

**IMPACT OF METAL THICKNESS AND FIELD-SHAPER
ON THE TIME-VARIANT PROCESSES DURING
IMPULSE ELECTROMAGNETIC FORMING
IN TUBULAR GEOMETRIES**

By:

**Pedram Gharghabi, Peyman Dordizadeh
and Kaveh Niayesh**

**University of Tehran, Iran
School of Electrical and Computer Engineering**



Outline of Contents



University
of Tehran

- Preliminary concepts
- Qualitative analysis
- Validating Simulation Results
- Conclusions

Preliminary concepts



University
of Tehran

ELECTROMAGNETIC FORMING (EMF)

is a process which uses a magnetic pulse to form a conductive object.

Sequence of this process :

Discharging the capacitor bank

Producing great highly time varying current and magnetic field

Inducing Eddy currents in the workpiece

Generating the repulsive force

Mathematical relations :

$$\nabla \times E [V / m] = - \frac{\partial B [T]}{\partial t [S]} \longrightarrow J_{eddy} [A / m^2] = \sigma [S / m] \cdot E [V / m] \longrightarrow \vec{F} = \vec{j} \times \vec{B}$$

Preliminary concepts



University
of Tehran

Energy point of view :

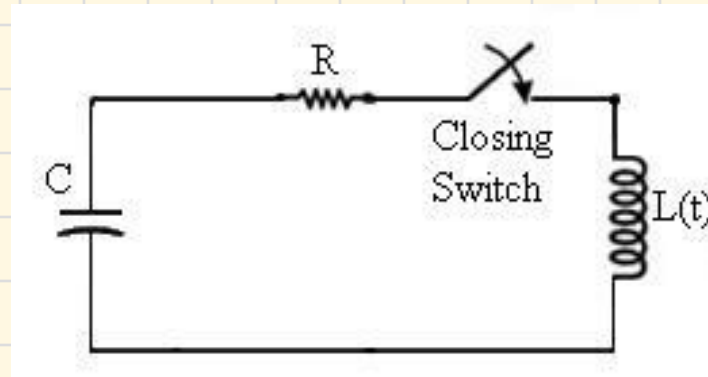
Energy stored in
the capacitor bank

Energy in the coil

Energy in the
air gap

Kinetic energy of
the work piece

Circuit Schematic :



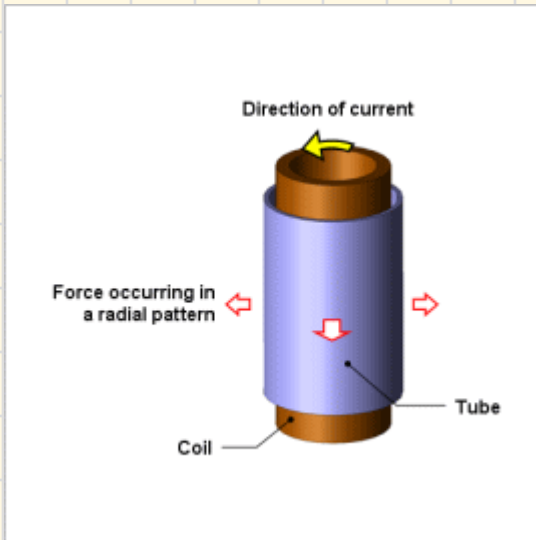
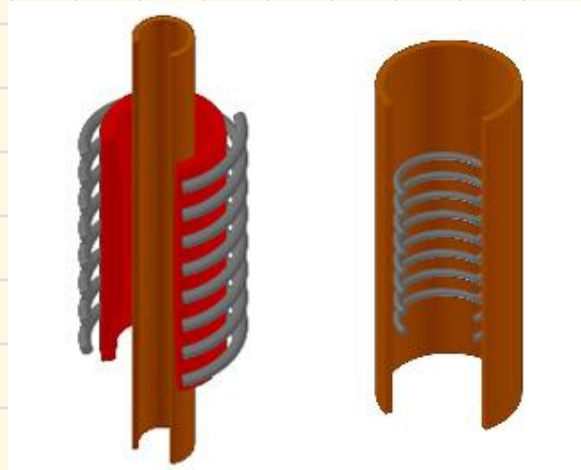
Preliminary concepts



