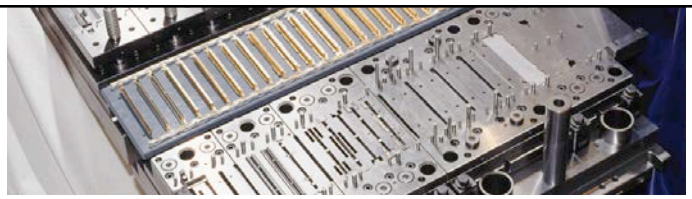

HYDRODYNAMICS OF THE ELECTRICAL DISCHARGE MACHINING PROCESS (EDM)

Patrick Haas, Prof. HES

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Haute Ecole Spécialisée de Suisse occidentale

L'avenir est à créer

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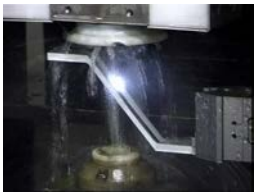
THE ELECTRICAL DISCHARGE MACHINING PROCESS (EDM)

« Use of electrical discharges to remove material »






The processes available today are the following :

- EDM die-sinking (ex. credit card injection moulds)
- Wire-EDM (ex. extrusion moulds)
- EDM hole drilling (ex. engine injectors diam. < 0.100 mm)
- EDM milling (ex. complex parts, small, hard material). New method developed by Agie Charmiles with hepia (Prof. J. Richard)

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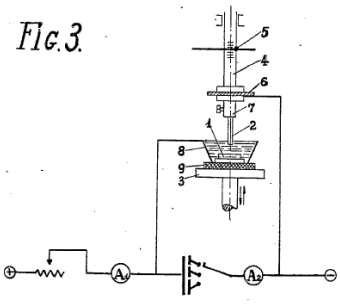
HISTORY

- 1770 Priesley (GB): Study of the effects on material of electrical discharges
- 1943 Work from the Lazarenko (2 persons from Russia)

Work on the efficiency of an engine electrical contact breaker. Impact on the contacts.

- 1955 1st Charmilles Technologies (EMO show)



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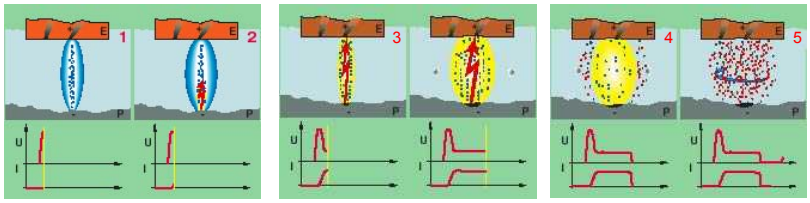
THE EDM PROCESS

1. Application of a potential between the electrode and the material
2. A ionized channel is created
3. A plasma is formed. The spark generator decrease the potential to stabilize the current.
4. After a imposed time, the current is stopped. A plasma implosion is created (low pressure in the plasma zone)
5. Some material are removed.

- Temperature : 5000 – 8000 °C
- Pressure : 1 to 2 bars (?)
- Energy density : 10^{11} - 10^{14} W/m^2
- Temperature gradient : 10^8 °C/m



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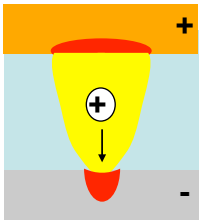
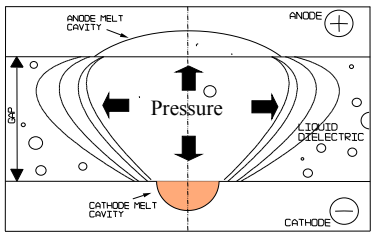
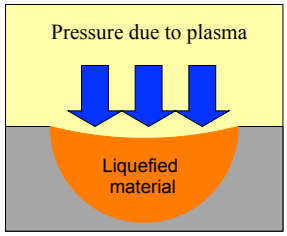
THE EDM PROCESS : EFFECTS OF THE PROCESS ON THE MATERIAL (1)







- A presure is generated by the plasma
- The plasma contain ions and electrons
- Craters are created on the cathode and the anode
- The pressure of the plasma is applied on the liquefied material surface

