"Simulation for process and die design in forging"

Presented by

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CPM GmbH, Herzogenrath, Germany

Korea Metal Week 2007
Seoul, 26.10.2007

“Simulation for process and die design in forging”

History and fields of business of CPM

Industrial applications of Simulation

Conclusion

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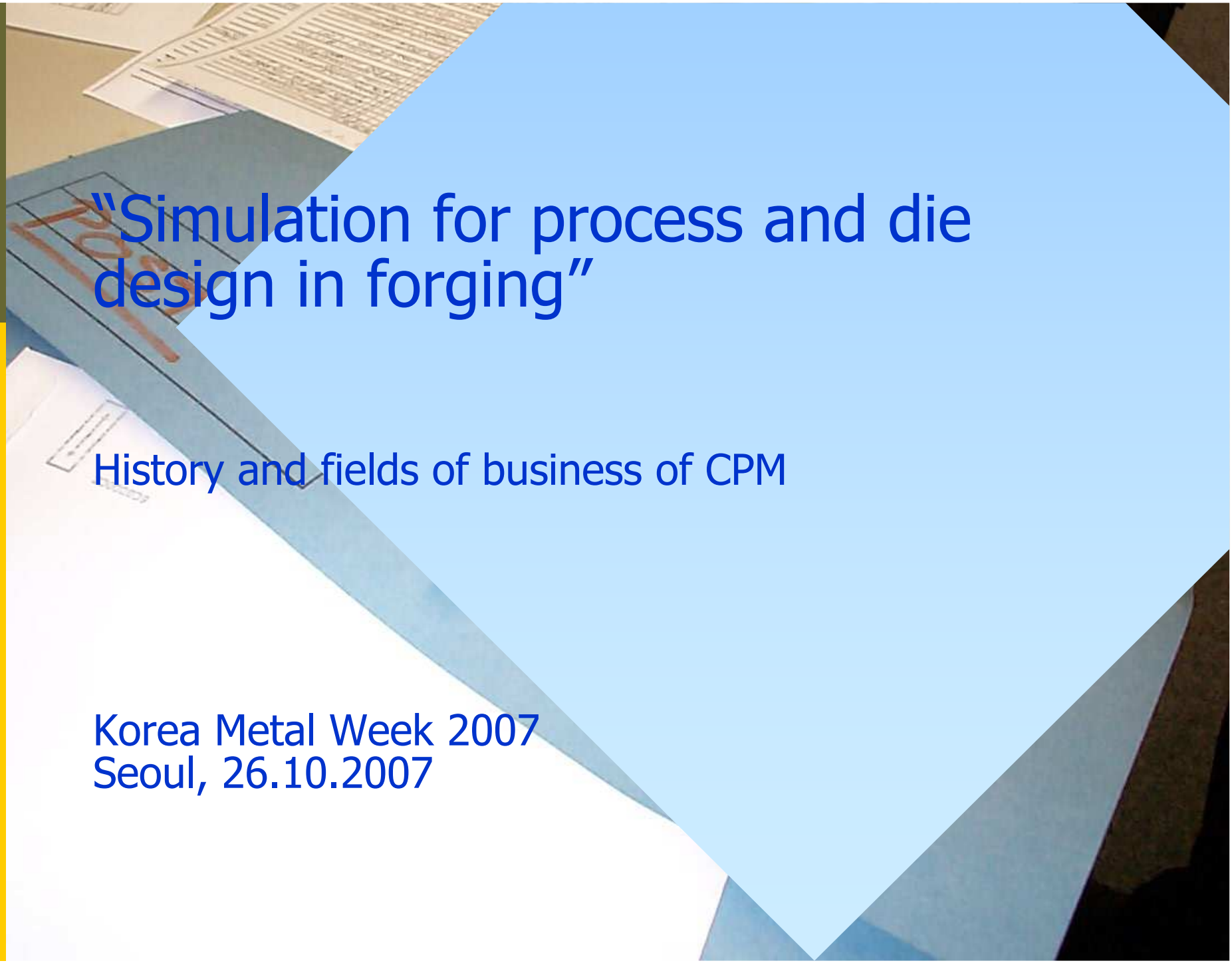

“Simulation for process and die design in forging”

History and fields of business of CPM

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History of CPM

CPM was founded in 1987 in Aachen, Germany as a spin-off of the University of Technology of Aachen – one of the biggest and best in its field in Europe.

CPM worked on software solutions in the field of metal forming in general.

In 1990 CPM moved to Herzogenrath, Germany and and changed its focus to technology and simulation in forging.

CPM provides engineering service to forging companies worldwide.

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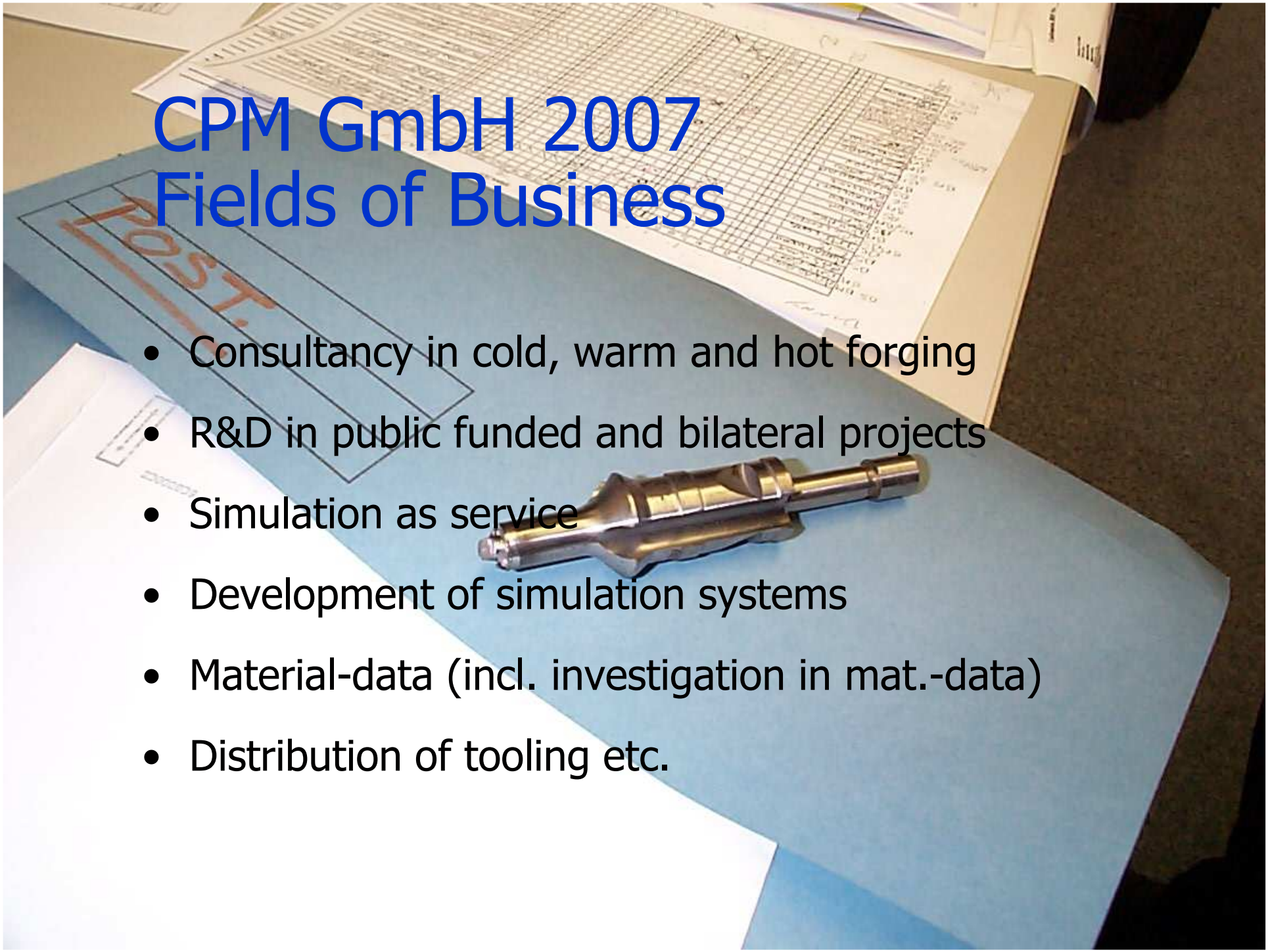
Business of

CPM Gesellschaft für Computeranwendung, Prozeß- und Materialtechnik mbH



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Fields of Business

- Consultancy in cold, warm and hot forging
- R&D in public funded and bilateral projects
- Simulation as service
- Development of simulation systems
- Material-data (incl. investigation in mat.-data)
- Distribution of tooling etc.

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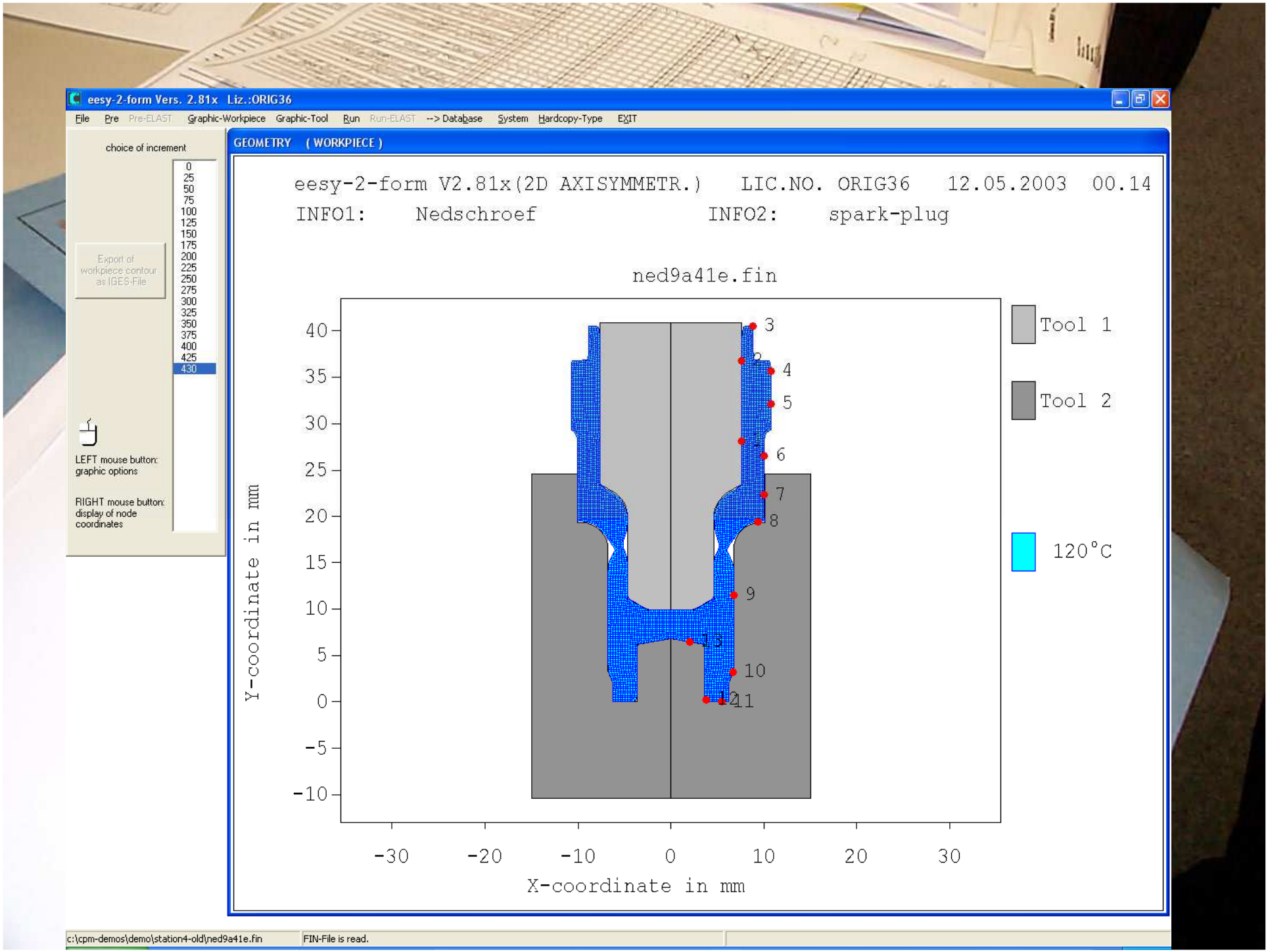
- Consultancy in cold, warm and hot forging

Example: Spark Plug

Problem : Cracking because of wrong adjustment


Zündkerze - Windows Bild- und Faxanzeige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INFO1: Nedschroef INFO2: spark-plug
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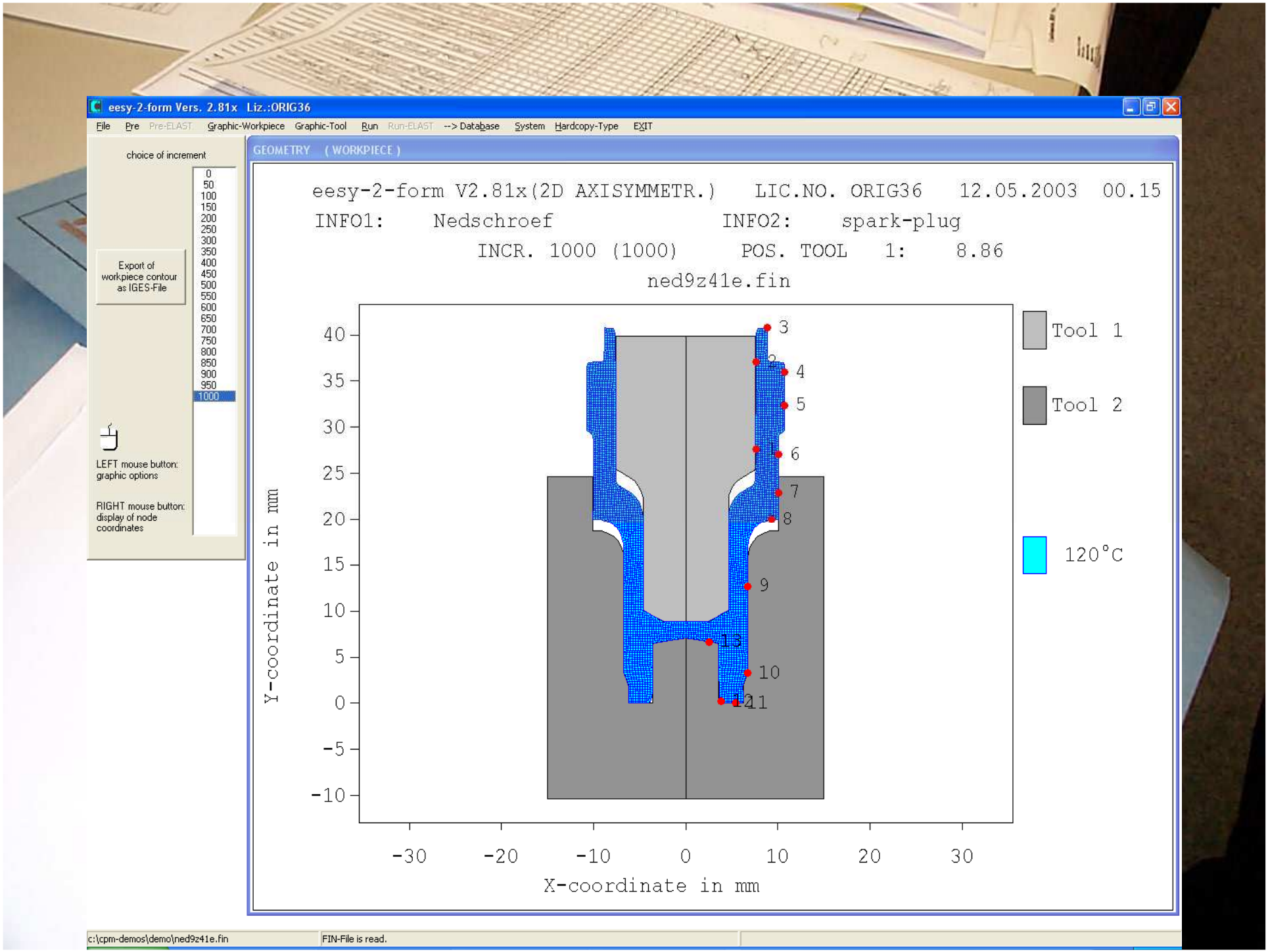
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R&D in public funded and bilateral projects

