Dry Wire Electrical Discharge Machining of Thin Workpiece

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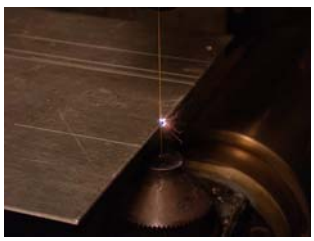
Objectives

- To investigate the dry wire electrical discharge machining (EDM) of workpiece with thin thickness.
- To study the effects of spark cycle, spark on-time, air flow, thickness, and type of work-material were studied under wet and dry EDM conditions.

State-of-the-Art

- Gas is used as the dielectric fluid in place of liquid (deionized water or kerosene) during wire EDM process.
- Because of the thinner recast layer and narrower cutting groove width, dry wire EDM is applied to the finish cutting of precision components.
- Oxygen can accelerate the machining speed in die-sink EDM of ferrous material due to the quasi-explosion caused by rapid oxidation.
- Piezo actuator is applied in the dry EDM process to improve the control over gap width and prevent the short circuit.



Dry wire EDM of Al 6061

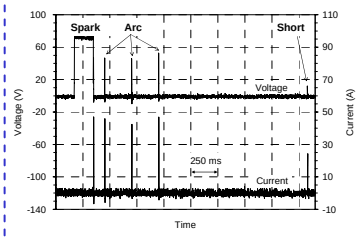
Approaches

- Conventional wire EDM machine was used to perform dry EDM experiments.
- Three EDM conditions were studied: 1. wet, 2. dry with air flow., and 3. dry without air flow.
- An EDM process monitoring system was developed to identify the EDM pulses: spark, arc, and short.

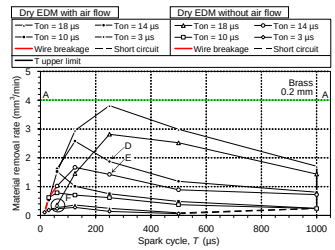
Experiment setup of dry wire EDM

Accomplishments

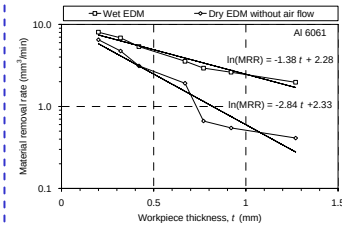
- Effects of spark cycle, spark on-time, air flow, thickness, and type of work-material on the MRR for dry wire EDM of thin workpiece were investigated.
- The rate and percentage of spark, arc, and short pulses were compared and discussed under the wet, dry with air flow, and dry without air flow EDM conditions.
- The groove width and deposition of debris in the groove during dry EDM were studied.
- Wear of the wire electrode were observed using optical and scanning electron microscopy.



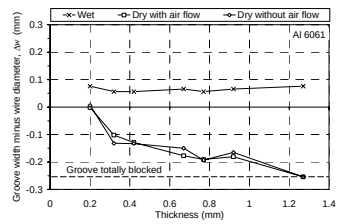
Online monitoring of dry wire EDM process



Envelope of feasible EDM parameters for 1.27 mm brass



Effects of thickness on the MRR of Al 6061



Effects of thickness on the cutting groove width

Future Work

- This research in dry EDM is continuing to improve the precision, MRR, and to reduce environmental impact.
- The usage of deionzied water mist will be investigated to reduce the odor of smoke and help collect the floating metal particulate in air.
- The mechanism of debris deposition and new methods minimizing the deposition to improve part accuracy will be investigated

Sponsors

NIST Advanced Technology Program

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Dry and Near-dry EDM Processes Development

Research Assistants/Staff:
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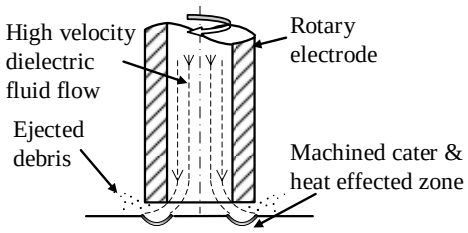
Faculty:
J. Ni, A. Shih

Objectives

To develop dry and near-dry electrical discharge machining (EDM) processes as integrated secondary super finishing methods of direct metal deposition (DMD) products including tools and dies with 5DOF die sinking and milling capabilities.

State-of-the-Art

• In stead of using dielectric liquid in conventional EDM, dry and near-dry EDM use gas and mist, respectively, to minimize the amount of liquid used.



• Dry and near-dry EDM are characterized by
  - Less environmental impact
  - High material removal rate (MRR) using oxygen as dielectric fluid
  - Low residual stress
  - Less electrolytic corrosion
  - High cutting efficiency at small discharge energy in near-dry EDM.