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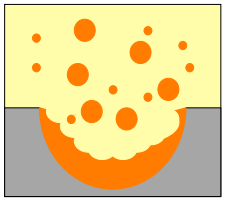
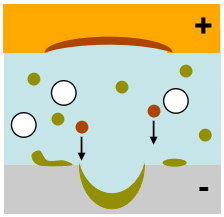
THE EDM PROCESS : EFFECTS OF THE PROCESS ON THE MATERIAL (2)

- When the plasma disappears, the pressure reduces sudently
- The material start to evaporate !
- Ejection of material particles in the dielectric (liquid) and solidification.
- One part of the particles solidify in the crater
- The others are ejected in the gap





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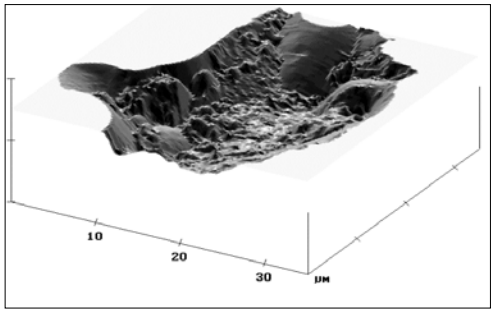
THE EDM PROCESS



Views of craters

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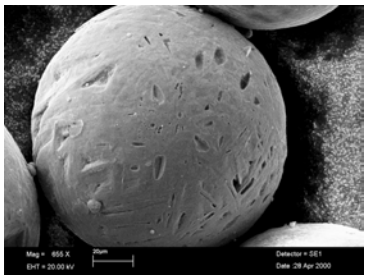
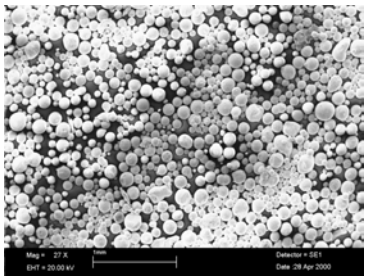
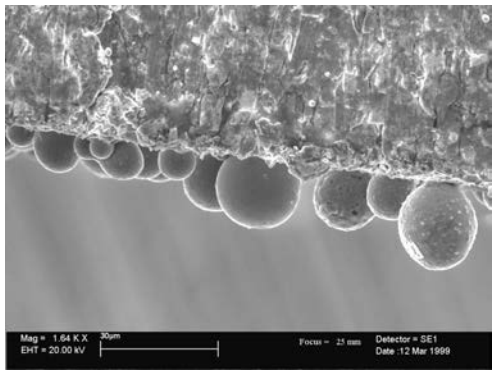
THE EDM PROCESS







Views of particles

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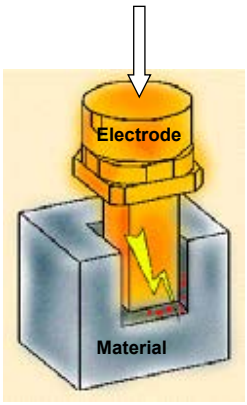
PROCESS APPLICATIONS : DIE-SINKING

The electrode is pushed in the material or moved laterally



Mobile phone moulds

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PROCESS APPLICATIONS : DIE-SINKING

The electrode can be very big !

Sport equipment moulds

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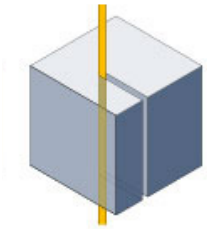
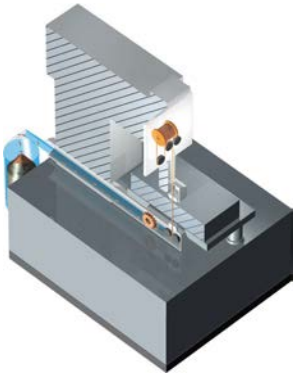
PROCESS APPLICATIONS : WIRE EDM

- The electrode is a wire moved to cut the marterial as a « butter knife »
- The wire is unrolled during the process