Verbesserte Verfahren der Gewindeherstellung

3D Simulation

Forgenet

Ecologically Optimised Cold Forging

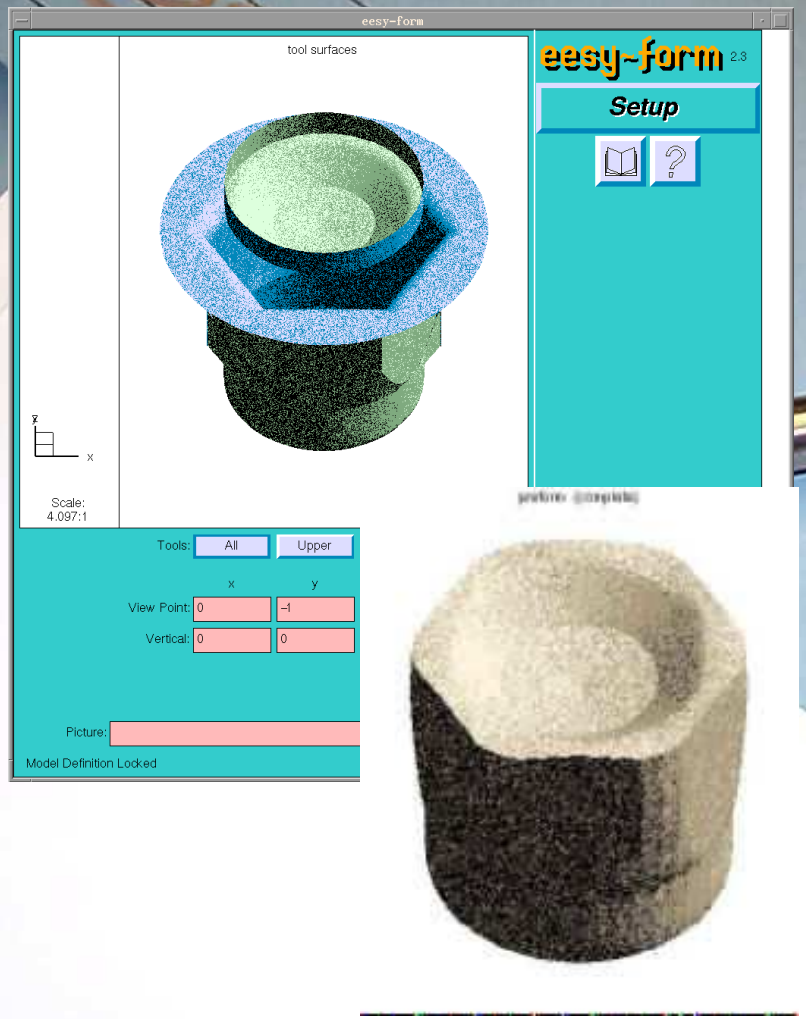
Yield Stress Strain Curves

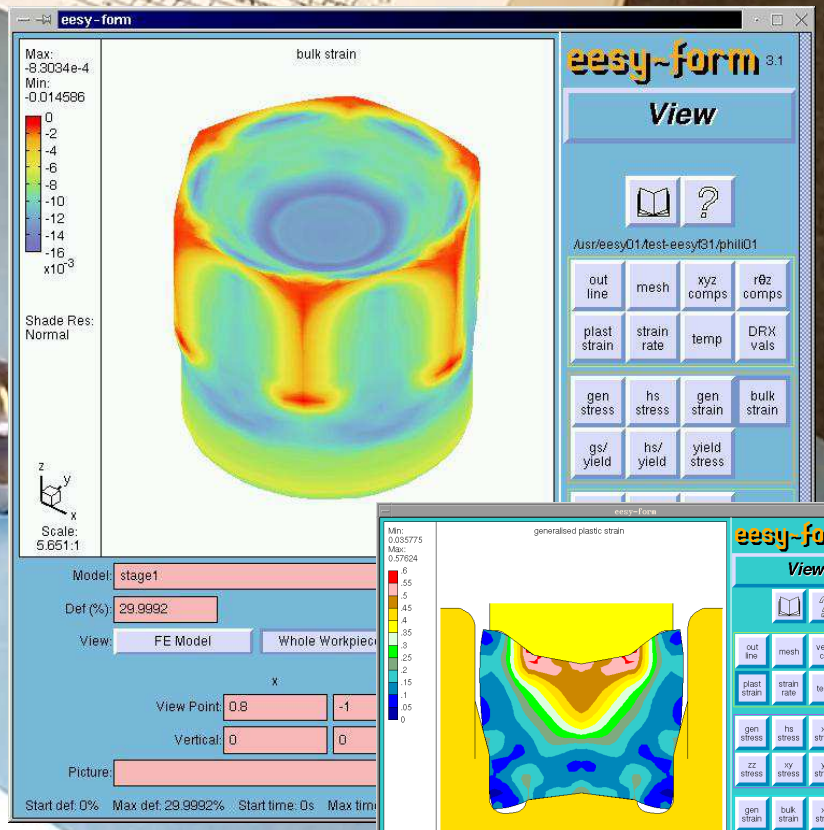
Modeling of Metal forming based on microstructure for micro-alloyed steels in multi-station forging operations

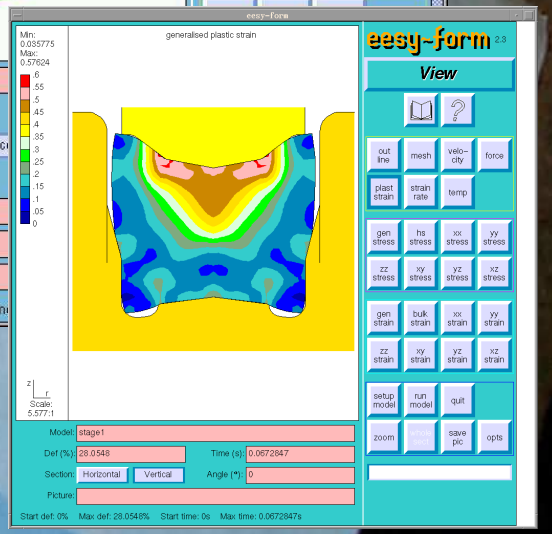
Aluminum parts for Automotive applications

