How EDM and ECM can effectively reduce costs on many of today’s critical components, especially those made from metals with high machinability ratings

John Stackhouse - Executive Vice President
Global Specialty Machines, Mason Ohio, USA
www.gedms.com
Processes to be considered on difficult to machine materials

1.0. **EDM – Electro Discharge Machining**
   
   1.1. Sinking EDM  
   1.2. Wire EDM  
   1.3. FHD (Fast Hole Drilling) EDM  
   1.4. Micro EDM

2.0. **ECM – Electro Chemical Machining**
   
   2.1. Electro Chemical Machining … ECM  
   2.2. Precision (Pulsed) ECM …… PECM  
   2.3. Electro Chemical Deburring …. ECD  
   2.4. Electro Chemical Grinding …… ECG  
   2.5. Shaped Tube ECM …………… STEM  
   2.6. ElectroStream Drilling  
   2.7. Capillary Drilling

3.0. **LASER – Light Amplification by Stimulated Emission of Radiation**
   
   3.1. Laser Drilling  
   3.2. Laser Ablation  
   3.3. Laser Cutting
Processes to be discussed in this presentation

1.0. EDM – Electro Discharge Machining
   1.1. Sinking EDM
   1.2. Wire EDM
   1.3. **FHD (Fast Hole Drilling) EDM**
   1.4. Micro EDM

2.0. ECM – Electro Chemical Machining
   2.1. *Electro Chemical Machining ... ECM*
   2.2. *Precision (Pulsed) ECM ... PECM*
   2.3. Electro Chemical Deburring ..... ECD
   2.4. Electro Chemical Grinding ...... ECG
   2.5. **Shaped Tube ECM ............... STEM**
   2.6. ElectroStream Drilling
   2.7. Capillary Drilling

3.0. LASER – Light Amplification by Stimulated Emission of Radiation
   3.1. Laser Drilling
   3.2. Laser Ablation
   3.3. Laser Cutting
**Fast Hole Drilling EDM**

**FHD-EDM Machines**

- Multi-axis positioning and machining system
- Tilting head EDM Slide carries 600mm Electrodes
- Robot Tool Changer for untended production

<table>
<thead>
<tr>
<th></th>
<th>FH40</th>
<th>FH50</th>
<th>FH60</th>
</tr>
</thead>
<tbody>
<tr>
<td>X, Y Axis</td>
<td>40”x20” (1000x500mm)</td>
<td>50”x25” (1250x635mm)</td>
<td>60”x30” (1500x750mm)</td>
</tr>
<tr>
<td>Z Axis</td>
<td>26” (660mm)</td>
<td>24” (610mm)</td>
<td>24” (610mm)</td>
</tr>
<tr>
<td>W Axis</td>
<td>26” (660mm)</td>
<td>26” (660mm)</td>
<td>26” (660mm)</td>
</tr>
</tbody>
</table>
Fast Hole Drilling EDM

**FHD-EDM Machines**

- **X, Y Axis Travel**: 31.5” x 23.6” 800mm x 600mm
- **Z Axis Travel**: 19.7” 500mm
- **W Axis Travel**: 19.7” 500mm
Fast Hole Drilling EDM

Robotic Tool Changer (RTC) - A 24 station tool changer that uses a Fanuc LR Mate Robot with a two position end effector to change up to 18 electrodes and 6 guides. RTC is supplied with a full compliment of electrode collets and guides. This system uses the standard GE Fanuc tool management software. This selection requires full enclosure and riser.
Fast Hole Drilling EDM

Tilting EDM Head has +/- 100° travel
Fast Hole Drilling EDM

Shown with large Turbine Bucket being drilled


**Fast Hole Drilling EDM**

**Process principles**

- EDM, using Deionized water as a dielectric
- Tubular Electrodes - both hollow and Multi-core – with dielectric flushed through – Copper or Brass
- High Depth to Diameter ratios possible because of the Dielectric through-flushing
- A Thermal process, so Recast layer and Heat-affected zone result
- Machines any conductive material, regardless of hardness or machinability
Fast Hole Drilling EDM

Applications

Aircraft Engine Combustion Liners

- Material ............ Hastalloy X
- Ca 2,500 holes
- Holes ............... 0.025” - 0.046” (0.64 - 1.20mm)
- Wall thickness .... 0.060” - 0.080” (1.50 - 2.0mm)
- Total time ........ 8.00 hours
- Time per hole .... < 12 seconds
- Finish .............. < 250 μ” (6.3μm) Ra
- Tolerance, diameter ... 0.004” (0.13mm)
- Tolerance, TP .......... 0.020” (0.5mm)
- Number of Toolchanges ....... 68

Note curved Electrode Guide for access
Fast Hole Drilling EDM

Applications

Industrial Gas Turbine Dome Ring

• Material ............. Hastalloy X

• Ca 4,250 holes @ angles so 0.33” (7.62mm) dp

• Holes ............. 0.050” - 0.070” (1.30 – 1.80mm)

