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BEST PRACTICE METHODOLOGY FOR SPRINGBACK PREDICTION AND COMPENSATION

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Extended Abstract

Forming simulation technologies continues to develop at a rapid pace, to address formability, tolerance control, and product performance issues in an increasing range of processes, and in ever more detail.

This has meant a shift in focus from formability, which is essentially a strain based phenomena, to springback and surface quality checks, which are essentially stress based phenomena. This shift has seen a rise in a 2 stage approach, with faster solvers being developed to handle the strain based formability predictions, the speed being used to allow the investigation of different tooling concepts, and multiple iterations for optimization of process parameters, and higher level numerical techniques being used to capture accurately the stress based phenomena. These 2 approaches must of course work seamlessly together, as they follow the evolution of a tool development process.

The prediction of accurate stresses is far more sensitive than the prediction of accurate strain, which is why springback prediction remains a topic for discussion, but forming simulation is generally regarded as being at an acceptable industrial level for quite some time already. In order to achieve an accurate and reliable stress prediction, there is sensitivity to a number of different parameters, some physical, and some purely numerical. Each of these parameters addressed individually will perhaps only have a limited impact on the results, but by addressing a number of them, it is possible to have reliably accurate and predictive simulation results.

Springback prediction and compensation continue to evolve, with new concepts for improving the accuracy of the springback prediction, and subsequent compensation. Prediction is addressed both from the numerical methods perspective, for example, using enhanced contact algorithms to ensure accurate respect of the discretized geometry, enhanced finite elements to simulate bending in a very accurate and robust way, sophisticated material models with elasto-plastic springback, and from a process perspective, for example by the incorporation of geometric drawbeads as opposed to the more common equivalent drawbead models which have been widely used in simulations for the last decade or so.

Die compensation highlights how the integration of simulation and geometry plays an ever more important role, both in terms of improving accuracy and reducing lead time. Accurate die compensation cannot be a simple 'one shot' method, it is an iterative process, where the

new or modified Die geometry will need to be re-simulated through the entire forming process and subsequent springback, in order to validate the result, typically we have seen that between 3 and 5 iterations are needed to achieve good results, though of course this depends on material, geometry and of course the acceptance criteria.

The overall industrial objective is moving rapidly from Draw-Die compensation, towards full ‘line die’ compensation, in particular, considering the influence of ‘re-striking’ as a means of springback control. Significant differences in springback behaviour can be observed after re-striking or re-forming, this influence is as a result of through thickness stress distributions. This effect is not captured with conventional shell element formulations, and the authors propose that this is an area where progress is still required to improve the predictions, and this is an area where we are working actively with industrial & academic partners to provide robust and industrially validated solutions.

Tool Compensation techniques are also being applied to flanging operations, and to some fluid forming operations such as rubber pad forming, more typically used in Aerospace applications due to the long cycle times of the process. These processes differ in the sense that the drawing angle limitations of draw die compensation do not apply, so there is a greater freedom for geometric corrections, though of course there will be limitations from a tool design point of view, so inevitably some form of knowledge capture & integration will be required.

The presentation will discuss how the PAM-STAMP2GTM integrated solution for springback prediction & compensation is already successfully used in industry to deliver a positive business impact on cost and quality, with emphasis on the Best Practices applied by users to different aspects of the prediction & correction methodology.

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PAM-STAMP 2G

IIDRG 2007
Györ Hungary

Dave Ling, Jean-Luc Babeau, Alain Vaizian, Fouad El-Khaldi
ESI-Group Stamping Solutions Team

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Introduction

- Springback compensation for full line dies is the overall aim today.
- A high level of Accuracy and confidence in Springback prediction is a pre-requisite to compensation.
- To achieve this level of confidence we need to focus on many factors which contribute to the accuracy

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- Springback prediction & compensation accuracy; contributing factors
  - Material Modelling
  - Contact treatment
  - Friction modelling
  - Process modelling
  - Compensation
  - CAD update
  - Measurement
  - Solver technology
  - Methodology

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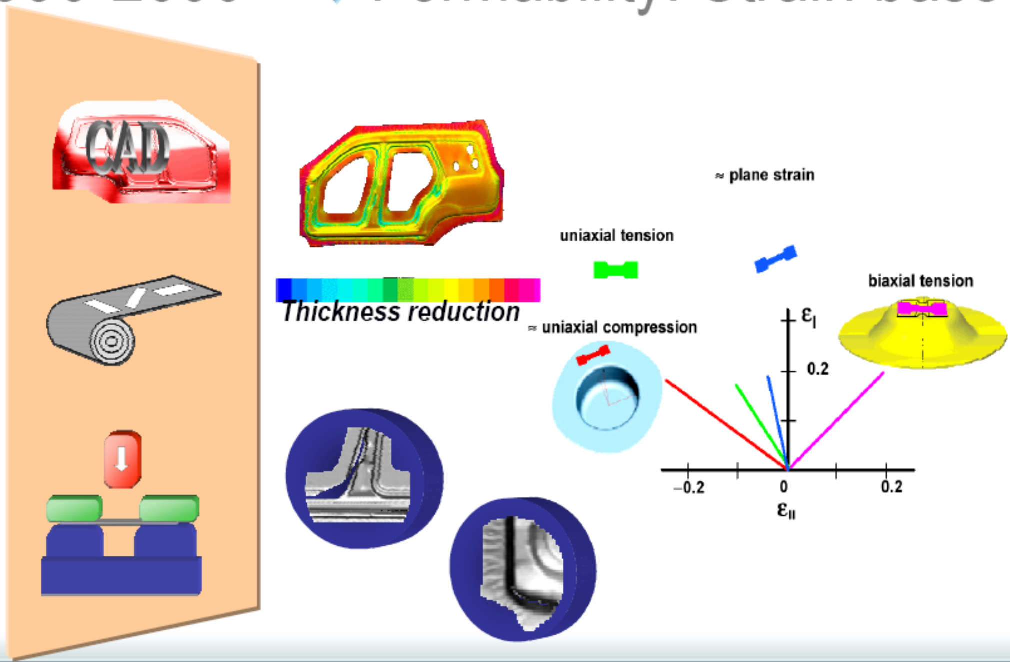
Stamp simulation evolution

