Materials and Solid Mechanics (MSM)

Modeling Industrial Forming Processes with the Finite Element Method

Single Point Incremental Forming (SPIF)

Principle of SPIF

Single Point Incremental Forming (SPIF) is a recently developed dieless sheet metal part production technique that is gradually evolving towards industrial applicability. In this process a sheet metal part is formed in a stepwise fashion by a CNC controlled rotating spherical tool without the need for a supporting (partial) die. This technique allows a relatively fast and cheap production of small series of sheet metal parts.

* Sheet metal deformed by a small tool
* Tool guided by a CNC machine
* Dieless, with high sheet formability
* For rapid prototypes, small batch productions

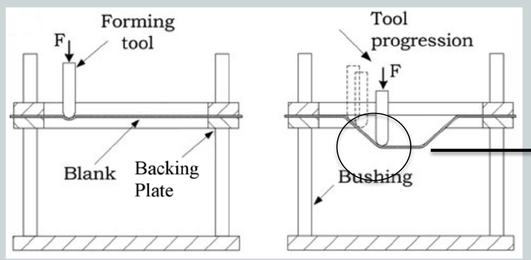
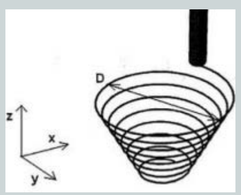


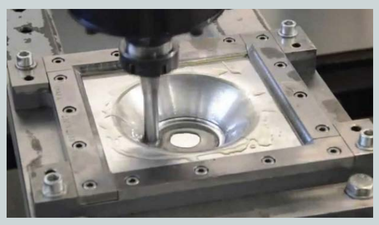
Illustration of principle of SPIF setup (Jeswiet et al., CIRP ANN-MANUF. TECHN., 2005)



SPIF spiral toolpath

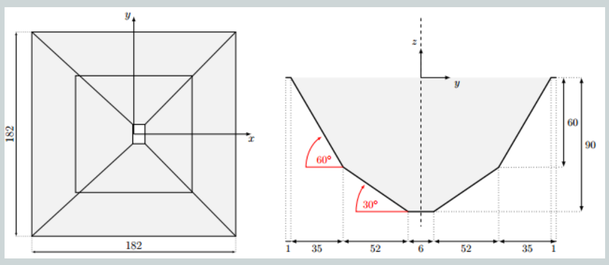
SPIF hardware setup in KUL

Industrial applications

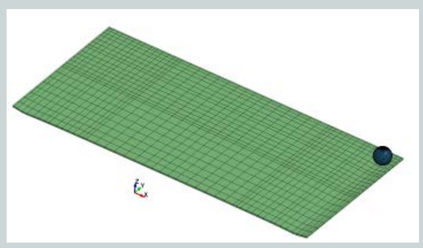


SPIF FE Simulation

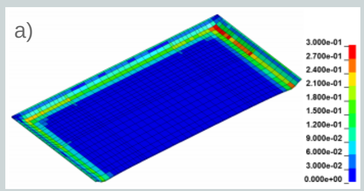
- Pyramid test

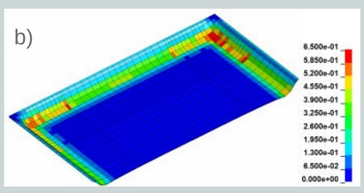


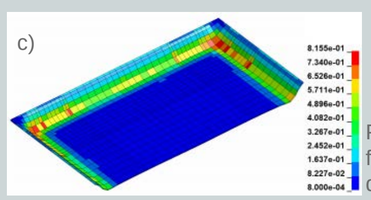
Top view and side view of target geometry



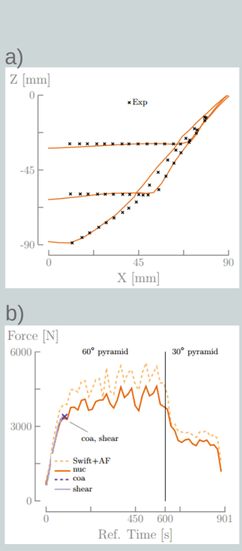
FE considered mesh for simulation of pyramid test







Equivalent plastic strain for a) 33s, b) 83s and c) 103s.



