TRANSVALOR

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ICHSF21 INTERNATIONAL CONFERENCE ON HIGH SPEED FORMING

3D Simulation of the Magnetic Pulse Welding Process

Mohammadjavad Lashkari

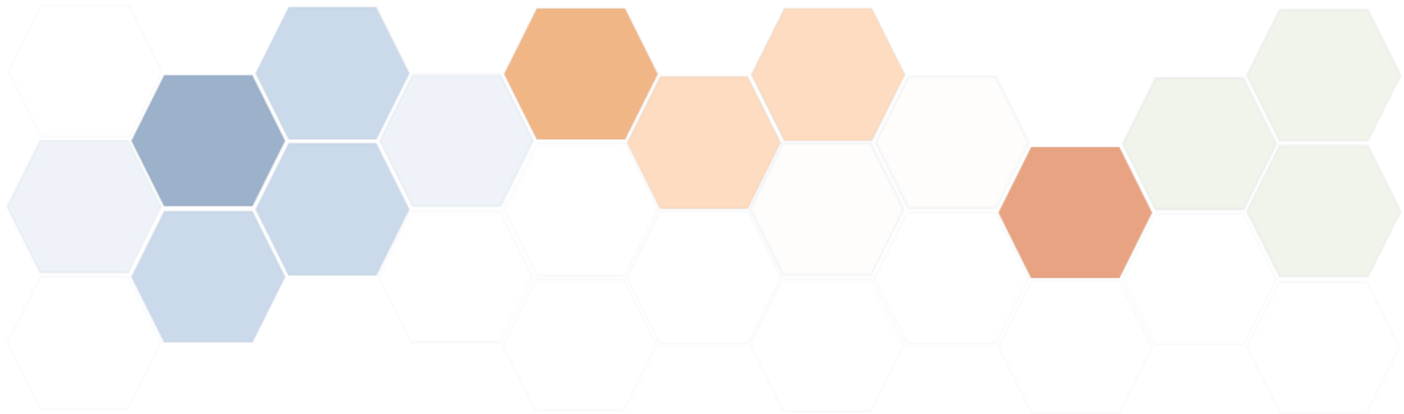
Under Supervision of:

José Alves, Siddhant Goyal, Marlon Hahn, Christine Beraudo, A. Erman Tekkaya

IUL Institute of Forming Technology and Lightweight Components

AGENDA

- Introduction
  - Motivation
  - Magnetic Pulse Welding Introduction
- Current Problem
  - Current Setup
  - Forming stage
  - Welding Window
- Conclusions



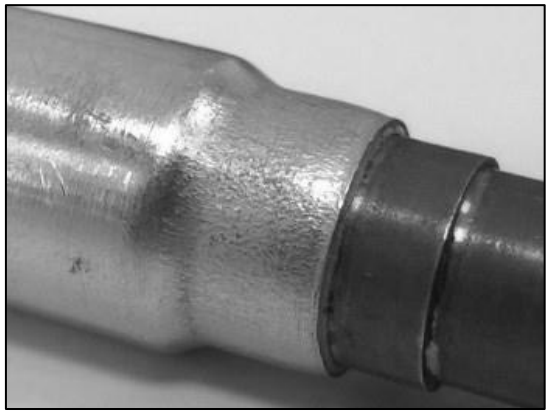
Introduction

Motivation and Objectives

[G. Zittel, '*A historical Review of High Speed Metal Forming*', 2010]

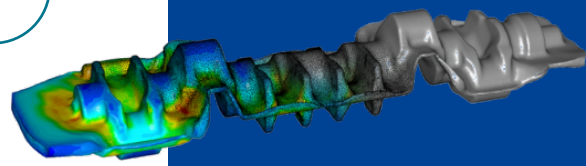
Motivation

- Magnetic pulse welding: Benefits and Complexities
- Experimental knowledge available
- Potent software by Transvalor
- Influence of welding on the ongoing process



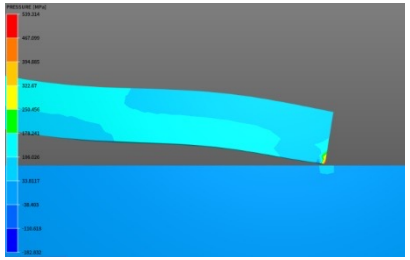
Objectives

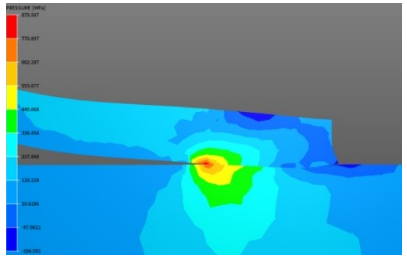
- Including the weld criteria in software
- Automated weld checking
- Better simulation of the process
- Simulation capable of being as close to experiments as possible