1990-2000 → Formability: Strain based



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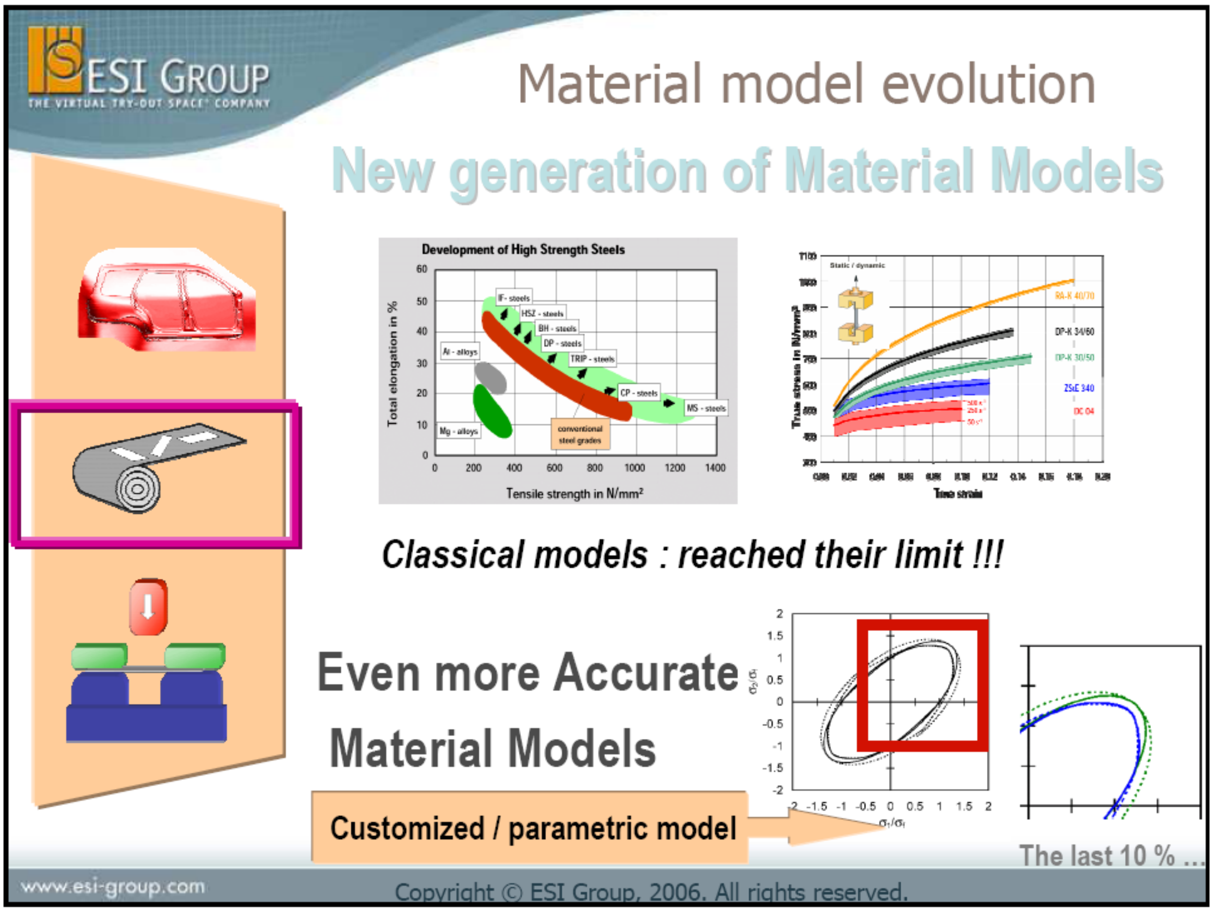
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Material model evolution
New generation of Material Models
Development of High Strength Steels
Total elongation in %
Tensile strength in N/mm²
IF - steels
HSZ - steels
BH - steels
DP - steels
TRIP - steels
Al - alloys
CP - steels
MS - steels
Mg - alloys
conventional steel grades
Classical models : reached their limit !!!
Even more Accurate
Material Models
Customized / parametric model
The last 10 % …
