Produce a large aluminium alloy sheet metal using electromagnetic-incremental forming *(EM-IF)* method: Experiment and Numerical simulation

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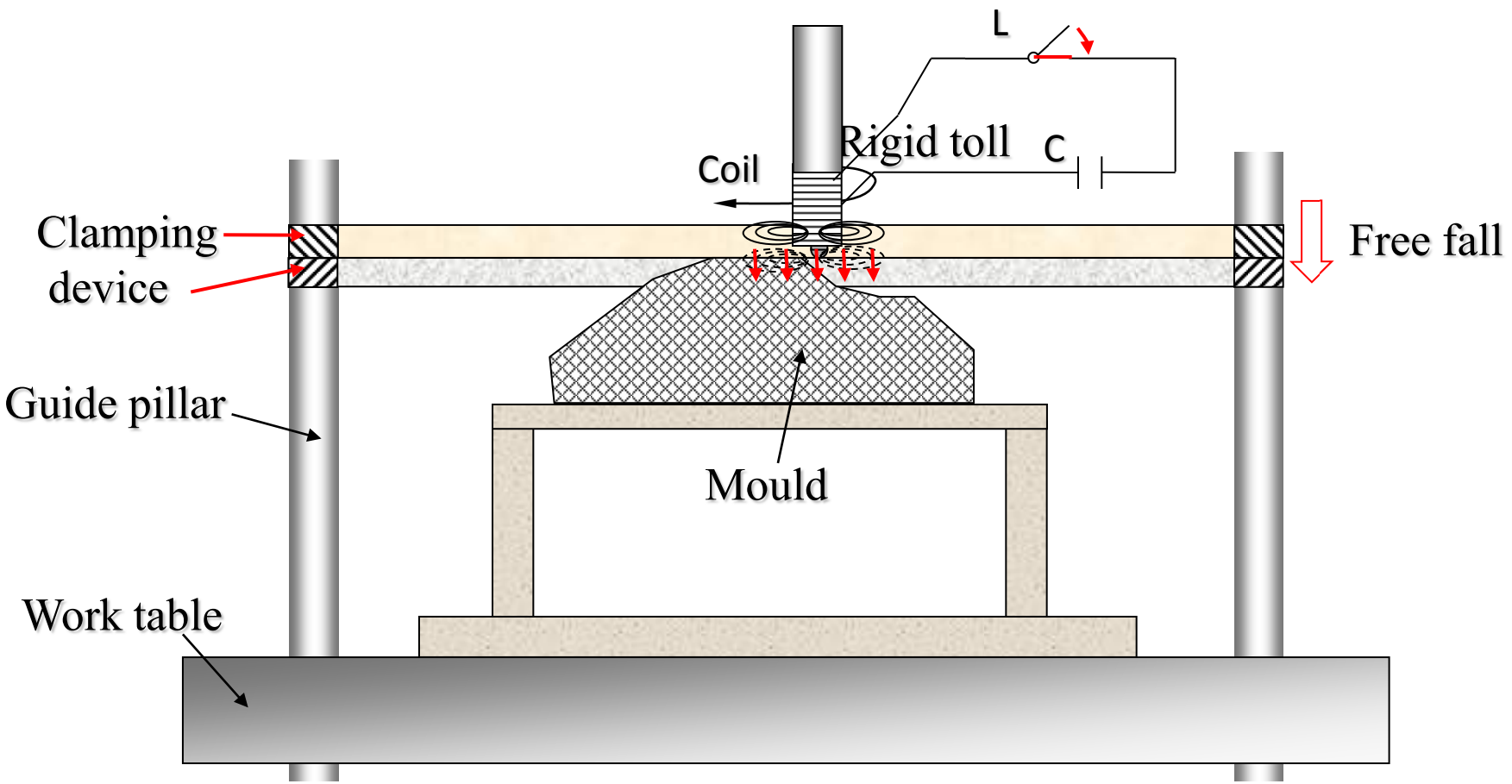
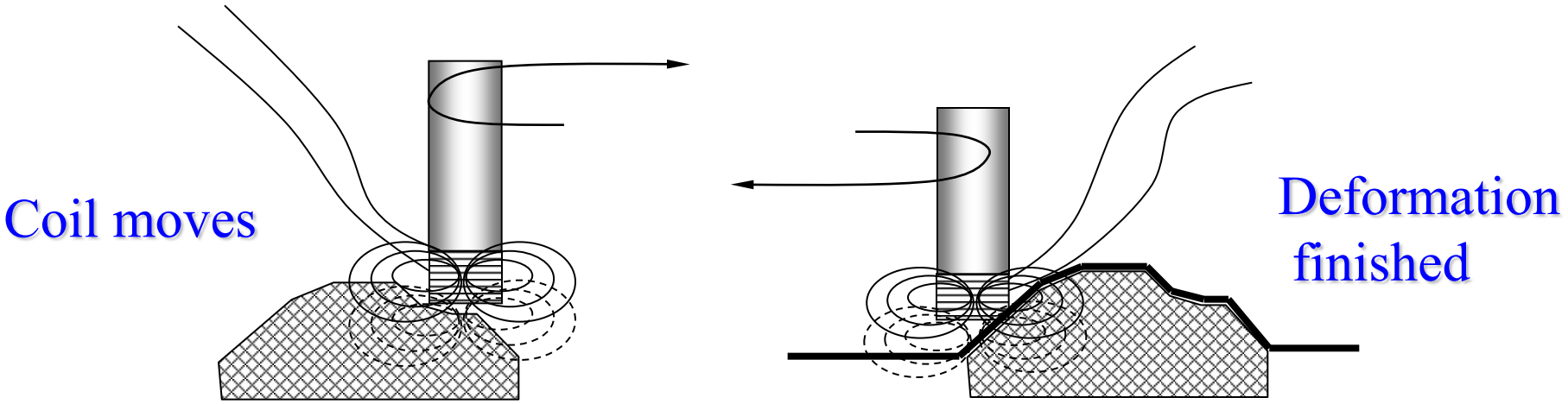
Research purpose



Electromagnetic incremental forming (EM-IF)

Incremental forming

Research purpose



Advantage for EMIF:

- No mechanical contact exists between the working coil and workpiece and no imprint occurs on the workpiece surface ;
- Improve the formability of sheet metal;
- Small working coil and small energy device for large, complex and deep drawing parts.

Research purpose

Whether or not the EMIF method is feasible to produce large parts?

Some important problems needed to be studied:

- **Effect factors on dimensional accuracy;**
  Such as: Vent hole; Dicharge voltage; Discharge times.

- **Suitable numerical simulation;**
  The EMIF technology is more complex than incremental forming or traditional electromagnetic forming due to the different sheet regions are deformed sequentially and the air region must be considered in FEM for magnetic field analysis.