Development of simulation systems

Example of a 3D application

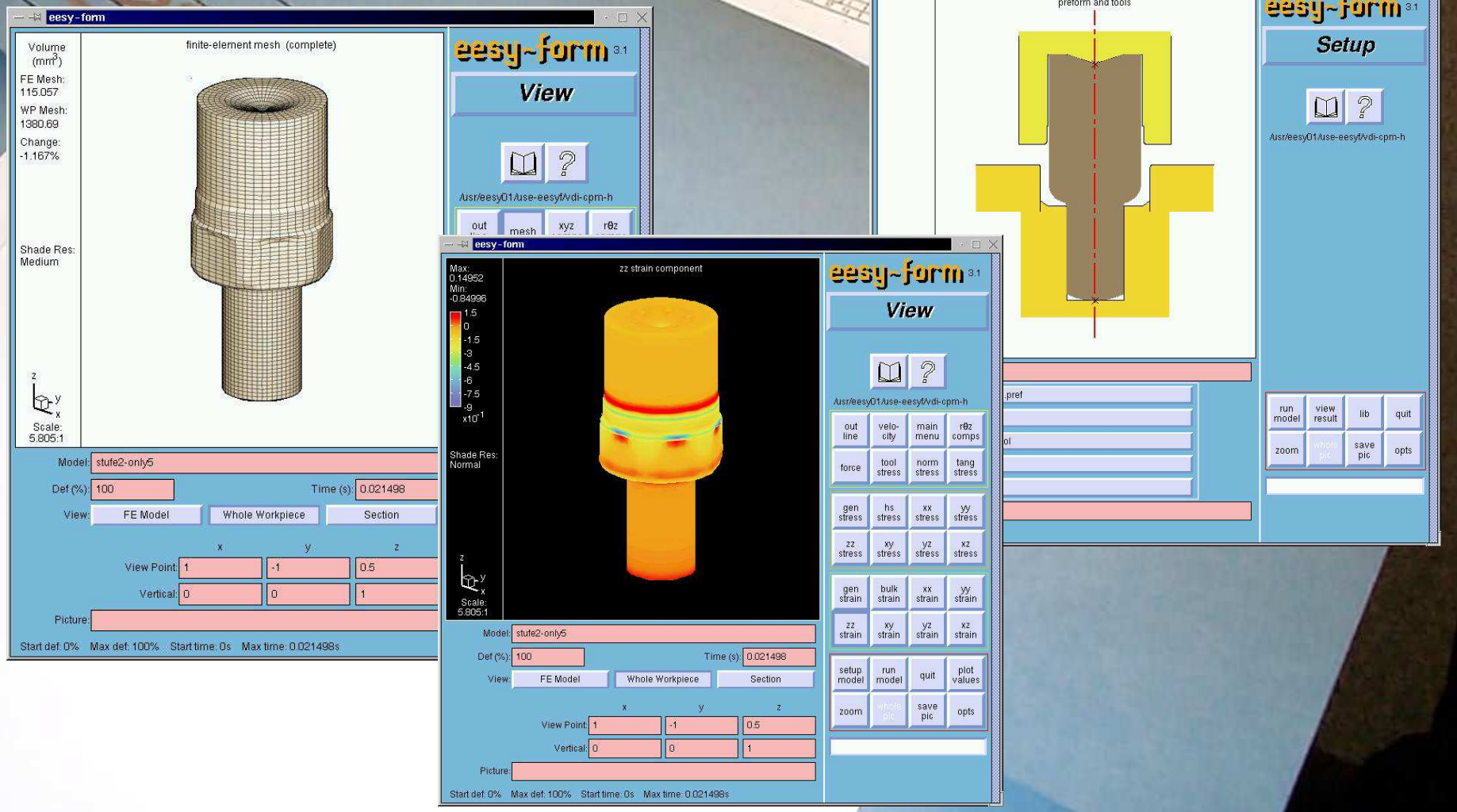






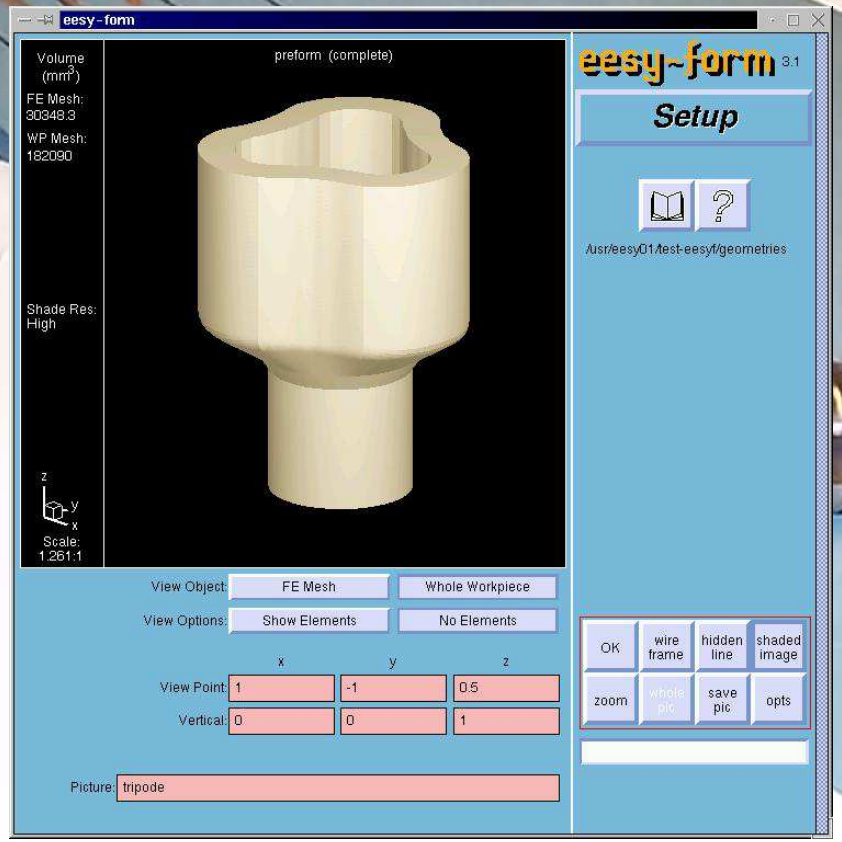
Development of simulation systems

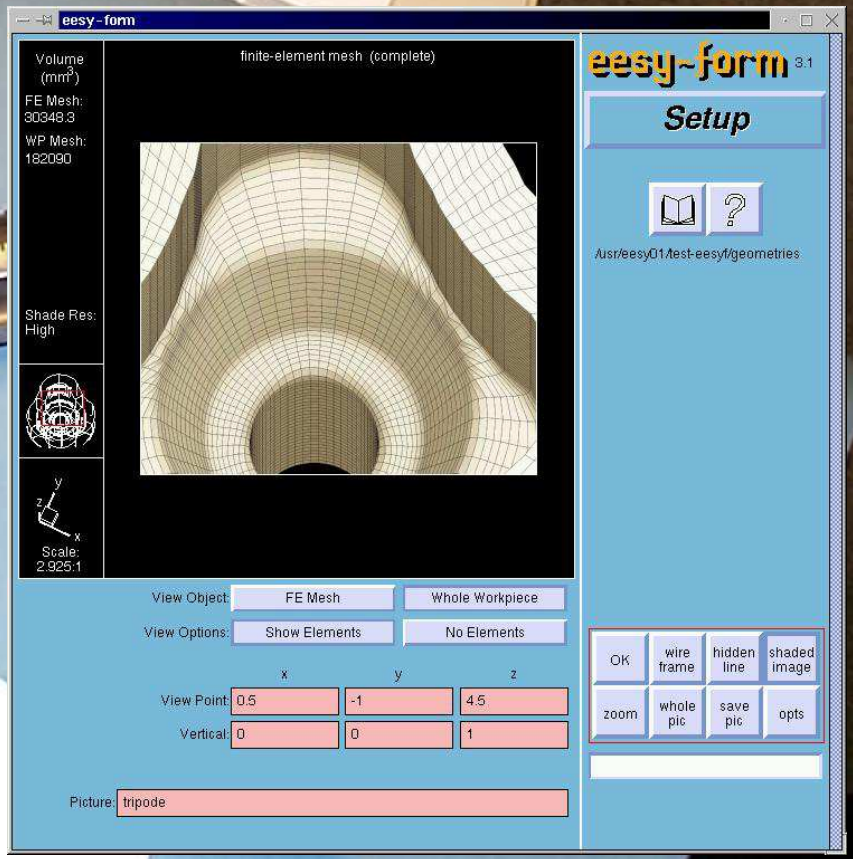
Example of a 3D application



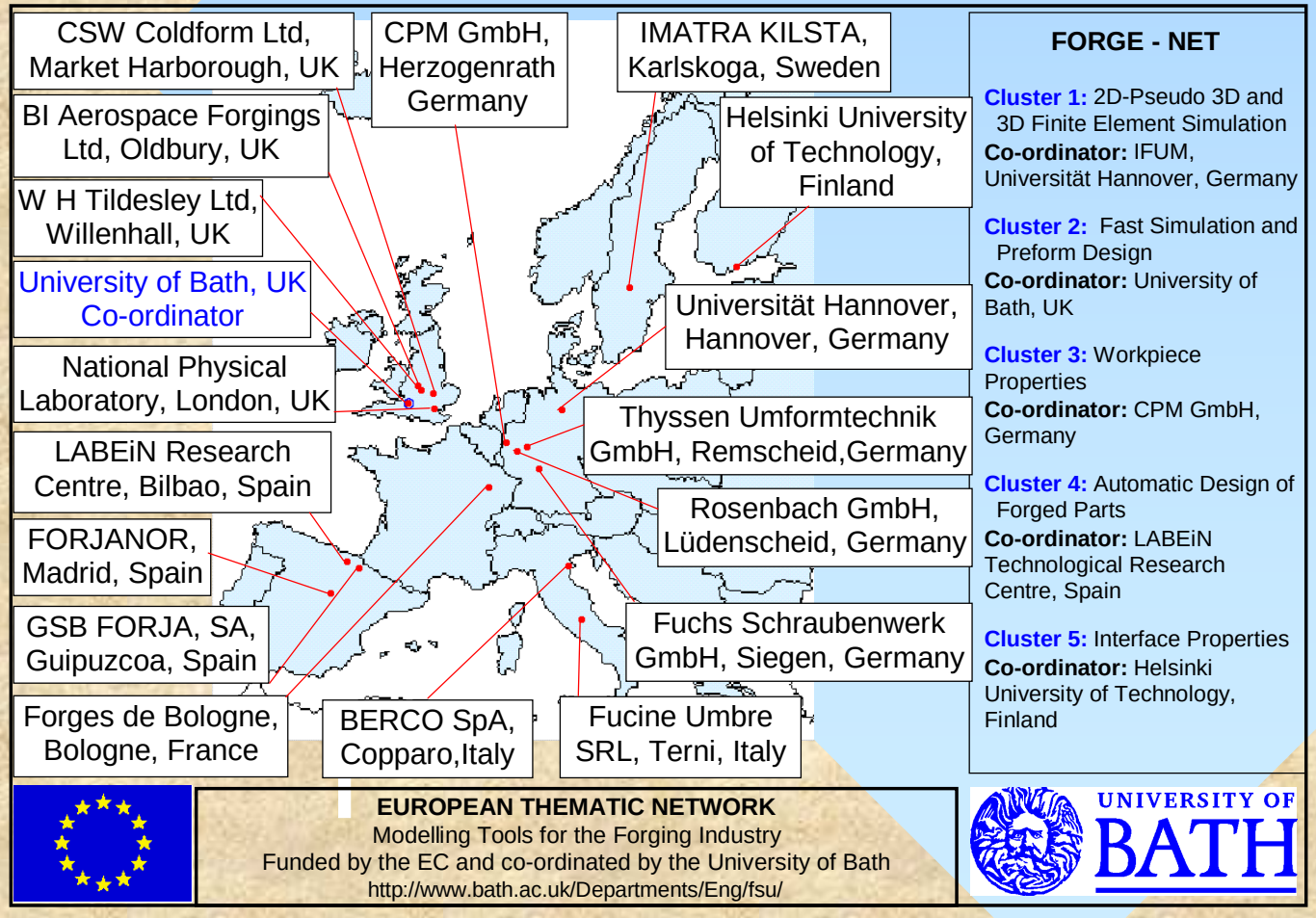
Development of simulation systems

Example of a 3D application





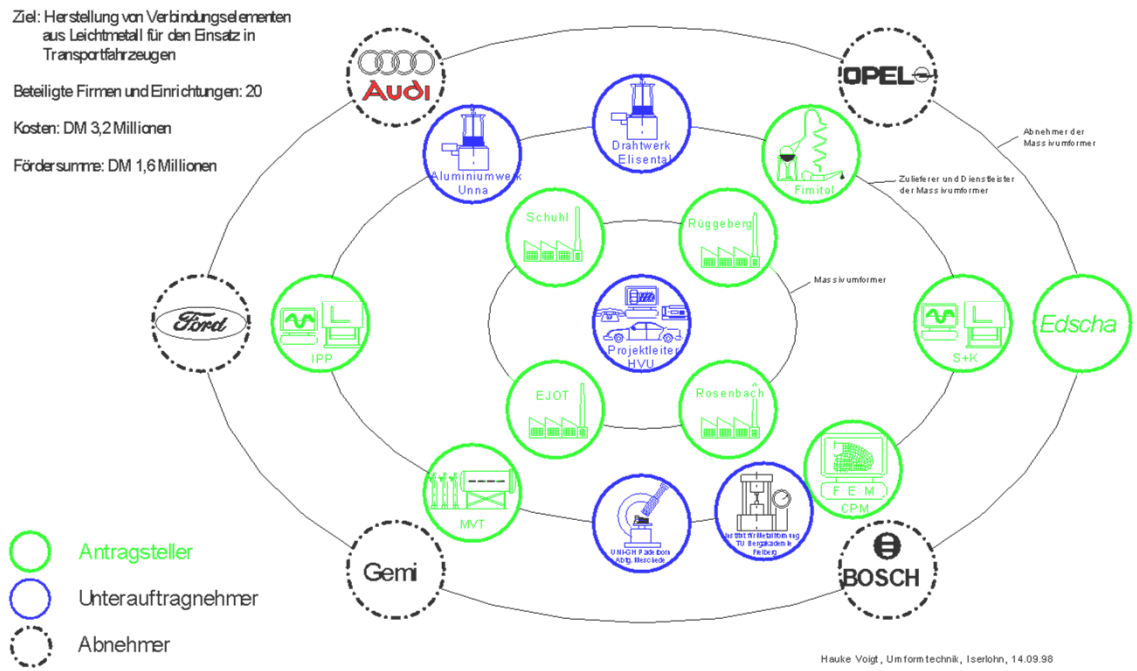
R&D in public funded and bilateral projects: Forgenet



R&D in public funded and bilateral projects

Innovative processes in producing screws (Aluminium) (MWMTV-NRW)

Vom Ministerium für Wirtschaft, Mittelstand, Technologie und Verkehr des Landes NRW gefördertes Verbundprojekt "Innovative Fertigungsverfahren in der Schraubenindustrie"



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- Tasks to solve:
  - Garde of aluminium
  - History before forging (casting, drawing, heat-treatment)
  - Forging technology
    - Progression
    - Tooling
    - Tool Coating
    - Lubrification
    - Handeling
  - Heat-treatment
  - Coating

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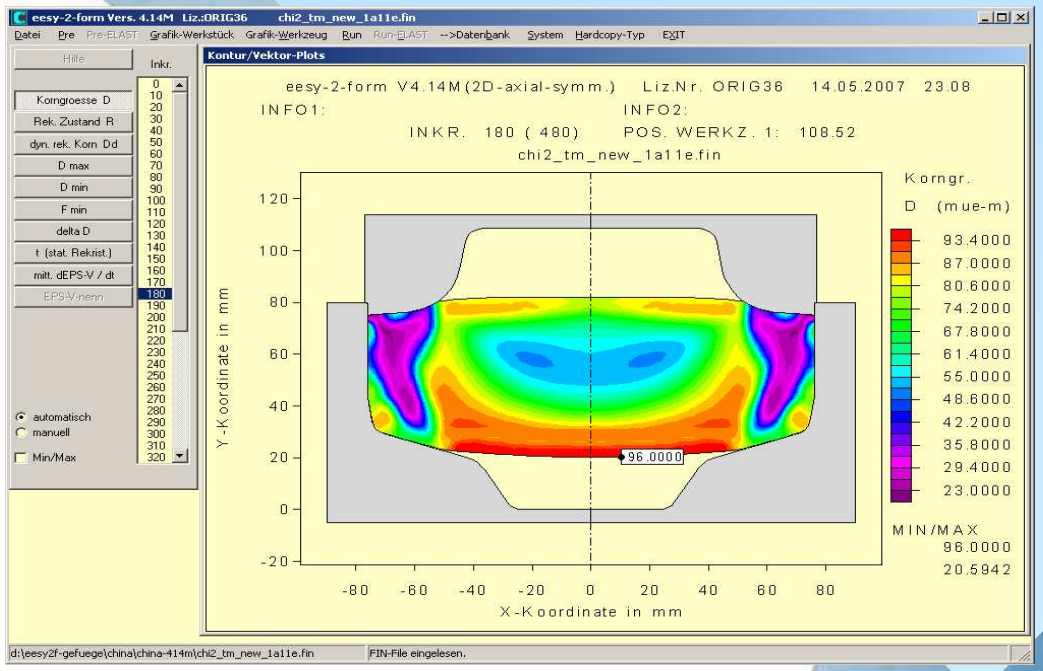
R&D in public funded and bilateral projects

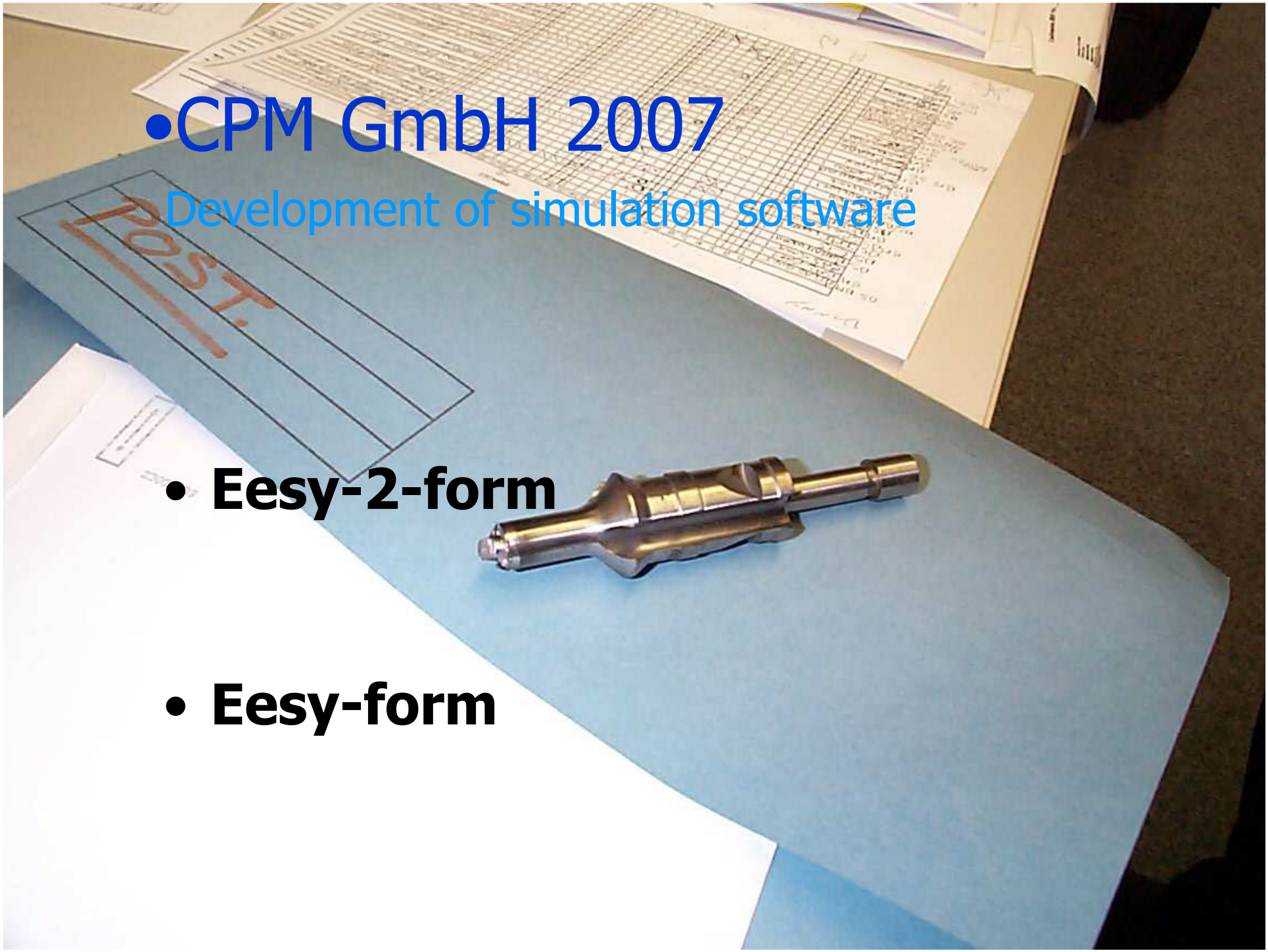
Ecologically Optimized Cold Forging

- no phosphate
- coated wire
- new oils
- tool surface treatment
- ....

R&D in public funded and bilateral projects

Modeling of Metal forming based on microstructure for micro-alloyed steels in multi-station forging operations





- CPM GmbH 2007
  - Development of simulation software

- **Eesy-2-form**

- **Eesy-form**

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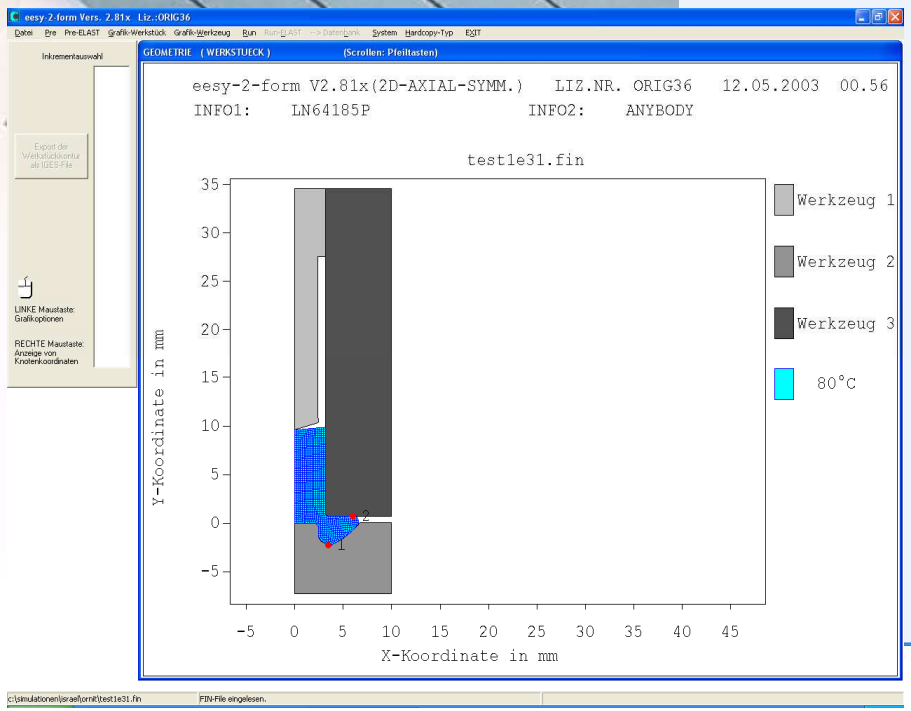
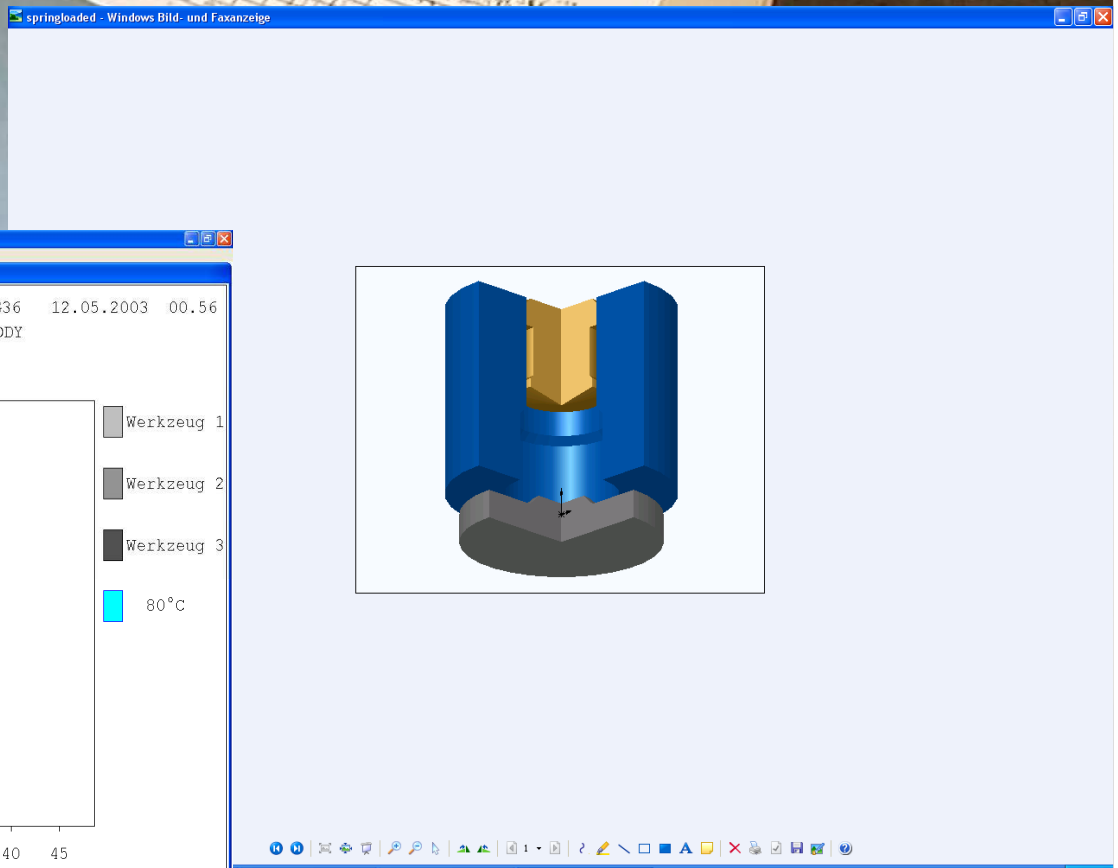
eesy-2-form