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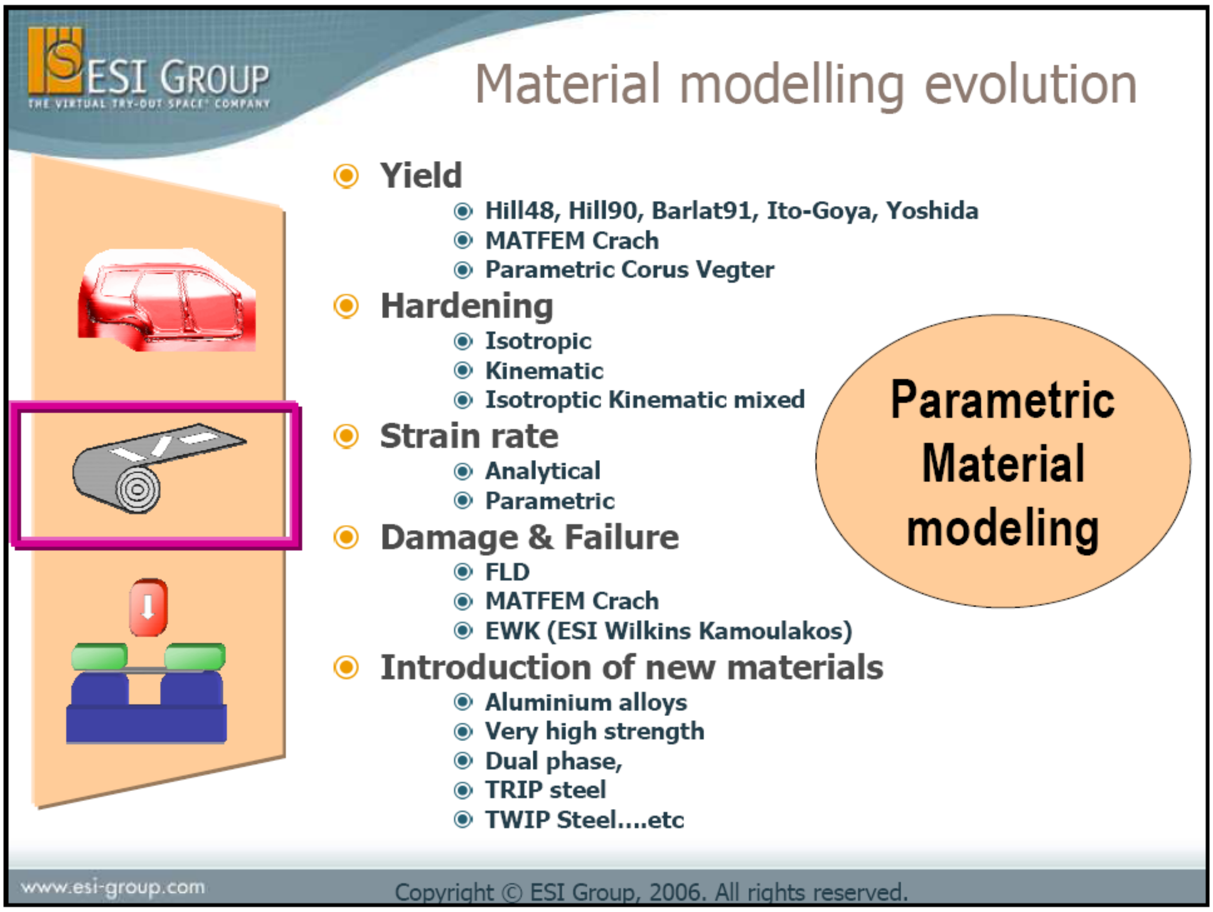
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Material modelling evolution
Yield
Hill48, Hill90, Barlat91, Ito-Goya, Yoshida
MATFEM Crach
Parametric Corus Vegter
Hardening
Isotropic
Kinematic
Isotroptic Kinematic mixed
Strain rate
Analytical
Parametric
Damage & Failure
FLD
MATFEM Crach
EWK (ESI Wilkins Kamoulakos)
Introduction of new materials
Aluminium alloys
Very high strength
Dual phase,
TRIP steel
TWIP Steel....etc
Parametric Material modeling
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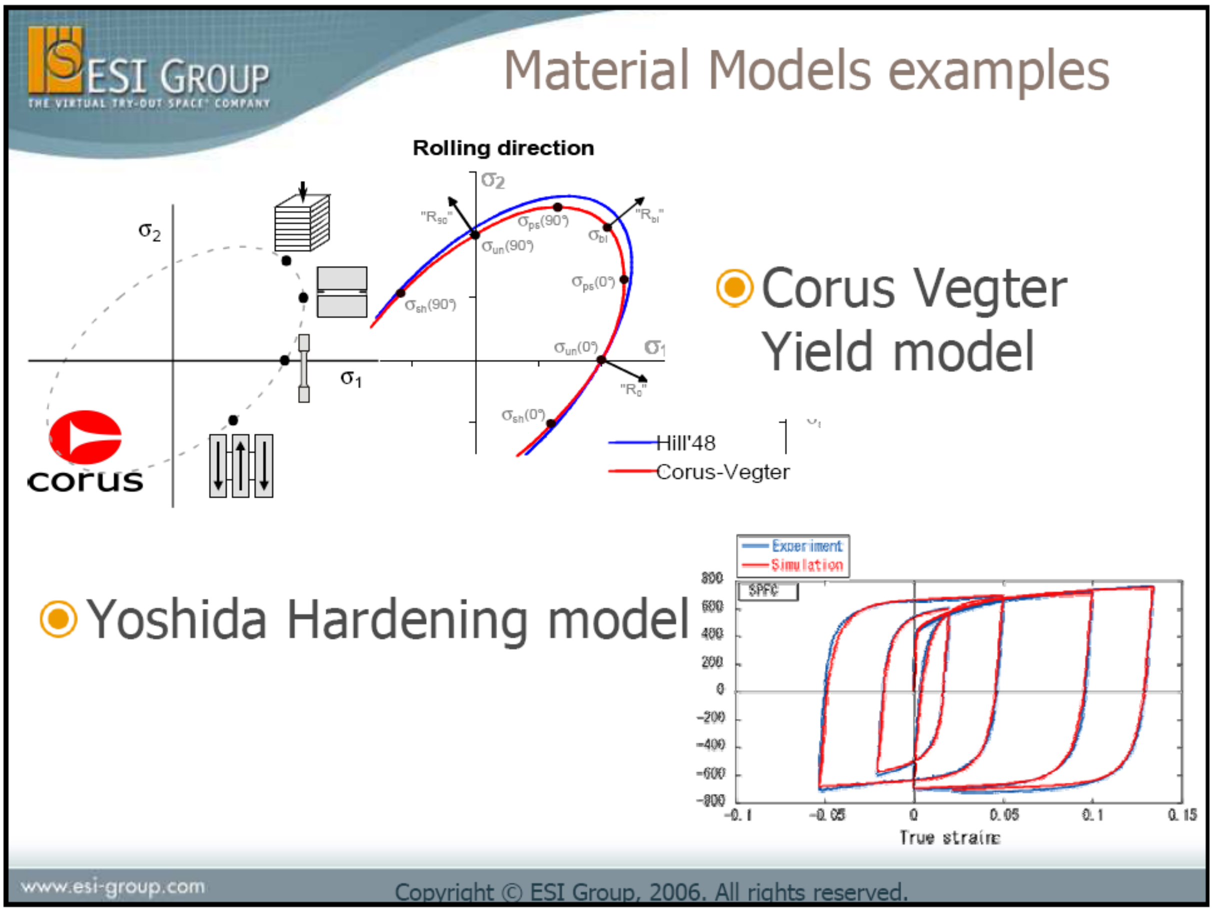