University
of Tehran

Tube Electromagnetic Forming

- spiral coil
- tubular metallic conductor
- field shaper



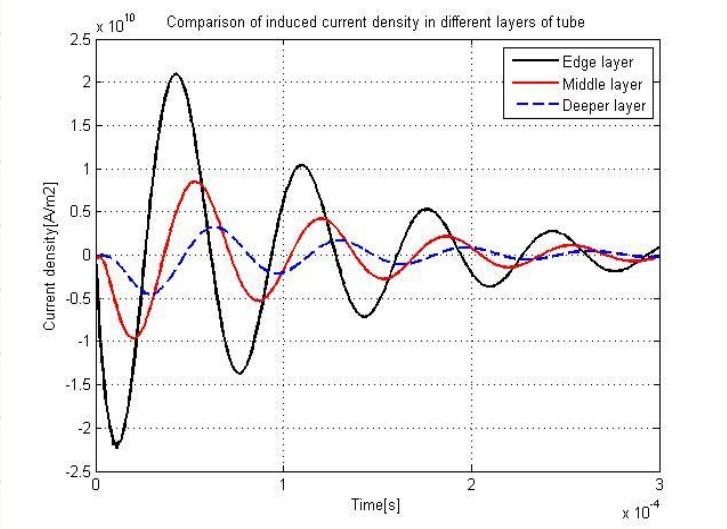
Qualitative Analysis



University of Tehran

Thickness of the Workpiece

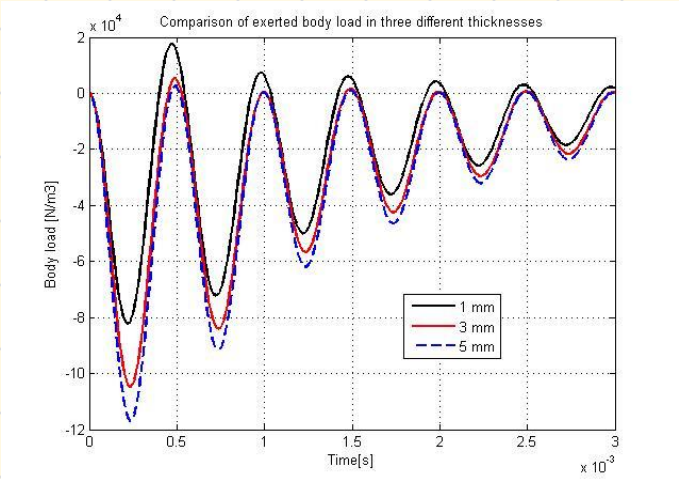
Eddy currents need time to diffuse into the workpiece.



And eddy currents do not penetrate the whole depth of the conductor.

$$\delta [m] = \sqrt{\frac{1}{\pi \cdot f [Hz] \cdot \sigma [S/m] \cdot \mu [Wb/A.m]}}$$

The Thickness of the workpiece influences the form of the resultant force.



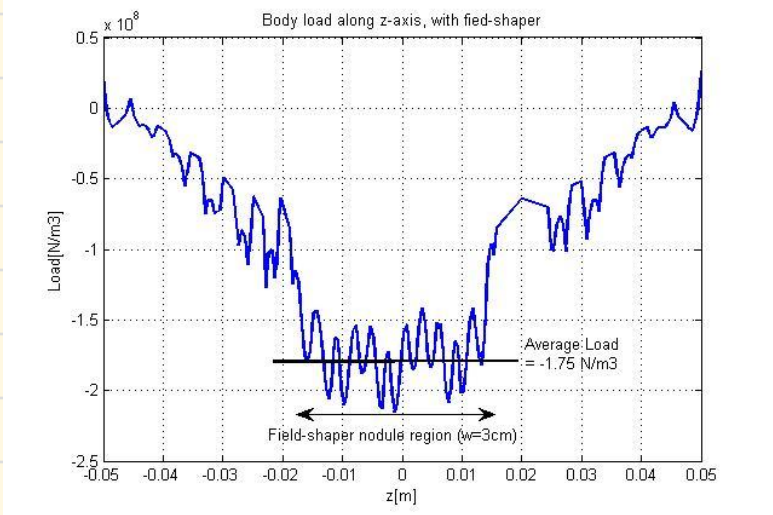
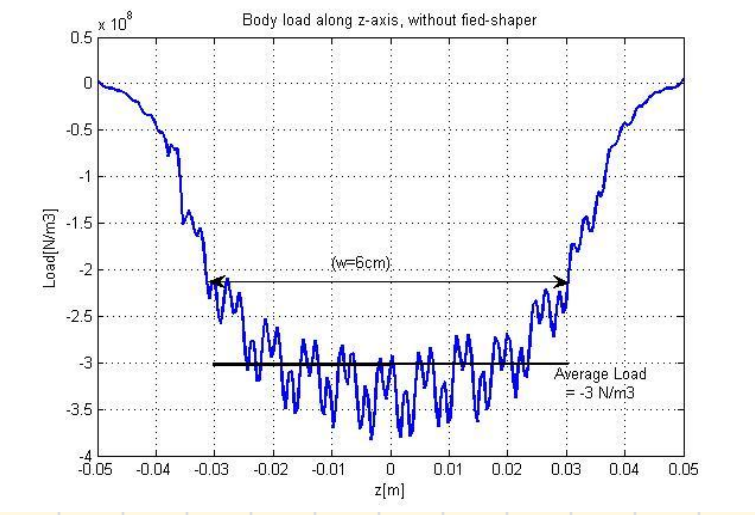
Qualitative Analysis