Experiment

E_{max}=50KJ

U_{max}=10KV

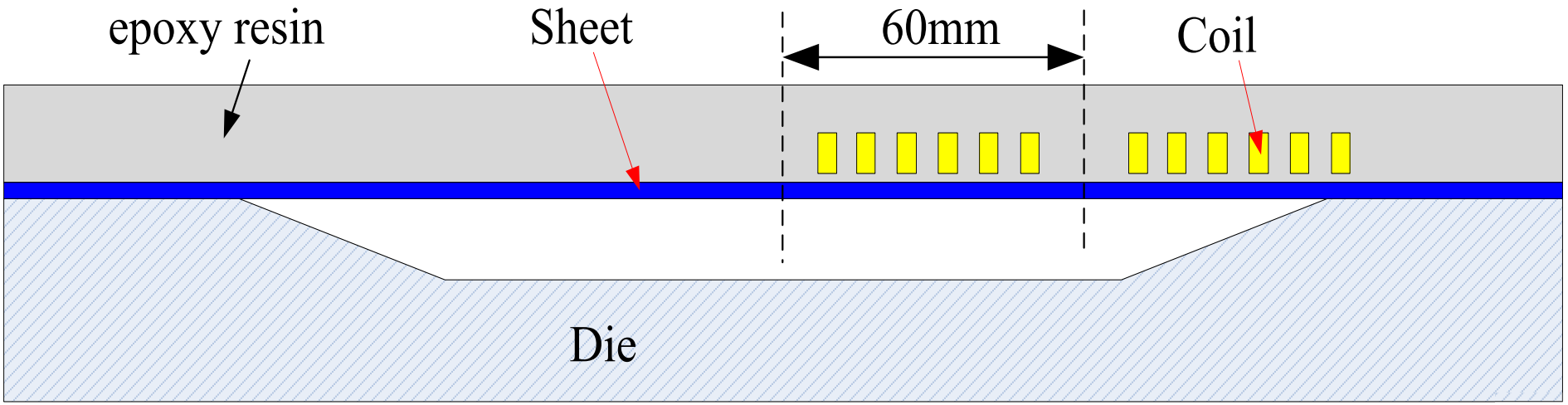
C_{max}=1000μF

No. of windings:6

Inner radius:12.25mm

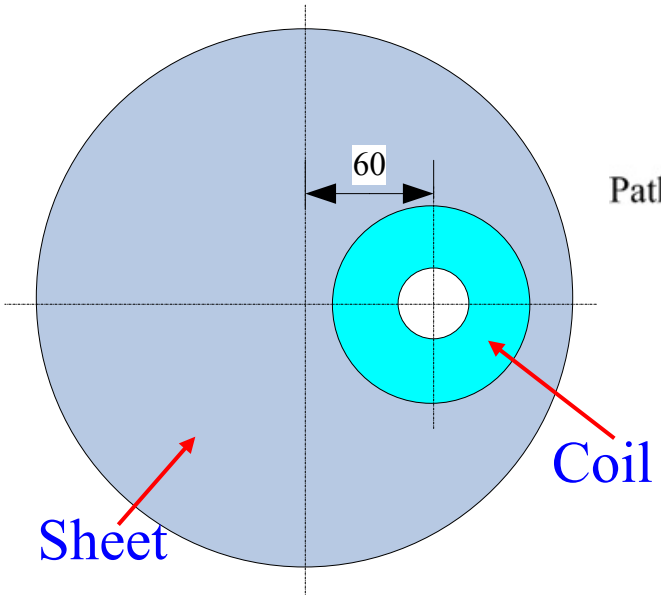
Pitch:6.2mm

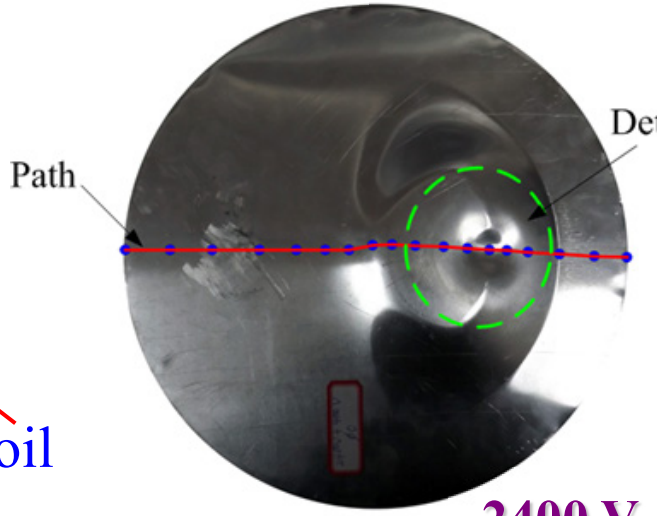
Section:3mm×6mm

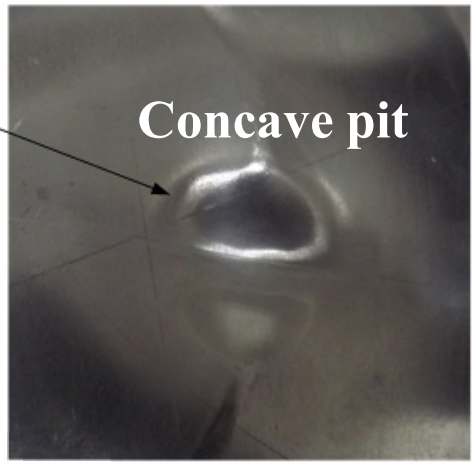


Experiment (*Plan1*)

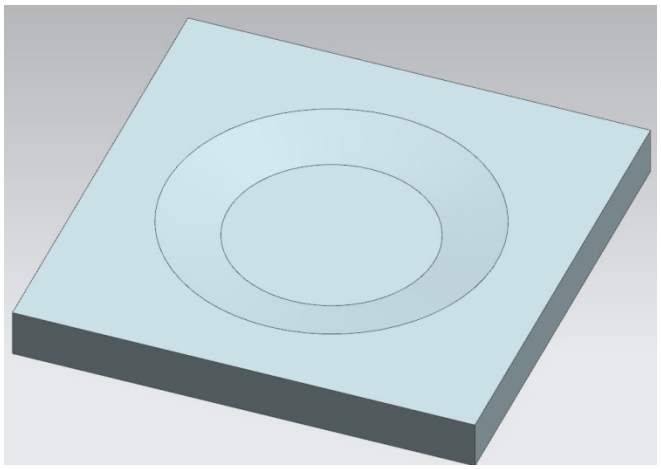
***Plan1*：** The coil stays in a fixed position;

