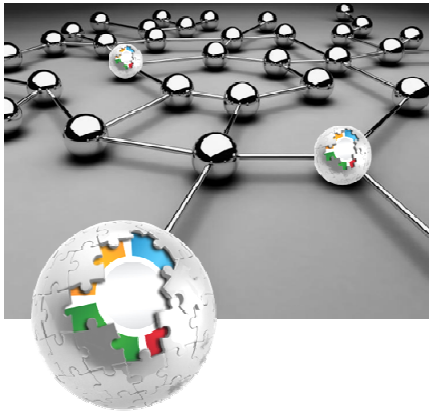
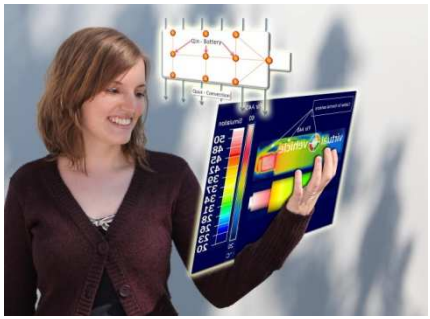
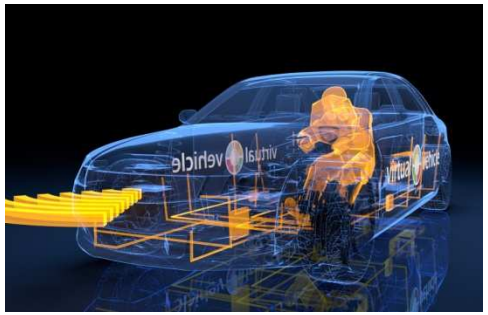
Vehicle concepts for the future.

Charakterisierung von biege-beeinflußten Umformvorgängen in komplexen Tiefziehprozessen

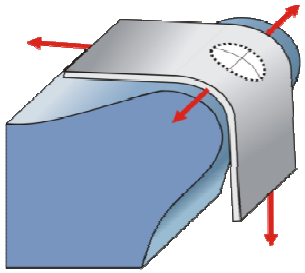
Daniela Schalk-Kitting

Kompetenzzentrum – Das virtuelle Fahrzeug,
Forschungsgesellschaft mbH (Virtual Vehicle)

background

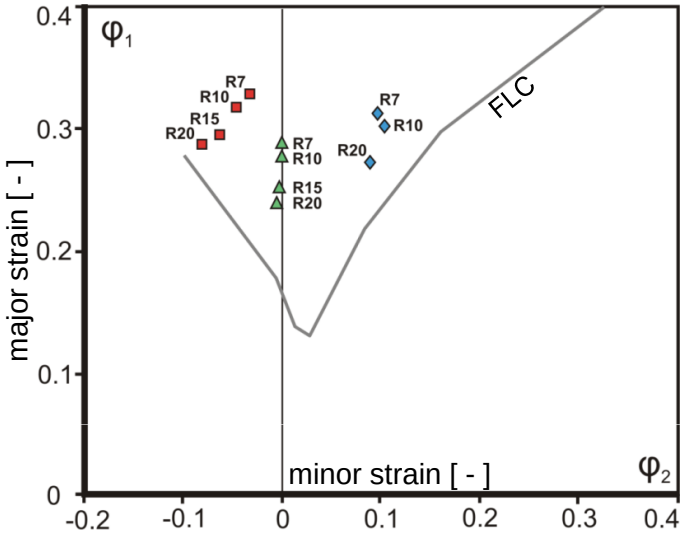
Deep Drawing of Advanced High Strength Steels (AHSS)

➡ tend to fail at tool radii

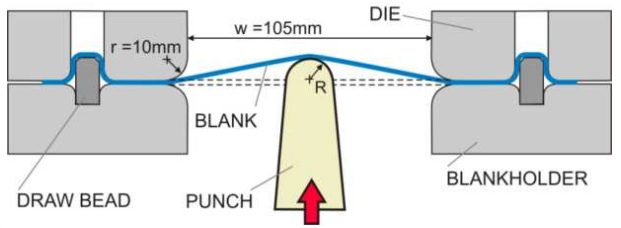


deformation scenario at tool radii:
combined stretching and bending

➡ conventional failure criteria fail to reliably predict forming limits if bending is involved



Results for CP800 [Kitting2011]



[Wagoner2006] R.H. Wagoner: „Advanced High Strength Steel Workshop“, Report (Arlington, Virginia (USA)), 2006.
[Kitting2011] D. Kitting et al.: Experimental Characterization of Stretch-Bending Formability of AHSS Sheets, ESAFORM 2011.

background

Deep Drawing of Advanced High Strength Steels (AHSS)

deformation scenarios of combined stretching and bending

- bending is always involved in deep drawing!
- due to complex part geometry and resulting material flow: various „forming scenarios“ of combined stretching and bending exist
- individual forming scenarios may affect the material formability

Which types of stretch-bending forming scenarios will occur in complex deep drawing parts?

Which are the critical scenarios?

Do the small scale stretch-bending tests represent the critical scenarios where failure will occur in complex deep drawing parts?

.....