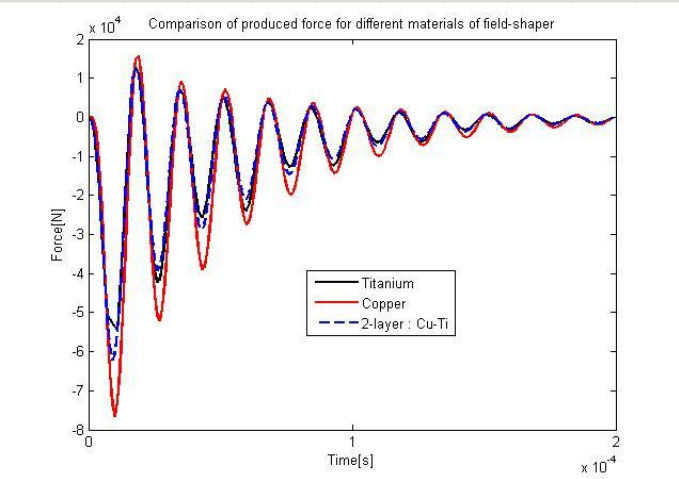
University of Tehran

Field Shaper

A conductive medium which empowers us to control the magnetic pressure exerted on the workpiece.



Field shaper can be made from different materials.



Qualitative Analysis

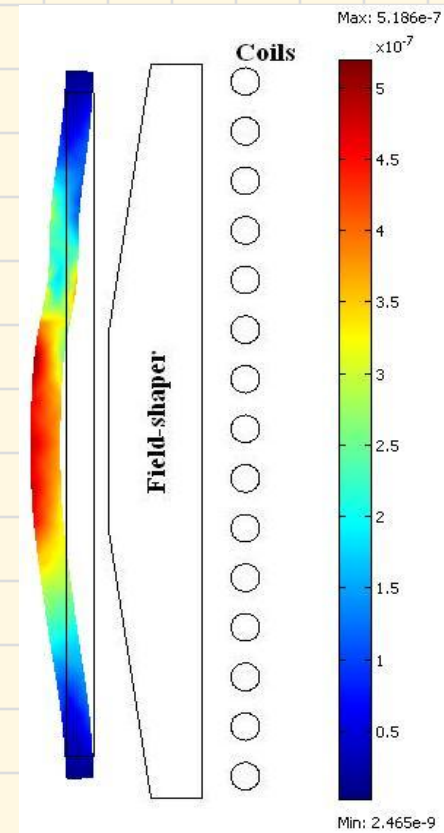
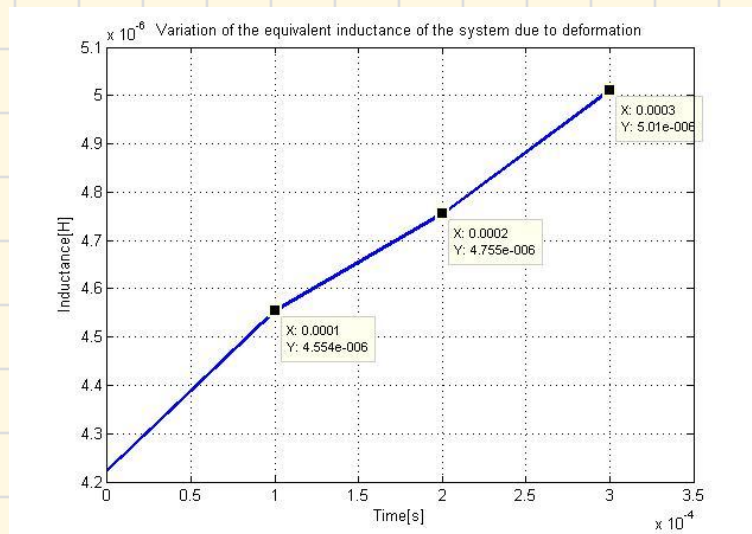