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Material Models examples
Rolling direction
corus
Hill'48
Corus-Vegter
Corus Vegter
Yield model
Yoshida Hardening model
Experiment
Simulation
SPFC
True straine
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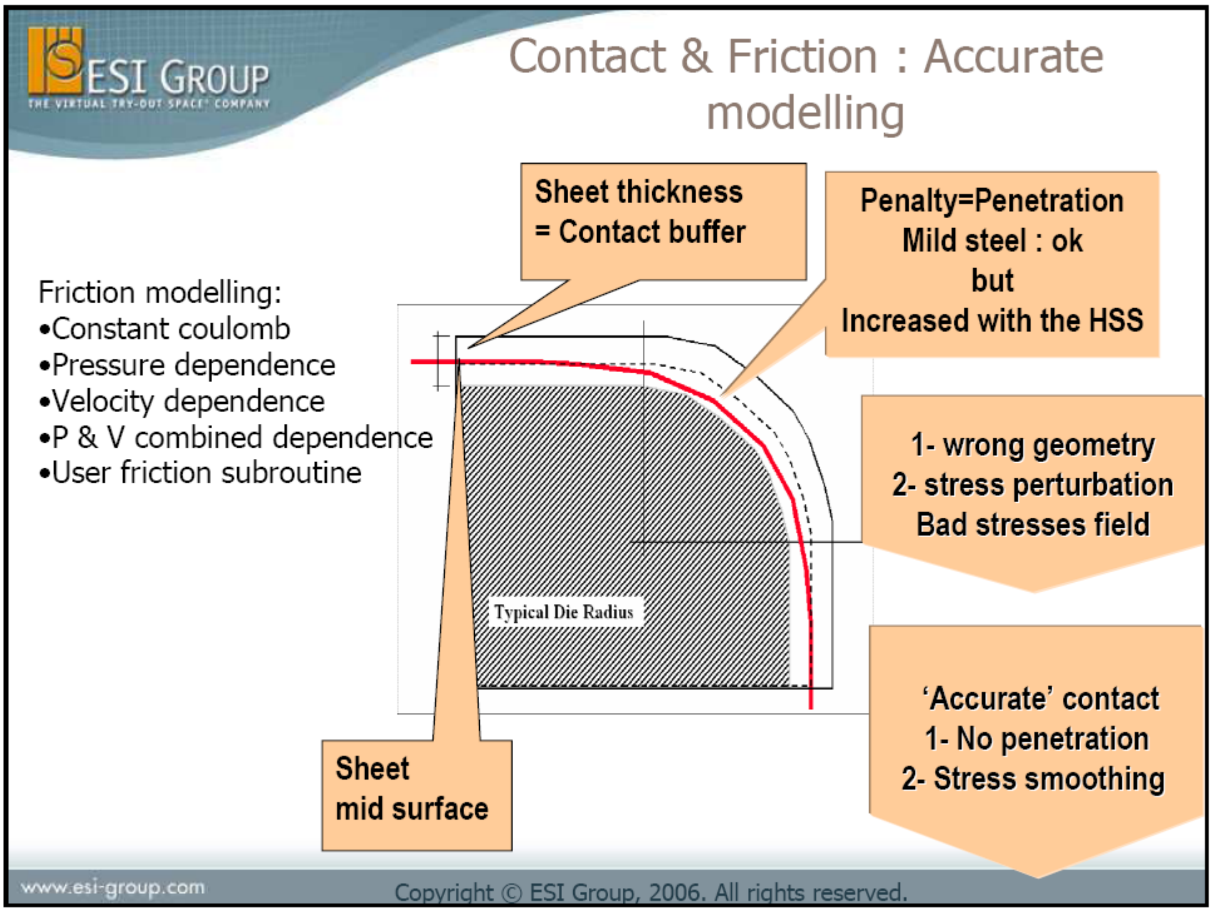
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Contact & Friction : Accurate modelling
Friction modelling:
•Constant coulomb
•Pressure dependence
•Velocity dependence
•P & V combined dependence
•User friction subroutine
Sheet thickness
= Contact buffer
Penalty=Penetration
Mild steel : ok