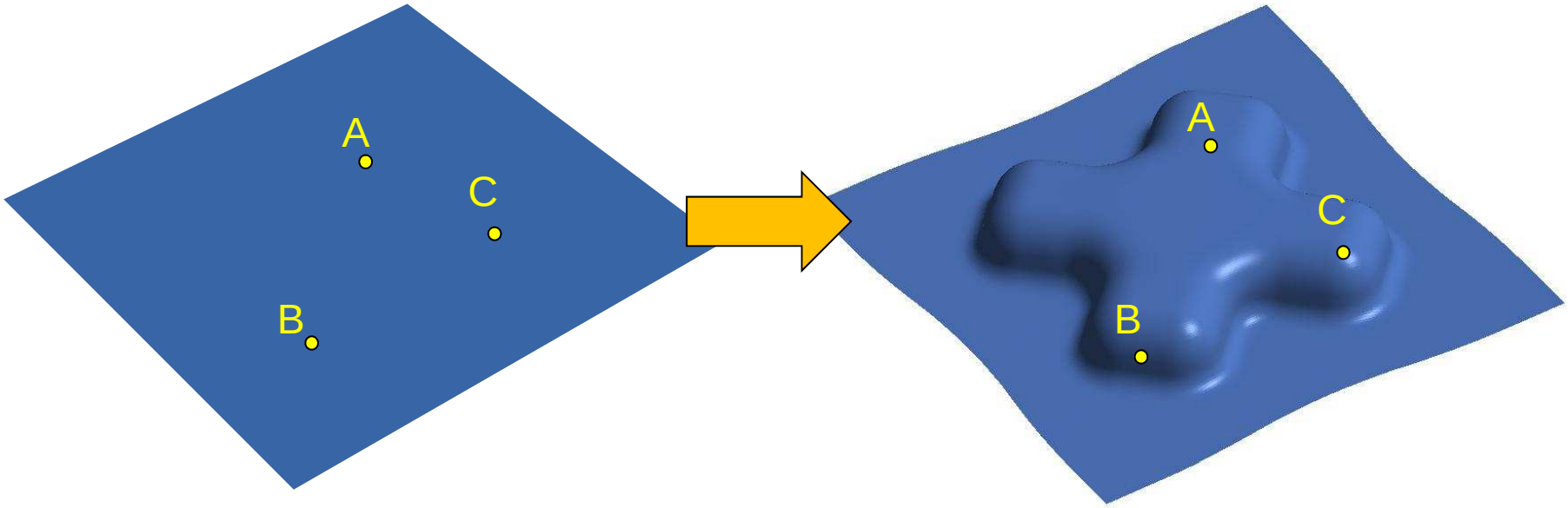
strategy based on deformation history

t_{start}

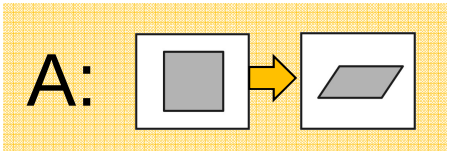
undeformed sheet

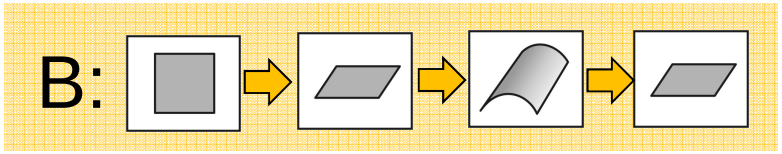
t_{end}

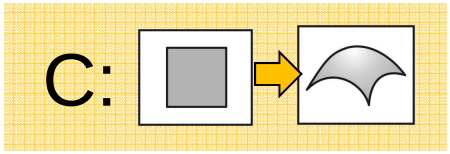
final shape



Individual forming scenarios of material point A, B and C:



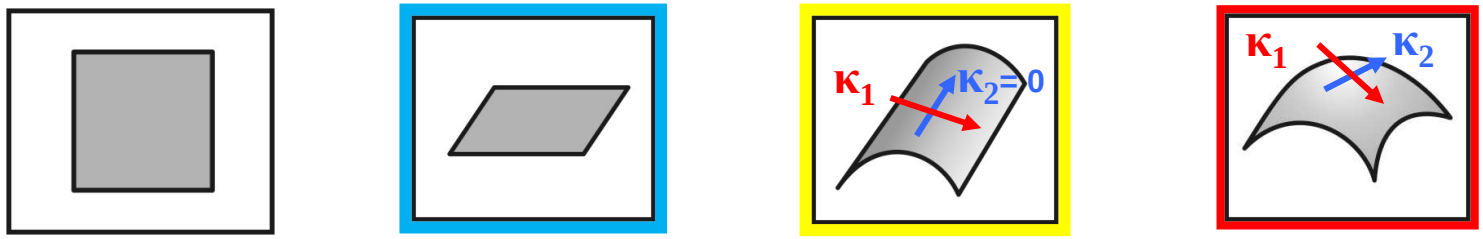


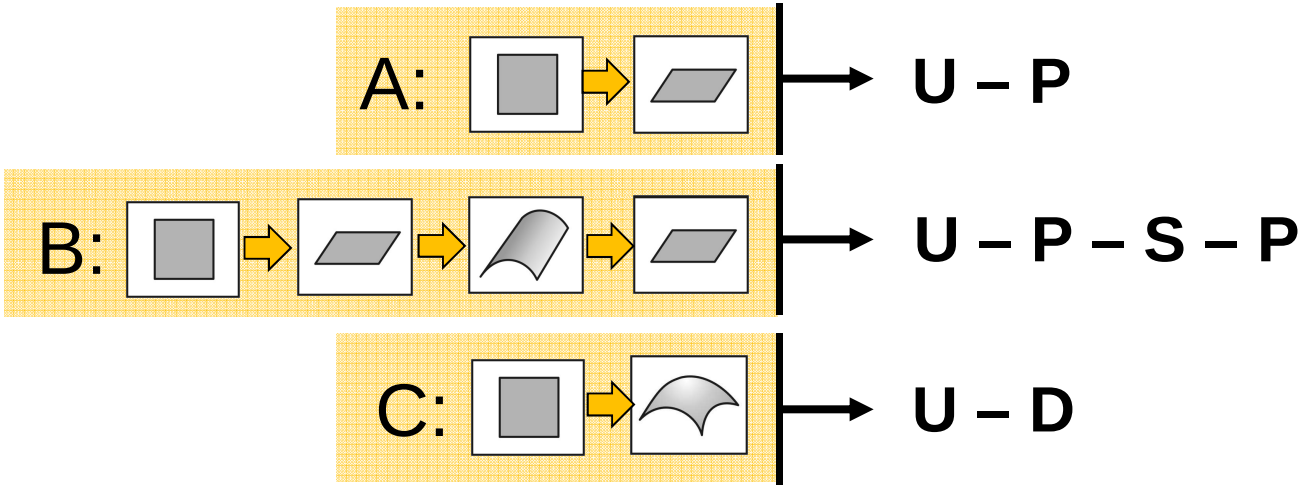


strategy based on deformation history

from this perspective: possible deformation conditions:

undeformed | in-plane | single-curved | doubly-curved

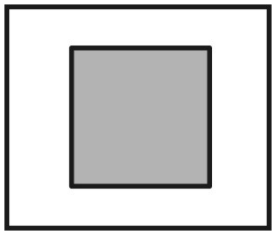




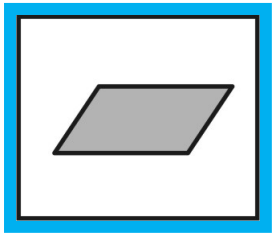
strategy based on deformation history

"tree" of stretch-bending categories

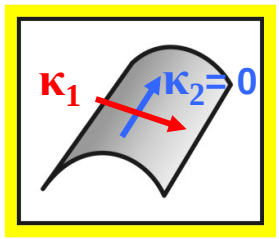
U
undeformed



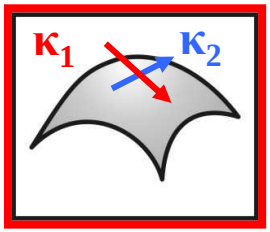
P
in-plane

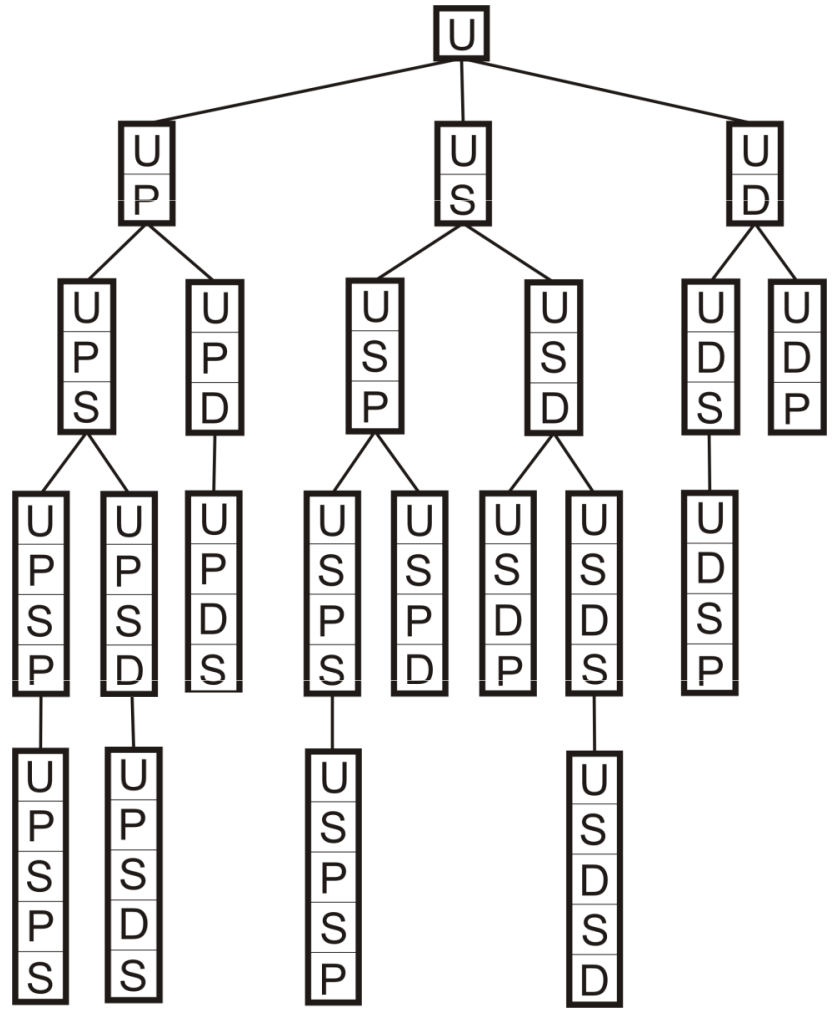


S
single-curved



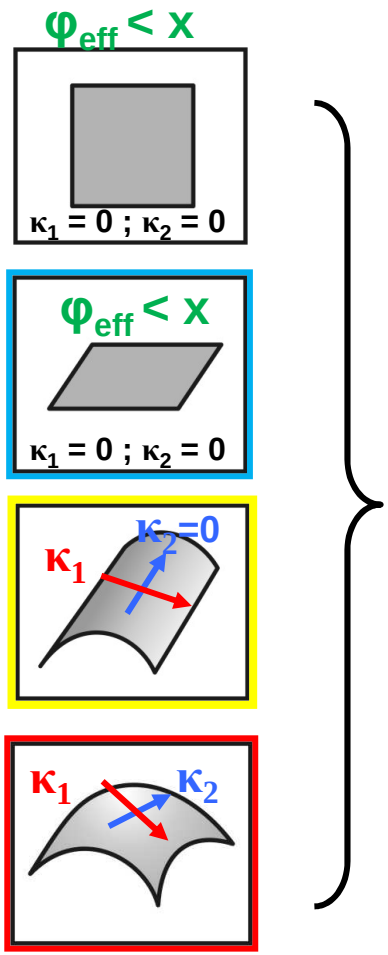
D
doubly-curved





approach to categorize complex deep drawing parts

required deformation history information from FE simulation



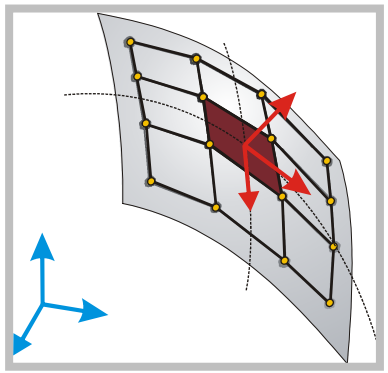
φ_{eff}

information on strain evolu

standard FE-simulation result

κ_1

κ_2



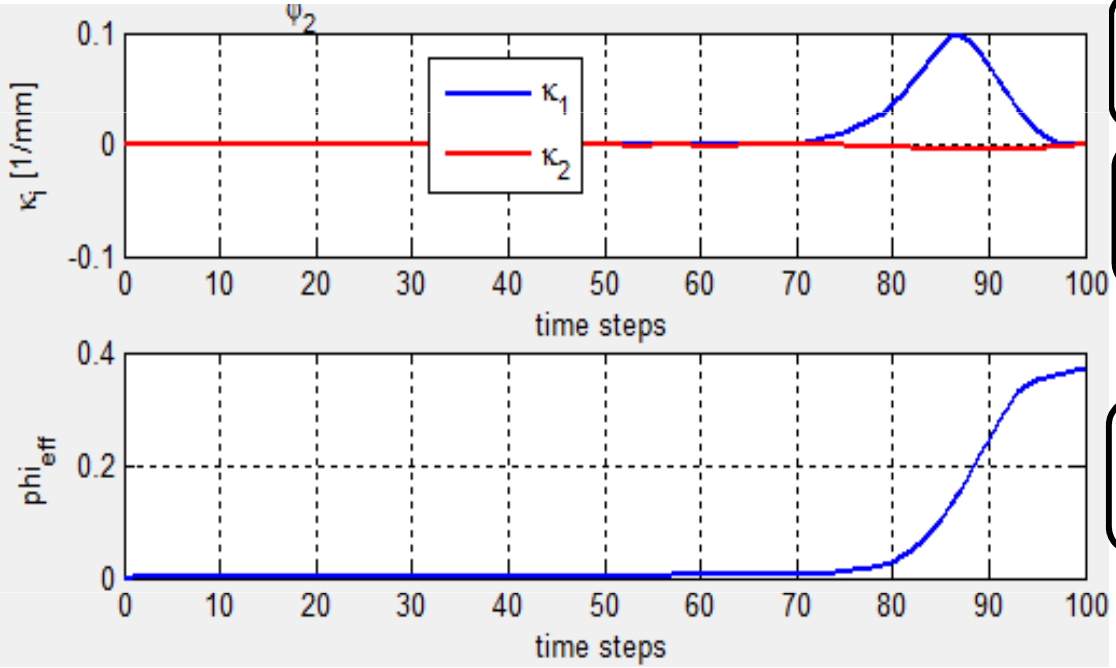
! to be calculated for each element from nodal information