A wire in action

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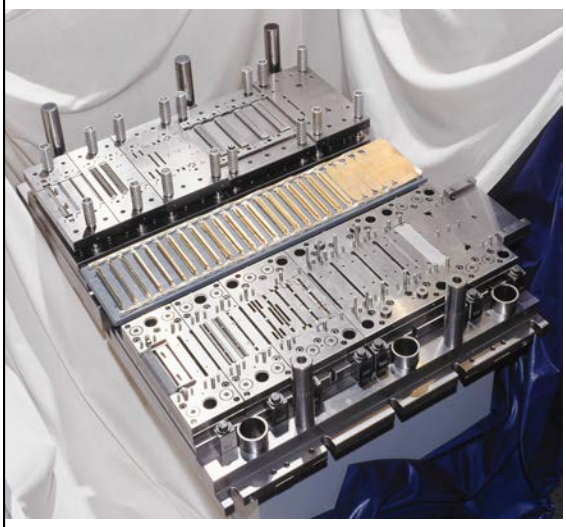
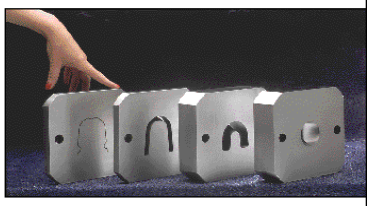
PROCESS APPLICATIONS : WIRE EDM





Extrusion moulds

Complex moulds for plastic injection

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HYDRODYNAMICS OF THE EDM PROCESS

- During the EDM process, the spark start at the location where the dielectric resistance is the smallest
- The EDM process can be used for production only if the next spark moves to the smallest gap location
- There is a necessity to find a way to regenerate the dielectric and to clean the gap. Although, the spark stays all the time at the same location and the process can not work.

→ The production speed is governed by hydrodynamics

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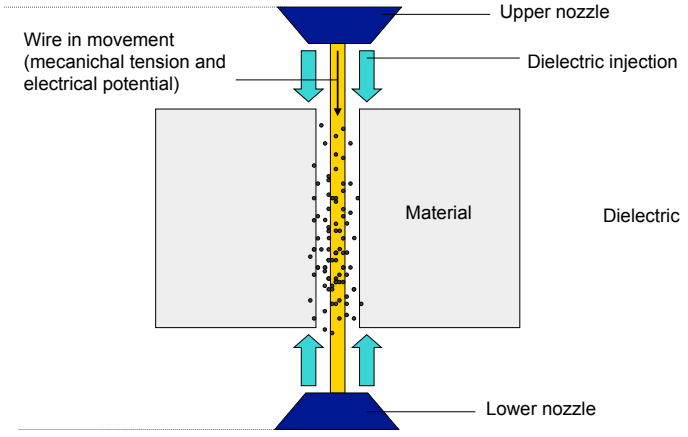
THE WIRE EDM SCENARIO

- A dielectric injection is applied continously by 1 or 2 nozzles
- We can improve the production by working on the nozzle design
- The design methods are theoretical, experimental and CFD



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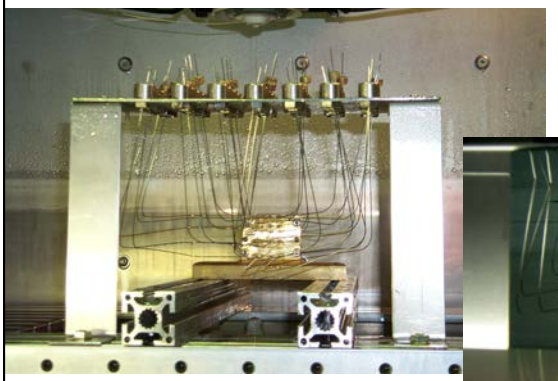
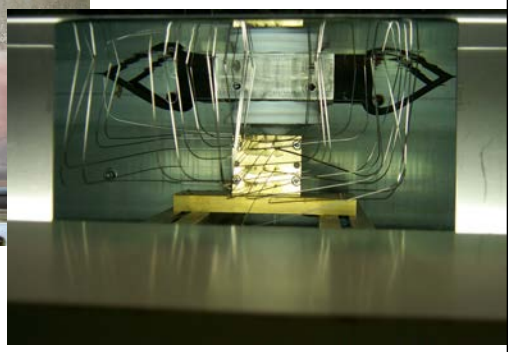
THE DESIGN OF WIRE EDM NOZZLE

