Recent Developments and Roadmap Part 4: Electromagnetics

12th International LS-DYNA User's Conference
June 5, 2012

LSTC
Livermore Software Technology Corp.

Outline

- Introduction
- Recent developments

LS-PrePost	Mr. Philip Ho
Dummies	Dr. Christoph Maurath
Incompressible CFD	Dr. Facundo Del Pin
Electromagnetics	Dr. Pierre L'Eplattenier
ALE, DEM, SPH, Particle	Dr. Jason Wang

- Conclusions

Electromagnetism

Dr. Pierre L'Eplattenier

Presentation of the Physics

Source Electromagnetic Fields
(Source currents in Conductors,
External fields, …)

Magnetic and Electric fields as well as Induced Currents in conducting parts

Lorentz Forces

Possible Motion, and deformation of the Conductors which in turn changes EM related properties (fields, and currents).

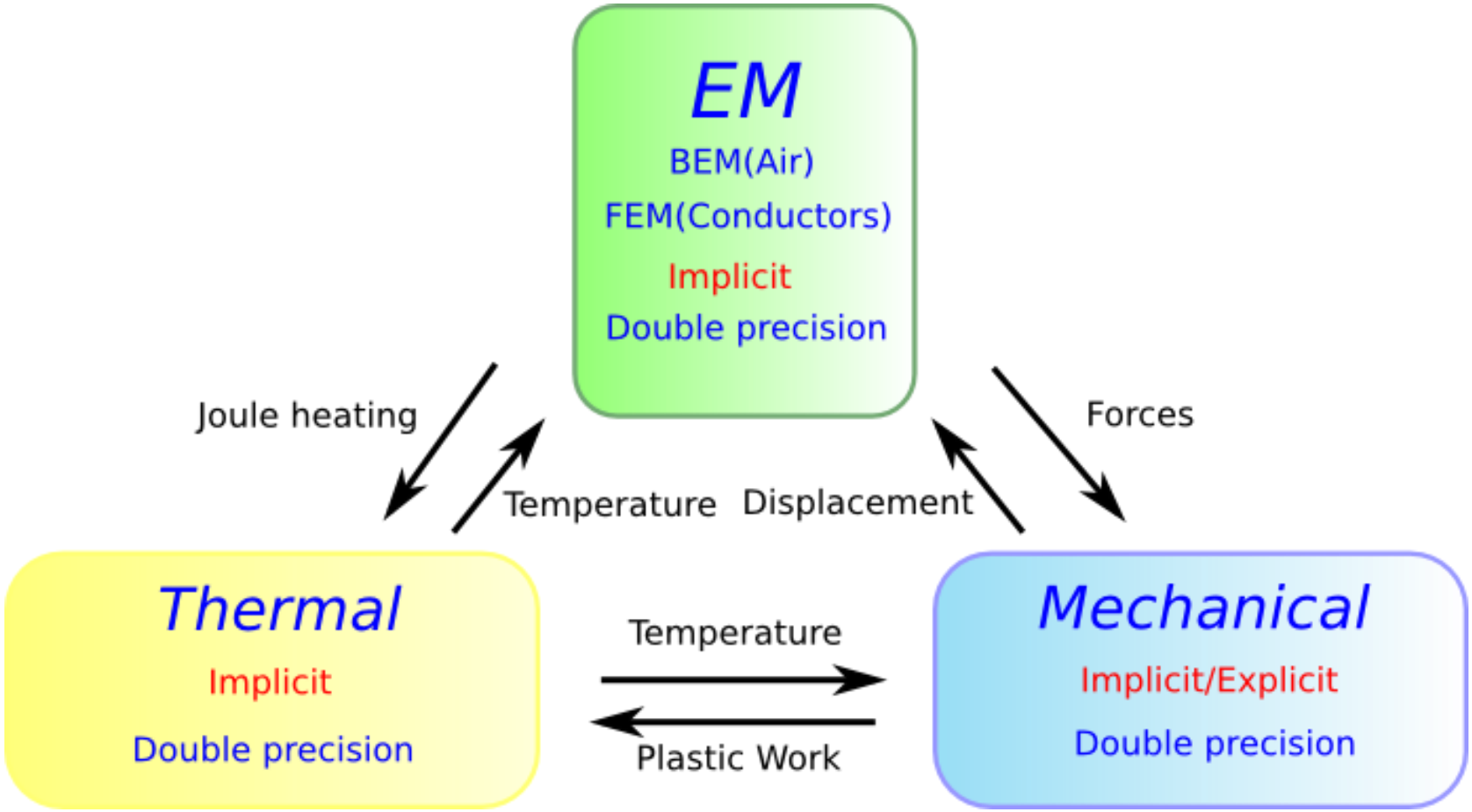
Joule heating

Possible heating which in turn changes EM related material properties
(electrical conductivity, …).