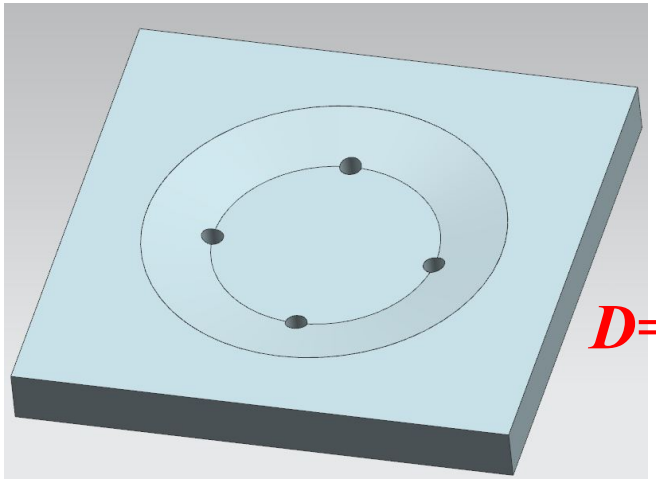






2400 V, 700μF

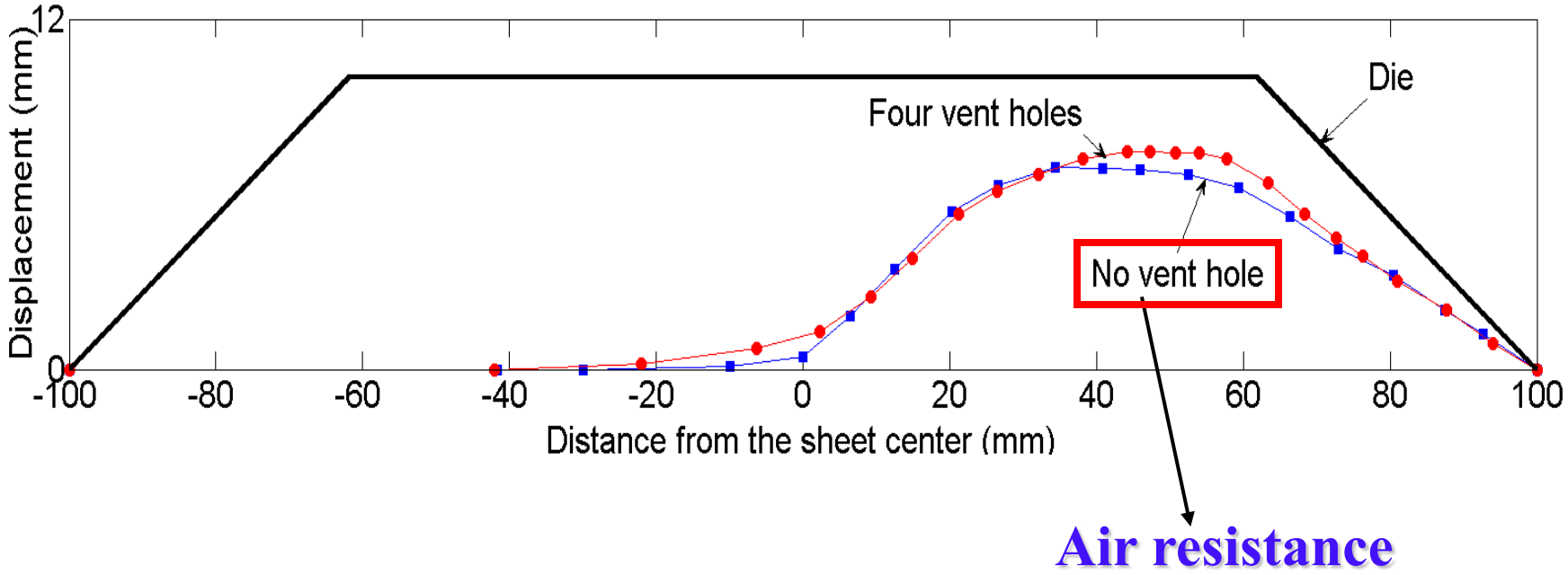




D=12mm

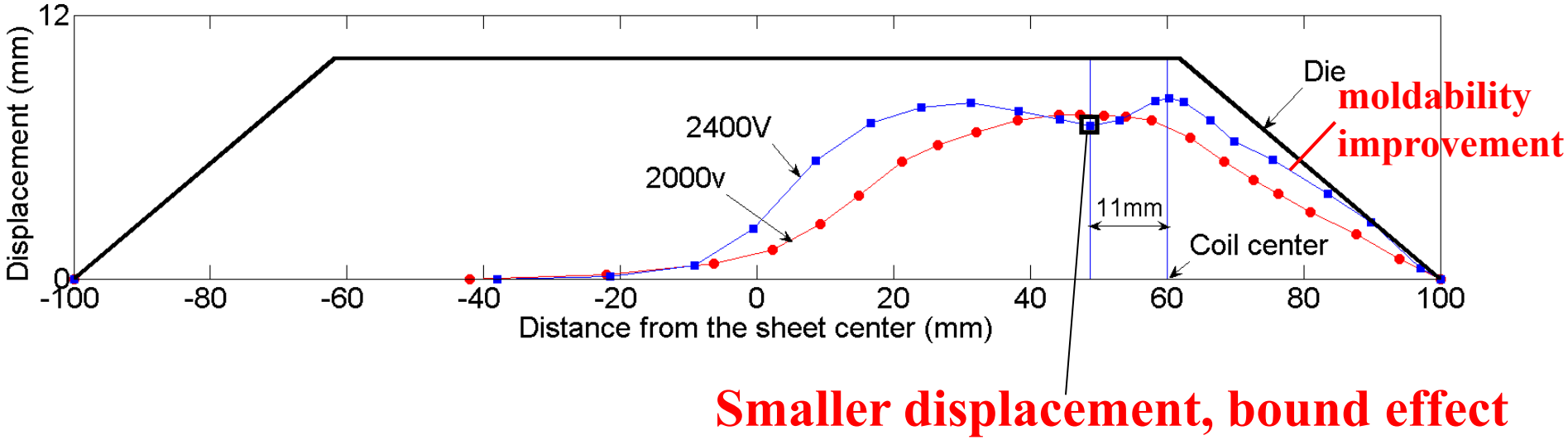
Experiment (*Plan1*)

(1) Effect of vent holes on sheet forming (*E=1.4KJ, U=2000V,C=700μF*)

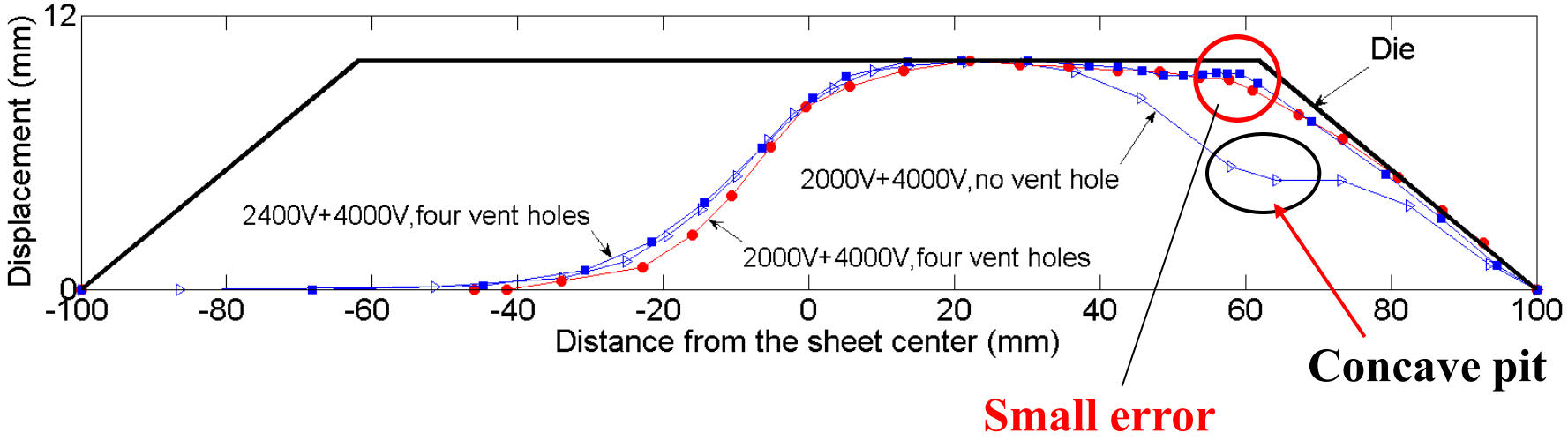


Experiment (*Plan1*)

(2) Effect of discharge voltage on sheet forming (*D=12mm,C=700μF*)