• Wall ............. 0.120” – 0.200” (3.00 - 5.00mm)

• Total time .......... 40.00 hours

• Time per hole ...... < 34 seconds

• Finish ................. < 250 u” (6.3um) Ra

• Tolerance, diameter ... 0.006”(0.15mm)

• Tolerance, TP .......... 0.020”(0.5mm)

• Number of Toolchanges ............ 569
Fast Hole Drilling EDM

Shaped Hole Technology

Creating a Shaped Hole by Interpolating the Brass Electrode during the EDM process. The Fanuc Control will Track Voltage to Simulate Servo and Gap functions.
Fast Hole Drilling EDM

Shaped Hole Technology
**Diffuser Shape Technology** – Diffuser holes created with oapatented two-step process. First the cooling holes are drilled; then the diffuser electrode is shaped using a built in electrode dresser programmed to generate the correctly sized diffuser dimension on the electrode. The machine then retraces the initial hole installation path to install each diffuser in the correct location. The “Z” axis actually uses an encoded servo to deliver the 6th axis that is required to position the diffuser in the correct attitude relative to the surface of the part. This process is exclusive to FH Series and Fanuc Control.
Fast Hole Drilling EDM

For Videos on Fast Hole Drilling go to:

https://www.youtube.com/watch?v=Wz2lXpfBpd8

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

https://www.youtube.com/watch?v=BB6mAlVexGg

https://www.youtube.com/watch?v=2iaTIClZijo
**ECM**

**Process principles**

- Think of it as “Accelerated Reverse Electro Plating”
- Material is removed “Molecule-by-molecule”
- Stress-free surfaces produced
- Not a thermal process, so no Recast layer or Heat-affected zone
- Significant forces as Electrolyte flows up to 300psi/300gpm (20bar @ 1,200l/m)
- Material Removal > 1.00 Cubic Inch per minute per 10,000 amps
**ECM**

*ECM is used in machining applications, including:*

- Automotive - nozzles, drilling, deburring, production of cavities and curved channels
- Aerospace – airfoils, BLISKS, casings and cooling channels in vanes
- Industrial Gas Turbines – buckets, fuel nozzles
- Domestic Appliances – electric razor foils
- BPE/Semiconductor Fittings
- Micro parts - microscopes and other measuring equipment, molds, fuel cell tooling
- Medical - implants and medical devices
- Textile Industry
- Optical Industry - lenses and micro drillings
- Printing Industry - micro and macro textures on large upper surfaces
**ECM**

An ECM system consists of the following main components:

- Machining unit with CNC controlled axes – single or multi Ram
- Tooling
- Electrolyte tanks
- Power Supply – up to 40,000 amps
- Electrolyte Filtration Unit
- Electrolyte Cooling Unit
- Control System
Applications

- Compression blade
- Guide blade
- Turbine blade
- Detail view
- Cut in radial direction
- Titanium blisk
**ECM**

**Tooling**

- Cathodes made of copper or stainless steel
- Workpiece holding fixture
- Flow box to control the electrolyte flow
Applications

Medical Implants

<<<<<< Cathode shown for Knee Implant

Hip Implant
Applications

- Diaphragm Valve Body
- Replaces long and tedious hand-finishing
- Repeatable fine surfaces produced in rapid time-cycles with multi-cavity Tooling
Applications

• These 6.000” (150mm) diameter Titanium discs are ECM’ed to a stress-free condition with extremely thin wall thickness

• Result is a close-tolerance part with no distortion
ECM

Applications

- Tube Fittings has been ECM’ed after welding or bending to remove the excess weld material and to polish the internal surfaces.

- This can be done extremely rapidly with accurate tolerance and high repeatability on BPE and Semi Conductor Fittings.
**ECM**

**Summary of ECM Characteristics**

- Medium - conducting electrolyte, generally a Saline solution of Sodium Nitrate or Sodium Chloride

- **Mechanics of material removal – electrolysis**

- Tool material - Copper, brass, steel

- Tool life - infinite

- Machining gap 10 to 100 μm (0.0004” – 0.004”)

- Materials application - all conducting metals and alloys

- Critical parameters - voltage, current, feed rate, electrolyte conductivity

- Surface finishes down to 0.1 μm (4 MicroInch) Ra

- Shapes application - blind complex cavities, curved surfaces, through cutting, large through cavities

- Material Removal > 1.00 Cubic Inch per minute per 10,000 amps
Various machine types
PECM

PECM:

- Pulsed (or “Precision” ECM)
- Oscillating Z Axis and Pulsed Power Supply
- Enables closer gaps
- Still uses Saline solution
- Gives much better Surface Finish than traditional ECM
- Enables much finer detail to be produced
- Capable of ECM’ing Tungsten Carbide
**PECM**