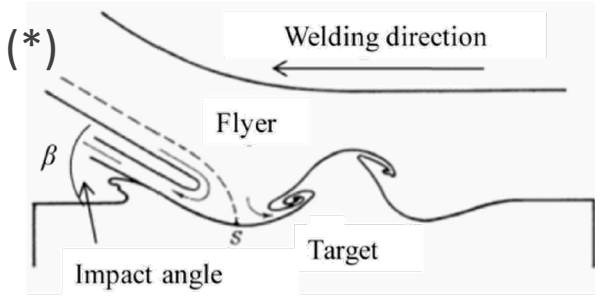


Magnetic Pulse Welding

… An open research field …





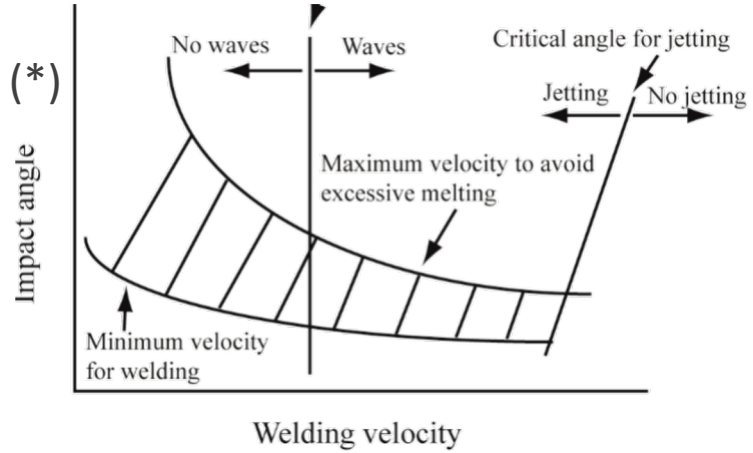


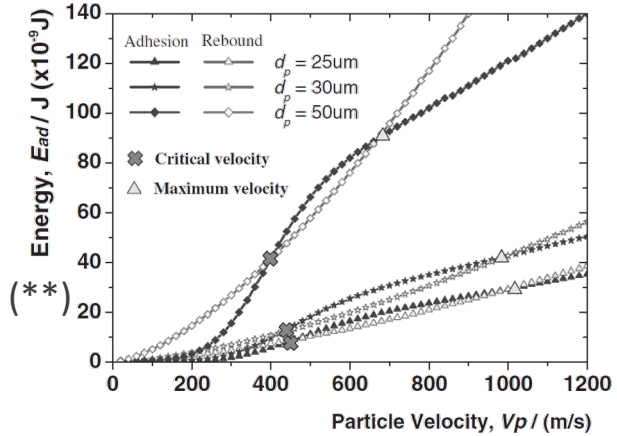
Scheme of the impact condition.

Metal behaves as liquid at the small scale and during small time laps

Characterization is typically done as a function of:

- Impact velocity
- Impact angle
- Thickness of flyer





How to transform macroscopic parameters into local variables?

Temperature, Pressure, velocity, angle, material properties, etc.

Still under research!!

(*) [Huimin Wang and Yuliang Wang, "High-Velocity Impact Welding Process: A Review," *MDPI*, jan. 2019.]

(**) [Wu J., Fang H., Yoon S. Lee C. Kim H.J., "Critical Velocities for high Speed Particle Deposition in Kinetic Spraying," *Materials Transactions*, Vol. 47 pp. 1723-1727, jul. 2006.]