Solver Coupling Needed

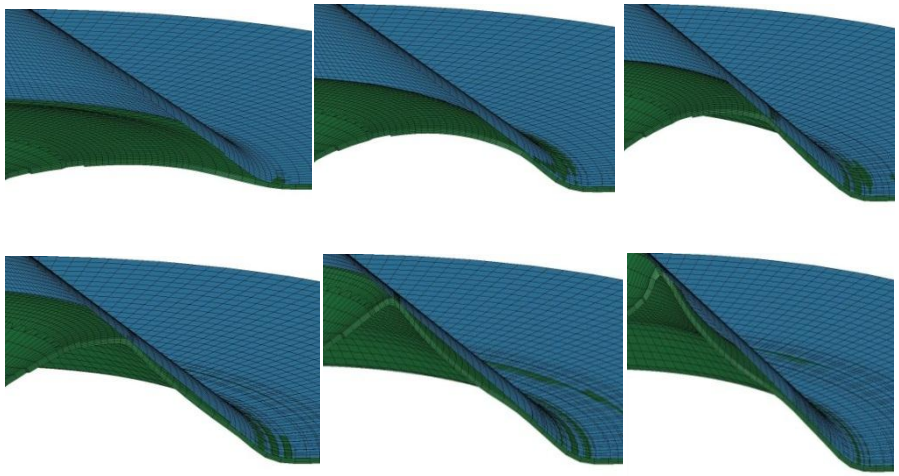
Coupling with other LS-DYNA Solvers

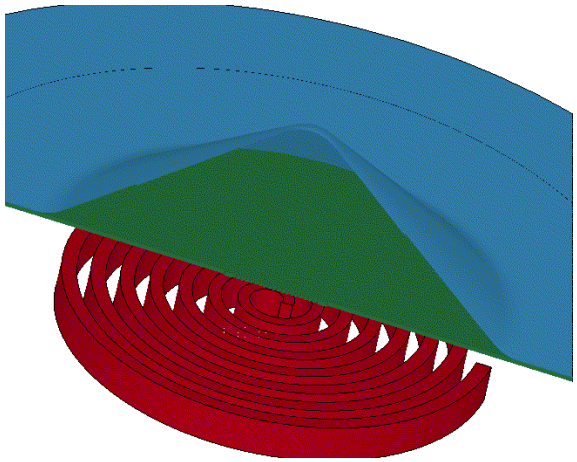
Scope of the new 980 solvers : to be coupled with LS-DYNA solvers in order to solve complex multi-physics problems