University
of Tehran

Field Shaper

The deformed shape of the workpiece by using the field shaper is shown.

Deformation of the workpiece changes the equivalent inductance of the system.



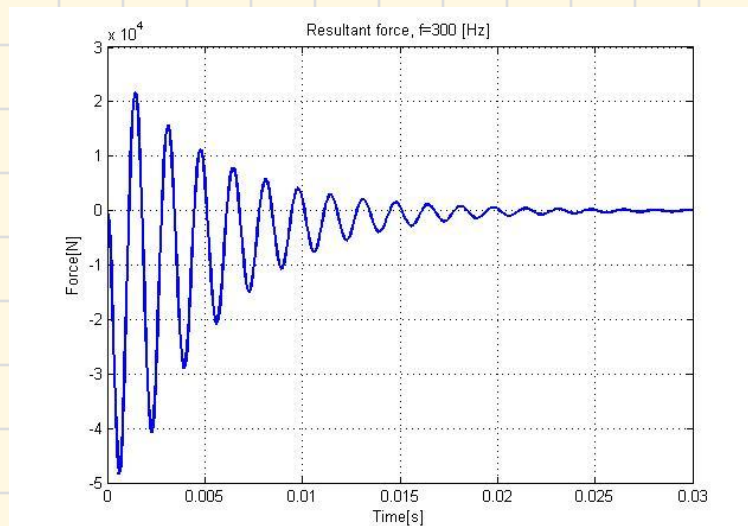
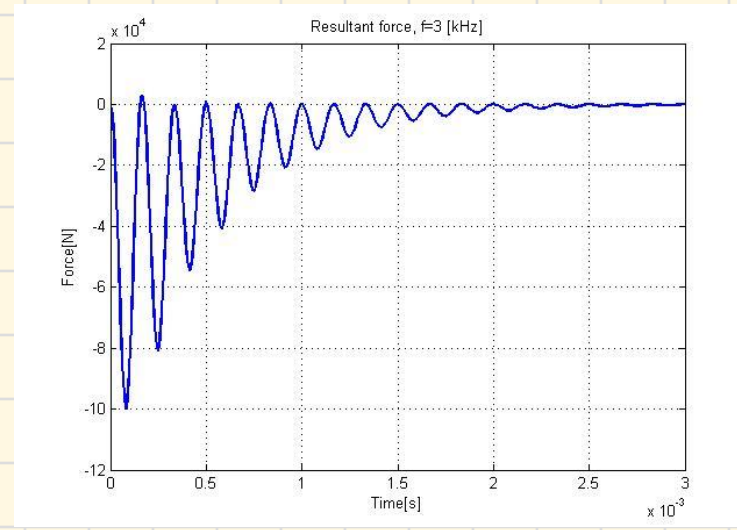
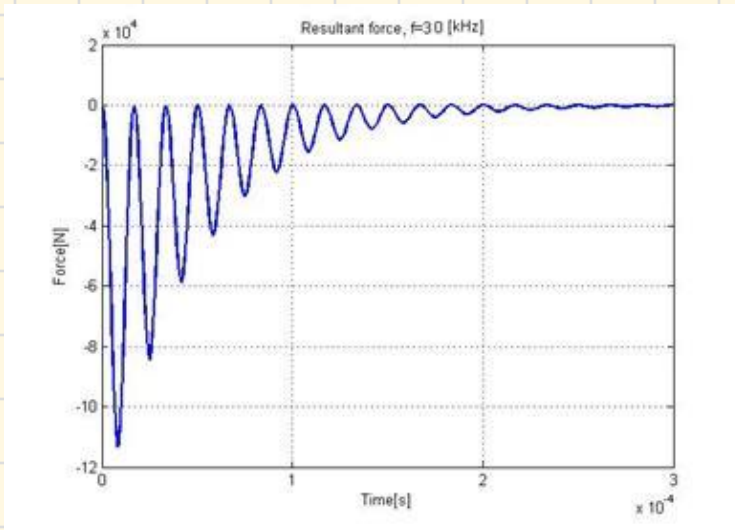
Qualitative Analysis