1) Experimental investigations





Pressure measurements in the gap

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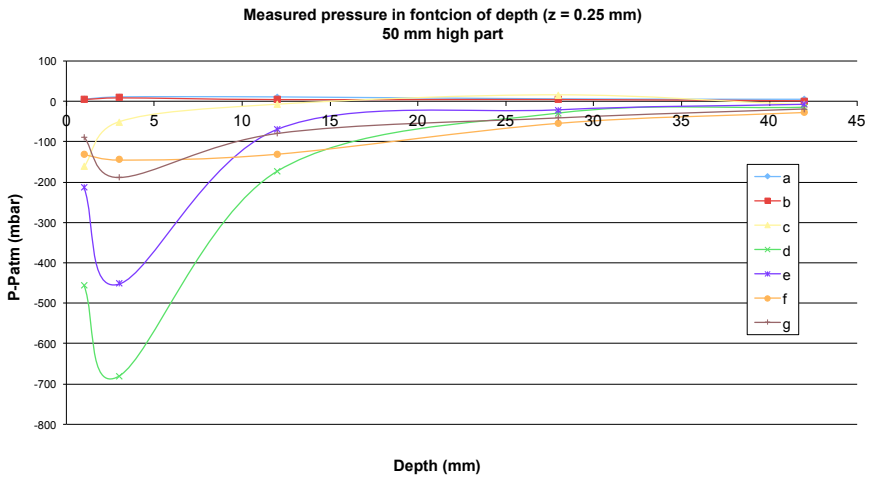
THE DESIGN OF WIRE EDM NOZZLE



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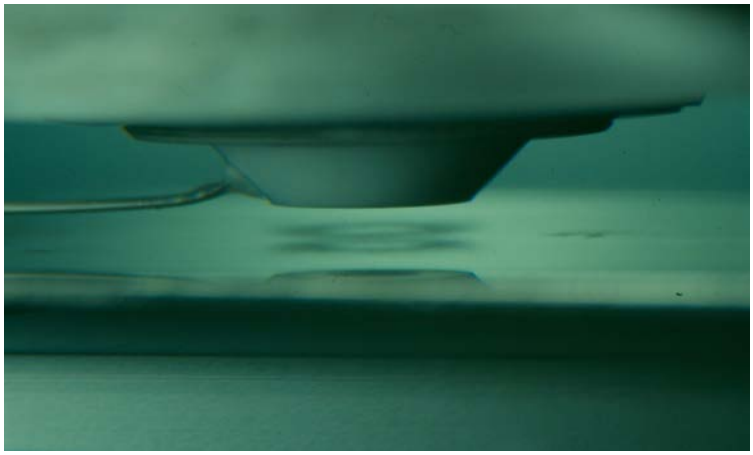
THE DESIGN OF WIRE EDM NOZZLE



Annular vortices are generated

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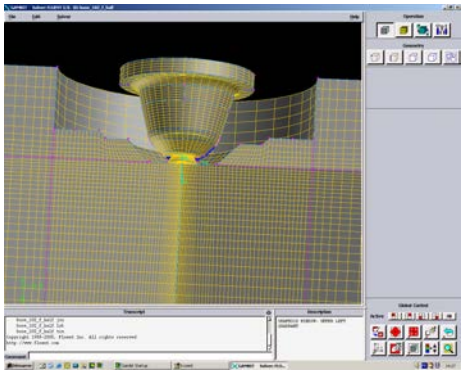
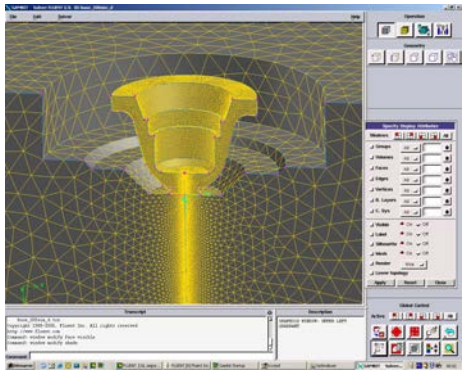
THE DESIGN OF WIRE EDM NOZZLE

2) CFD investigations and design (Fluent)



Map mesh (hexahedra)



Tgrid patch conform mesh (tetrahedra)

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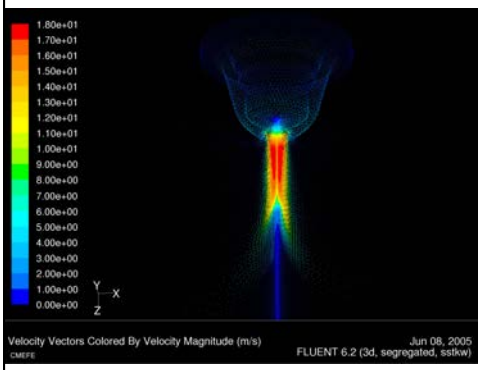
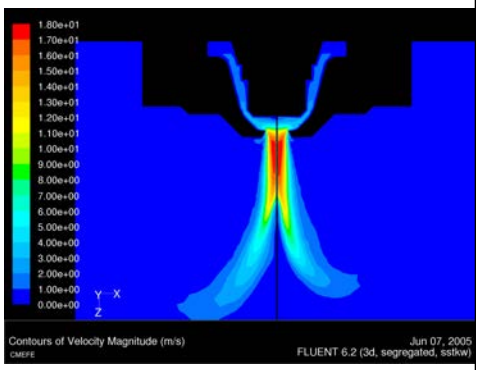
THE WIRE EDM SCENARIO