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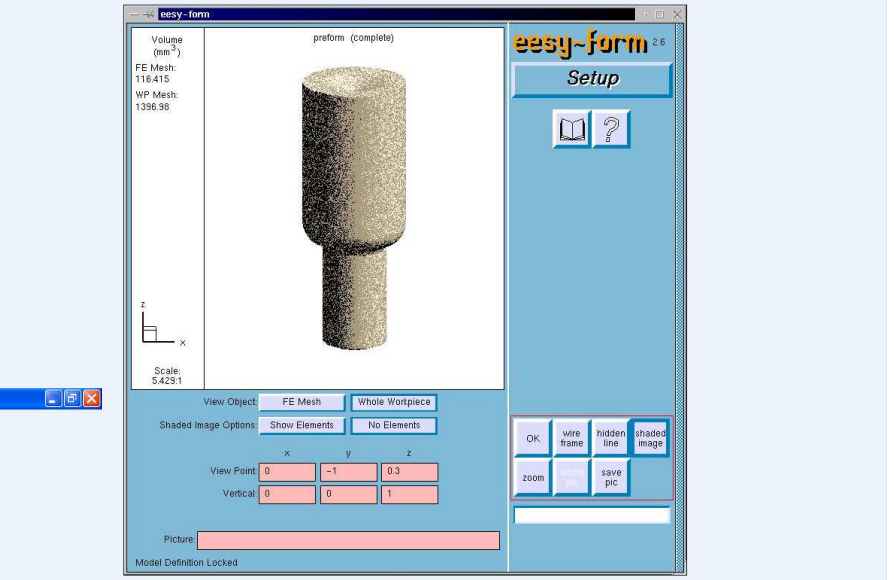
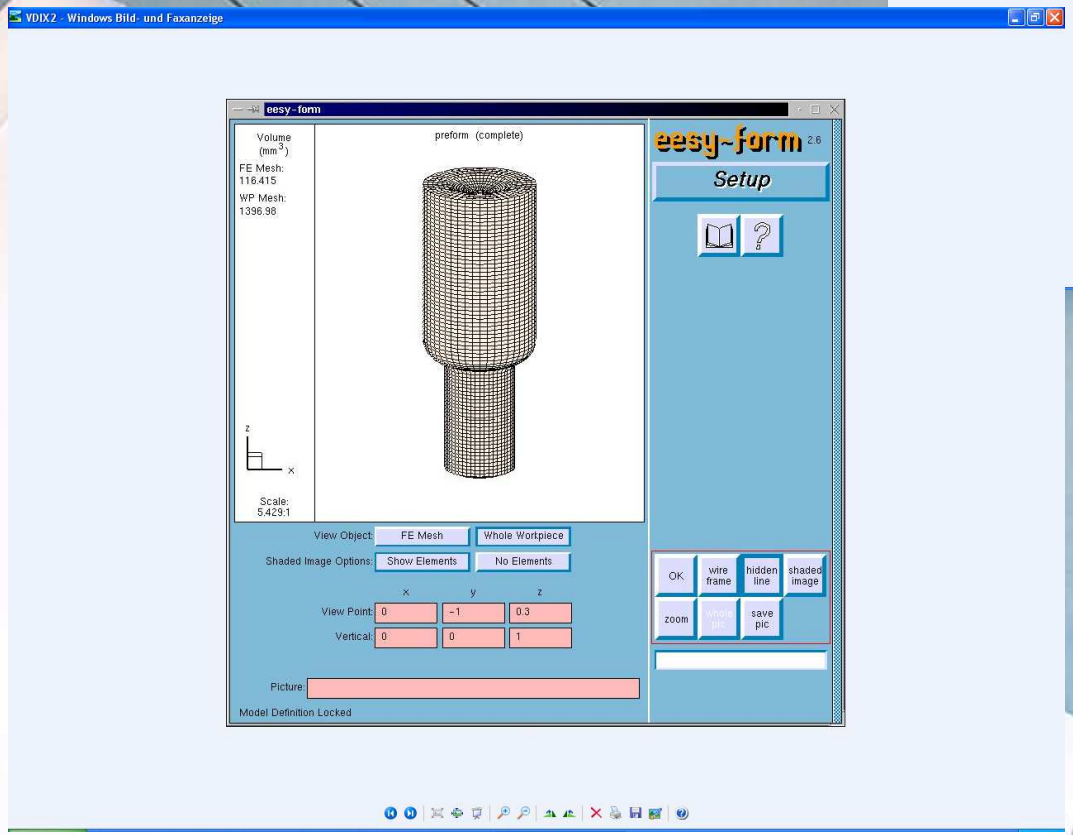
eesy-form





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eesy-form

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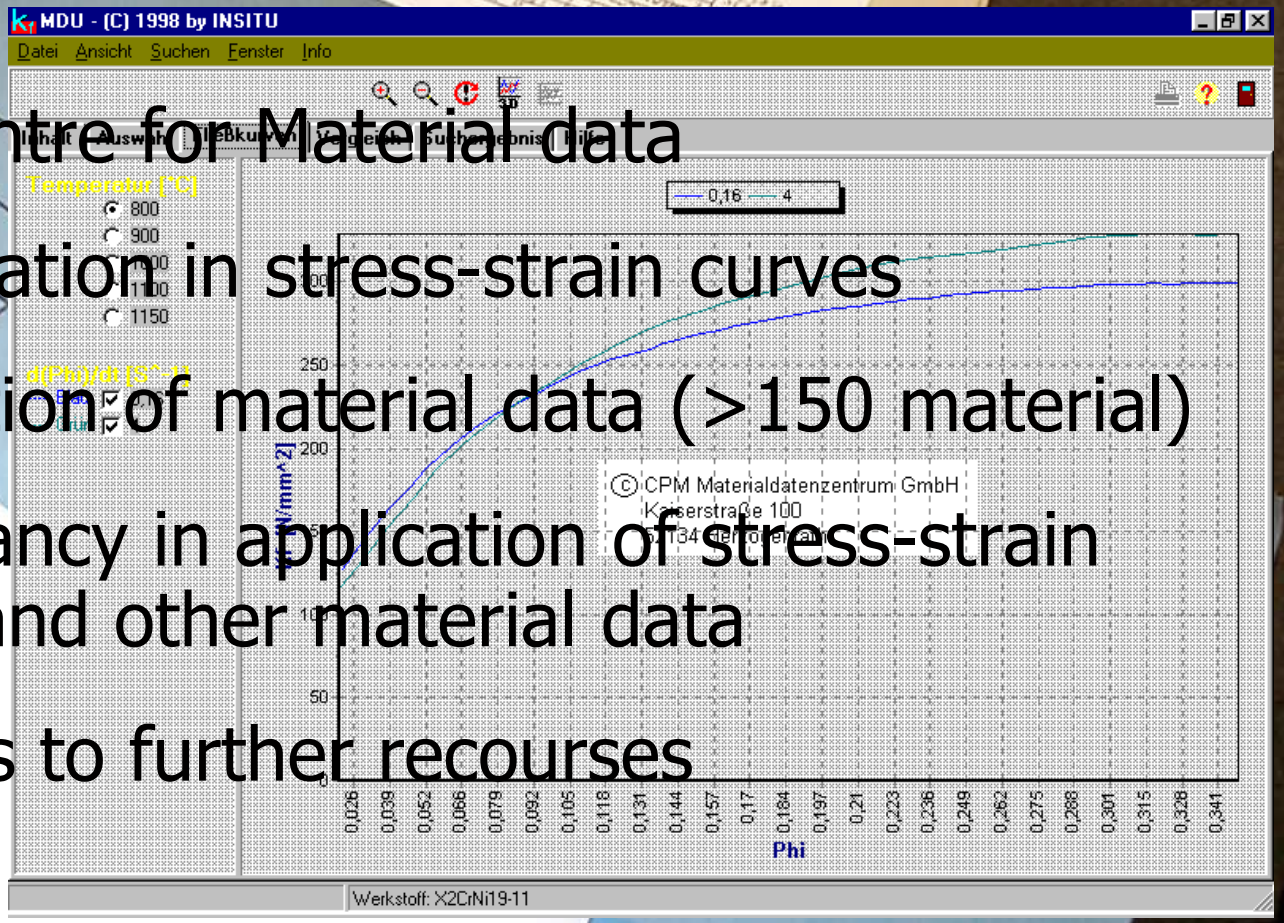
Material data

- Data centre for Material data
- Investigation in stress-strain curves
- distribution of material data (>150 material)
- Consultancy in application of stress-strain curves and other material data
- Contacts to further recourses



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Distribution of Tooling/etc.

- **Tooling of TNP for Cold-forging, Korea Standard tools und Specials**
- **Special punches (6-lobe,...), Korea**
- **Dosing-systems of Serte, Italy**
- **Tooling of Eurotool, Italy**
- **Tooling of "CG", Taiwan**
- **Export of special tooling from Germany**
- **Inspection machines from Italy**

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Distribution of Tooling/etc.

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Distribution of Tooling/etc.

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Partners

- India King Impex, India
- Chang Chi Metal, Taiwan
- Chang Chi Metal + partners, China
- Chierichetti, Italy
- Consultec, Brazil
- COMTESA, Spain
- Jin-A Commerce, Korea
- Extrusion Process System, Singapore, Malaysia, Ind.
- Memsan, Turkey
- Jury Lavrinenko, Russia
- Johnson Machines and Tooling, UK + Ireland
- Nedschroef, Begium + Worldwide

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Spectrum of clients

- **Companies producing cold, warm and hot forged parts**
- **Universities**

Companies in the range of small and medium size enterprises up to large companies in international business

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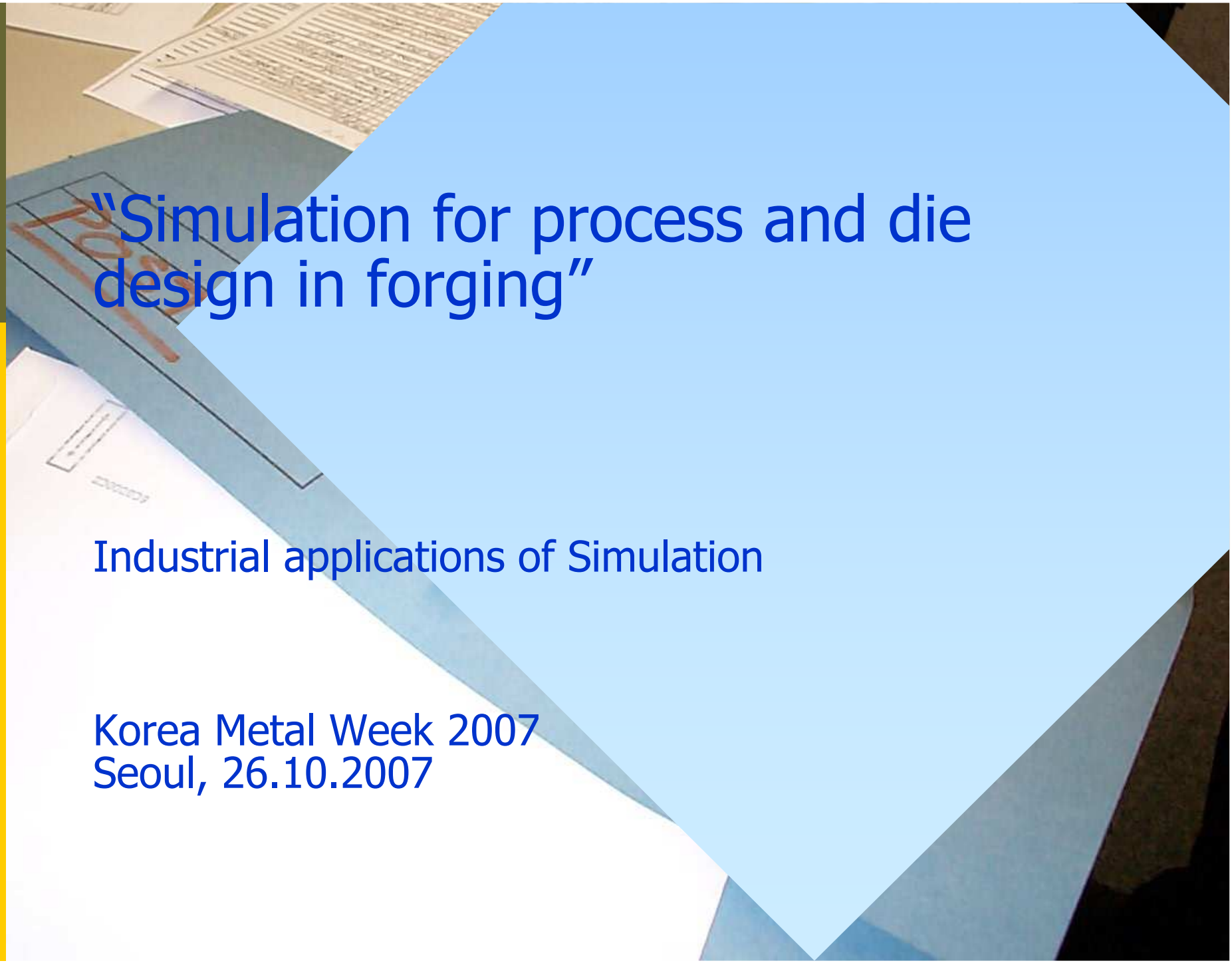
- **CPM Gesellschaft für Computeranwendung, Prozeß- und**
  Materialtechnik mbH
  Kaiserstraße 100
  D-52134 Herzogenrath

  E-mail: CPM@CPGMBH.COM
  www.cpmgmbh.com
  Tel.: +49-2407-95940
  Fax +49-2407-959466

- **Agent in Korea**
  Jin-A Commerce, Seoul



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Industrial applications of Simulation

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Seoul, 26.10.2007

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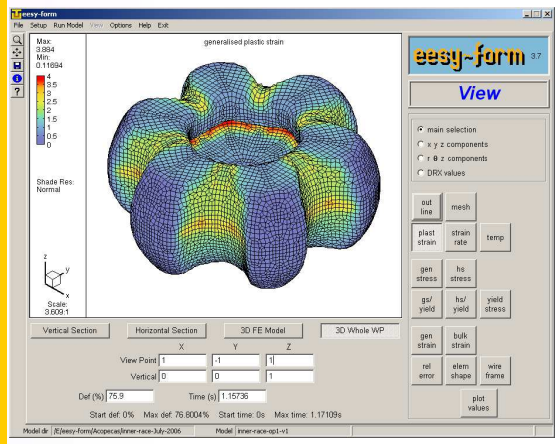

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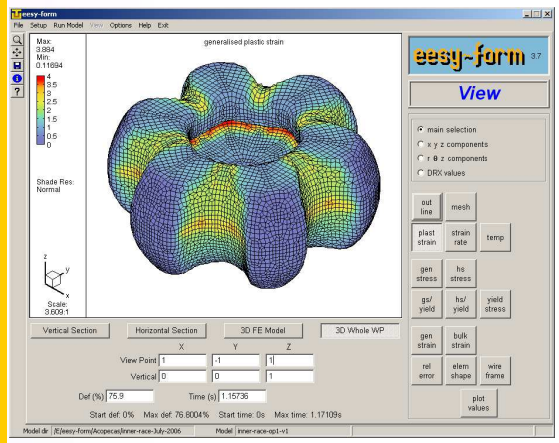

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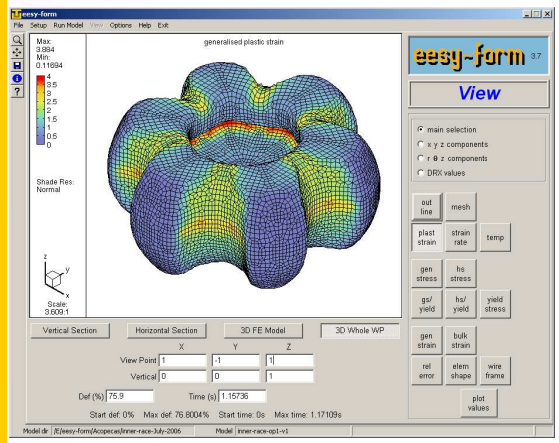