but
Increased with the HSS
1- wrong geometry
2- stress perturbation
Bad stresses field
Typical Die Radius
'Accurate' contact
1- No penetration
2- Stress smoothing
Sheet
mid surface
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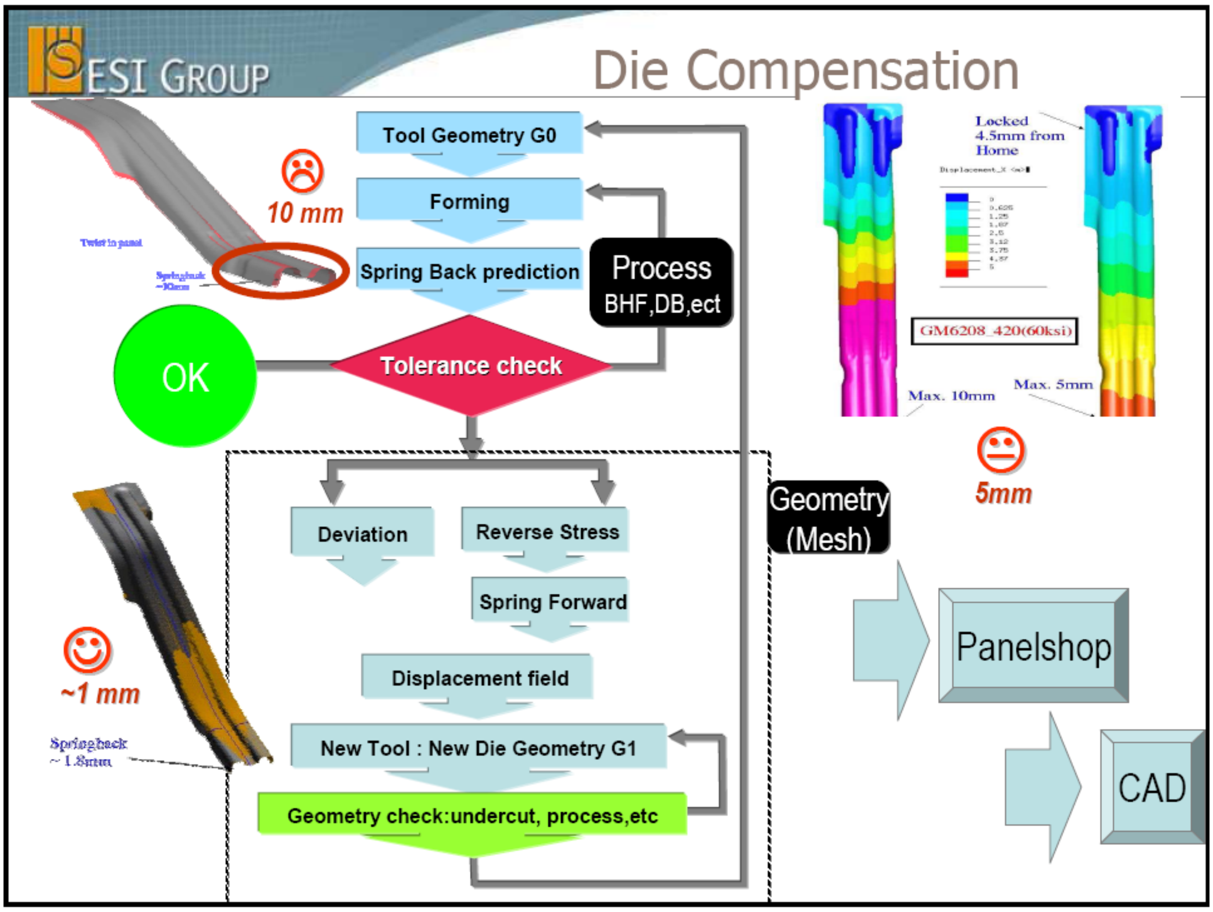
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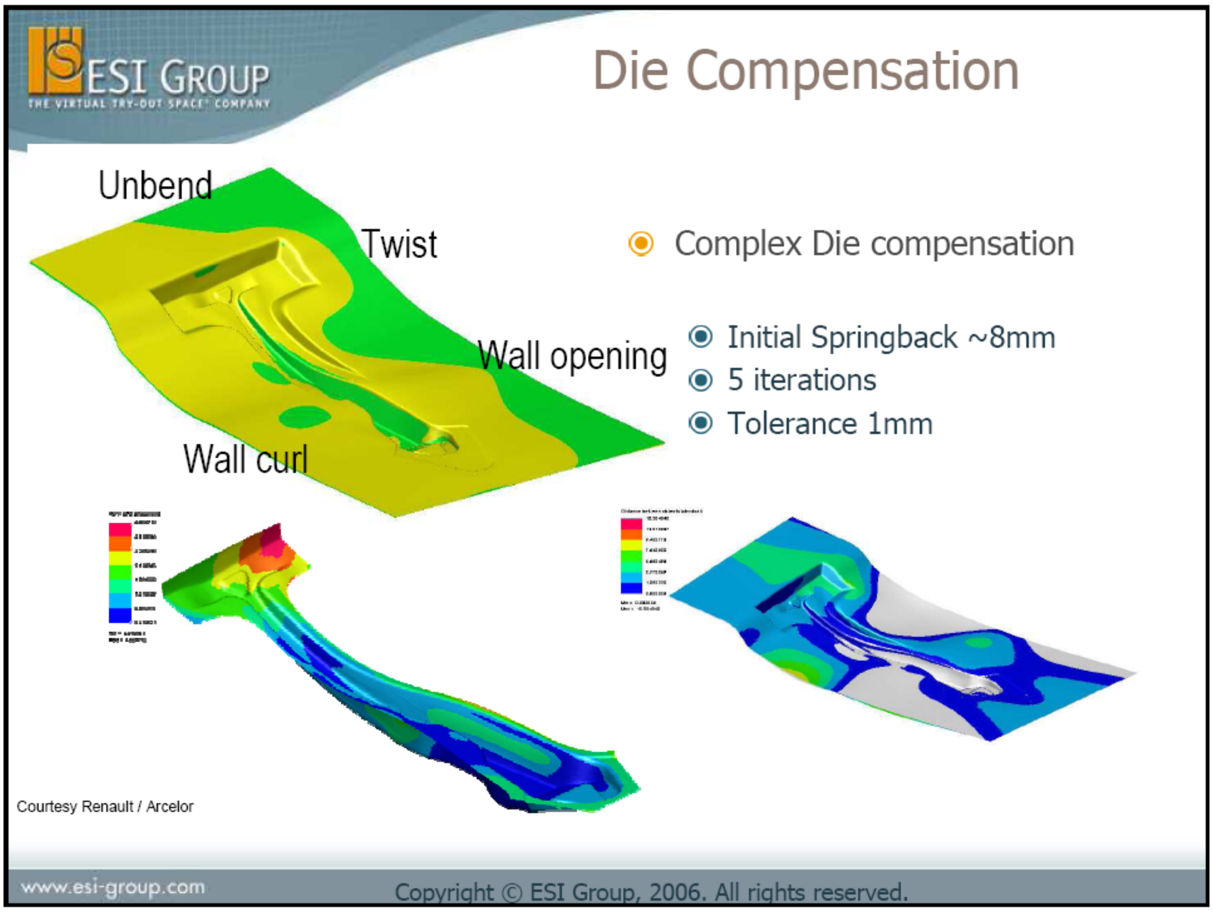
Die Compensation
Tool Geometry G0
Forming
Spring Back prediction
Process
BHF,DB,ect
Tolerance check
OK
10 mm
Deviation
Reverse Stress
Spring Forward
Displacement field
New Tool : New Die Geometry G1
Geometry check:undercut, process,etc
~1 mm