- Free jet in the dielectric (without part)





Jet speed in m/s

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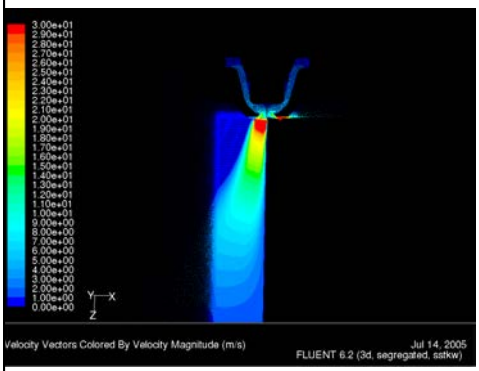
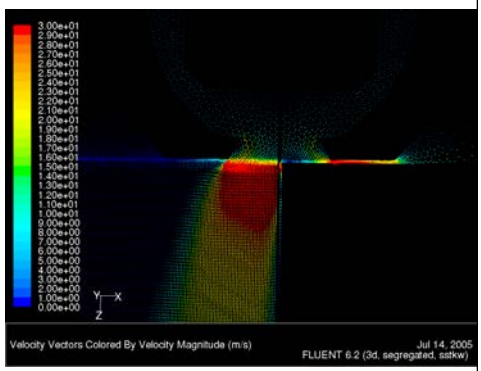
THE WIRE EDM SCENARIO

- Jet during production (with part)





Jet speed in m/s

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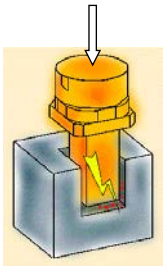
THE DIE SINKING SCENARIO



The production scenario is :

1. Spark cycles are generated for a while
2. The spark generator detect the presence of particles (analysis of the current and potential curves) and control the CNC
3. When the quantity of particles is too high, the cleaning process starts : « the electrode is moved up and down to generate a flow through the lateral gap and in the cavity »

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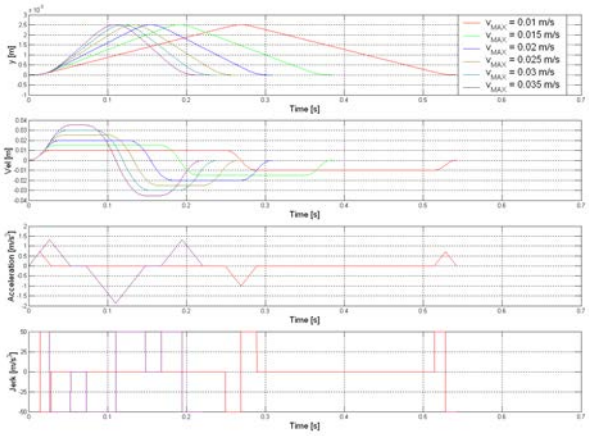
THE DIE SINKING SCENARIO

The challenge : « What is the most efficient movement ?»

- Amplitude ?
- Speed ?
- Sequence of small and big jumps ?



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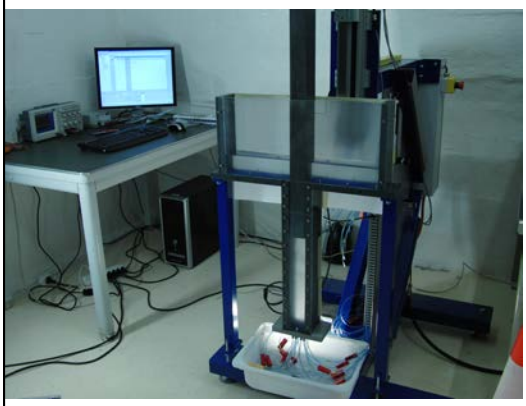
THE DIE SINKING SCENARIO

