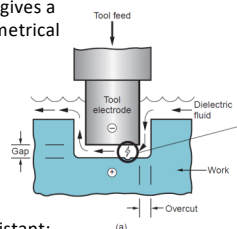


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Electrical Discharge Machining



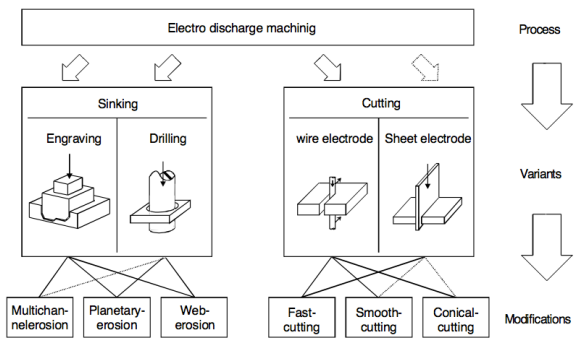
- Physical tooling, geometry of that tool gives a positive impression of the hole or geometrical feature to be machined.
- Electrically conductive
- Material remove rate, depends on?
 - Melting temperature of the work material
 - Specific heat of the work material
 - Density of the work material
 - Thermal conductivity of the work material



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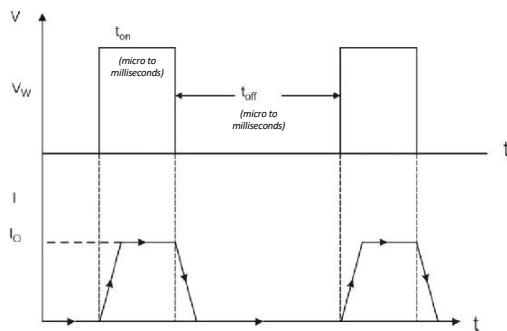
- Dielectric fluid should be thermally resistant;
 - Spark conductor in the spark gap between the tool and work material.
 - Coolant to quench the spark and to cool the tool and work piece.
 - Carry away the condensed metal particles and to maintain the gap for continuous and smooth operation.

Electrical Discharge Machining



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Electrical Discharge Machining



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Process Parameters



- The Open Circuit voltage – V_0
- The Working Voltage – V_W
- The Maximum Current – I_0
- The Pulse On time – t_{ON} (micro to milliseconds)
- The Pulse Off time – t_{OFF} (micro to milliseconds)
- The gap between the work piece and the tool, spark gap
- Dielectric Medium
- External flushing through the spark gap. (Not static, made to flow through the spark gap)

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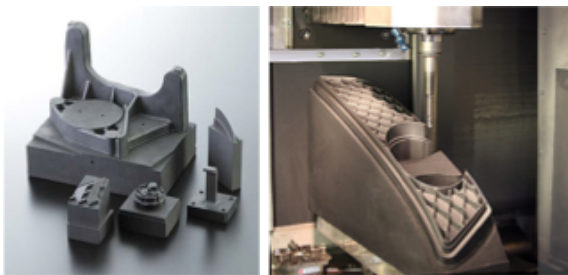
Tool characteristics



- High thermal conductivity
- High electrical conductivity
- Higher density material;
 - Higher the density, the lower the dimensional loss of the material.
- High melting point leading to lower tool wear.
- Manufacturability and machinability important.
- Graphite becomes the tool material of choice.

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Electrode Materials and Manufacture

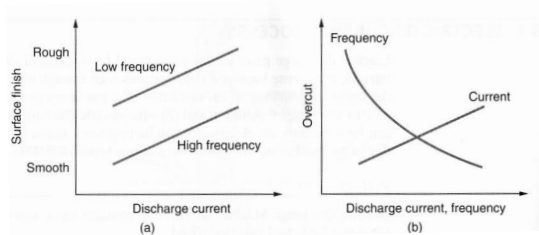


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Surface finish



a) Surface finish in EDM and b) Overcut both as a function of discharge current and frequency of discharges.

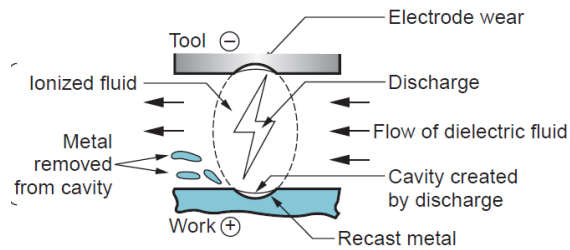


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Tool wear



- Considerations to tool wear?
- Is the hardness or strength of work material a factor?