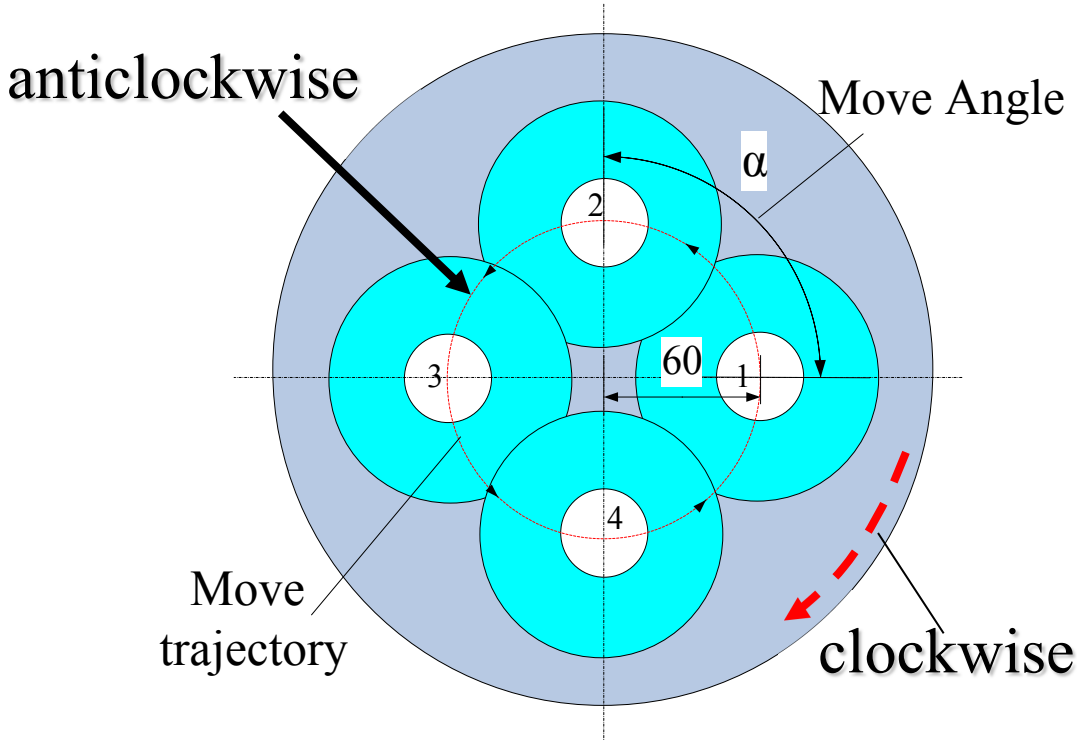


(3) Effect of previous discharge on second one (*D=12mm,C=700μF*)



Experiment (*Plan2*)

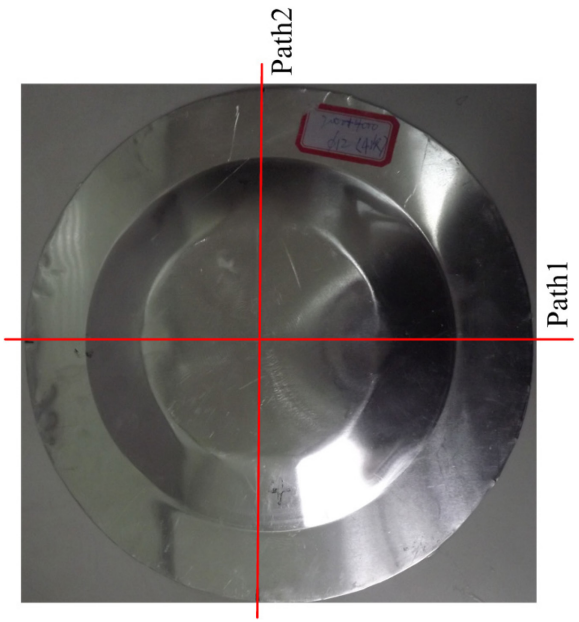
***Plan2*:** Coil moves along a special path

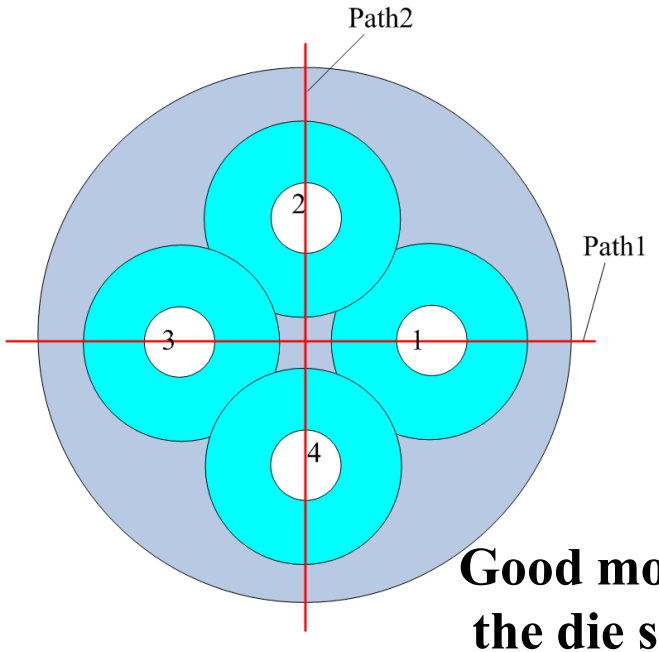


Four times
U=2000V+4000V
C=700μF

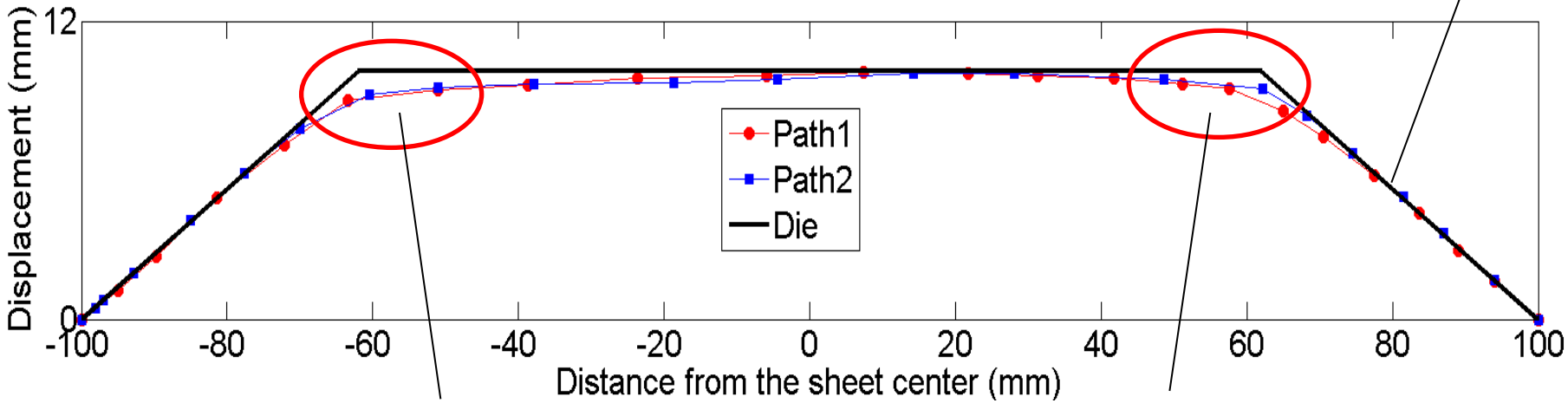
Simplify:
(1) Coil moves in X-Y plane;
(2) The coil stays in a fixed position and the sheet moves in a clockwise direction in experiments.

Experiment (*Plan2*)