1) Experimental investigations



20:1 scale test rig

- On the EDM machine : scale 1:1
- On a test rig : scale 20:1 in similitude

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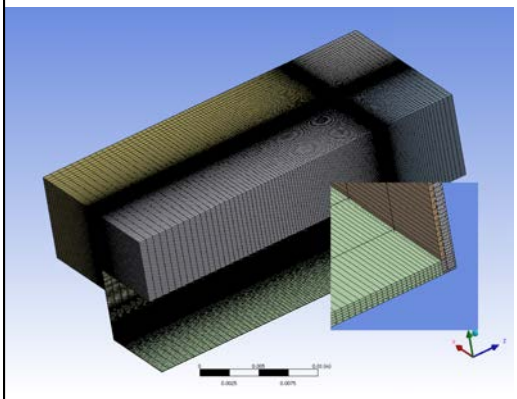
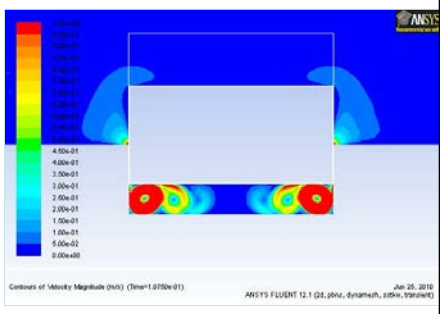
THE DIE SINKING SCENARIO

2) CFD investigations (Fluent)

- Transient model
- 2D and 3D studies
- RANS k-w turbulence model





Some CFD models

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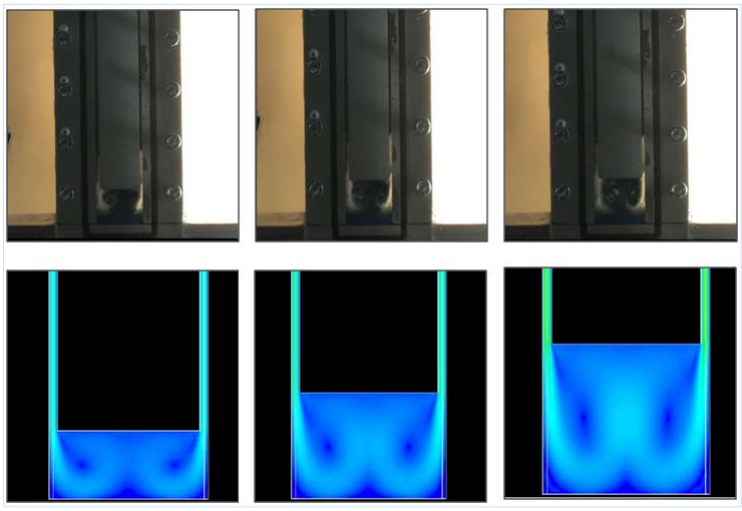
THE DIE SINKING FLOW ANALYSIS

1. At the beginning of the movement, two symetrical vortices are generated



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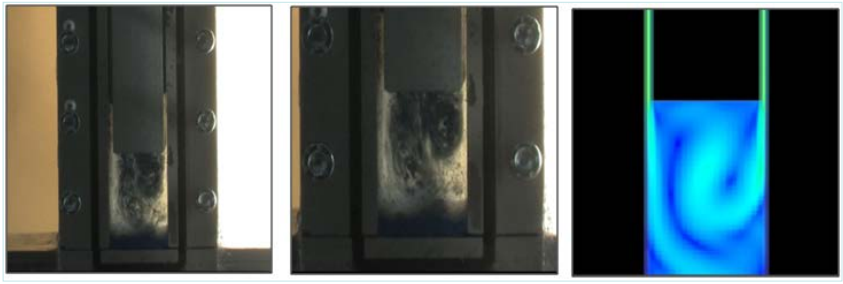
THE DIE SINKING FLOW ANALYSIS

2. The electrode going up, the aspect ratio of the two vortices increases



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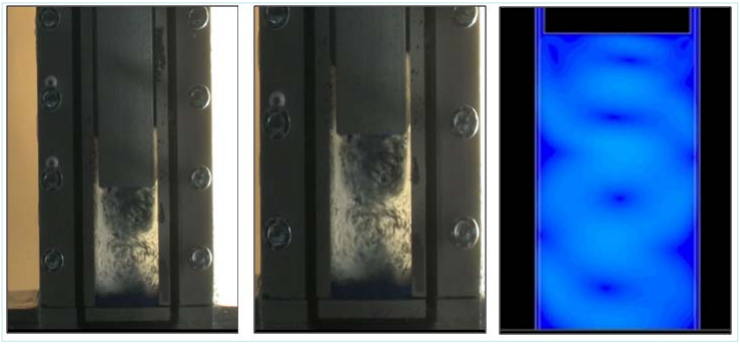
THE DIE SINKING FLOW ANALYSIS