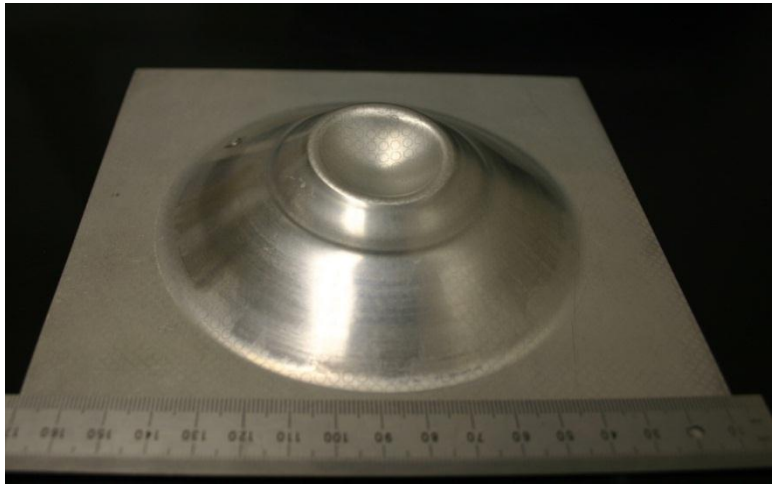


Electromagnetics for Magnetic Metal Forming

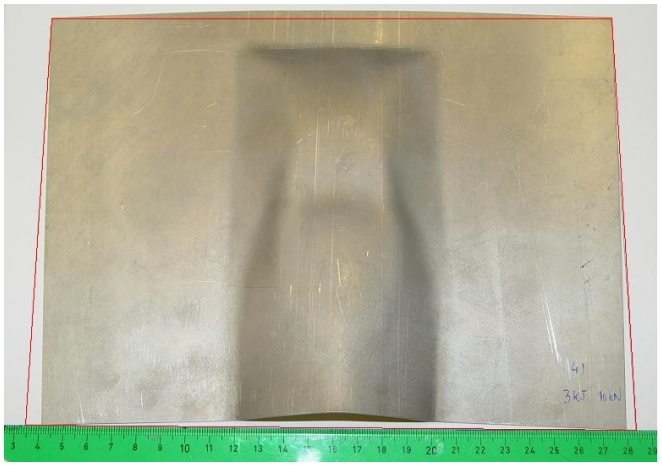
Al sheet forming on conical die :
In collaboration with:
M. Worswick and J. Imbert
University of Waterloo, Ontario, Canada