Approaches

• Select dielectric fluids and electrode materials in dry and near-dry EDM for high MRR and good surface finish, respectively

• Investigate the effect of electrical parameters

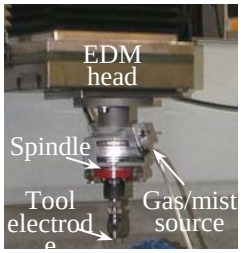
• Model the near-dry EDM process to predict the MRR and surface finish to achieve

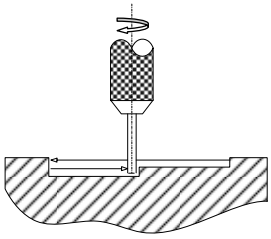
• Characterize the surface and subsurface quality after dry and near-dry EDM

Accomplishments

❖ Dry and near-dry EDM milling test bed

• Retrofitted a die-sinking EDM for dry and near-dry EDM milling usage by amounting a rotary spindle on the EDM head and modifying the spindle's fluid flushing supply





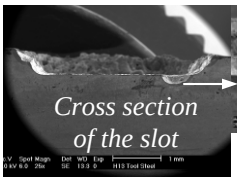
• Different dielectric fluids were tested: oxygen, air, nitrogen, helium and their mist mixture with water

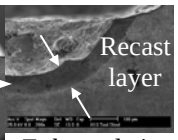
• Different electrode materials were tested: graphite, copper, brass, copper tungsten and tungsten carbide

❖ Preliminary results of rough and finish cutting

• For roughing, the MRR increases to 36 mm^3/min using oxygen medium and copper electrode, as compared to about 20 mm^3/min of conventional EDM

Upper view of EDMed slot





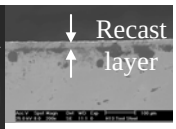
Enlarged view of the crater

• Deep crater and thick recast layer is caused by arcing

• Large amount of O occurs in the recast layer

• For finishing, the surface finish is improved from R_a=4 μm to 0.7 μm by using nitrogen mist and graphite electrode

Upper view of EDMed slot



• Uniform surface feature and recast layer

• Certain amount of N is in the recast layer

Future Work

• Lower the discharge energy of the power supply to achieve shiny surface finish, R_a=0.1 μm

• Study and compensate the tool wear of the process

• Construct a semi-empirical model to predict the performance of the process

• Improve gap servo control for dry and near-dry EDM

Sponsors

Advanced Technology Program (ATP) of National Institute of Standards and Technology

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Control of Five Degrees of Freedom Dry/ Near-Dry EDM Milling Machine

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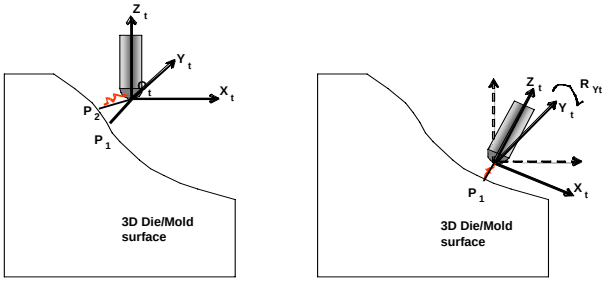
Faculty: *J. Ni, A. Shih*

Objectives

- To design and implement a controller for 5DOF dry/near-dry EDM milling machines that achieves ±1μm part accuracy within 50mm x 50mm x 50mm workpiece.
- To achieve higher material removal rate and higher surface finish compared with conventional 3DOF EDM milling machines

State-of-the-Art

- By controlling the EDM milling machine with five-degrees of fredom, the tool electrode can be oriented in such a way that it is perpendicular to the sculptured surface.
- An electode oriented perpendicular to the sculptured surface develops electrical discharges between them in the intended path, OP_1.
- Electrode's orientation with respect to the sculptured surface influences the flusing effect of debris, hence by controlling the orientation of electrode, the material removal rate can be maximized.
- Piezo actuator that controls the perpendicular normal gap distance between the electrode and the workpiece increases the bandwidth of gap control.



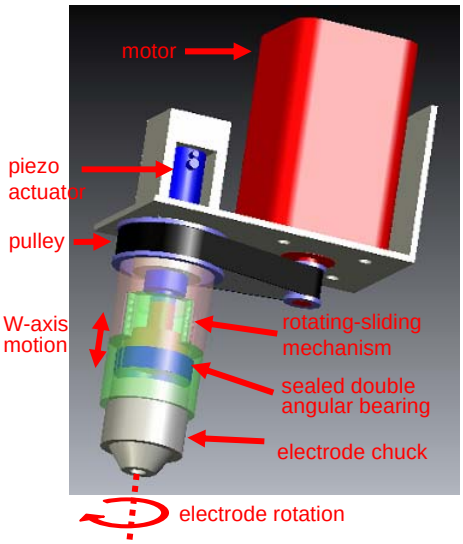
Schematic of 5DOF EDM milling

Approach

- Design and fabricate a custom spindle for EDM milling machine that has built in piezo actuator.
- Observe the characteristics of different types of discharge and its correlation to toolwear.
- Monitor voltage and current in each discharge and identify its characteristics in realtime.
- Estimate electrode wear based on the monitored discharges and compensate for toolwear in realtime.
- Investigate the effect of tool inclination angle with respect to sculpture surfce in terms of material removal rate and incooporate its result in CAM and the controller

Work in Progress

- An innovative design of spindle with built-in piezo actuator is currently underway. However, there are still technical difficulties, such as wiring planning and kinematic relations among each component.



Conceptual design of EDM spindle with built-in piezo actuator

Future Work

- Completion of the full design of EDM spindle with built-in piezo actuator.
- Fabrication of the spindle
- Acquirement of experimental data for each discharge profile and tool wear to material removal ratio
- Development of algorithm to identify different discharge types based on DSP technology
- Development of algorithm for adaptive tool inclination control and real-time collision check to maximize the material removal rate

Sponsors

- This research is sponsored by Advanced Technology Program, National Institute of Standards and Technology, Technology Administration, US Department of Commerce.

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