3. The vortices break into several ones aligned vertically (more stable configuration). The solid particles are mixed.



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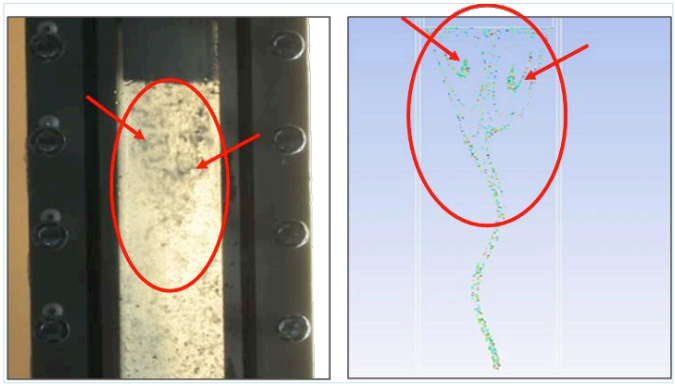
THE DIE SINKING FLOW ANALYSIS

4. When the electrode is near 5 to 10 times the width of the cavity, the intensities of the vortices decrease and the particles start to fall. It is not interesting to go higher with the electrode.



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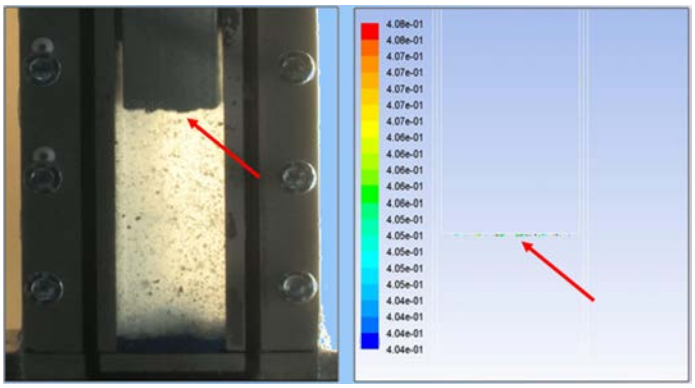
THE DIE SINKING FLOW ANALYSIS

5. When the electrode goes down, some particles stay under the horizontal part, the others are ejected through the vertical gap.



Sequences 1 & 2

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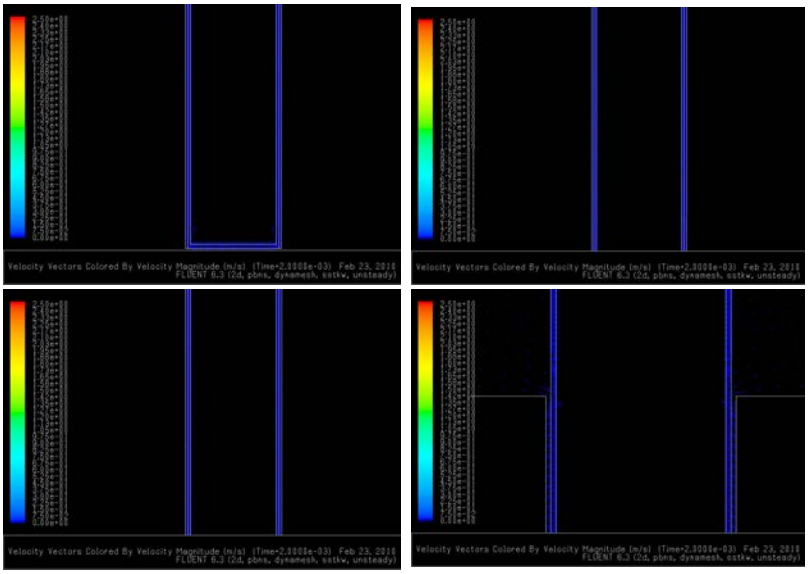
THE DIE SINKING FLOW ANALYSIS



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Thanks, questions ?

Patrick Haas, Prof. HES

hepia – cmefe
Groupe de compétences en mécanique des fluides
et procédés énergétiques