element wise surface approximation using parabolic quadrics

κ_1 and κ_2: eigenvalues of the shape factor

approach to categorize complex deep drawing parts

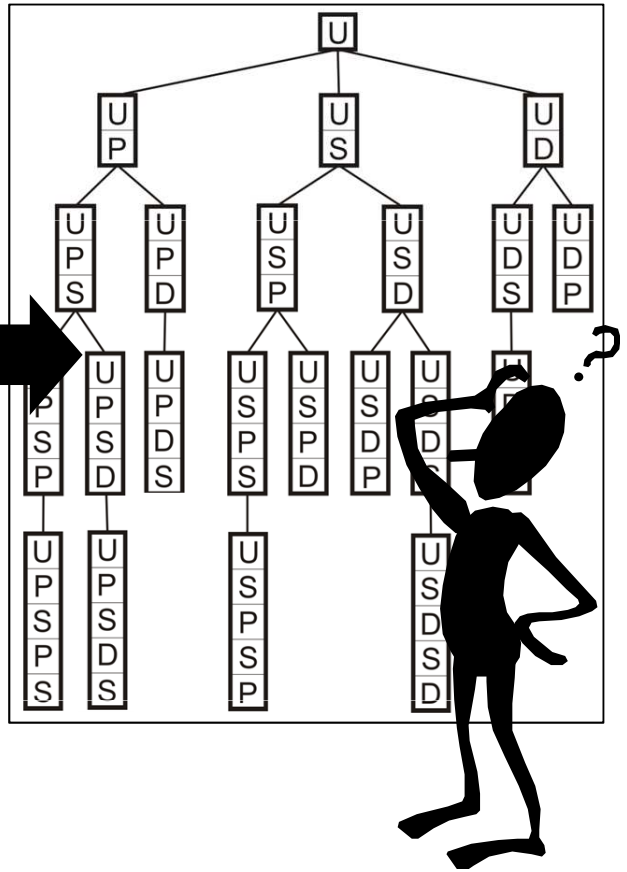
assessment of deformation histories



κ_1

κ_2

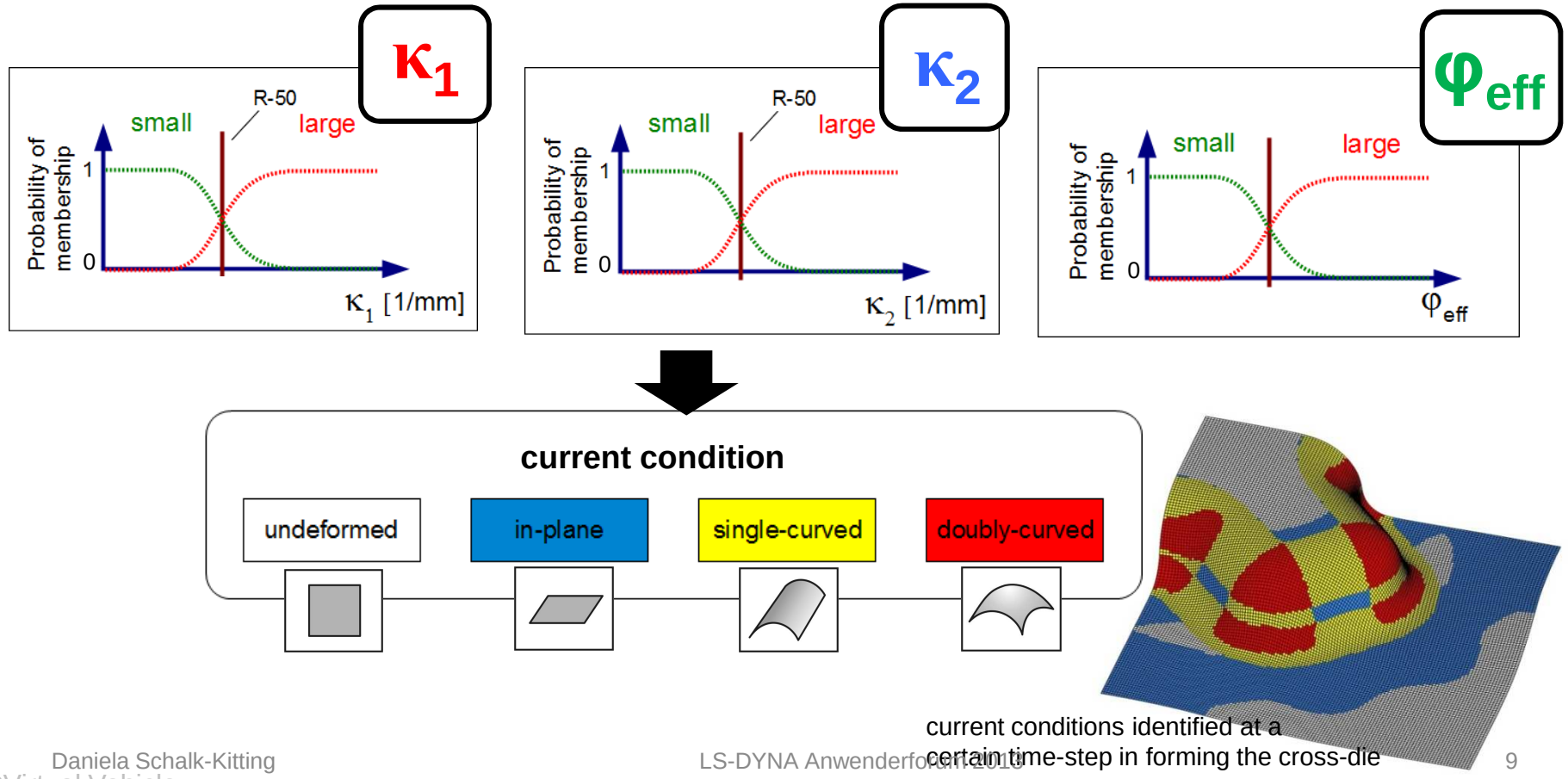
φ_{eff}



approach to categorize complex deep drawing parts

assessment of deformation histories

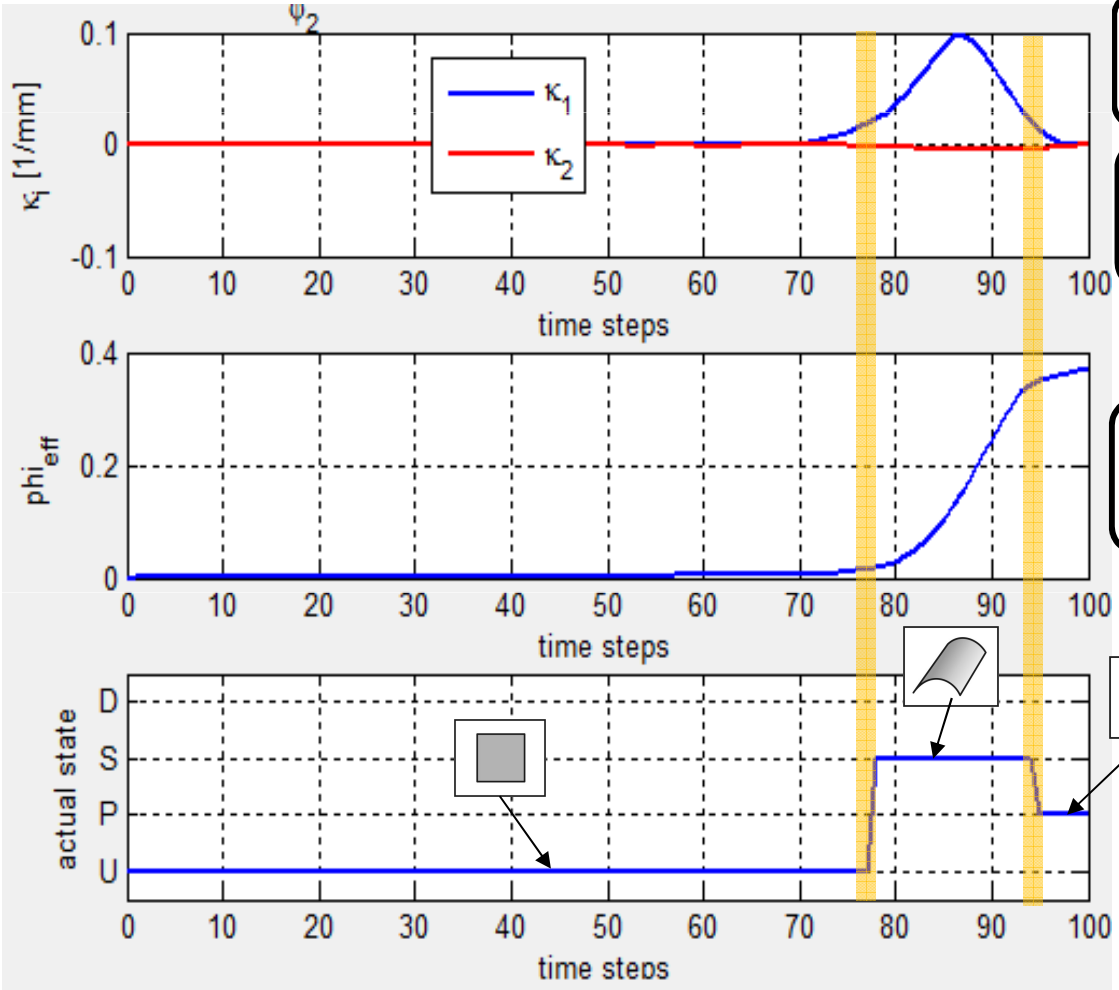
calculation of probability of membership in each time-step using fuzzy rules