*New Trends and Capabilities – using PECM*

- Razor blade
- Miniatursed structures (20 mm x 30 mm)

- Simple Blank
- Chip Breakers (Thread Cutting Shape is Ground)

- Cathode (electrode)
- Sintering Mold

---

*GLOBAL EDM*
**STEM Drilling**

**Introduction**

- An ECM process that enables holes to be “drilled” to extreme L/D Ratios

- Specialized Applications such as Turbine “Buckets” and Extrusion Dies for Catalytic Converter material
STEM Drilling

Typical STEM Drilling Setup

Machine Features and Options:

- Daylight
- Stroke
- Number of Parts to be drilled
- Absolute encoders
- Positive air to Z axis
- Stainless Steel hardware
- Composite Granite base
**STEM Drilling**

**Process principles**

- ECM with Acid as an Electrolyte
- Nitric or sulphuric Acids used Ca 25% concentration
- Single axis process (Z) where Insulated Tubes descend into the part to be drilled
- Not a thermal process, so no Recast layer or Heat-affected zone
- Tubes advance at Ca 0.080” (2.00mm) per minute, regardless of quantity of holes
- Tubes are Titanium with special insulation (ParaXylene) on Outside Diameter
- Tubes have angled front-ends and need periodic Dressing
- All ECM action occurs on the exposed end of the Tube(s)
- STEM – “Shaped Tube Electrolytic Machining” – although mostly ROUND Holes!!
**STEM Drilling**

*Power Supplies*

- Bi-Polar
- Forward Volts Machining - typically 15V for 5 seconds
- Reverse Volts to remove build-up of deposits on tip of tubes - typically 5V for 0.1s
- Sufficient Power to machine 3 blades simultaneously
- High Speed switch -off
- Water cooled
- Positive air pressure
STEM Drilling

Safety features

- Manufactured to ISO/CE Standards
- Timed Door interlocks – to allow fumes to be extracted
- Extraction of Hydrogen and acid fumes min 50m³/hour per 1000A
- Auto wash down of parts - valve directs water to separate tank
- Machine & Acid system connected to “Scrubber”
- PPE, including goggles, hats, aprons, gloves
- Stamp/handle drench shower
- Eye wash station
Acid management

- Acid must be a stable parameter
- Programmable emptying of dirty acid
- Programmable replenish of clean acid
- Remote control of wash down – with water
- Spreadsheet for Acid calculations
**STEM Drilling**

Machine Radial Cooling Holes in Industrial Gas Turbine Buckets, including the following:

- Siemens 94.2
- GE Frame 6 - Row 1
- GE Frame 6 - Row 2
- GE Frame 7 - Row 1
- GE Frame 9 - Row 1
STEM Drilling

Cooling Holes produced up to 24” (600mm) deep

“Turbulated” holes for greater cooling efficiency
**STEM Drilling**

*Typical Tooling includes*

- STEM Tube Manifold
- STEM Tube Guide
- STEM Tube Target Plate
- Airfoil 6 point nest
- Clamping system
**STEM Drilling**

*STEM Tube Manifold*

- Provides through-flushing of Acid
- Variable flow
- Multiple tube sizes
STEM Drilling

**STEM Tube Guide**

- Titanium
- Produced by wire EDM
- Applies correct vector
**STEM Drilling**

**STEM Tube Target Plate**

- Ensures alignment prior to machining

- Separate for root & tip machining

- Alignment is crucial to maintaining True Position

- True Position necessary to maintain “Minimum Wall” condition

- If “Minimum Wall” is not maintained then likelihood of Bucket burning-up in service!!
**STEM Drilling**

*Airfoil Fixture*

- Airfoil (6) point “nest” - to establish Stacking Axis of Bucket
- Clamping system
- Single or Multi Blade Fixtures
Processes discussed

1.0. EDM – Electro Discharge Machining
   1.1. Sinking EDM
   1.2. Wire EDM
   1.3. *FHD (Fast Hole Drilling) EDM*
   1.4. Micro EDM

2.0. ECM – Electro Chemical Machining
   2.1. *Electro Chemical Machining … ECM*
   2.2. *Precision (Pulsed) ECM ……… PECM*
   2.3. Electro Chemical Deburring …. ECD
   2.4. Electro Chemical Grinding …… ECG
   2.5. *Shaped Tube ECM …………… STEM*
   2.6. ElectroStream Drilling
   2.7. Capillary Drilling

3.0. LASER – Light Amplification by Stimulated Emission of Radiation
   3.1. Laser Drilling
   3.2. Laser Ablation
   3.3. Laser Cutting
Thank you for your attention

Be sure to visit us in the show at Booth E-5033

John Stackhouse - Executive Vice President
Global Specialty Machines, Mason Ohio, USA
www.gedms.com