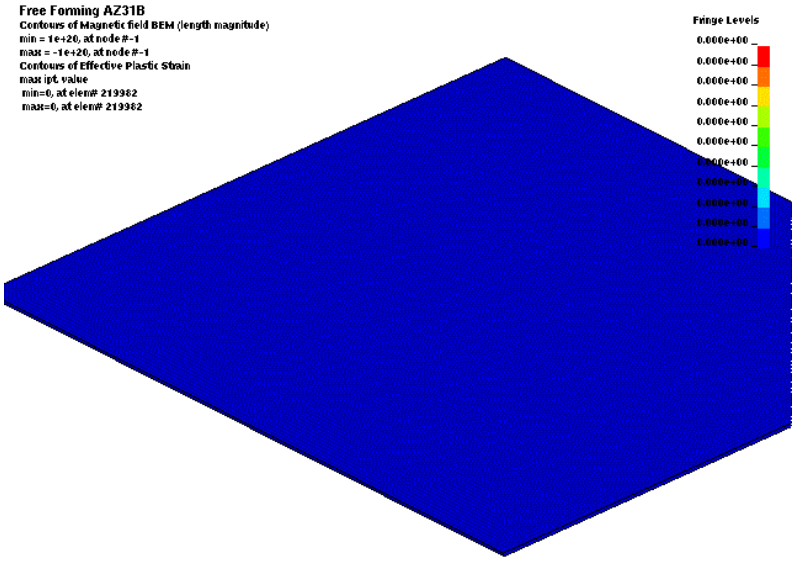




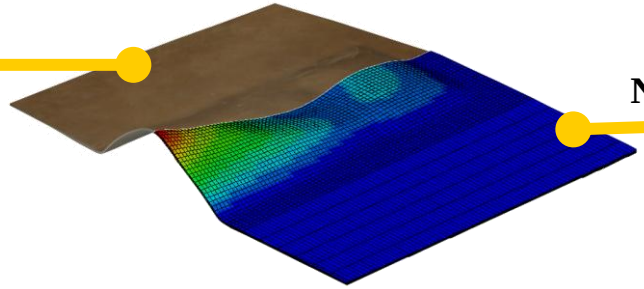


Electromagnetics for Magnetic Metal Forming





Experimental result

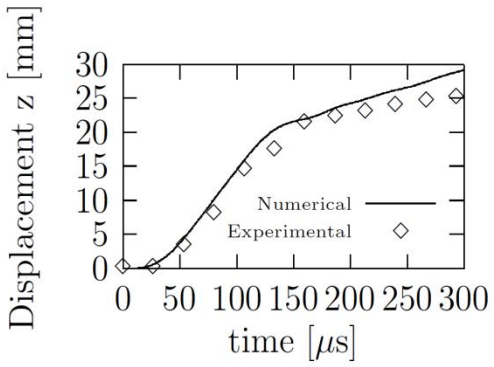


Numerical result

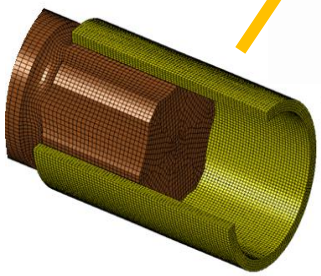
MONDRAGON UNIBERTSITATEA

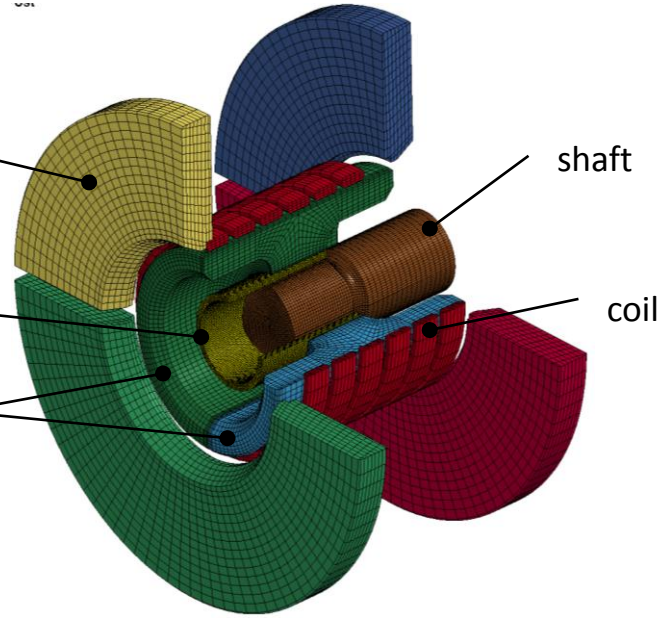
In collaboration with:

Ibai Ulacia , University of Mondragon, Gipuzkoa, Basque country



Electromagnetics for Magnetic Metal Forming

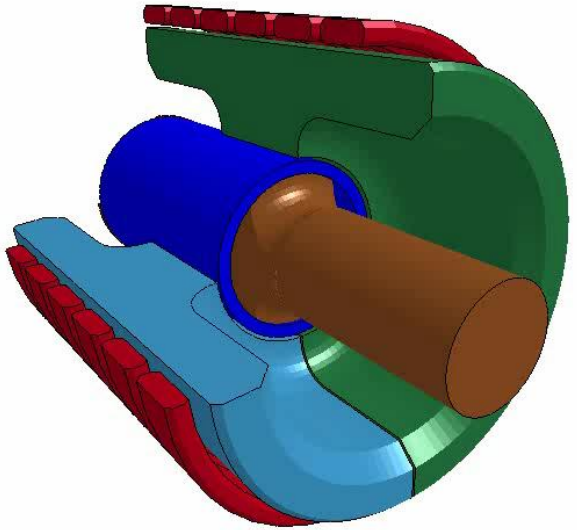




Fraunhofer
IWU

Simulation of a steel tube-shaft joint for
Automotive power train component

In collaboration with:
Fraunhofer Institute for Machine Tools and Forming Technology IW
Chemnitz, Dipl.-Ing. Christian Scheffler
Poynting GmbH, Dortmund, Dr.-Ing. Charlotte Beerwald