Springback
~ 1.8mm
Locked
4.5mm from
Home
GM6208_420(60ksi)
Max. 10mm
Max. 5mm
5mm
Geometry
(Mesh)
Panelshop
CAD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Die Compensation
Unbend
Twist
Wall opening
Wall curl
Complex Die compensation
Initial Springback ~8mm
5 iterations
Tolerance 1mm
Courtesy Renault / Arcelor
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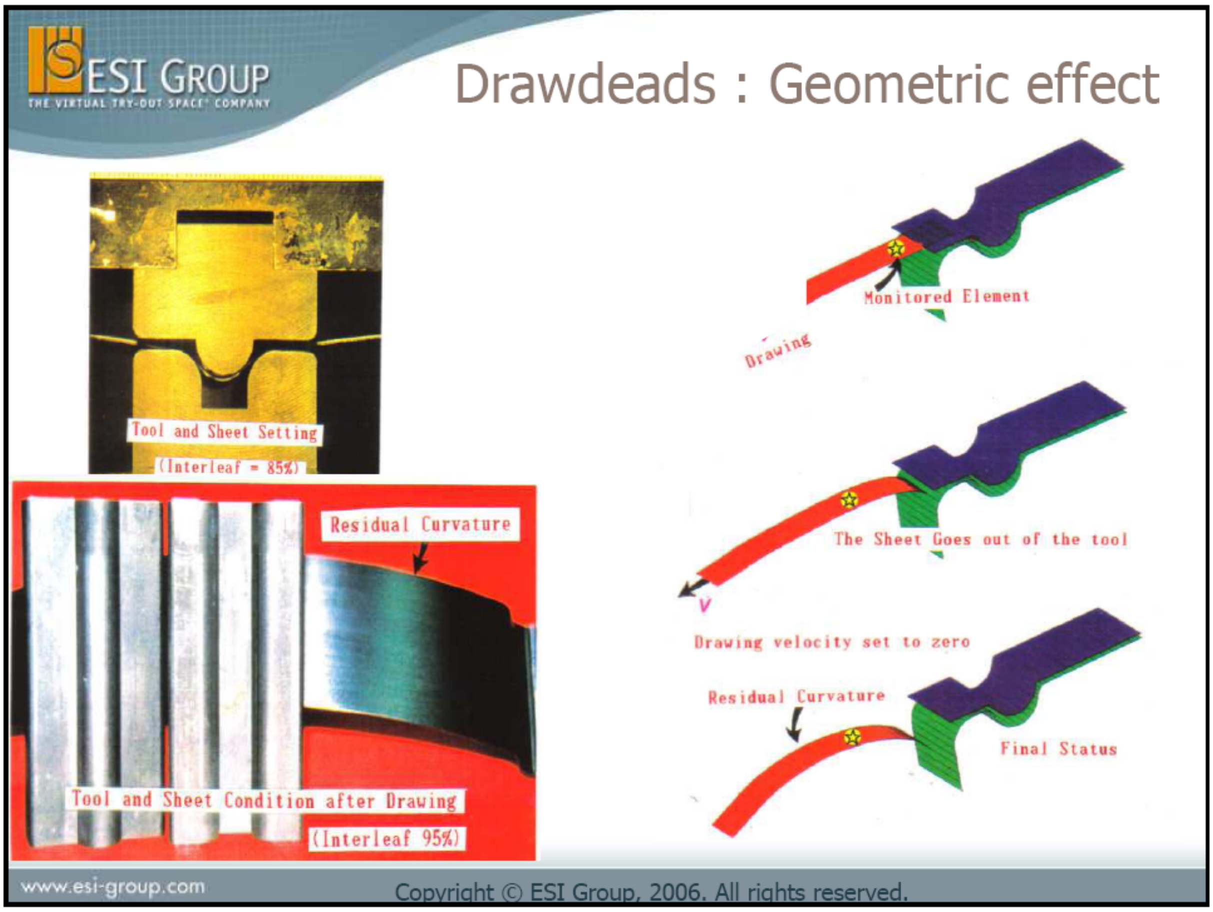
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Drawdeads : Geometric effect
Tool and Sheet Setting
(Interleaf = 85%)
Residual Curvature
Tool and Sheet Condition after Drawing
(Interleaf 95%)