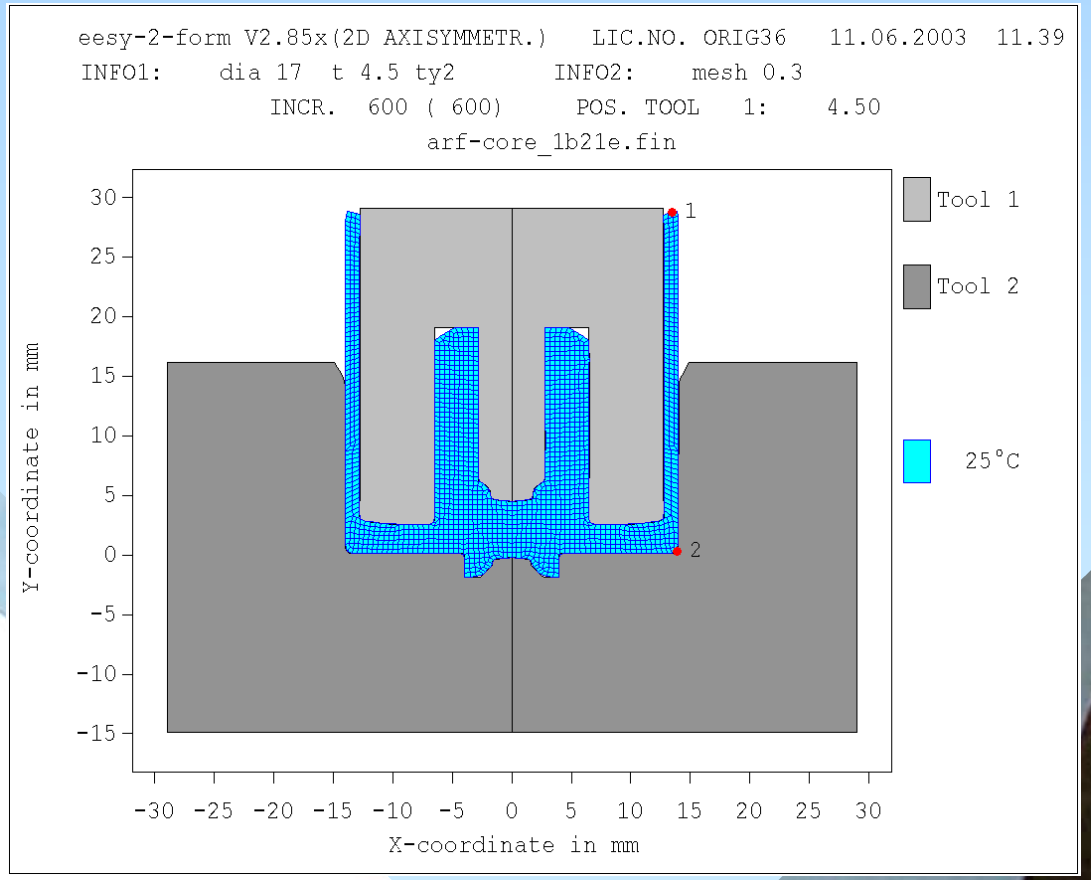

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Principle of Process Design Work

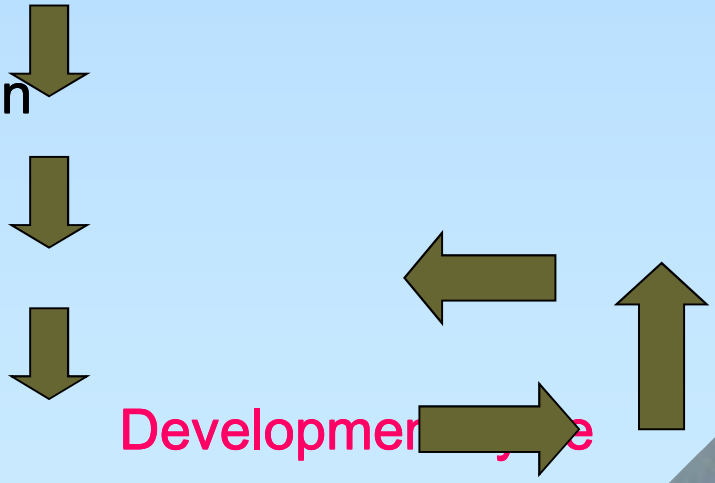
Product drawing

Empirical process design

Testing on the machine

Re-design

Developmen[illegible]e



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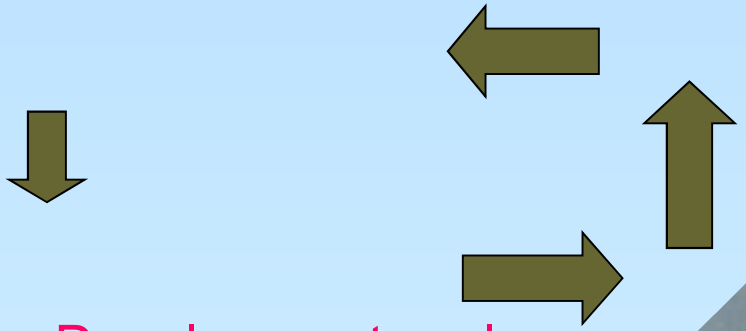
Principle of Process Design Work

This development cycle is very cost intensive and covers a lot of uncertainties

Testing on the machine

Re-design



Development cycle

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Besides reducing the costs of the product development Simulation can help

- To develop specific product properties
- To analyze the product application
- To train production and engineering personal
- To explain production tasks to a customer during common development
- To build up technological „know why“
- …….

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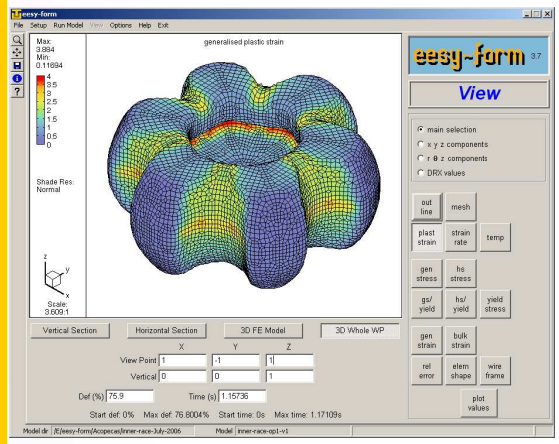
Examples of application



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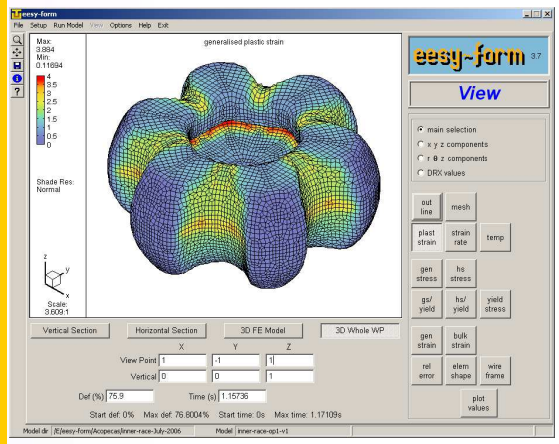
Examples of application

Tool failure in production of a valve spring retainer
Folding of material
Failure of punch because of contact problems
Cracking of a screw head do to tangential stress
Die failure
Die design
Forming station with spring loaded die
Difficult tool design for a combined forward and backward extrusion
Microstructure prediction in forging



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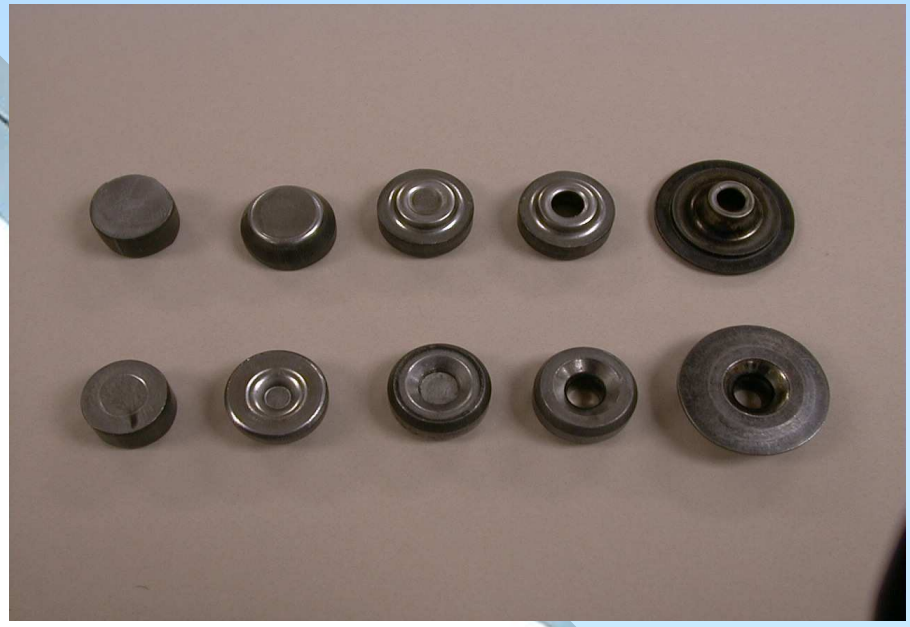
Tool failure in production of a valve spring retainer



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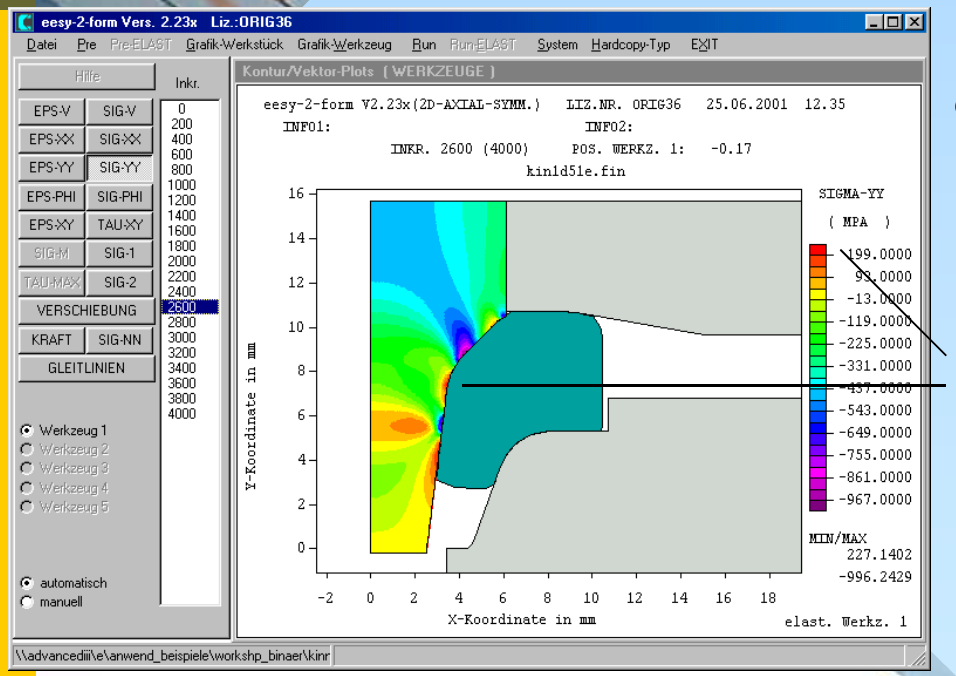
Tool failure in production of a valve spring retainer



- Searching for Failure of punch

High stresses!

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Tool failure in production of a valve spring retainer

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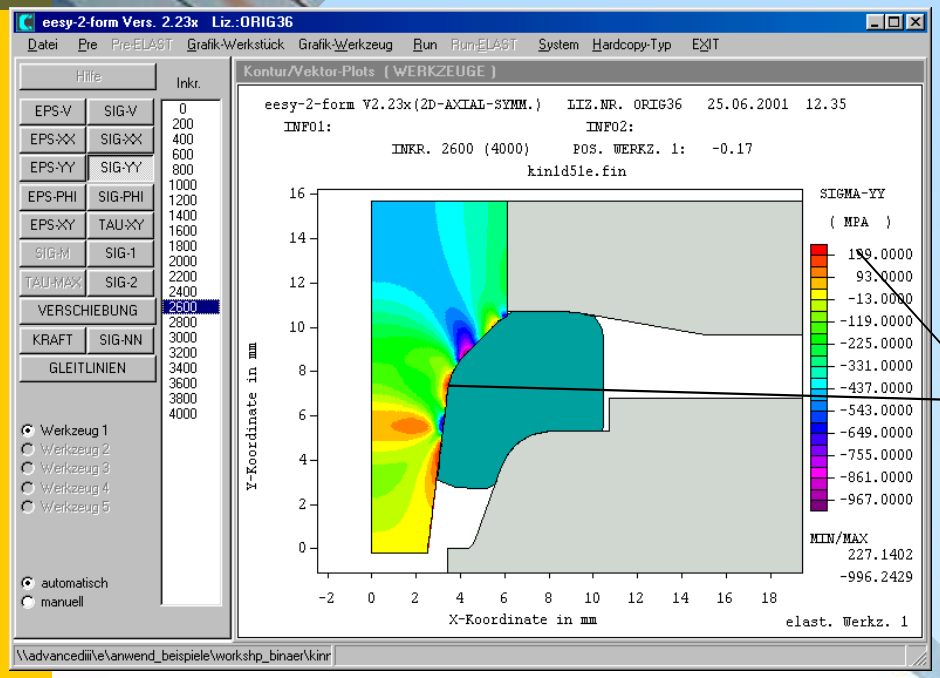
Tool failure in production of a valve spring retainer



- Avoiding of failures

Failure of a punch

wrong pre-form design!

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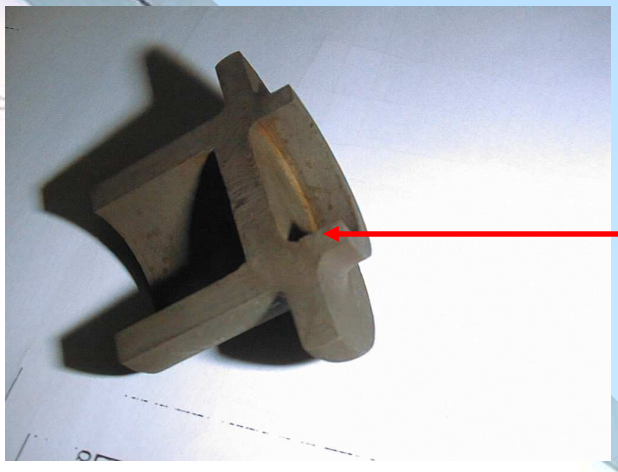
Folding of material



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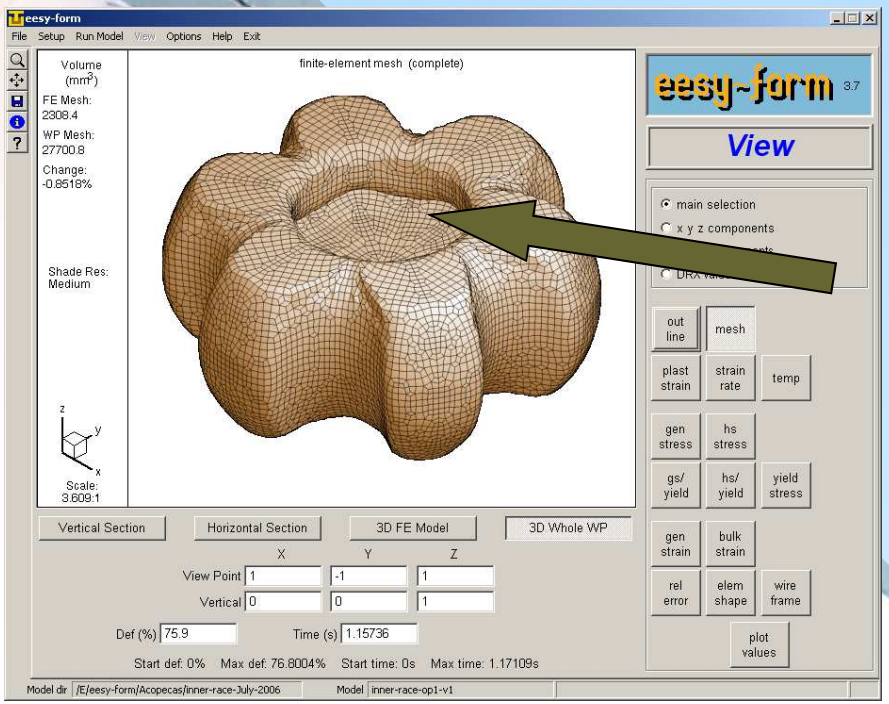