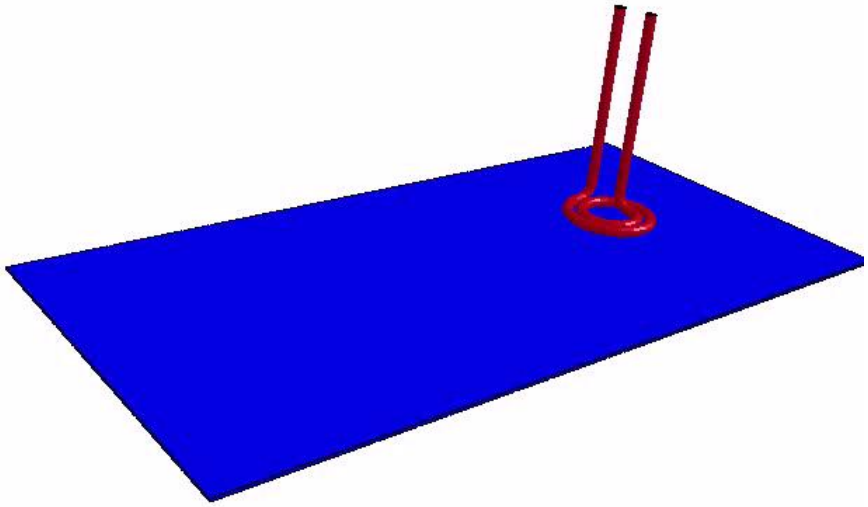
Electromagnetics for Inductive Heating

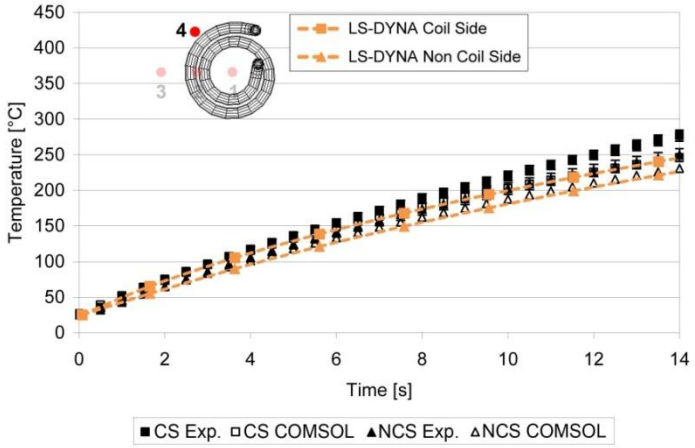
Institut für Verbundwerkstoffe

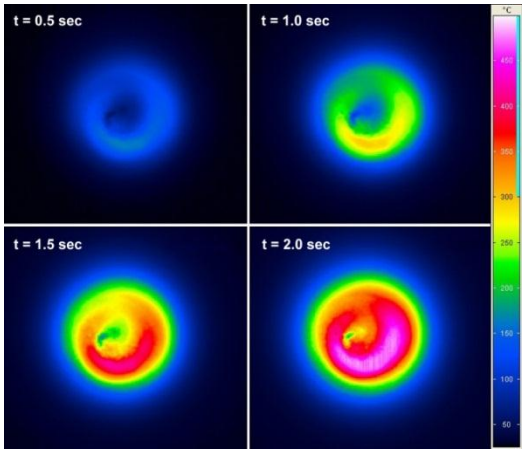
Heating of a steel plate by induction

In collaboration with:

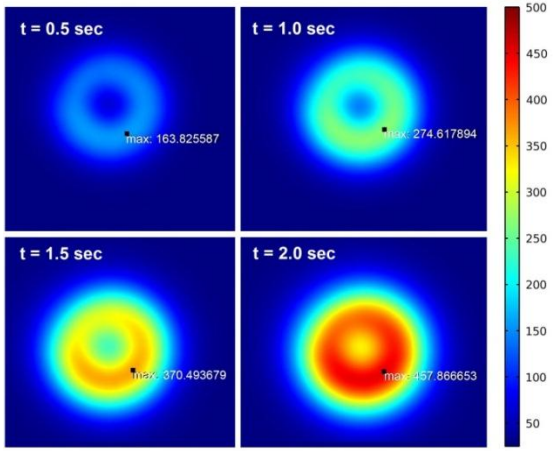
M. Duhovic, Institut für Verbundwerkstoffe, Kaiserslautern, Germany