Predicted shape and force for pyramid test by FEM for different constitutive laws

Results from Ph.D. thesis of C. Henrard 2009, C.P. Guzman, ULg, 2015, J. Sena ULg+ Aveiro 2015

Continuous Casting (CC)

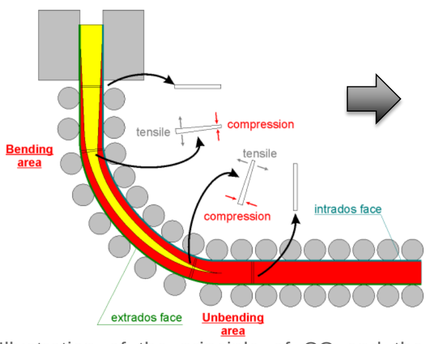
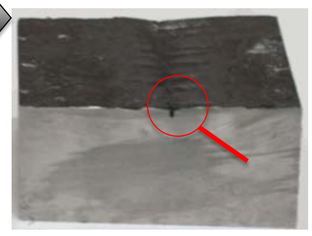
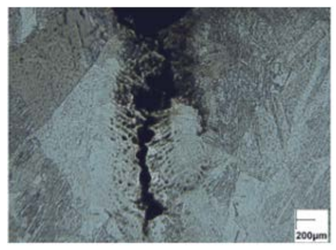


Illustration of the principle of CC and the different stress states during CC (F. Pascon, PhD thesis, Ulg, 2003)

Industrial setup for CC process

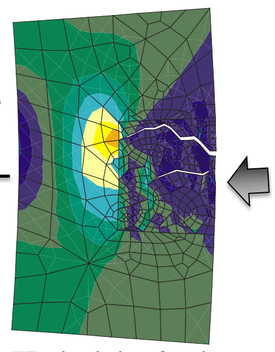


Macroscopic observation of a longitudinal crack after CC process



Microscopic observation of appearance of cracks

Results from PhD thesis of R. Schwartz, Ulg, 2011

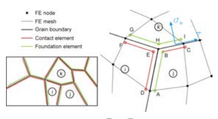


FE simulation for the crack after CC process

Analysis of the mechanical behavior

Micro-Macro model

* Material parameters identification
* Macroscopic constitutive law linked to microscopic behavior
* FE simulation of the process



S.Castagne, PhD thesis, ULg, 2007

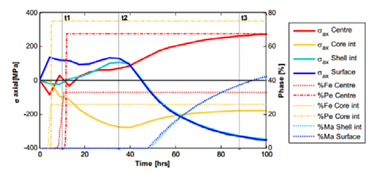
Bimetallic Rolling Casting

Advantages

- High wear resistance in the shell
- High toughness in the core

⟹ Since 1970, Marichal Ketin uses the vertical spin casting process to rolling mills manufacturing. Modeling can explain crack events.

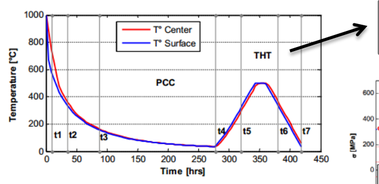
Centrifugal casting of bimetallic rolling mill rolls by MK Industry (L. Studer et al., 2007)



Axial stress and phase amount evolution during Post Casting Cooling (PCC) stage

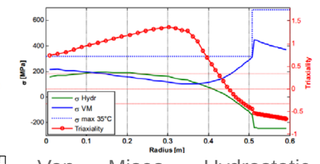
FE Simulation

Axisymmetric geometry for simulation of bimetallic mill roll



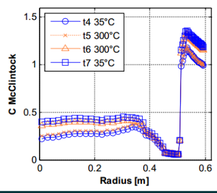
Predicted temperature evolution

THT = Tempering Heat Treatment



Von Mises, Hydrostatic stress and triaxiality value along the radius

McClintock rupture criterion at different time

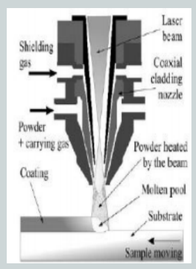


Results from PhD thesis of I.N. Torres, Ulg, UdeC, 2015

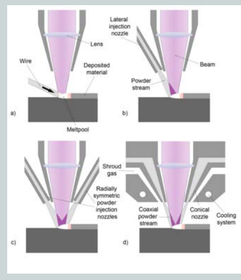
Laser Cladding (LC) – a method to deposit a metal powder