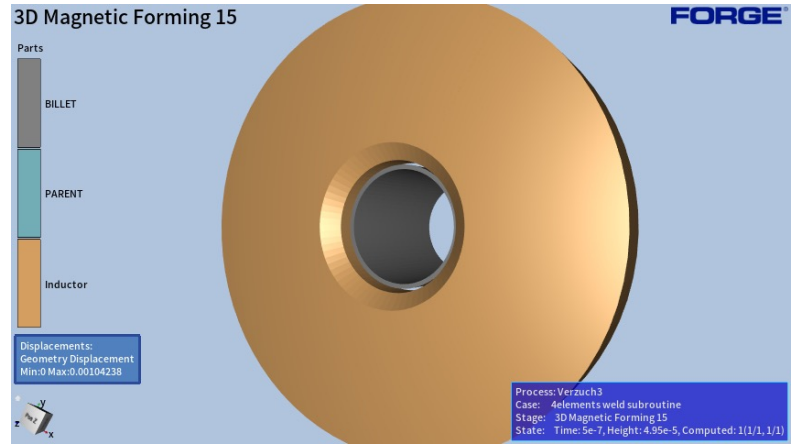
Current Problem

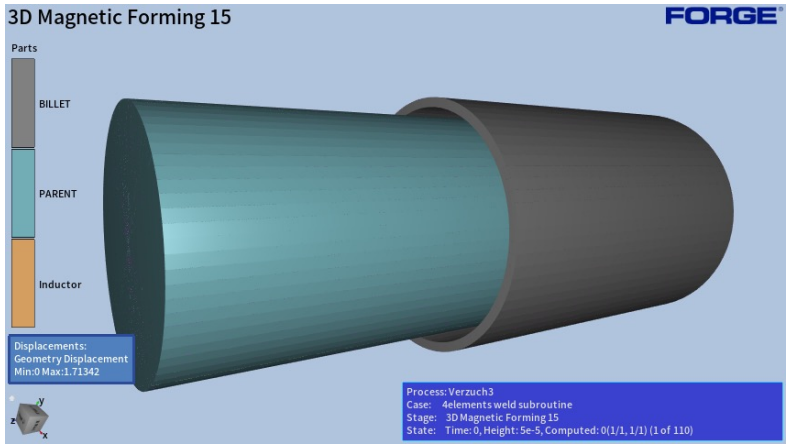
Current Setup

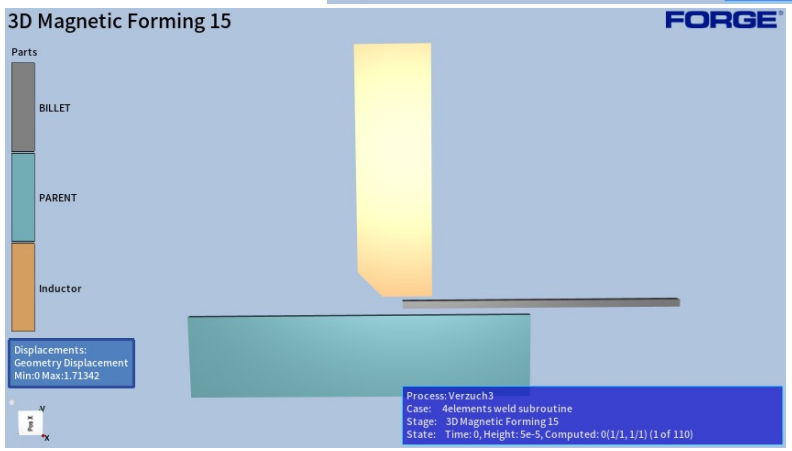
Geometry
- Tubular
- Concentric
- Fixed at the ends