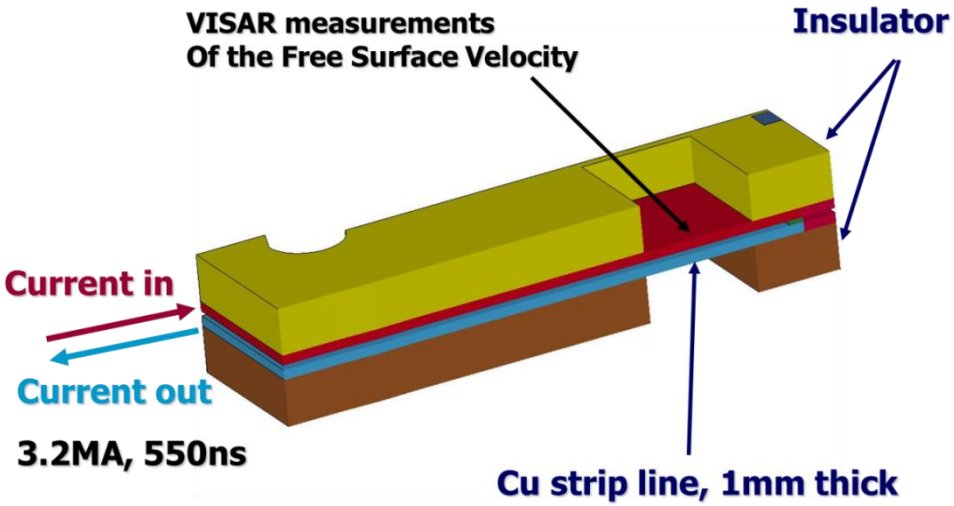
Thermal images from experiment



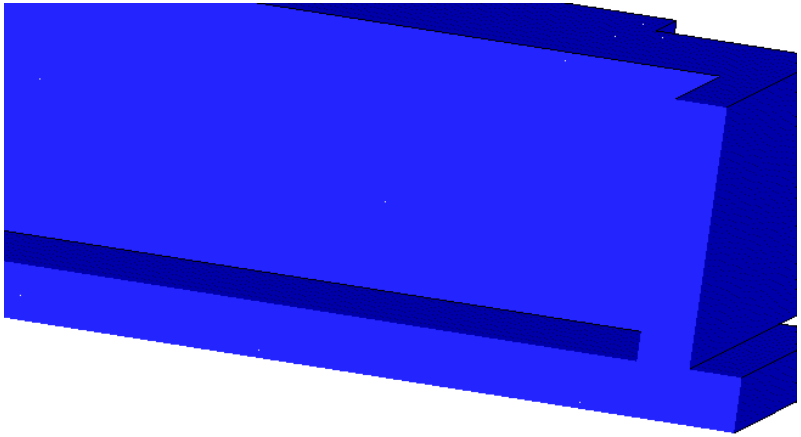
LS-DYNA temperature fringes

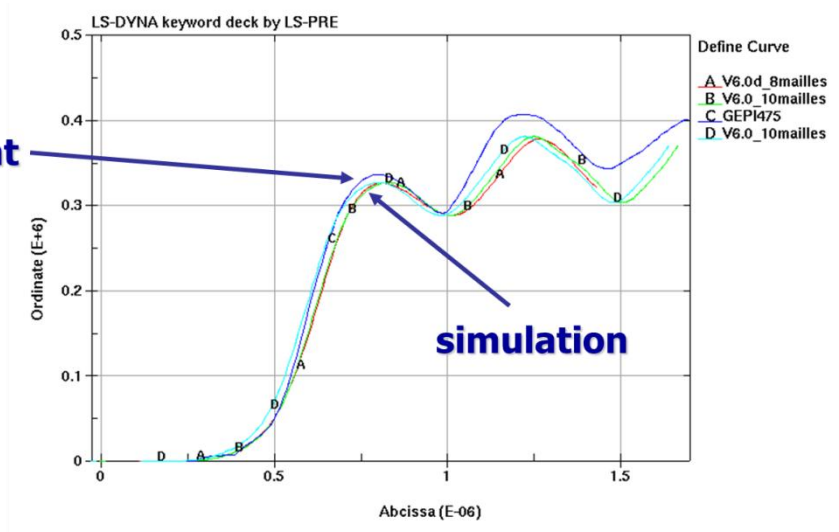
Electromagnetics for High Pressure Generation

G. Le Blanc, G. Avrillaud, P.L.Hereil, P.Y. Chanal,
Centre D'Etudes de Gramat (CEA), Gramat, France



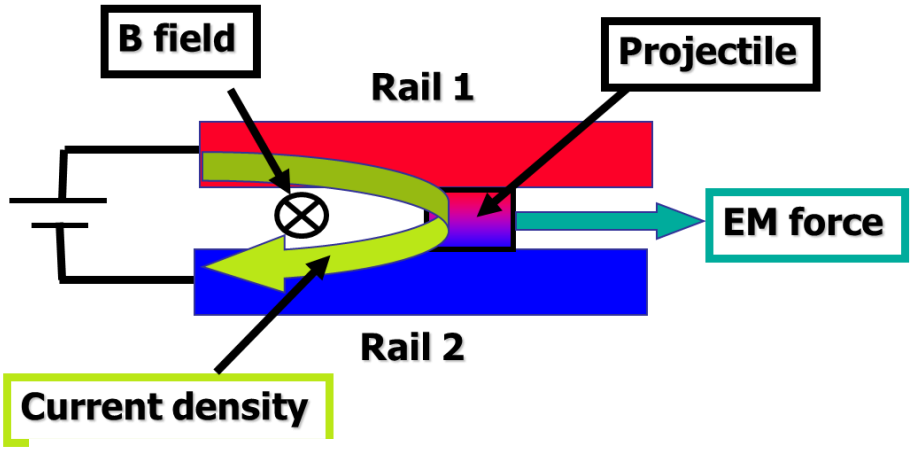
111,000 elements, 10 elements through line thickness