current conditions identified at a certain time-step in forming the cross-die

approach to categorize complex deep drawing parts

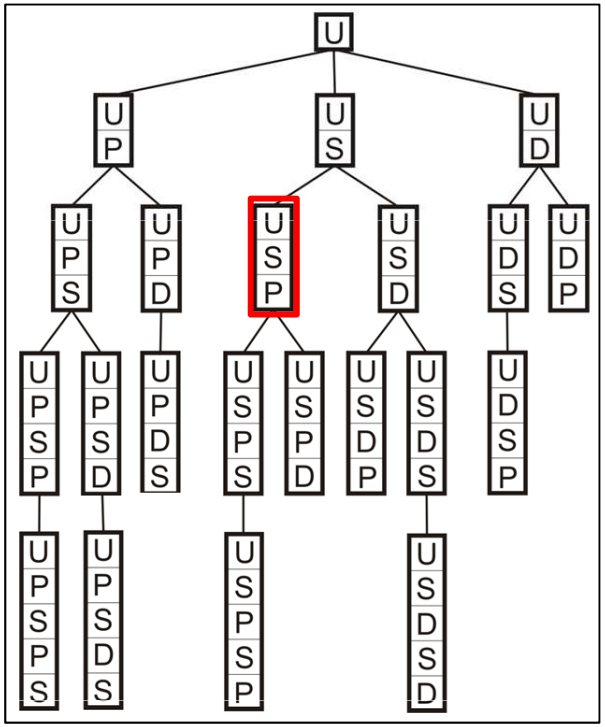
assessment of deformation histories



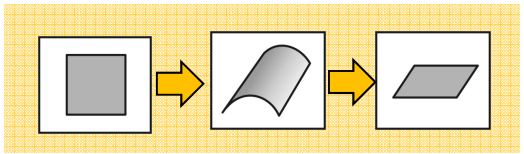
κ_1

κ_2

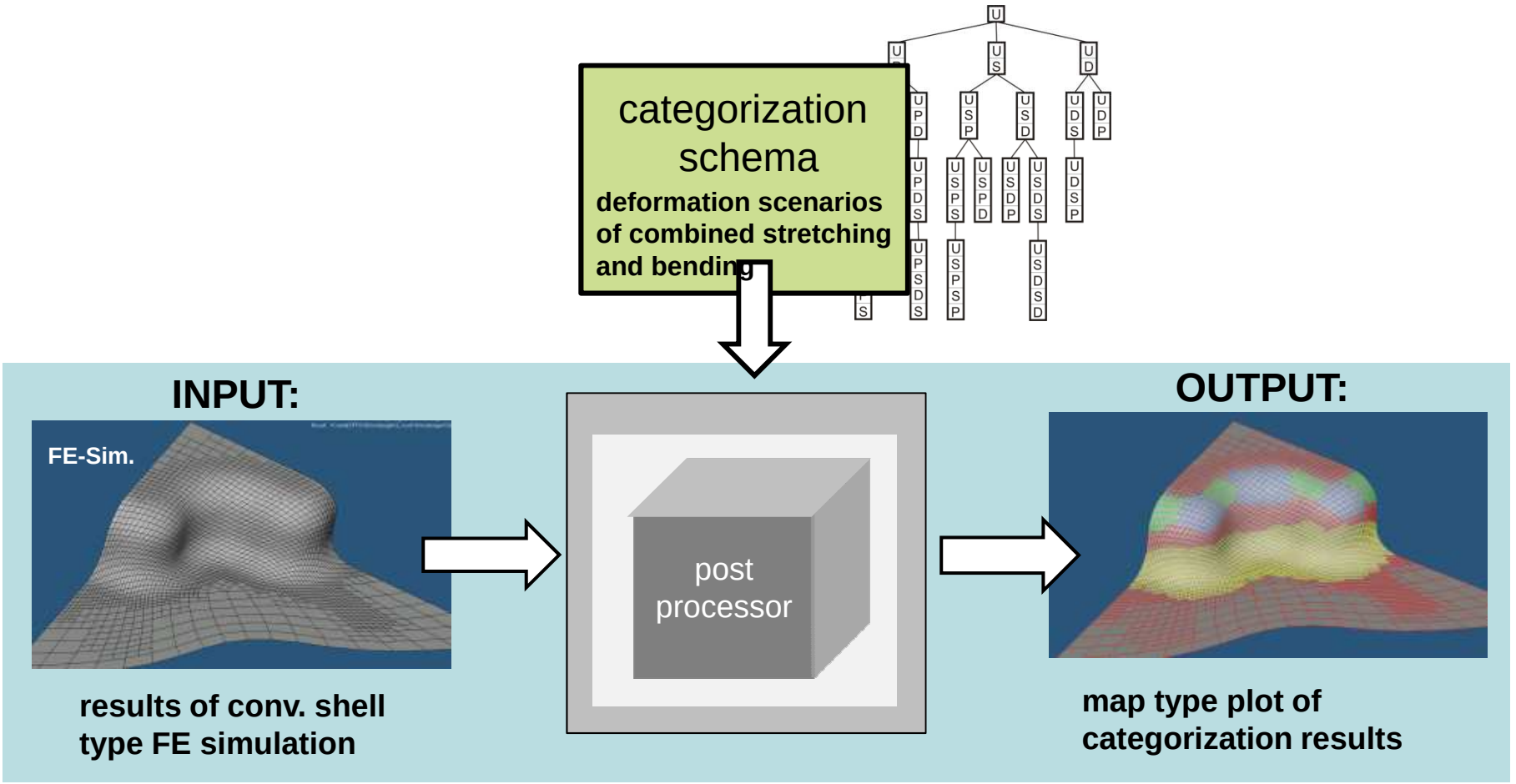
φ_{eff}



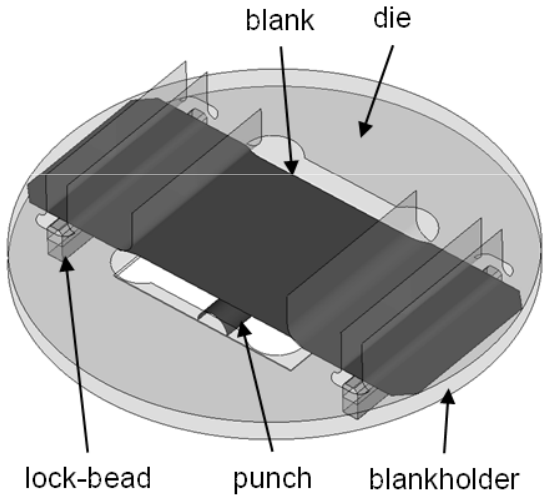
U – S – P



categorize stretch-bending forming scenarios in complex deep drawing parts

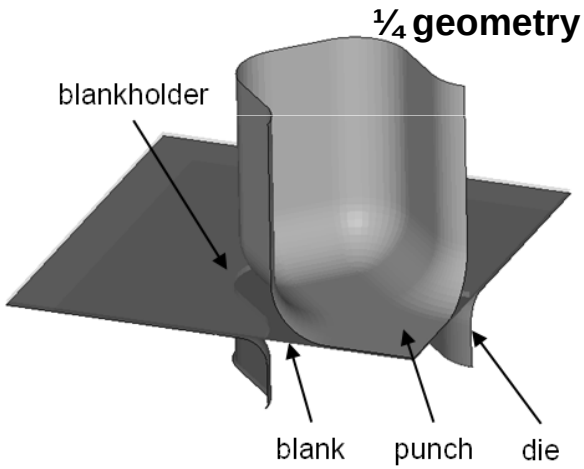