Parameters
- Flyer outer D: 40mm
- Flyer thickness: 1.5mm
- Gap: 1.5mm

Material
- AW 6060 T66, annealed
- C45- Normalized
- Copper Coil



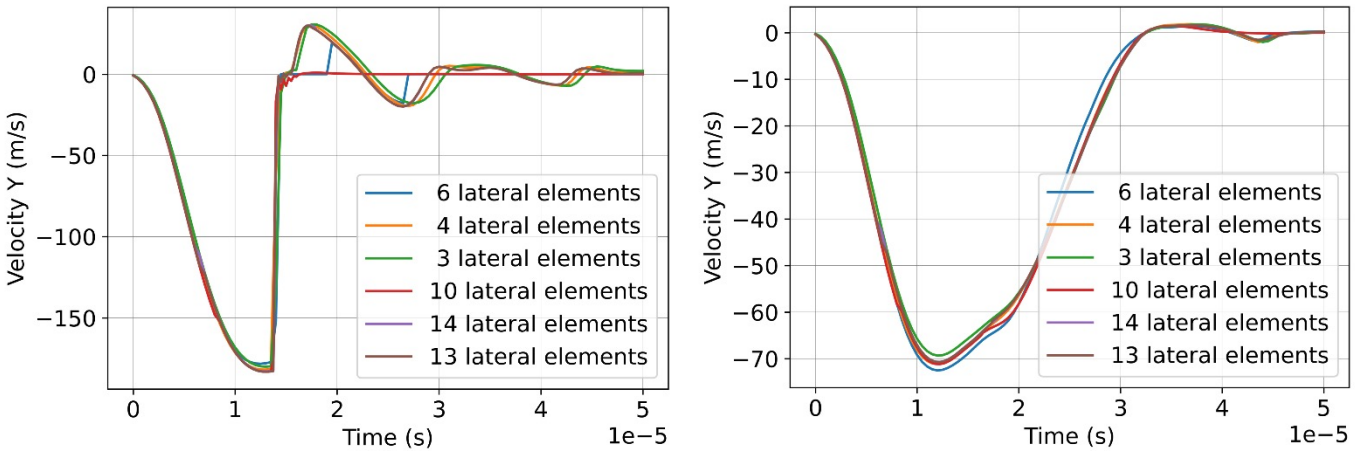


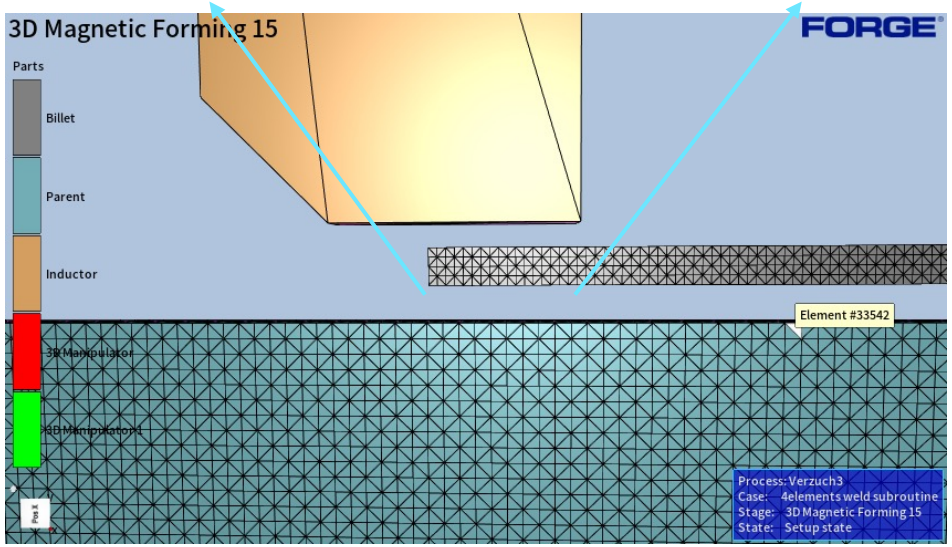


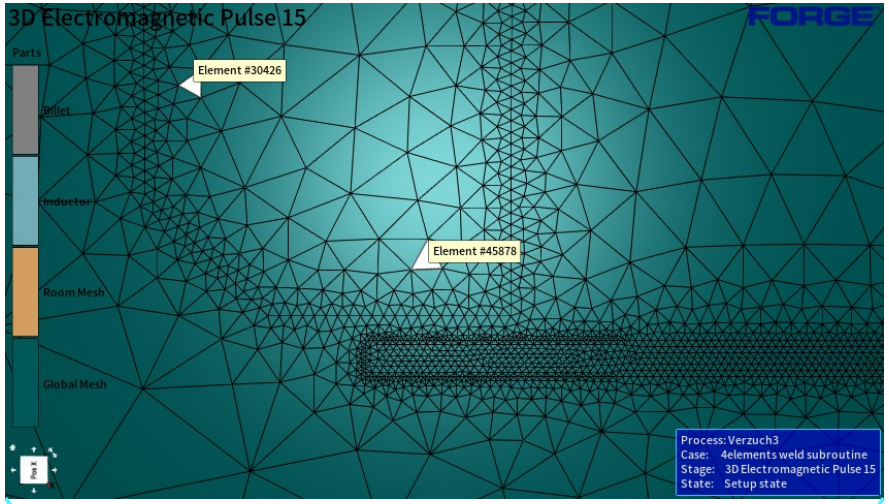
Reference: Lueg-Althoff, J., Bellmann, J., Gies, S., Schulze, S., Tekkaya, A.E. and Beyer, E., 2018. Influence of the flyer kinetics on magnetic pulse welding of tubes. *Journal of Materials Processing Technology*, *262*, pp.189-203.