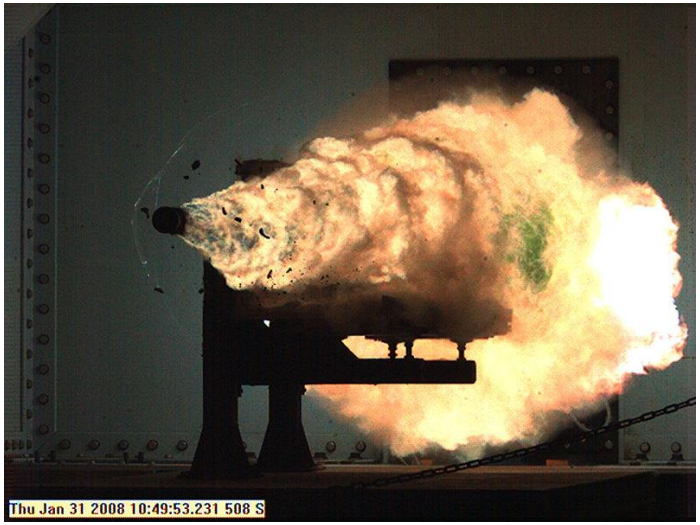


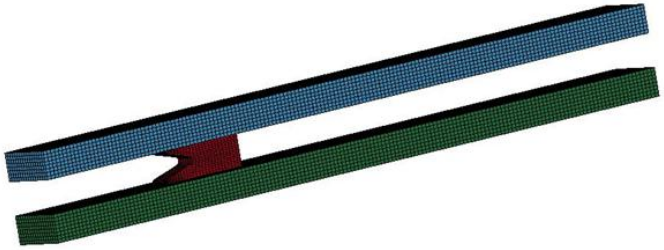


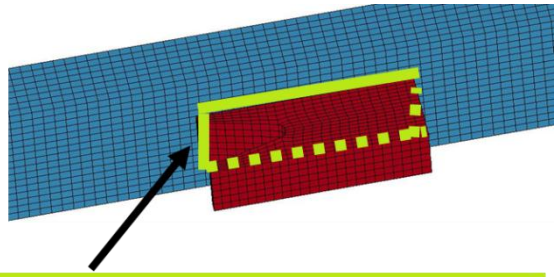
Free surface velocity vs time

Electromagnetics for Railgun Simulations

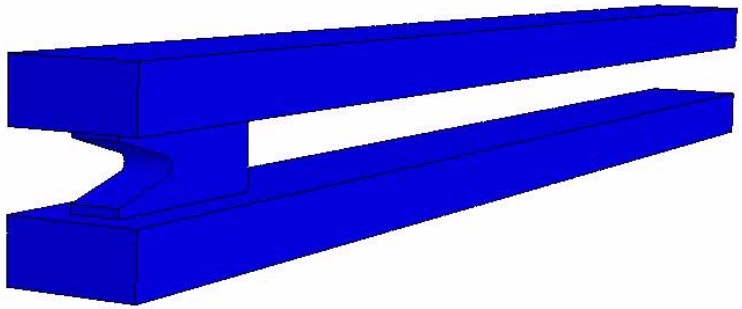






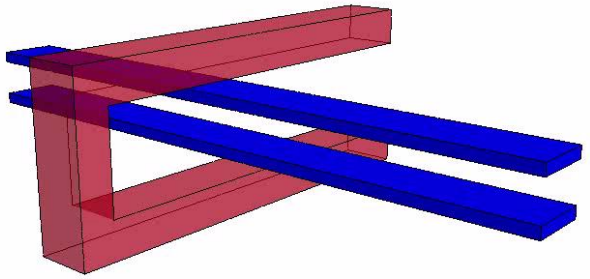


Sliding contact between the rails and the projectile



Other Possible Applications

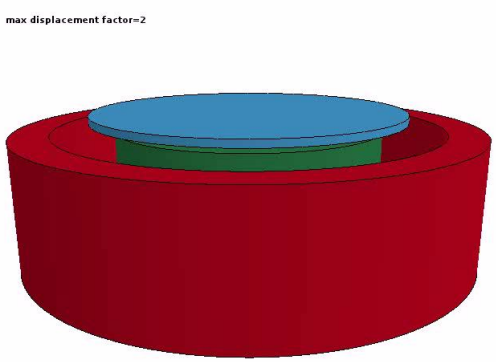
Magnetic Metal Welding in collaboration with
M. Worswick and J. Imbert,
University of Waterloo, Canada



Ring expansions experiments. Various Collaborations

- G. Daehn, Ohio State University.
- H. Kim, Edison Welding Institute, USA.
- D. Chernikov, Samara State Aerospace University, Russia.

And even Levitating objects !