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Metal Removal Rate Calculation 1



$$R_{MR} = \frac{KI}{T_m^{1.23}}$$

- R_{MR} = Metal Removal Rate (mm^3/s)
- K = Constant of Proportionality whose value = 664 in SI units.
- I = Discharge current (Amps)
- T_m = Melting temperature of work metal ($^{\circ}\text{C}$)
- Copper is to be machined in an EDM operation. If the discharge current = 25 Amps, what is the expected material removal rate?
- Melting point of copper = 1083°C

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Metal Removal Rate Calculation 1



- So we should have;

$$R_{MR} = \frac{664(25)}{1083^{1.23}} = 3.07 \text{ mm}^3/\text{s}$$

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Metal Removal Rate Calculation 2



$$R_{MR} = \frac{KI}{Tm^{1.23}}$$

- R_{MR} = Metal Removal Rate (mm^3/s)
- K = Constant of Proportionality whose value = 664 in SI units.
- I = Discharge current (Amps)
- T_M = Melting temperature of work metal ($^{\circ}\text{C}$)
- An injection moulding soft-tool made from Aluminum is to be machined in an EDM operation. The volume of material to be removed is $95,000\text{mm}^3$ If the discharge current = 20 Amps, what is the expected machining time?
- Melting point of Aluminum = 660°C

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Metal Removal Rate Calculation 2



- So we should have;

$$R_{MR} = \frac{664(20)}{660^{1.23}} = 4.52\text{mm}^3/\text{s}$$

- The volume of material to be removed is $95,000\text{mm}^3$
- **5.8 hours machining time.**

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Feedrate Calculation 1



$$R_{MR} = \frac{KI}{Tm^{1.23}}$$

- R_{MR} = Metal Removal Rate (mm^3/s)
- K = Constant of Proportionality whose value = 664 in SI units.
- I = Discharge current (Amps)
- T_M = Melting temperature of work metal ($^{\circ}\text{C}$)
- An EDM operation is to be performed on a slab of 2.6cm thick aluminium using a brass wire electrode whose diameter = 0.5cm.
- It is anticipated that the overcut will be 0.004cm, so that the kerf width will be 0.018cm.
- Using a discharge current = 7 amps, what is the expected allowable feed rate that can be used in the operation?
- The melting temperature of aluminium is 660°C

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Feedrate Calculation 1



- So we should have;

$$R_{MR} = \frac{664(7)}{660^{1.23}} = 1.58 \text{ mm}^3/\text{s}$$

- Material thickness: **2.4cm**
- Frontal area of Kerf (Wire diameter 0.5cm + Overcut 0.004cm*2) = **0.508cm**
- $2.4 * 0.508 = 1.22 \text{ cm}^2$
- Feedrate = $1.58 \text{ mm}^3/\text{s} * (0.1)^3 * 60 / 1.22 \text{ cm}^2 = 0.777 \text{ cm/min}$

To note:

- R_{MR} is in seconds.
- Feedrates are usually given per minute.

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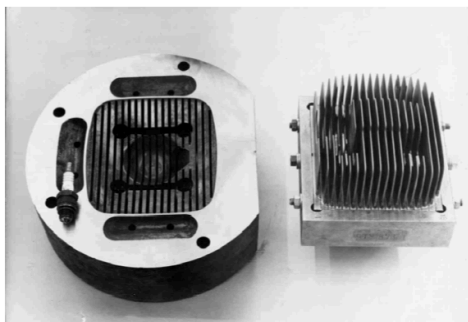
So we have...



- Reviewed the reasons why we use Non-Traditional Machining.
 - The efficiency of chip removing operations is limited;
 - By the mechanical properties of the material being machined.
 - By complicated geometrical workpiece shapes.
- The characteristics of chip removing processes make them wholly unsuitable for the production of certain cavities.
- Deep cavities and sharp inner edges are impossible to produce.
- Reviewed Electro Discharge Machining (EDM)
- Calculated some machining times for EDM.
- Further exercises will be available on Moodle on Tuesday 6th May

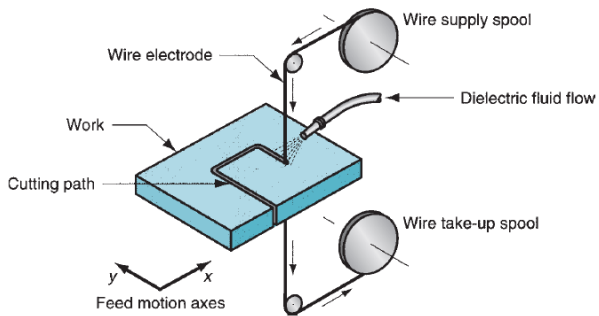
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Applications - Die-casting cylinder cover.



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Electric Discharge Wire Cutting - EDWC



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Applications - Die-casting cylinder cover.



- SME Electrical discharge machining
<http://www.youtube.com/watch?v=q4FinKsDfw>

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