Process

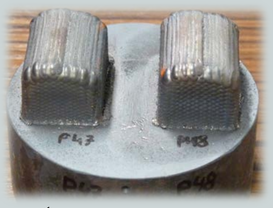
* Laser cladding is a process that bonds similar or dissimilar metals. It is a unique form of welding that uses a laser as a heat flux and a metal powder stream to add material

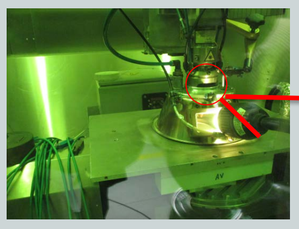


Principle of laser cladding with coaxial powder injection (L. dubourg et al., Surf. and Coating Tech., 2007)

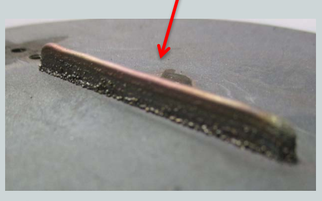


Different feeding systems for LC



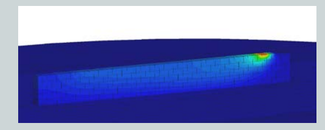


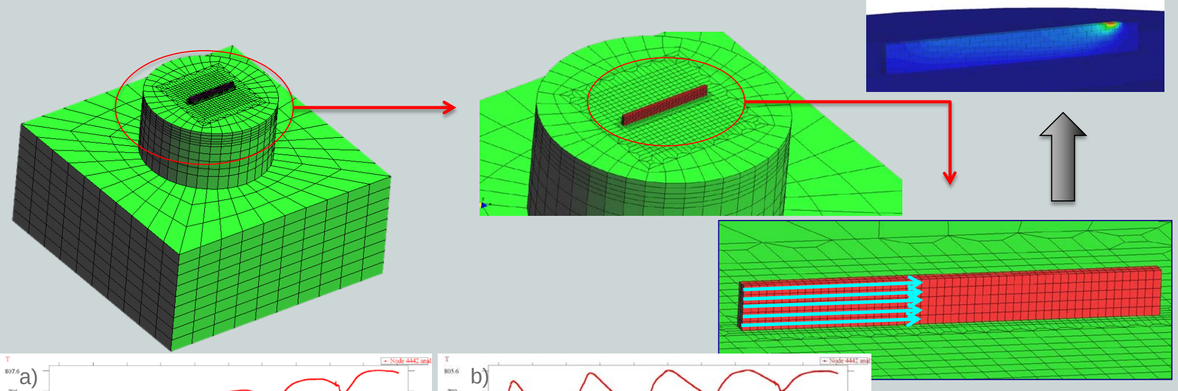
Industrial setup in Sirris

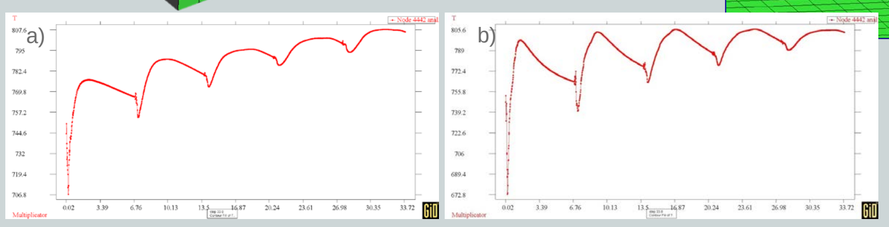


FE Simulation

The goal is to accurately predict thermal and stress fields, metallurgical properties and final geometry. Currently the use of FE code LAGAMINE is able to predict 3D thermal history.







Variation of temperature as function of time of same direction flux, a) without elements activation, b) with elements activation.

N. Hashemi & R. Jardin on going PhD thesis

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