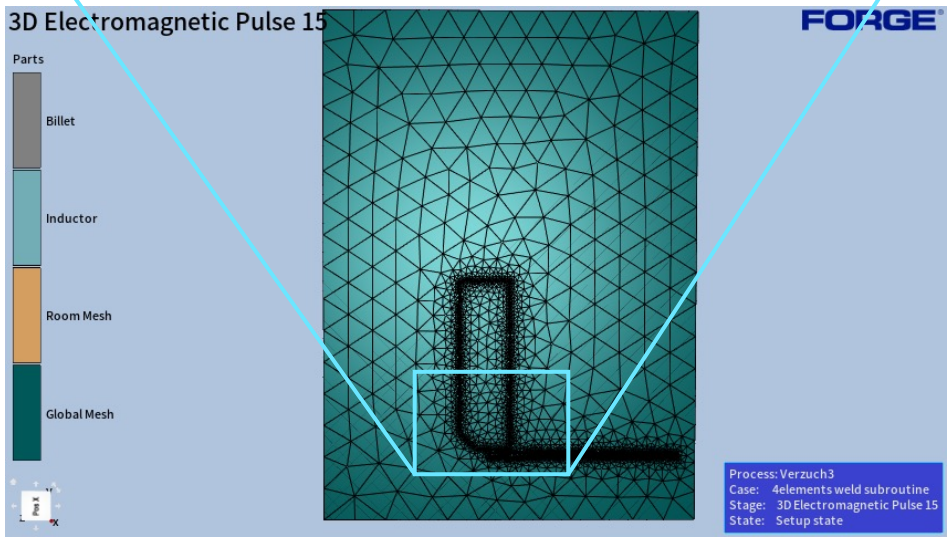
Magnetic Pulse Forming

Mesh sensitivity analysis









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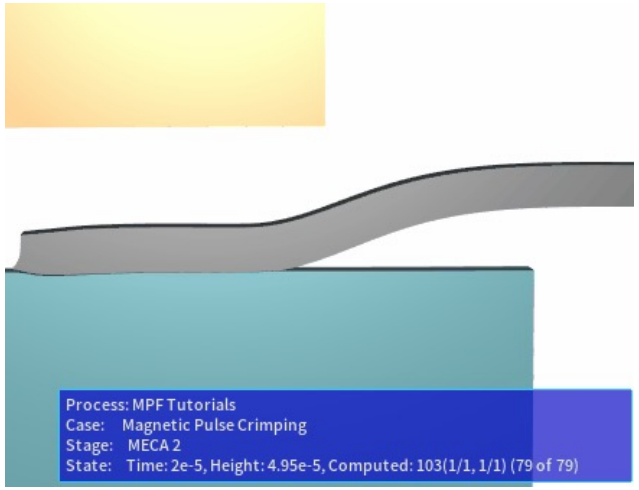
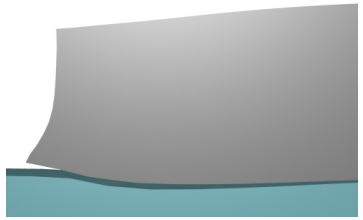
Surface-to-Surface welding criteria