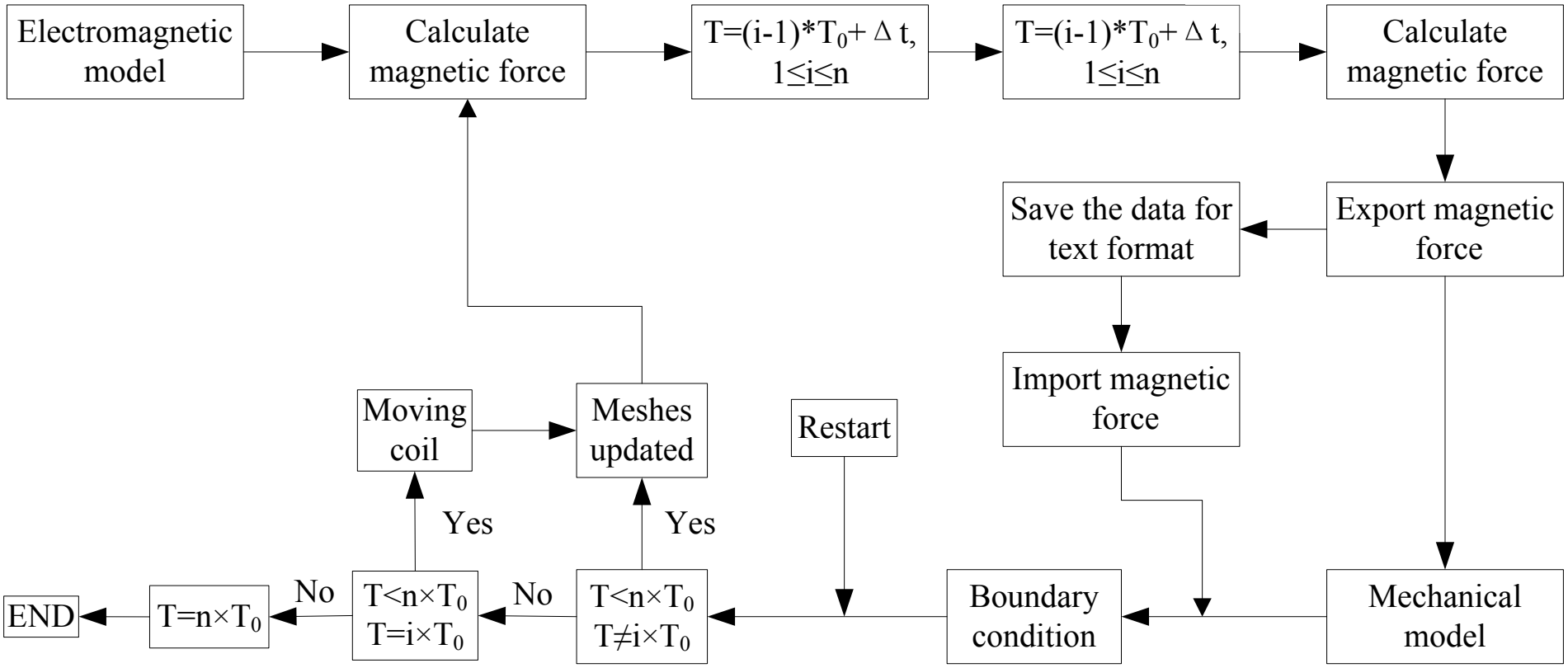
Good moldability with the die side surface



The displacement in this regions is less than the depth of the die, which affects the product accuracy.

Numerical simulation

Schematic diagram of **sequential coupling method:**



In the latter deformation, the deformed information is also considered from the former one, such as the deflection, velocity, stress, strain, et al.