Folding / Underfilling

on an inner race

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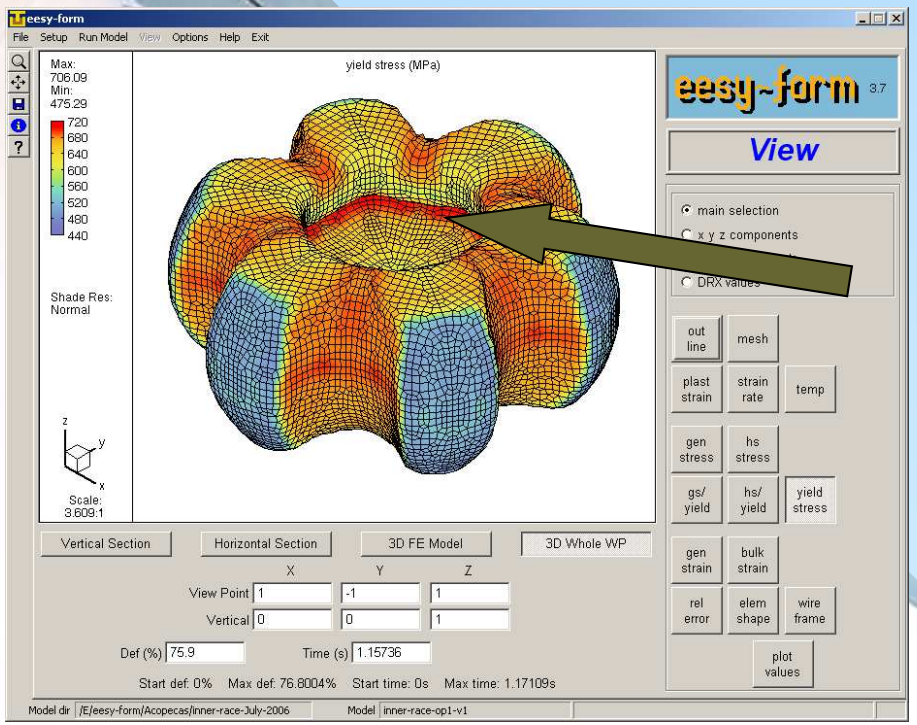
Folding of material



Folding / Underfilling

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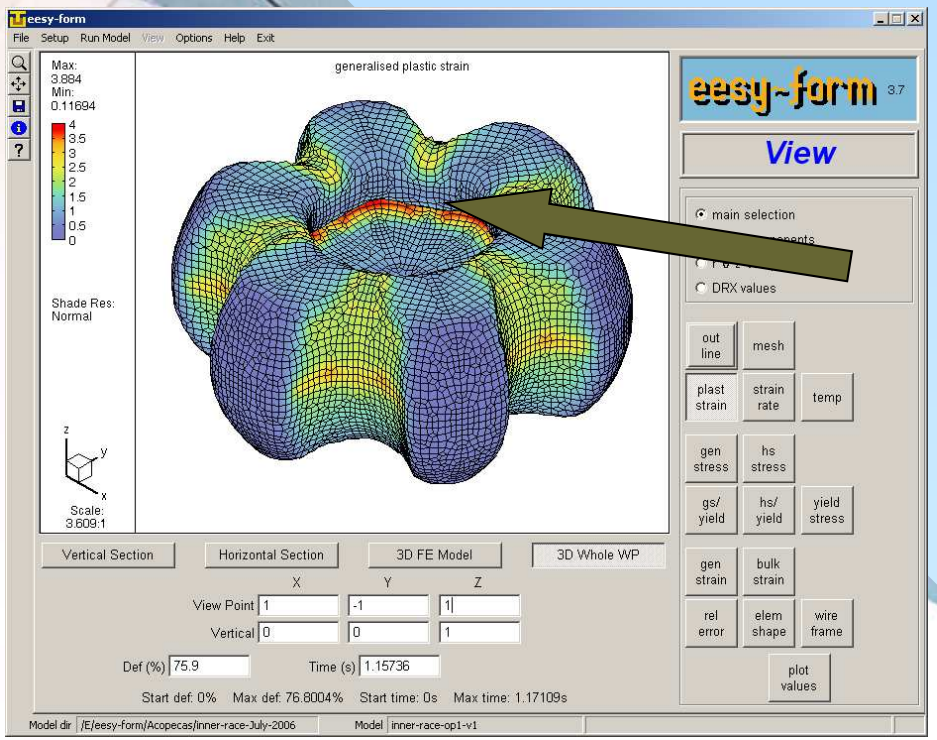

Folding / Underfilling

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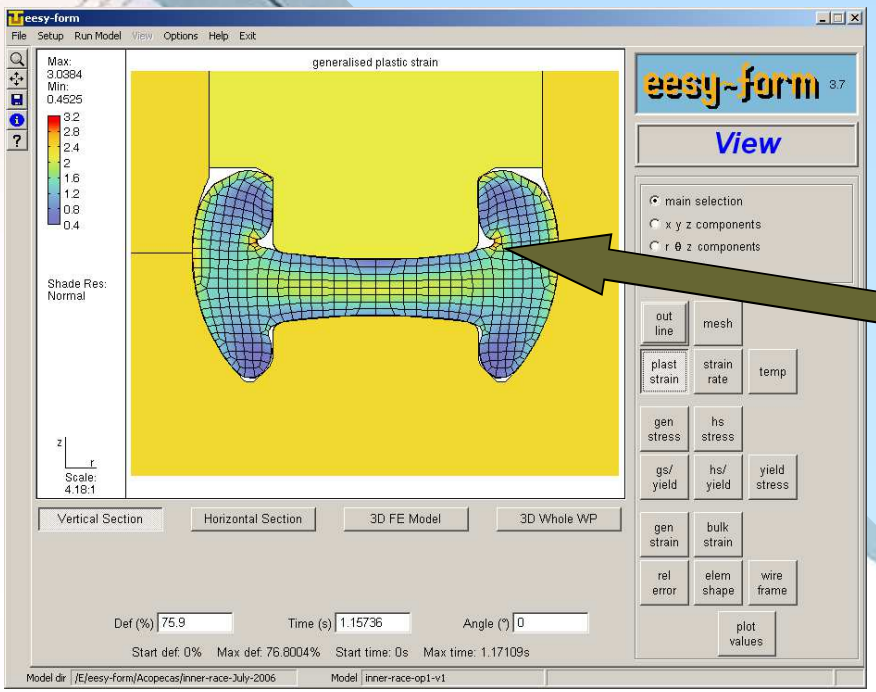

Folding / Underfilling

on an inner race

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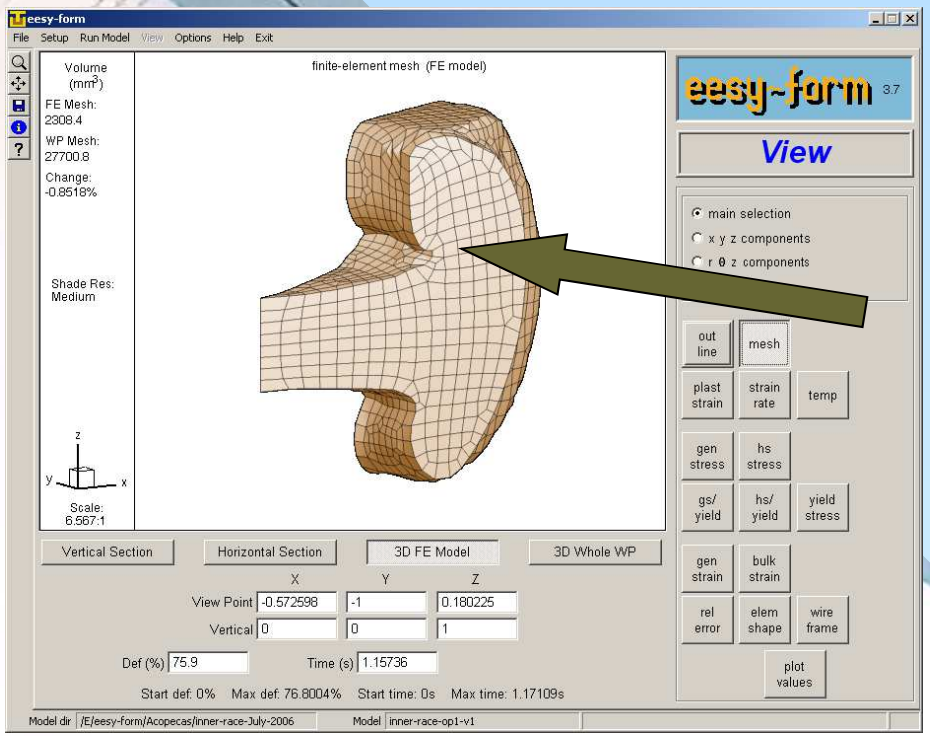

Folding / Underfilling

on an inner race

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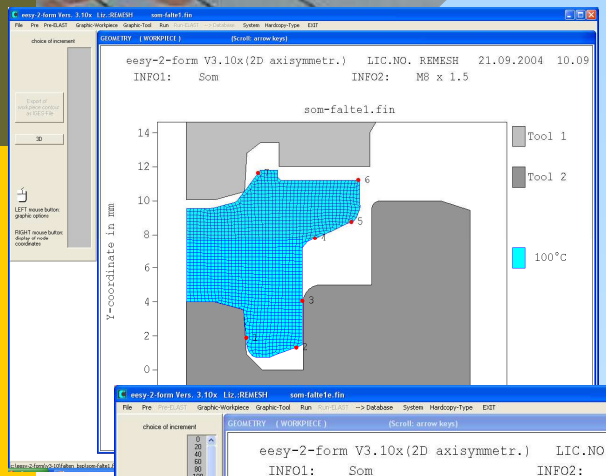

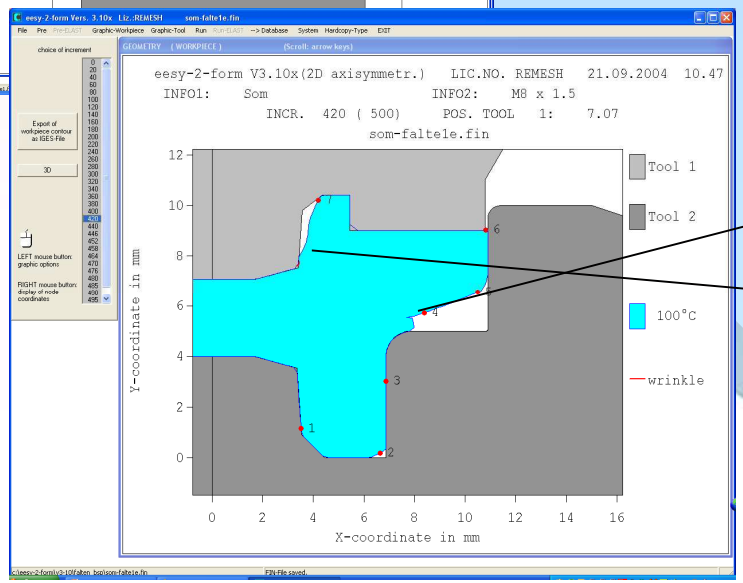

Folding of material

Folding at nut in

- Surface and
- Thread area

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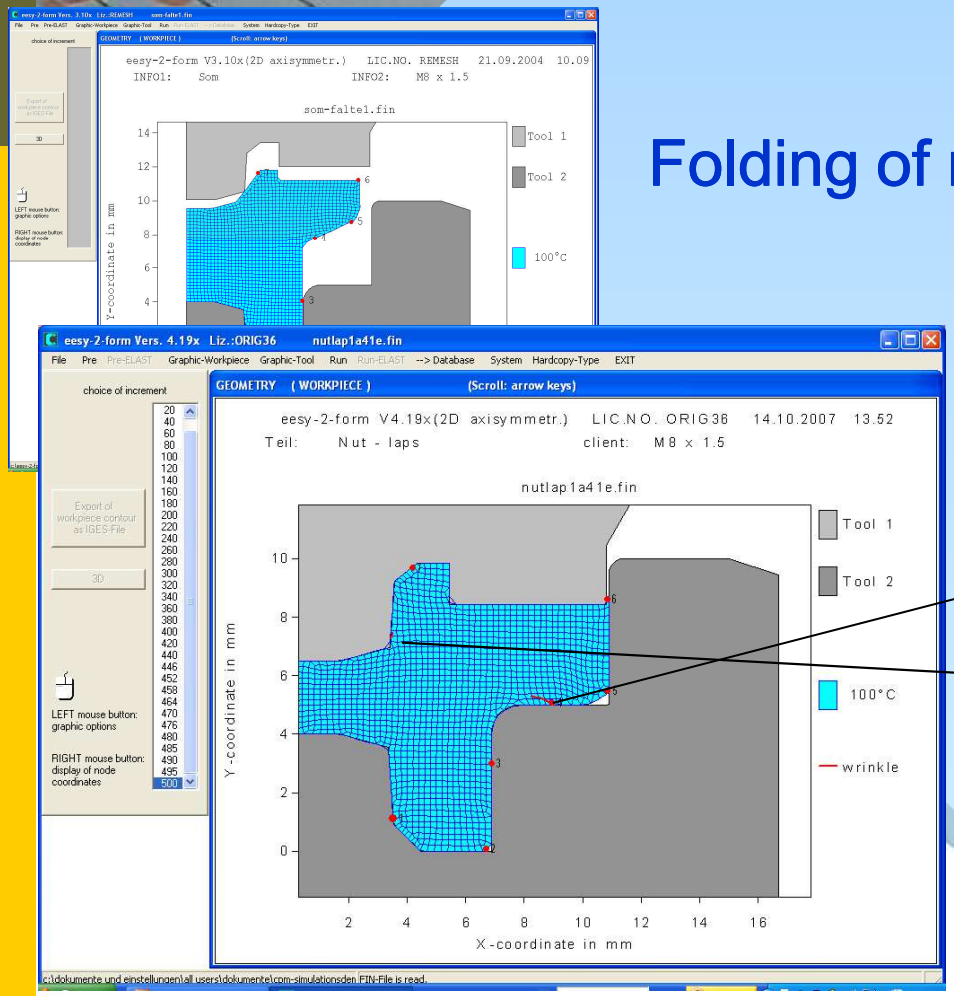

Folding of material

Folding at nut in

- Surface and
- Thread area

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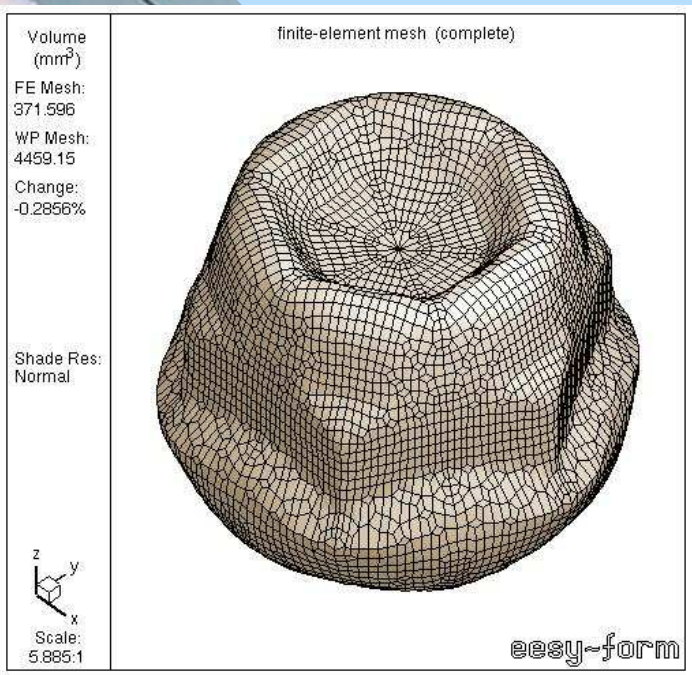
Failure of punch because of contact problems