Monitored Element
Drawing
The Sheet Goes out of the tool
V
Drawing velocity set to zero
Residual Curvature
Final Status
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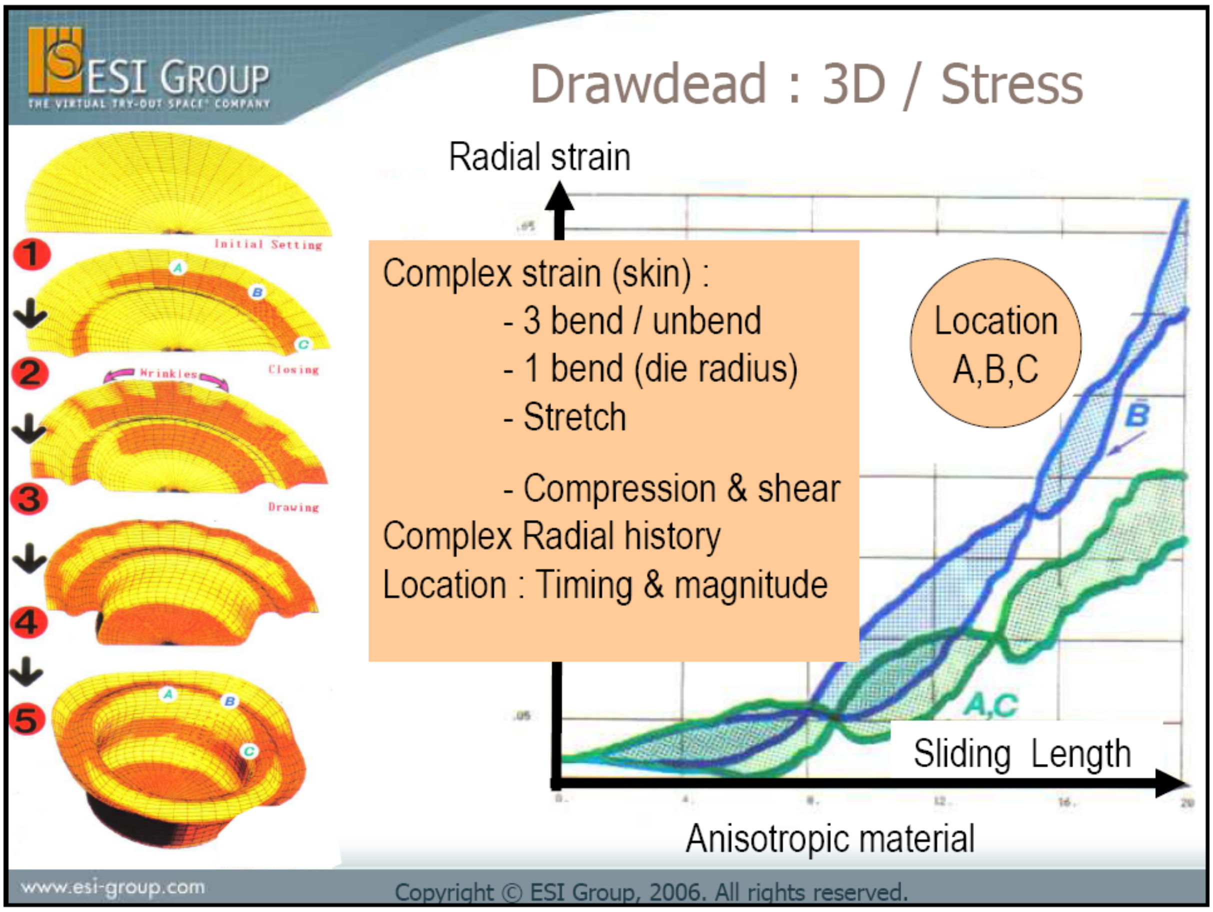
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Drawdead : 3D / Stress
Radial strain
Initial Setting
Wrinkles
Closing
Drawing
Complex strain (skin) :
- 3 bend / unbend
- 1 bend (die radius)
- Stretch
- Compression & shear
Complex Radial history
Location : Timing & magnitude
Location
A,B,C
B
A,C
Sliding Length
Anisotropic material
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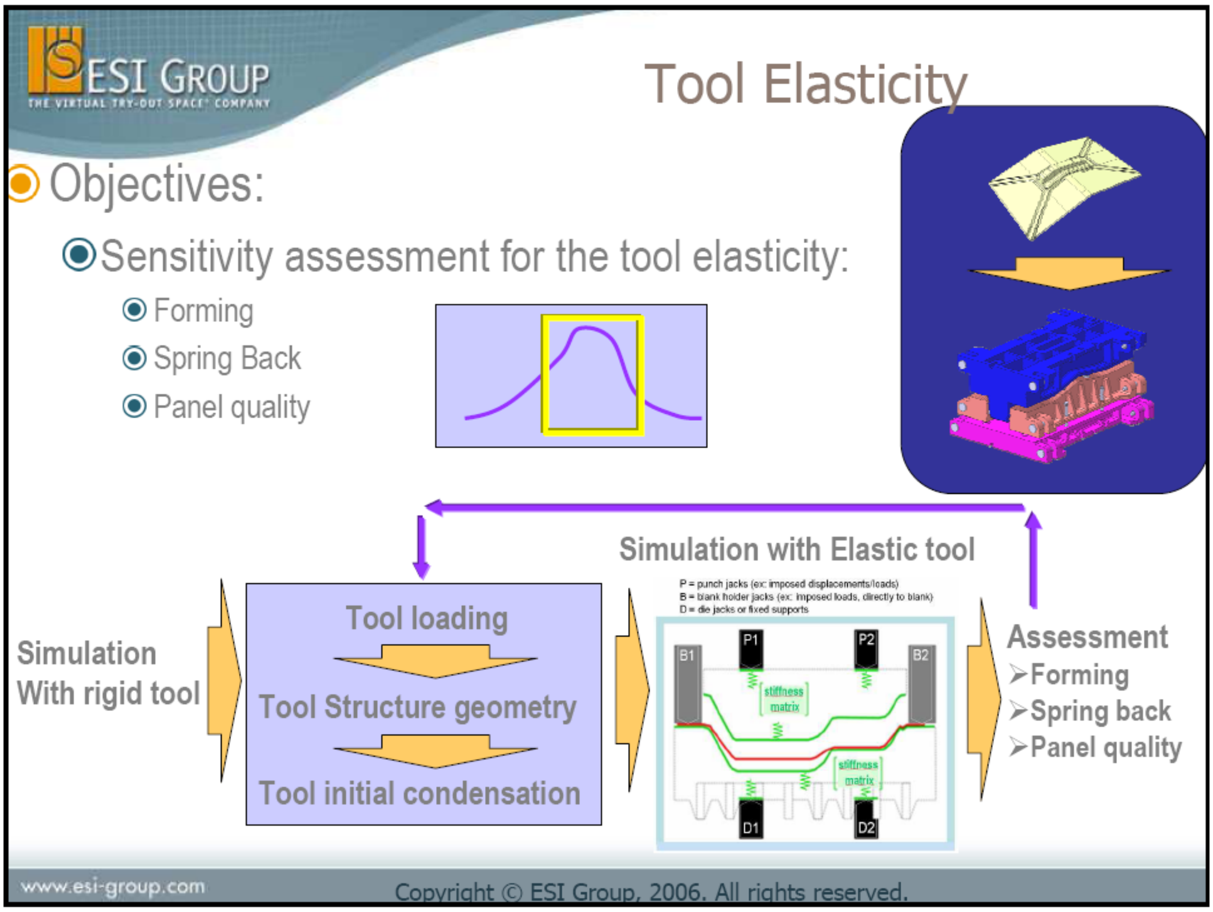
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Tool Elasticity
Objectives:
Sensitivity assessment for the tool elasticity:
Forming
Spring Back
Panel quality
Simulation with Elastic tool
Simulation
With rigid tool
Tool loading
Tool Structure geometry
Tool initial condensation
P = punch jacks (ex: imposed displacements/loads)
B = blank holder jacks (ex: imposed loads, directly to blank)
D = die jacks or fixed supports
P1
P2
B1
B2
stiffness matrix
stiffness matrix
D1
D2
Assessment
➢Forming
➢Spring back
➢Panel quality
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