FE forming simulation



ASBT

sheet thickness: 1.5 mm
tool radius: 10 mm



cross-die geometry

sheet thickness: 1.5 mm
punch travel: 29 mm

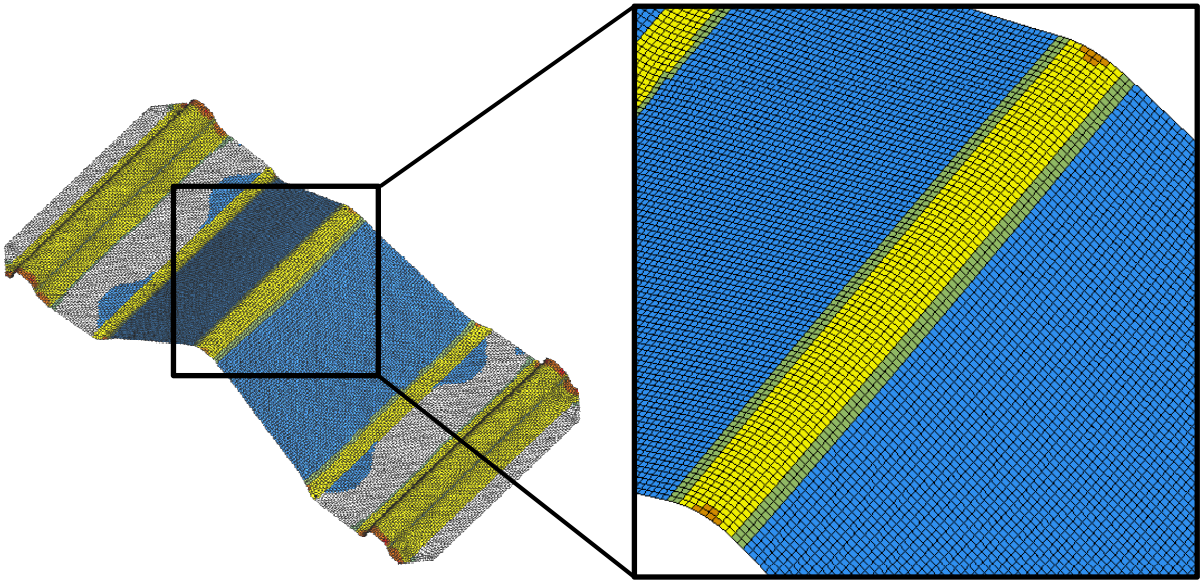
FE-model

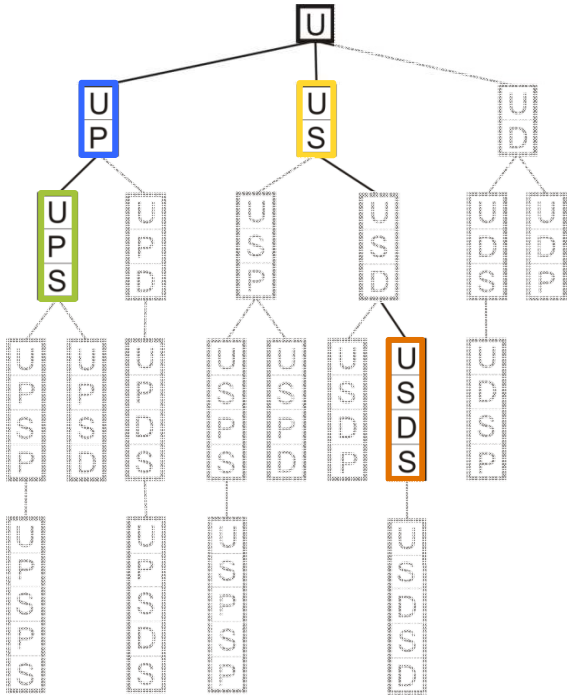
- **solver:**
  LS-dyna
- **blank – element type:**
  standard shell element (#2)
- **blank – element size:**
  1 x 1 mm
- **friction coefficient:**
  ASBT: FS = 0.001
  cross-die = 0.15
- **material model:**
  Hill48