Advancement Status

- All EM solvers work on solid elements (hexahedral, tetrahedral, wedges) for conductors.
- Shells can be used for insulator materials.
- Serial and MPP versions available.
- 2D axi-symmetric available.
- The EM fields as well as EM force and Joule heating can be visualized in LS-PREPOST :
  - Fringe components
  - Vector fields
  - Element histories

Plan for Future

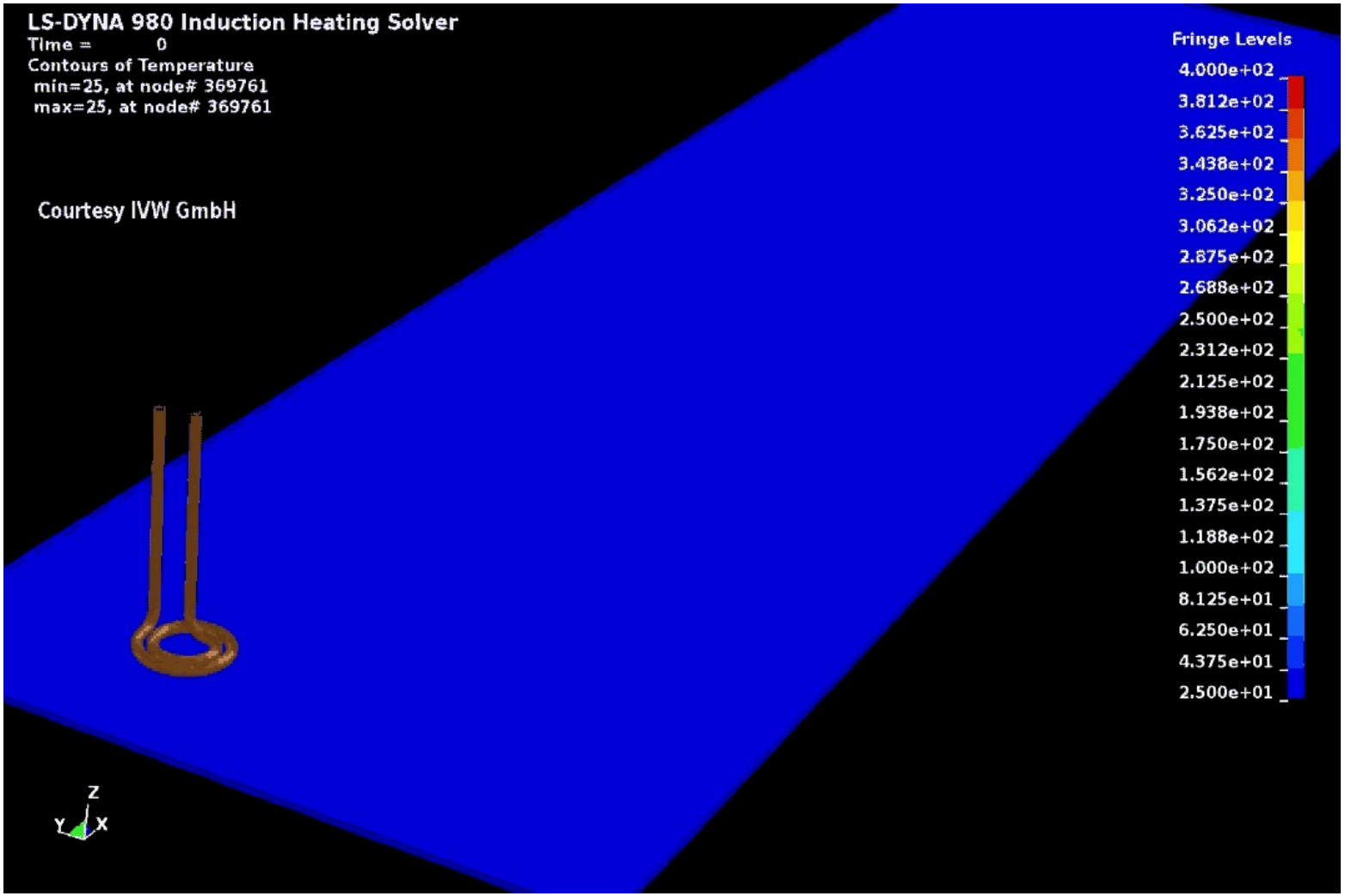
Introduction of Magnetic materials.

Further optimization of the FEM / BEM calculations.

Continue the validation process (T.E.A.M. problems).

Wishes from users. Please let us know !

Thank you for your Attention



Video: courtesy of M. Duhovic, Institut für Verbundwerkstoffe, Kaiserslautern, Germany

Thank You !