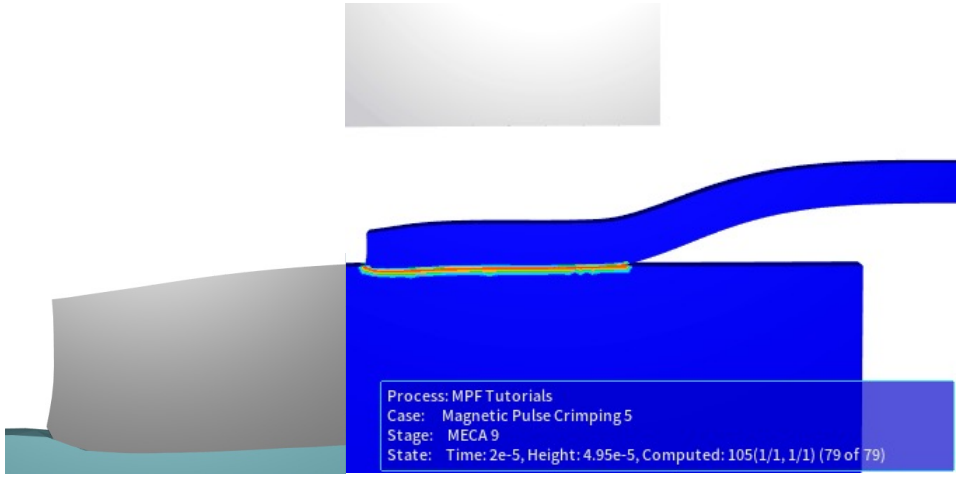
No welding criterion



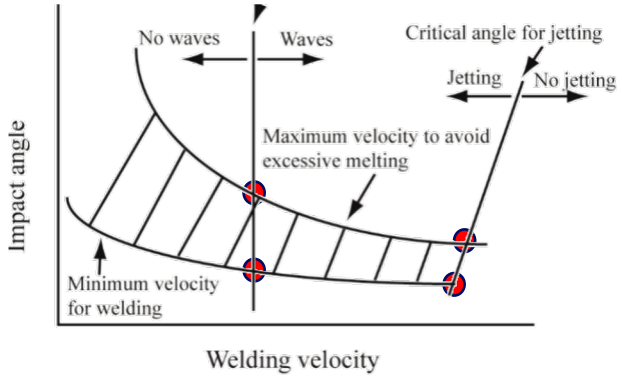


Bounce back at the tip
Usually the case in
such kind of welding

Instantaneous welding

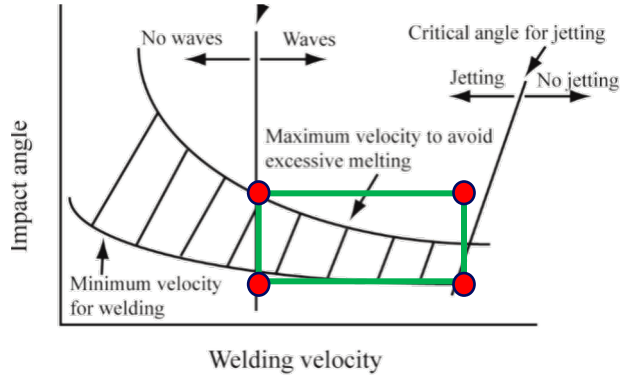


Development of an user-defined welding window model



1st Simplified criteria

Squared window



Welding Window

Development of welding window user subroutine

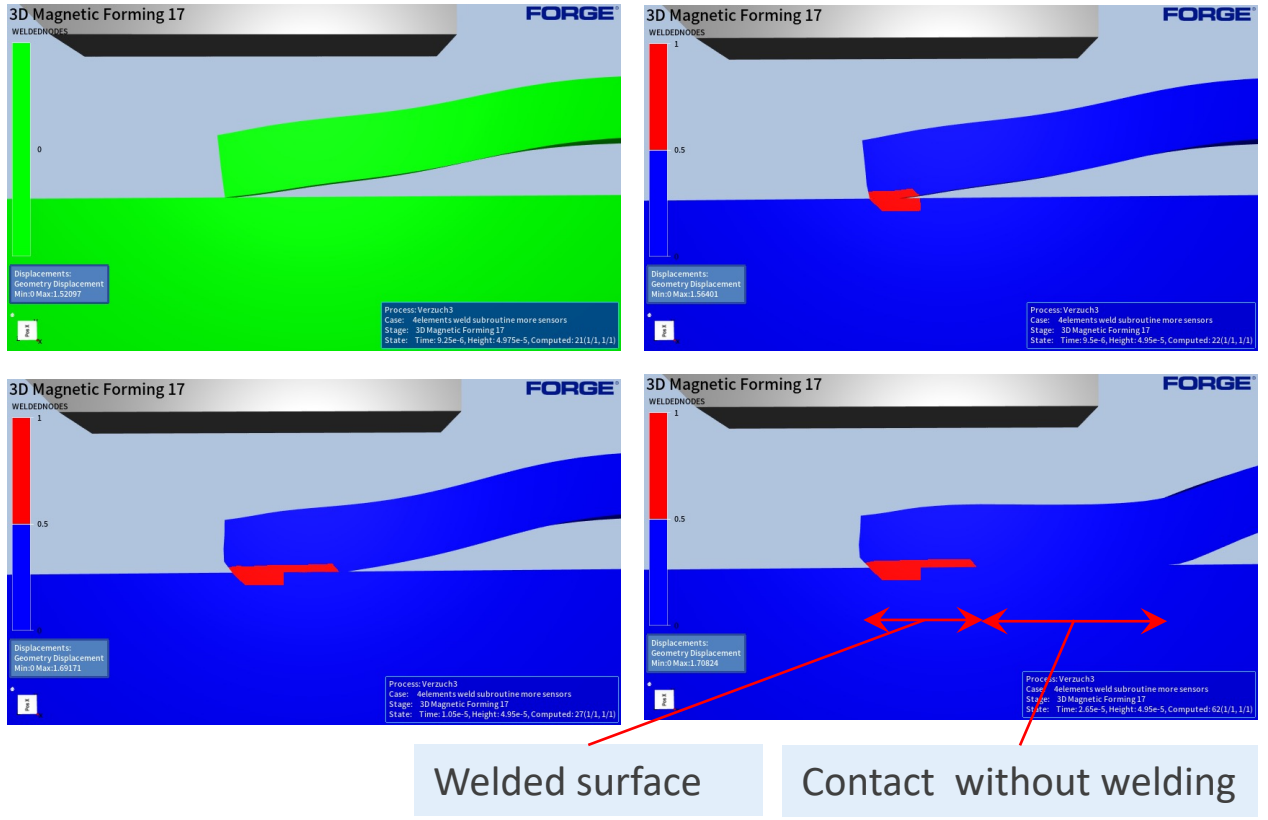
Preliminary result: Maximum angle: 10.5

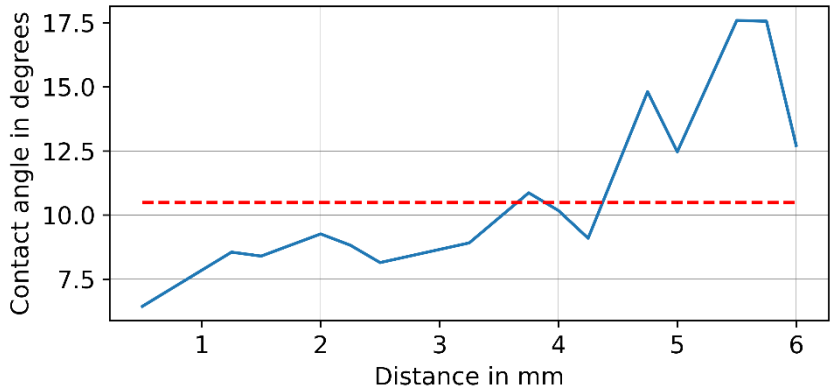
Minimum velocity: 325 m/s

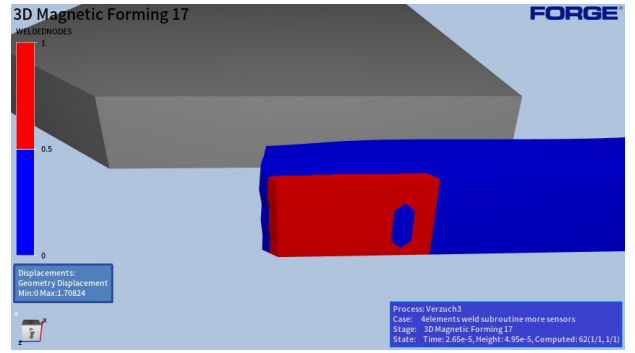
Ongoing project

More realistic welding window for current setup

Welding windows for different sets of materials







Conclusions

Conclusions & perspectives

Material modeling extensions

- Characterization of material model

Weld criterion as user subroutine

- Evaluation of welding of nodes

Solver Improvements

- Defining a bonding model based on different parameters

Novel Processes capacity

- Numerical torsion tests on the welded assembly

Simulation of bonding and debonding

- As an extension to the project, weld detaching criteria and subroutine

Q&A

Institute of Forming Technology and Lightweight Components

Mohammadjavad Lashkari

Tel: +49(0)1781475564

Email: mohammadjavad.lashkari@iul.tu-Dortmund.de

Dr. José ALVES

Tel: +33(0)4 9292 38 70

Email: jose.alves@transvalor.com

transvalor.com @transvalor transvalor-s-a Transvalor1984

Transvalor S.A. - 950 avenue Roumanille - CS 40237 Biot - 06904 Sophia Antipolis cedex - France
+33 (0)4 92 92 42 00 - marketing@transvalor.com