- **material: DP800**

Angular Stretch-Bend Test

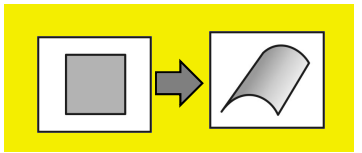
tool radius = 10 mm

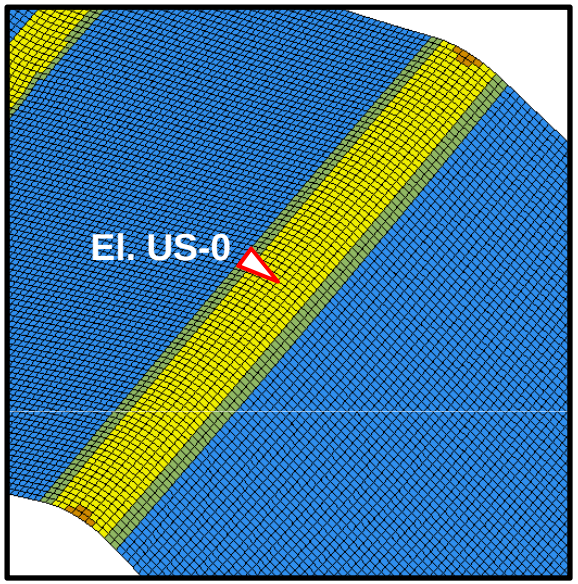


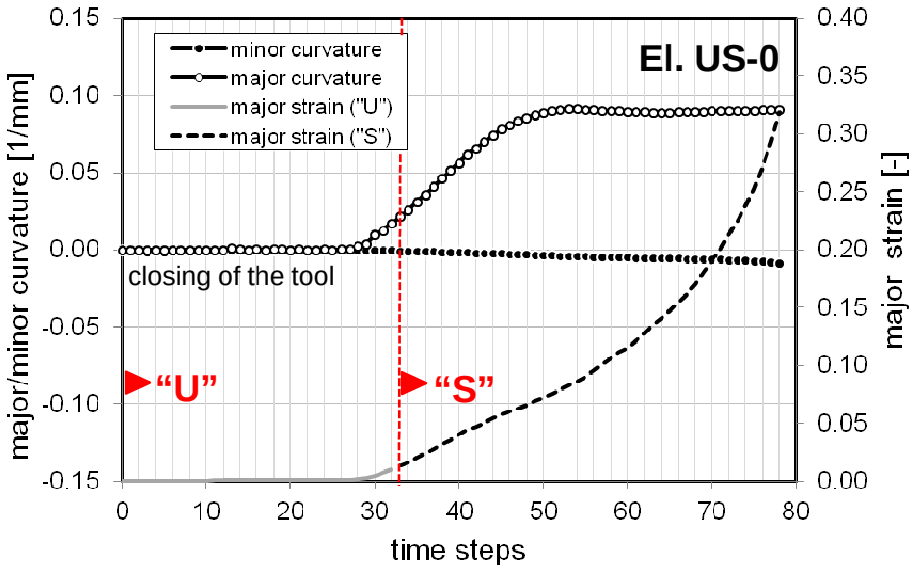


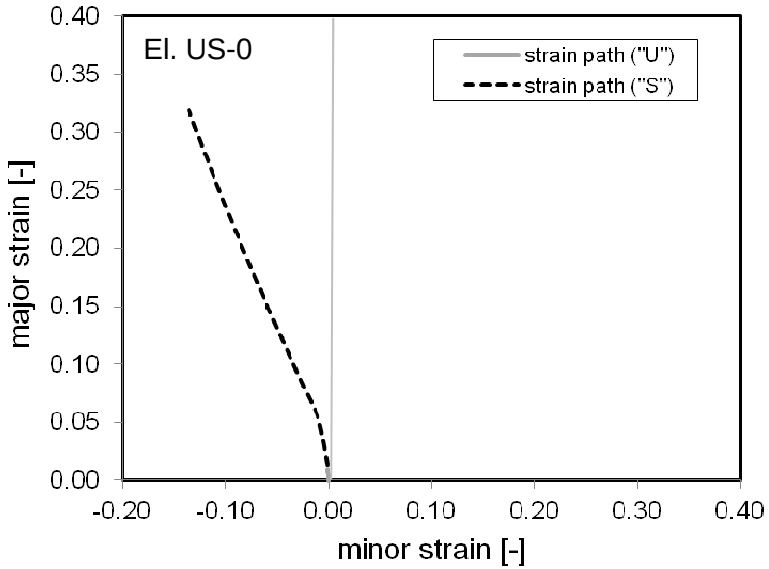
Angular Stretch-Bend Test

U – S



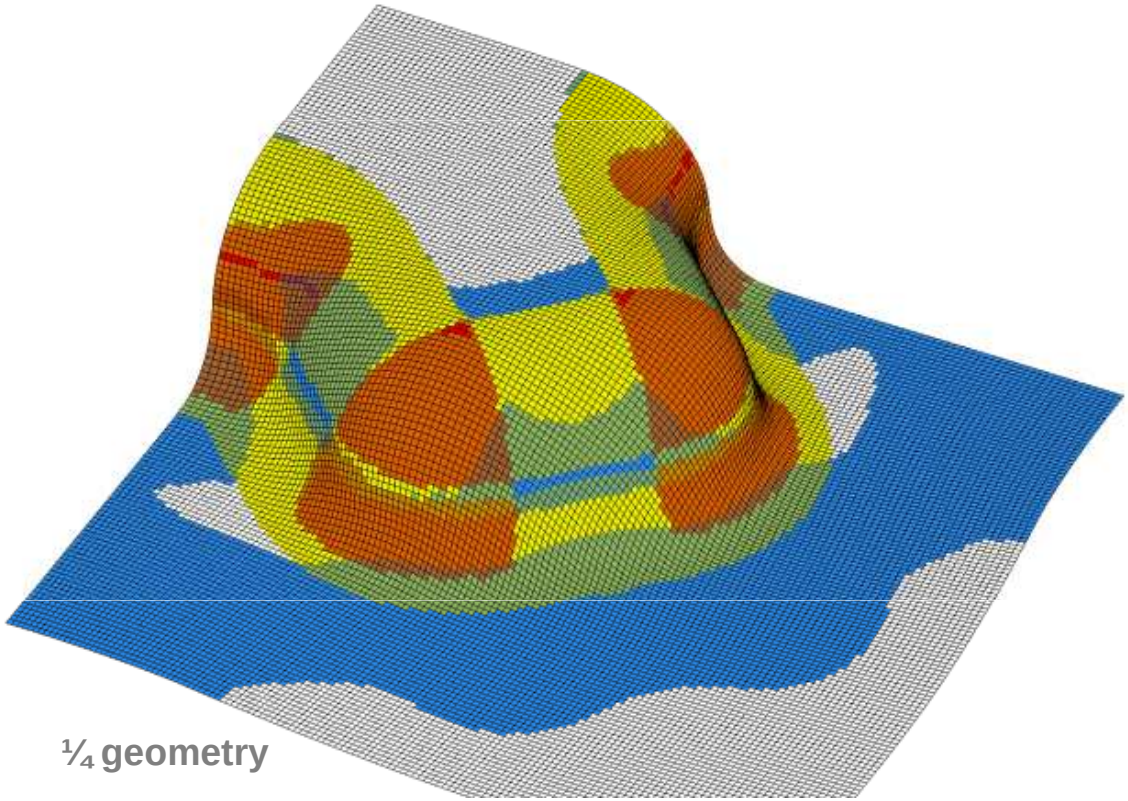




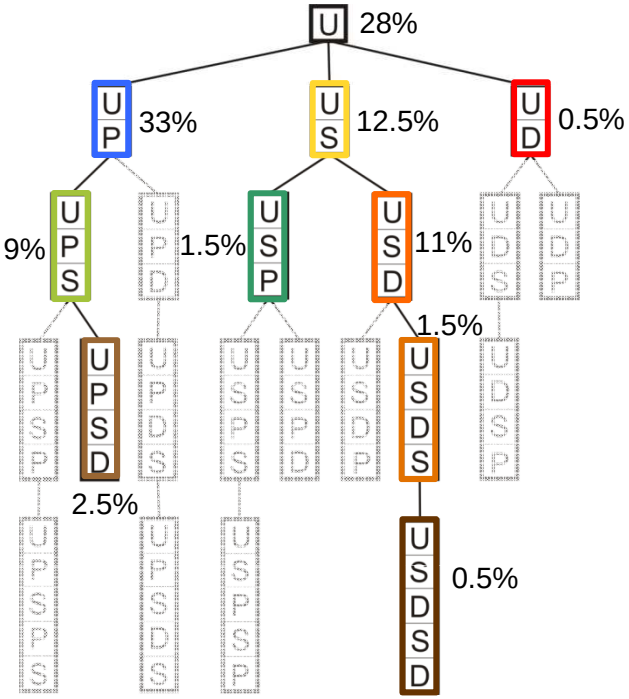


Cross Die Test

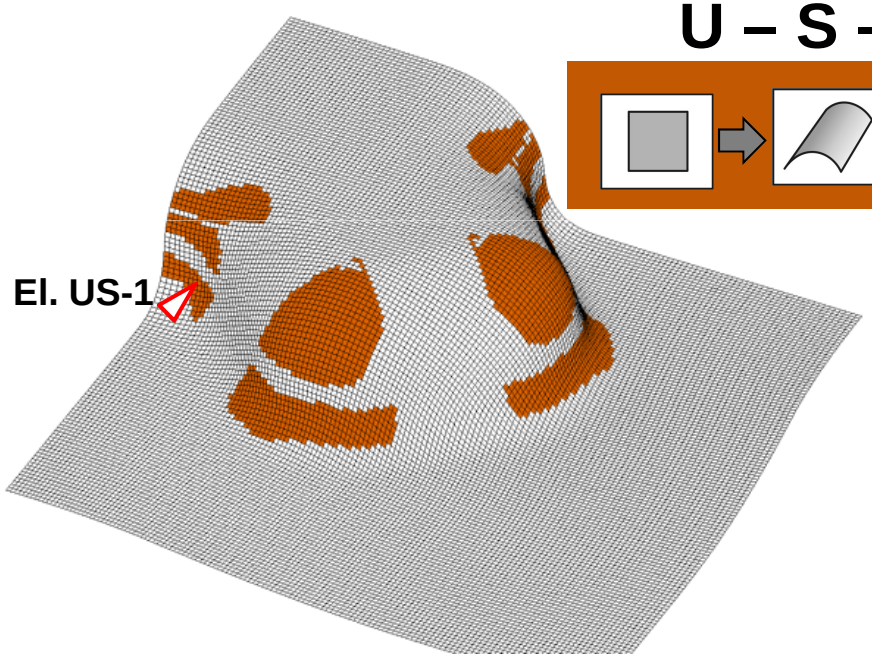
punch travel: 29 mm

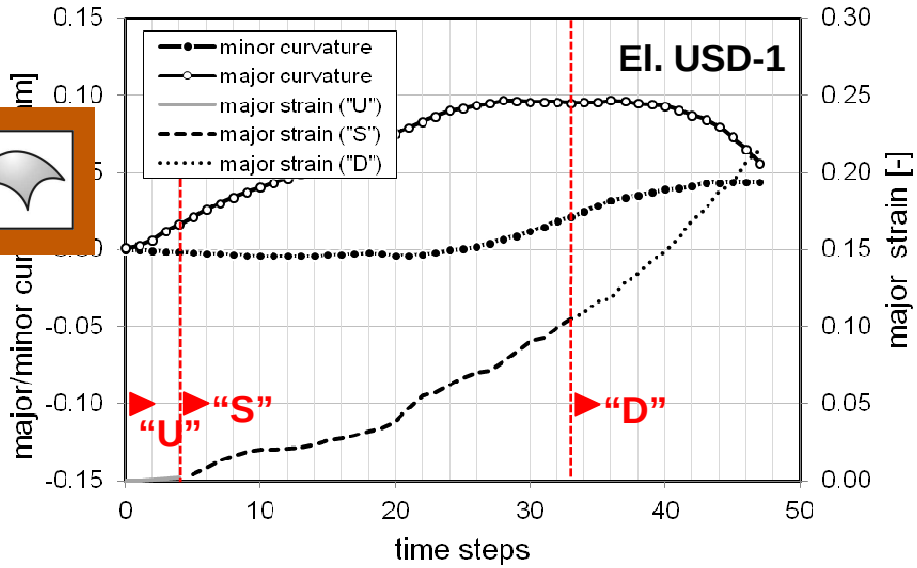


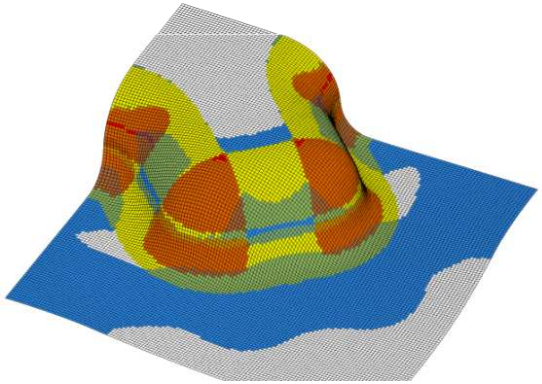
¼ geometry

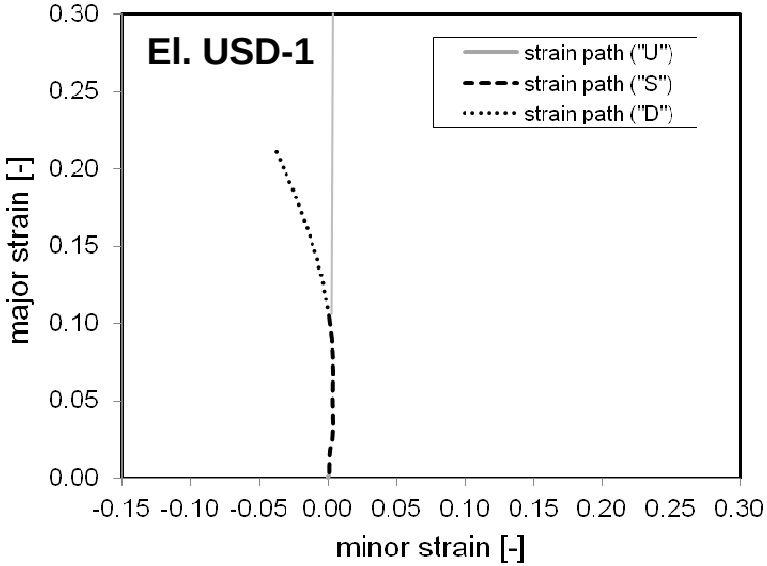


Cross Die Test









categorization of stretch-bending scenarios

- approach to systematically describe stretch-bending scenarios
- approach applicable in industrial environment
- results of categorization provide deeper insight in deep drawing process

outlook: application of categorization results and approach

- development of new test equipment for formability testing
- basis for “scenario dependent” failure assessment
- basis for process optimization
- basis for decisions in design
- .....

Thanks for your attention!

The research leading to these results has received funding form the European Community‘s Research Fund for Coal and Steel (RFCS) under grant agreement n°RFSR-CT-2011-00020.