Numerical simulation

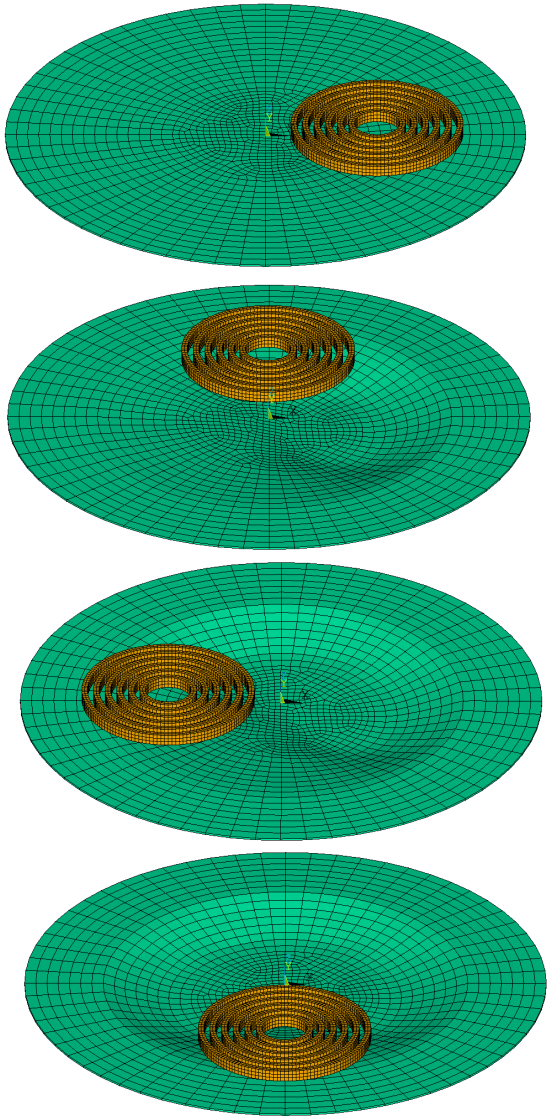
Position 1
150μs

Position 2
2150μs

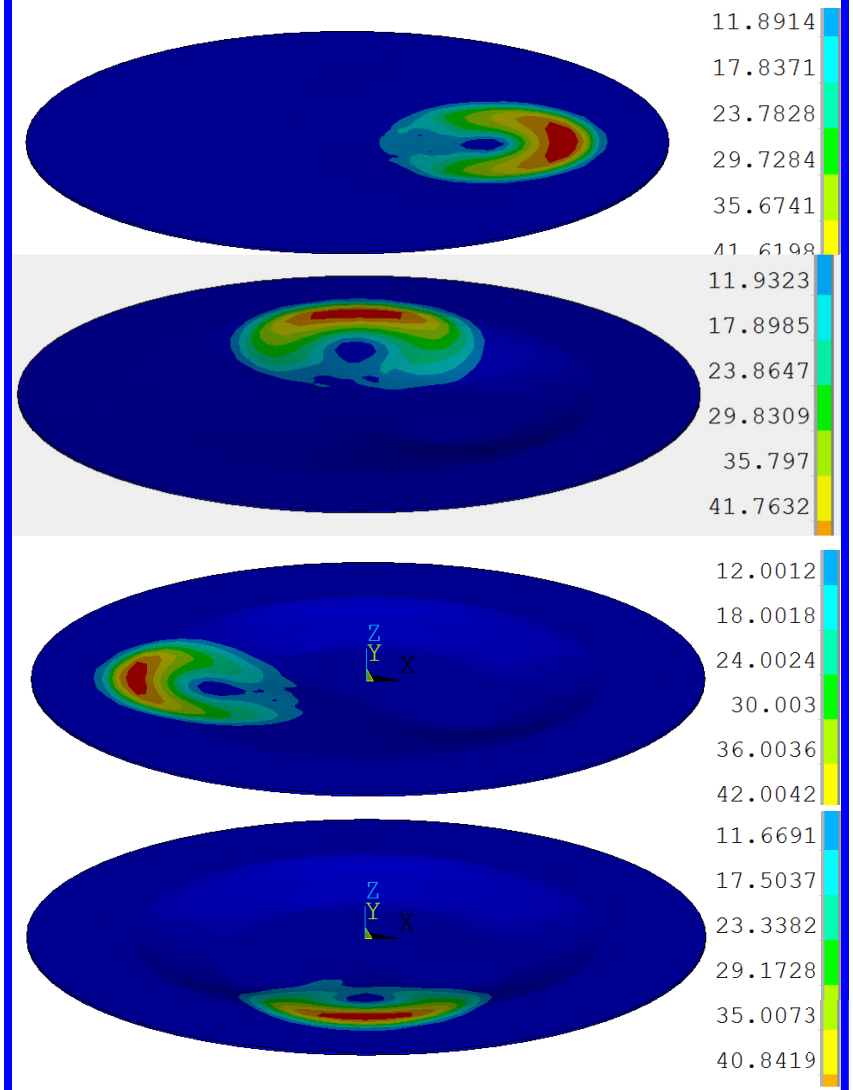
Position 3
4150μs

Position 4
6150μs

Deformed sheet meshes

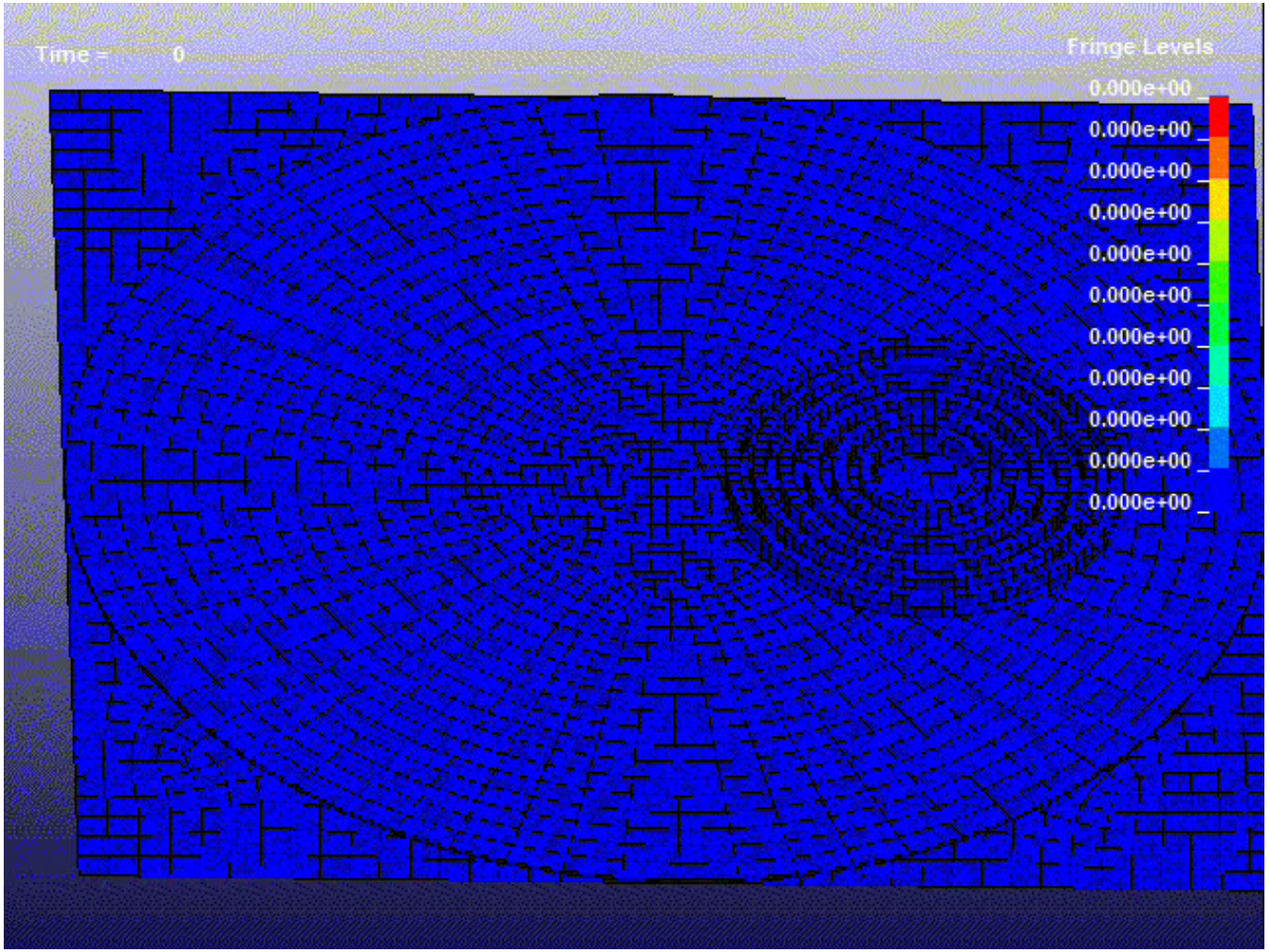


Magnetic force on sheet

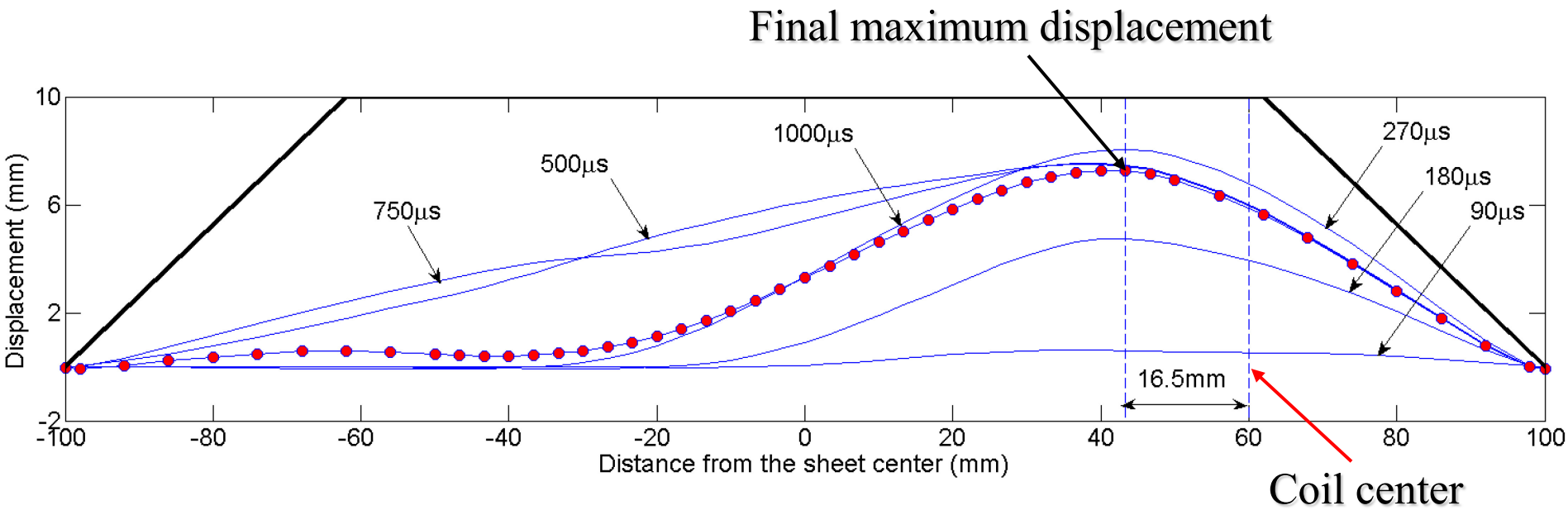


Numerical simulation

The coil stays in a fixed position and the distance between the coil centre and sheet centre is 60mm. The discharging voltage is 2000V and the capacitors is 700 μF.



Numerical simulation



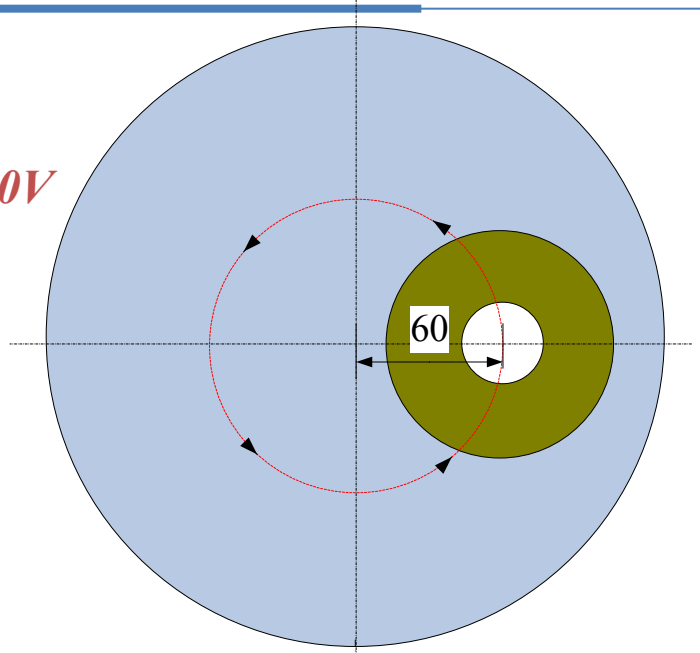
Deformation profiles at different times （Path1, 2000V,700μF）