University
of Tehran

Frequency of the applied current

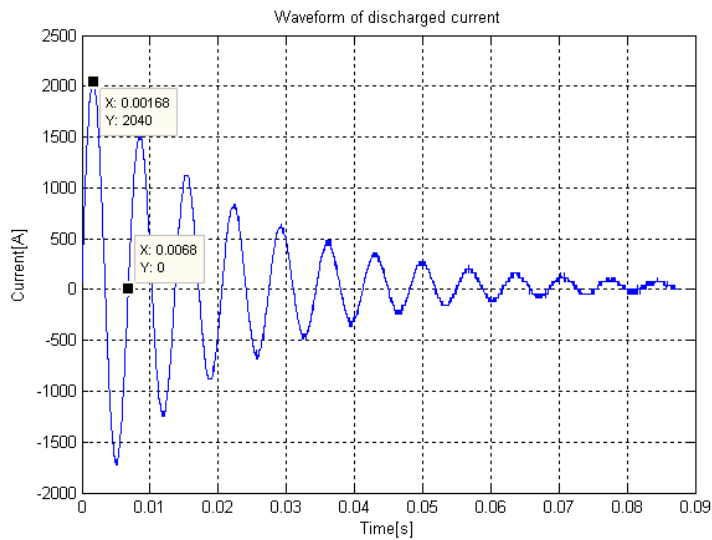
It influences the amplitude and the frequency of the resultant force.



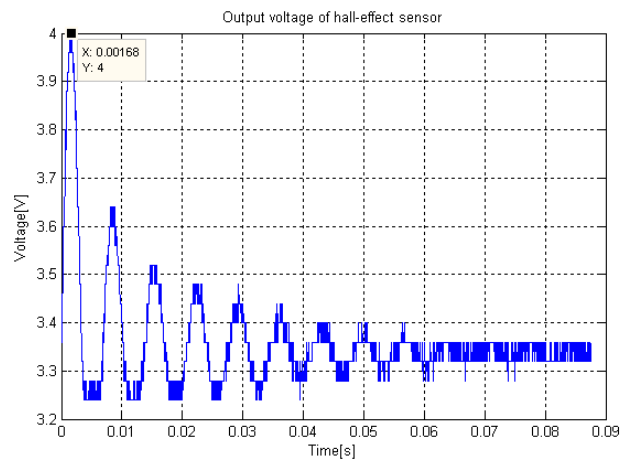
Validating Simulation Results



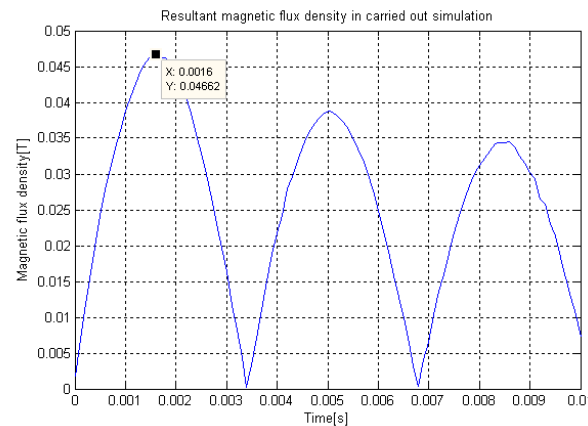
University
of Tehran



5 parallel 500 [uF] capacitor bank



0.0515 [T]



0.0466 [T]



Conclusions



University
of Tehran

- The thickness of the work-piece should be at least equal to the skin depth of the work-piece. Otherwise, the desired outcome would not be achieved.
- The frequency of the discharged current has two major influences. The higher the frequency is, the better results will be achieved.
- In some application of the electromagnetic tube forming the existence of the field shaper is inevitable.
- Although the variation of the equivalent inductance of the system vs. time is not considerable, but if accurate results are needed it must be taken into account.



University
of Tehran

Thank You for Your Attention.
Any Questions or Comments?