Flansh nut 2nd. Station

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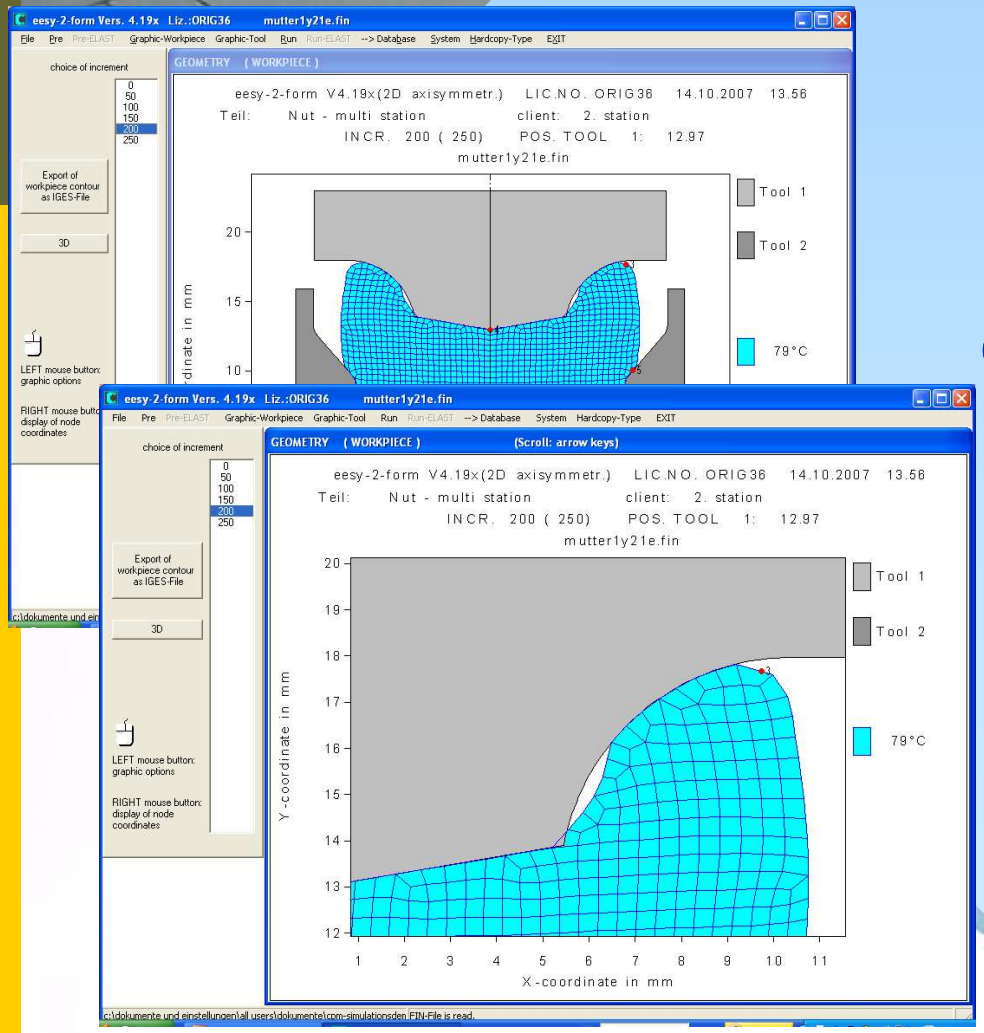

Failure of punch because of contact problems

Flansh nut 2nd. Station

Non sufficient contact between punch and material!

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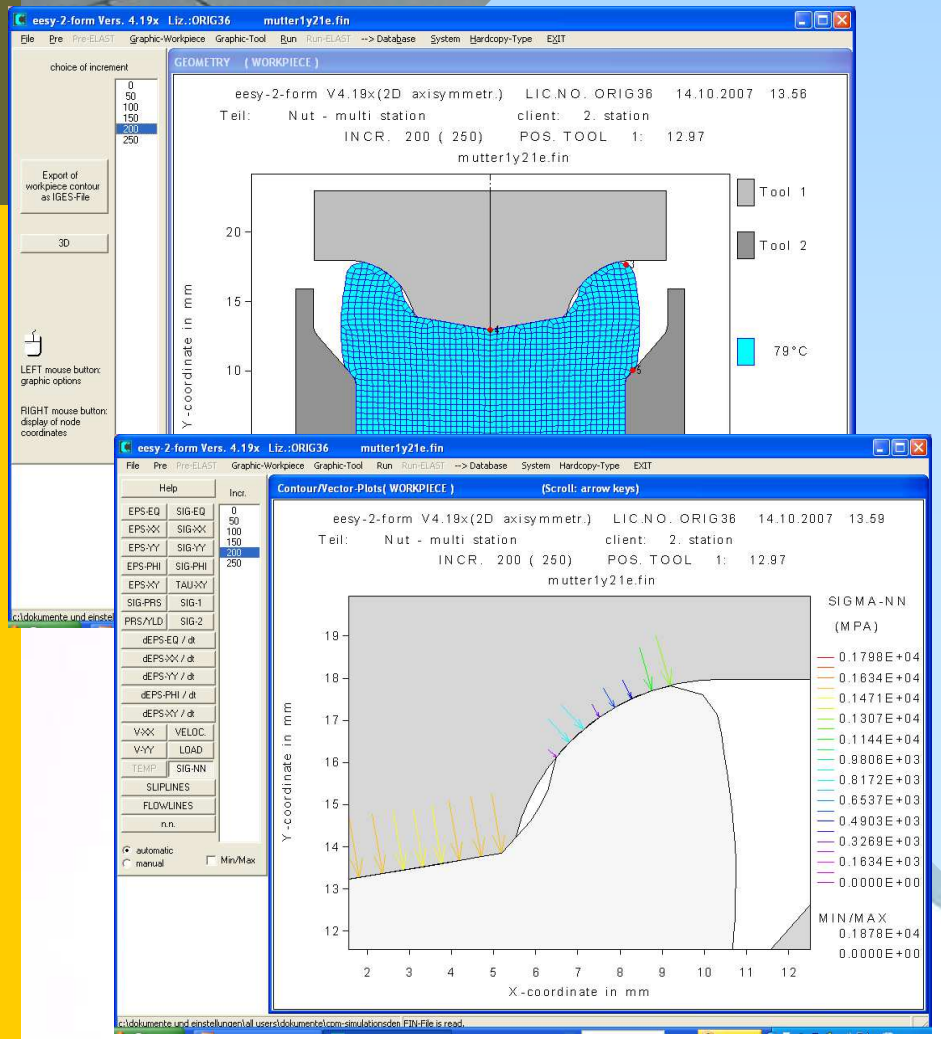

Failure of punch because of contact problems

Flansh nut 2nd. Station

inhomogeneous stress situation!

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Failure of punch because of contact problems

Failure of a punch in another nut making process due to the same reason

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Cracking of a screw head do to tangential stress

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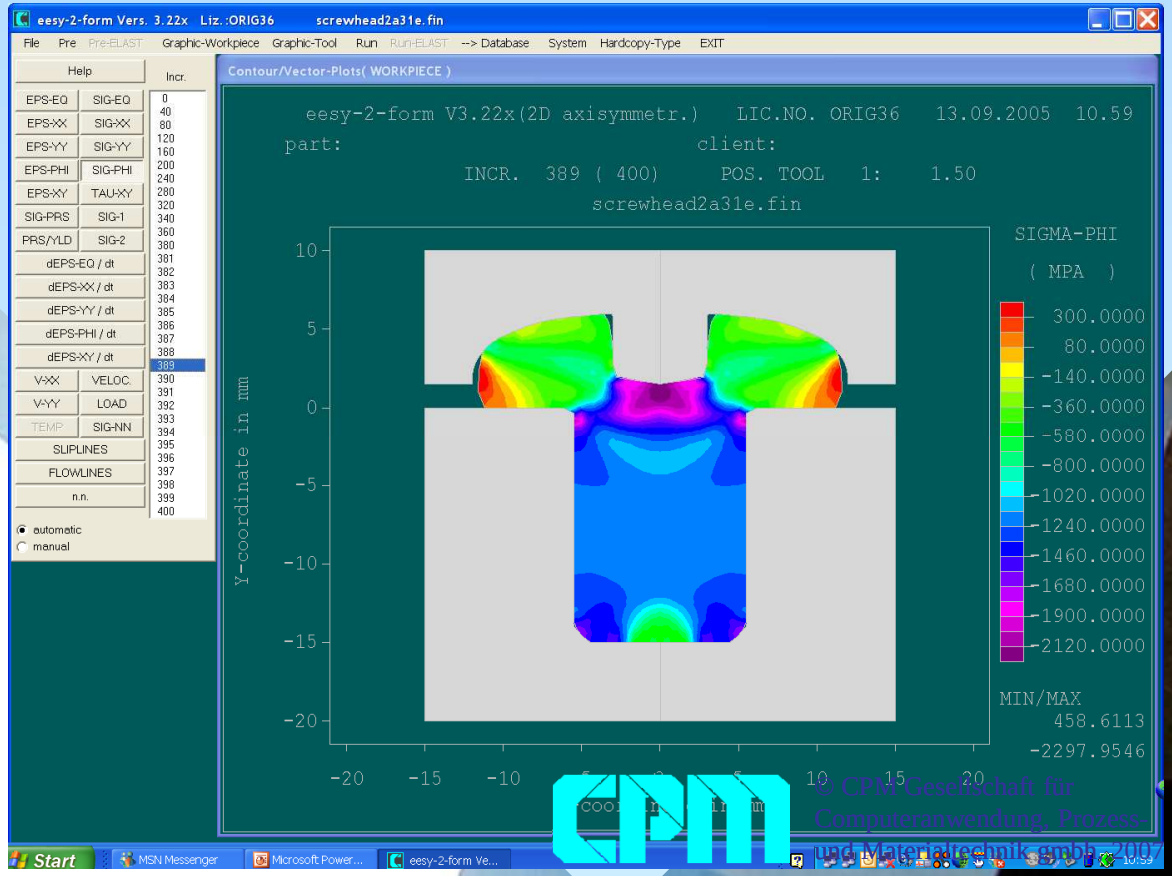
Cracking of a screw head do to tangential stress



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Die failure

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Die failure

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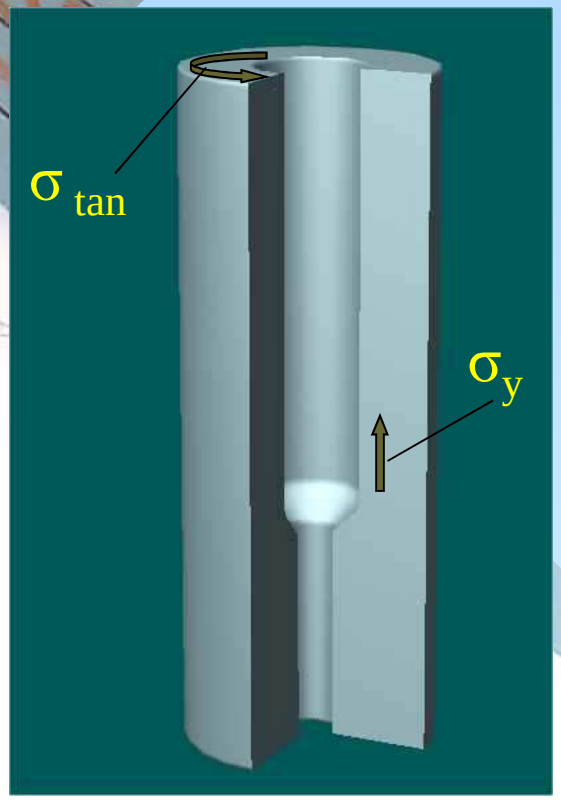

Die failure

Principle of Die Design

σ_{tan}: critical for axial crack

σ_y: critical for horizontal crack

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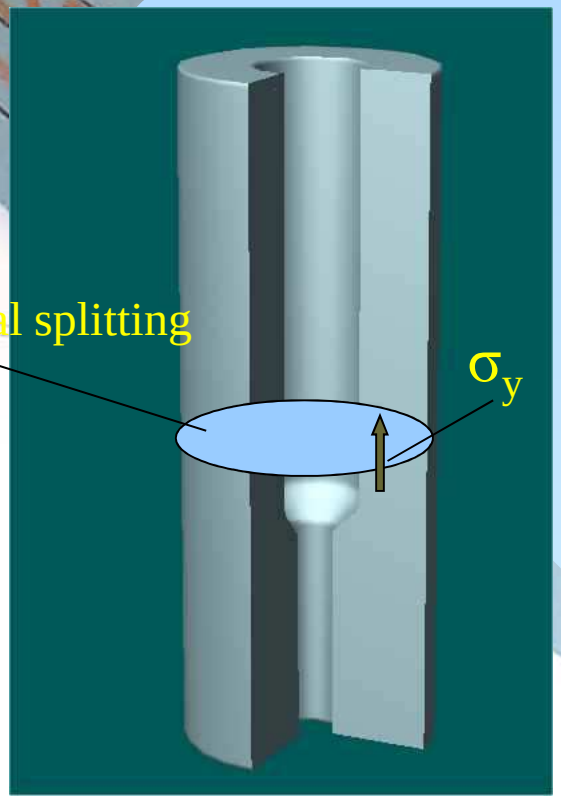

Die failure

Principle of Die Design

σ_y: critical for horizontal crack

➡ horizontal split of the insert

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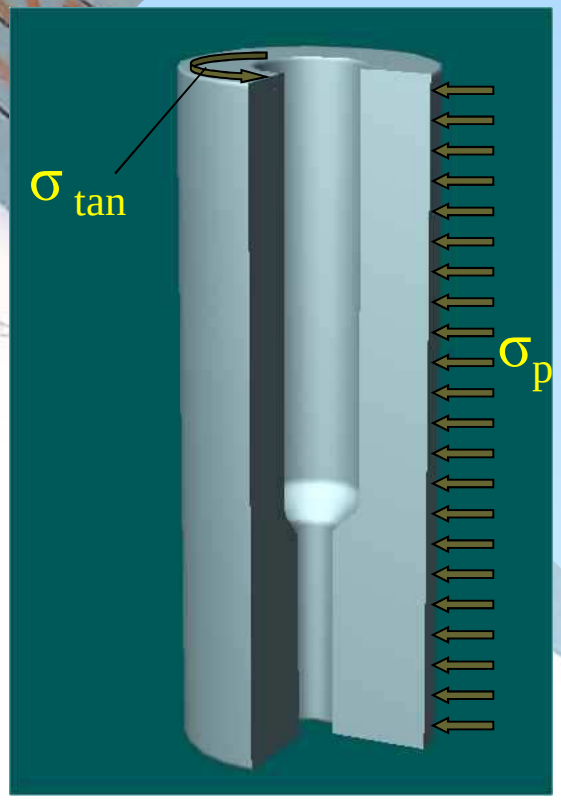

Die failure

Principle of Die Design

σ_{tan}: critical for axial crack

➡ Pre-stressing of the insert

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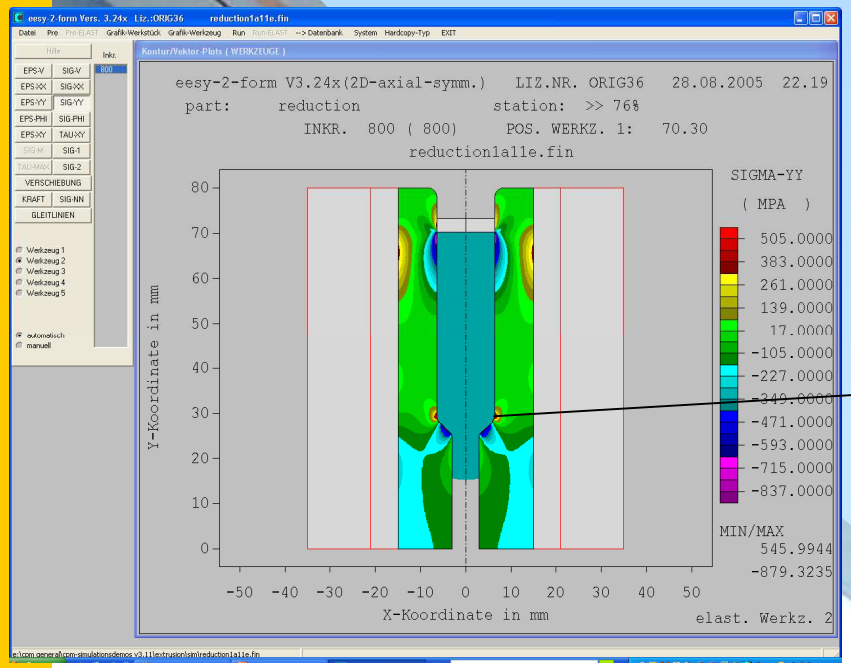
Die failure