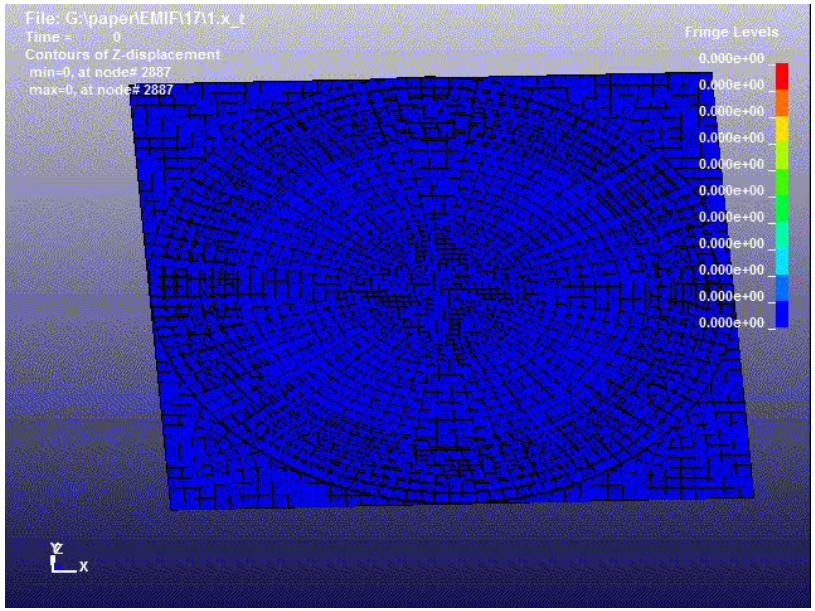
Numerical simulation

Position 1

U=2000V+4000V

C=700μF

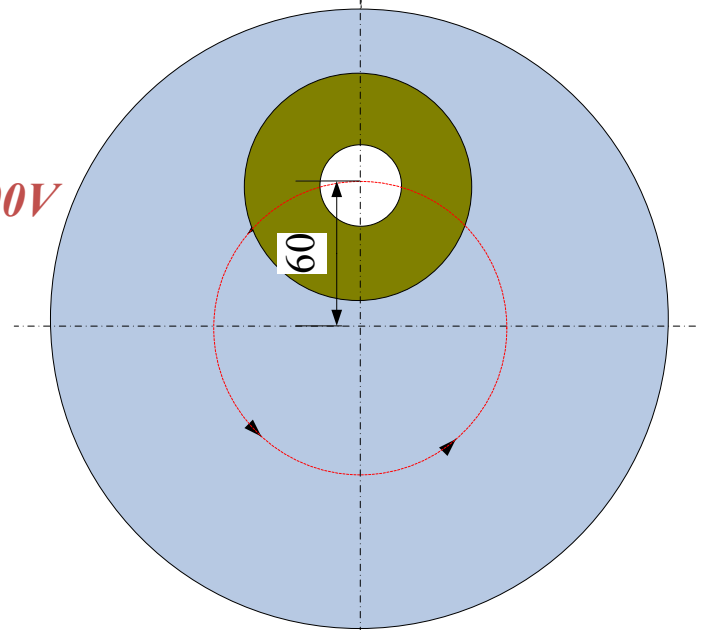


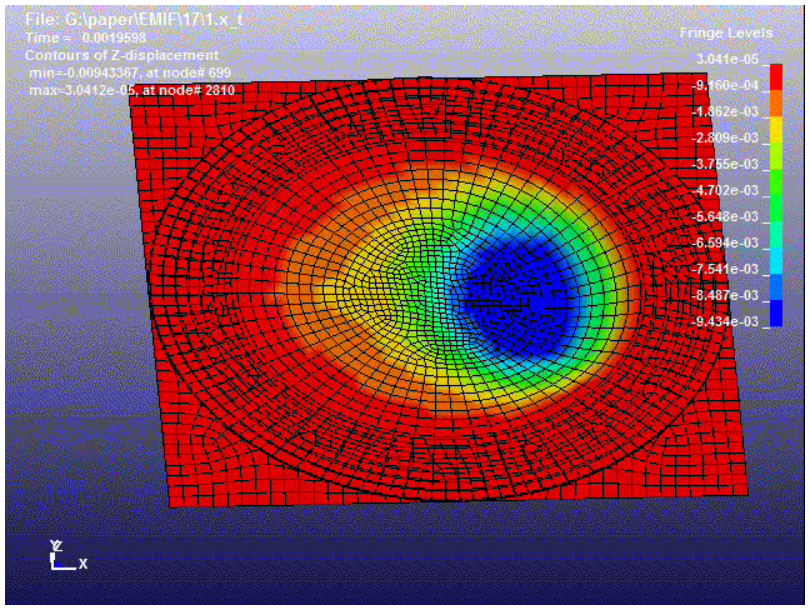


Position 2

U=2000V+4000V

C=700μF

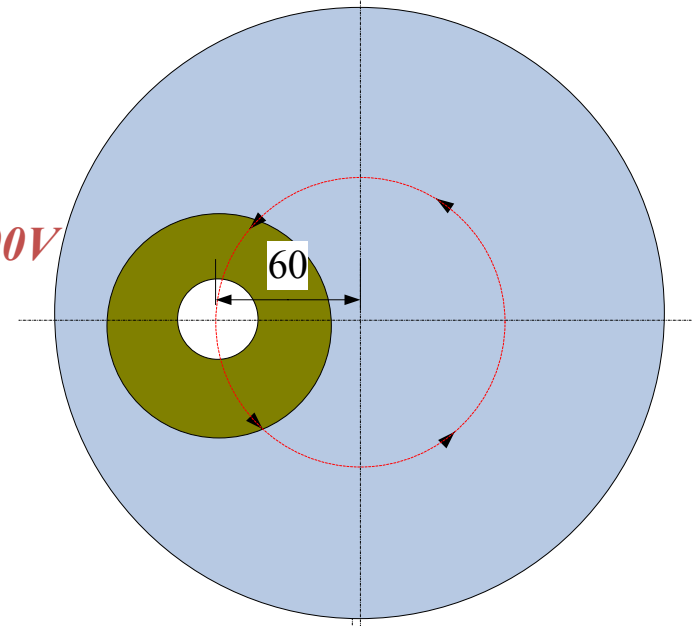


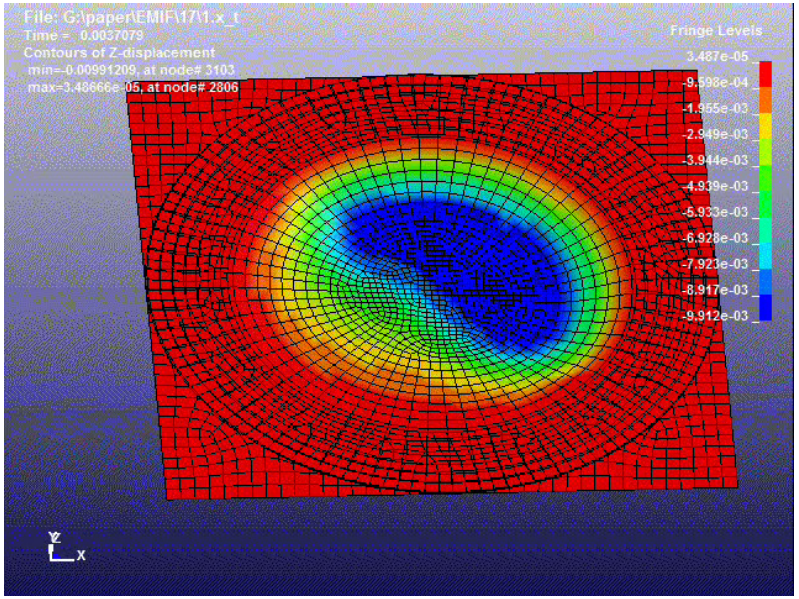


Numerical simulation

Position 3

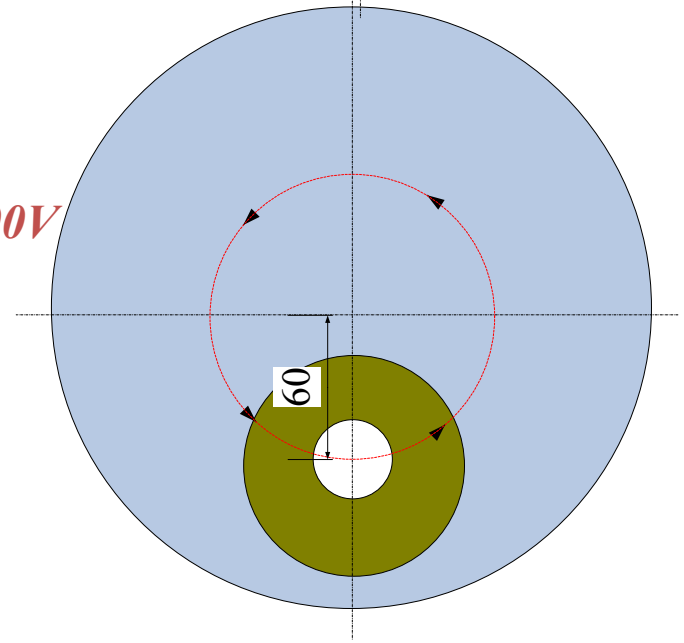
U=2000V+4000V
C=700μF

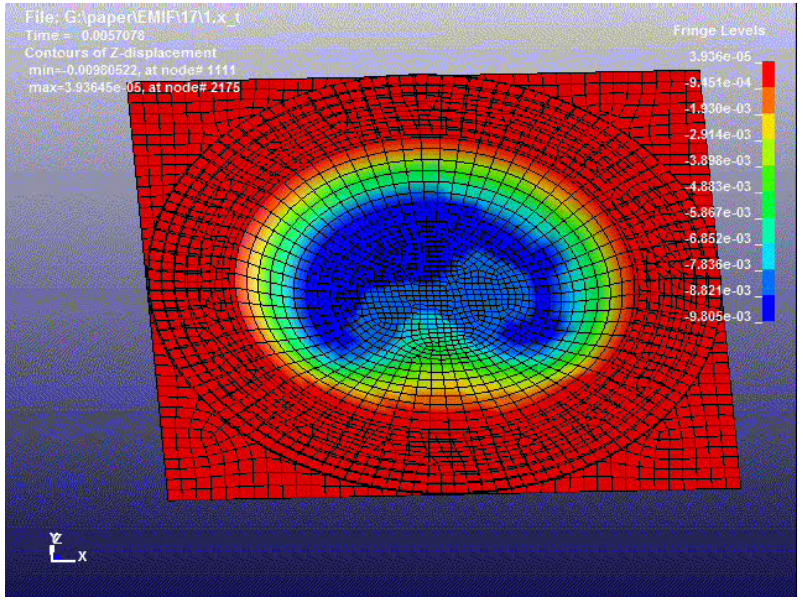




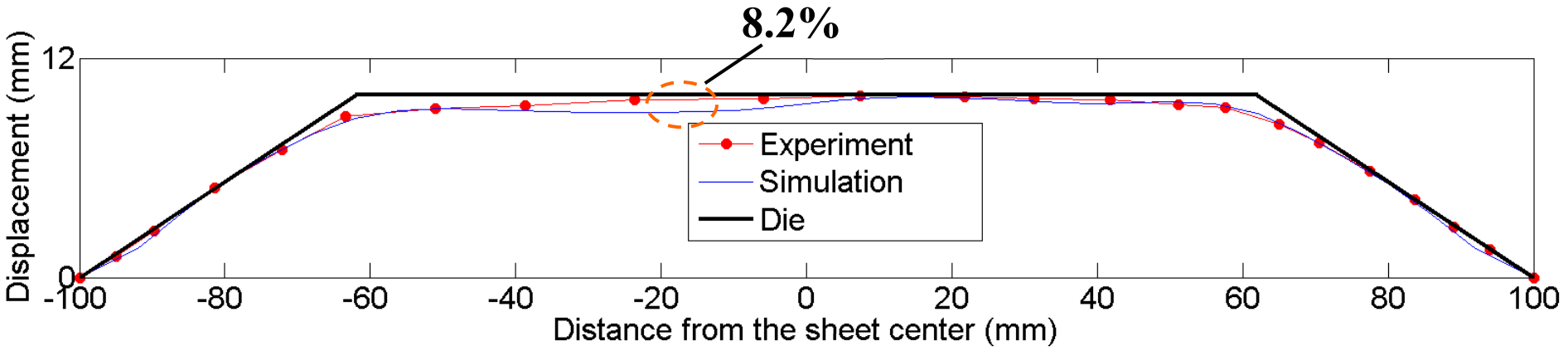
Position 4

U=2000V+4000V
C=700μF

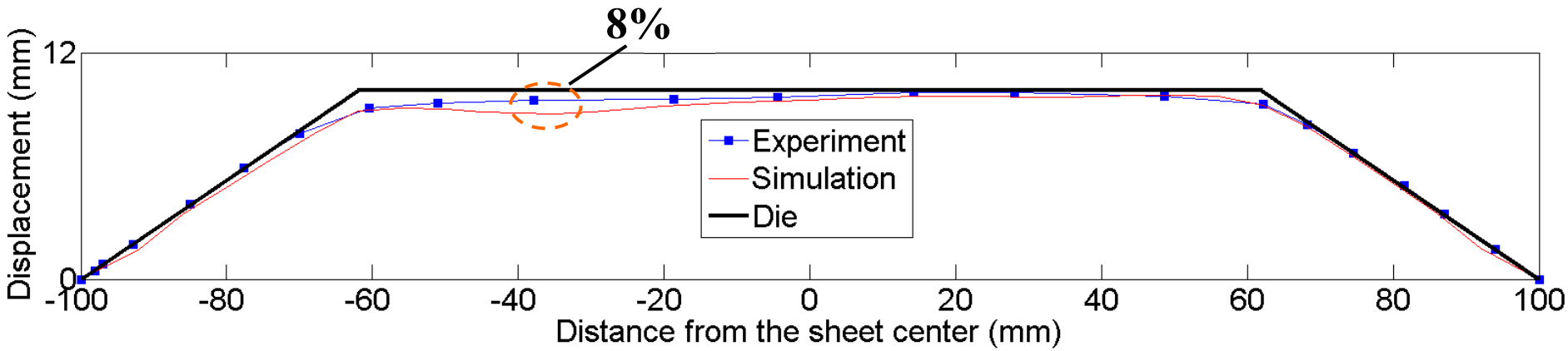




Numerical simulation



path 1



path 2

Conclusion

- The air resistance slow the deformation speed and has a great influence on the forming accuracy.
- A higher discharge voltage will cause sheet impact with the die in a high speed and the bound effect appears, while the sheet has a good moldability with the die side surface.
- Multi-times with varying value of discharge voltage can improve the sheet forming quality and reduce the bound effect.
- The EMIF technology is feasibly to produce a large part with small working coil and small discharge energy, which enhance the flexible forming process of EMF.
- A new simulation method for EMIF is proposed. The simulation results are good agreement with the experimental values.

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