- Avoiding of failures (elastic analysis of the insert with FEM) Splitting the die to avoid too high axial stresses

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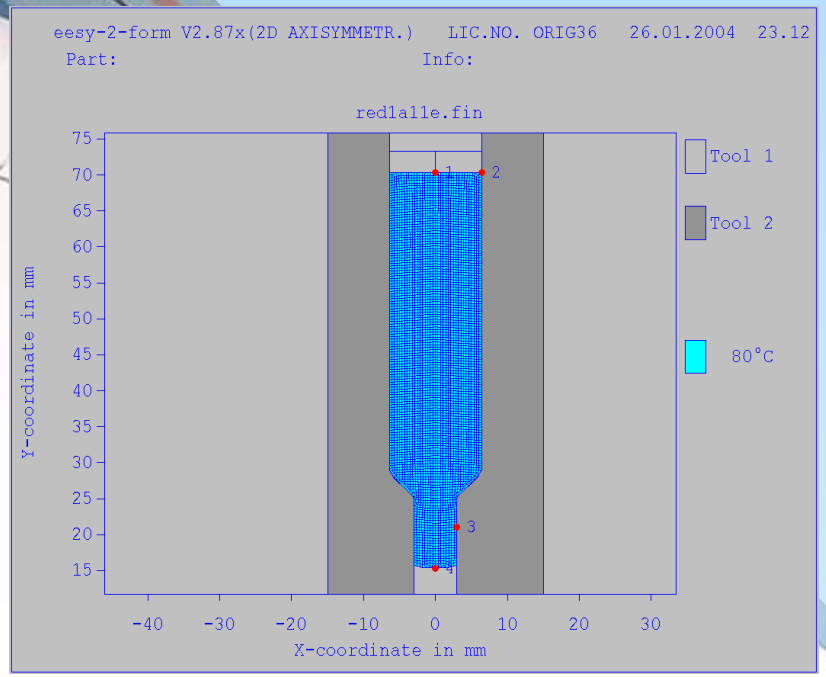

Die design

Pre-straining of dies

to avoid axial die breakage

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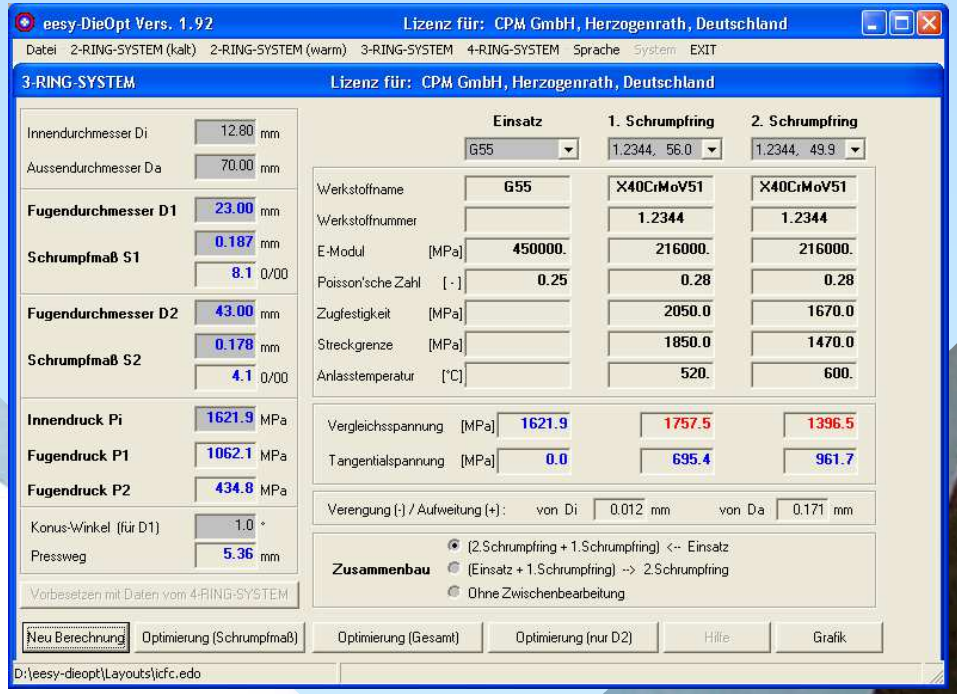
Die design

Calculation of Die Layout



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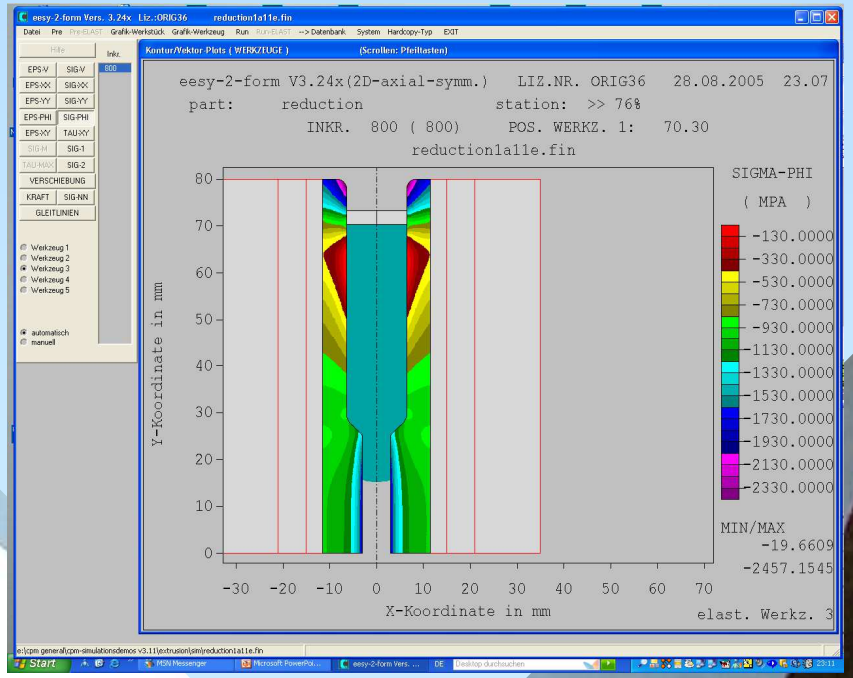
Die design

The stress distribution in an insert with pre straining optimisation



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Punch die to form torx recesses.

After systematic optimization such a punch produces more than 2.000.000 parts!

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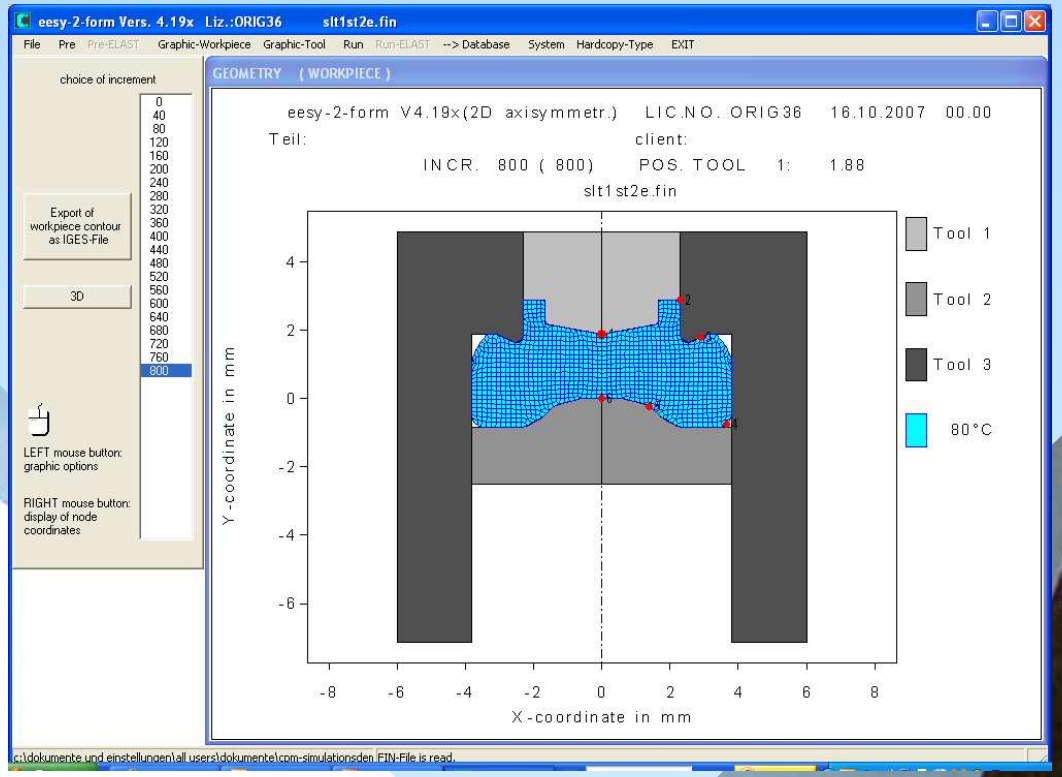
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

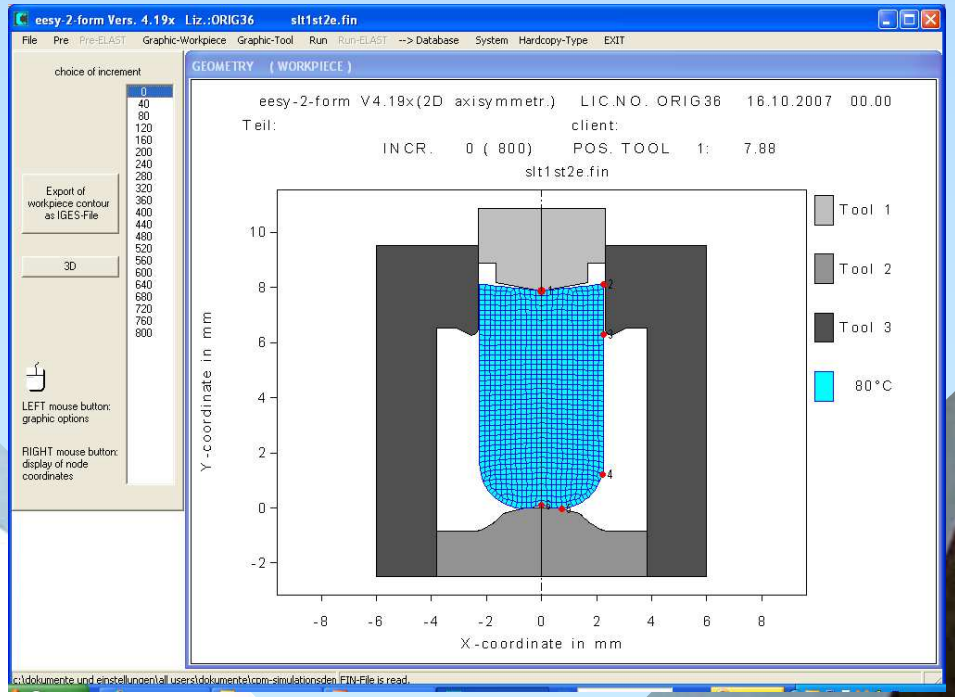


Korea Metal Week 2007

Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Initial position



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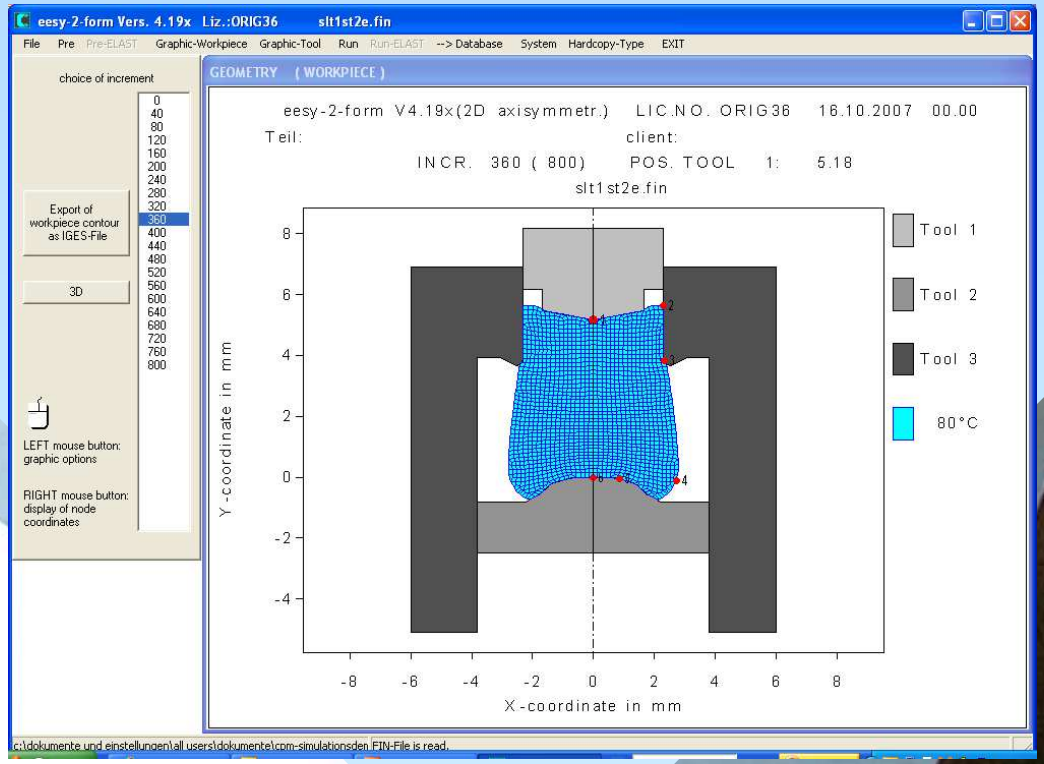
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Die starting to slide



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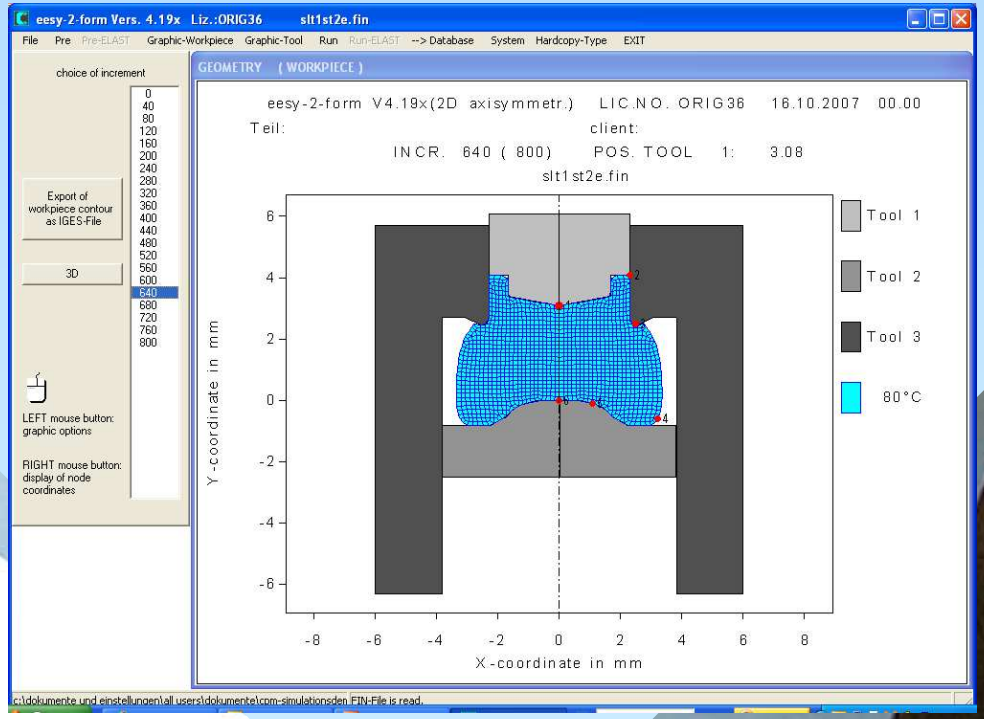
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Die sliding



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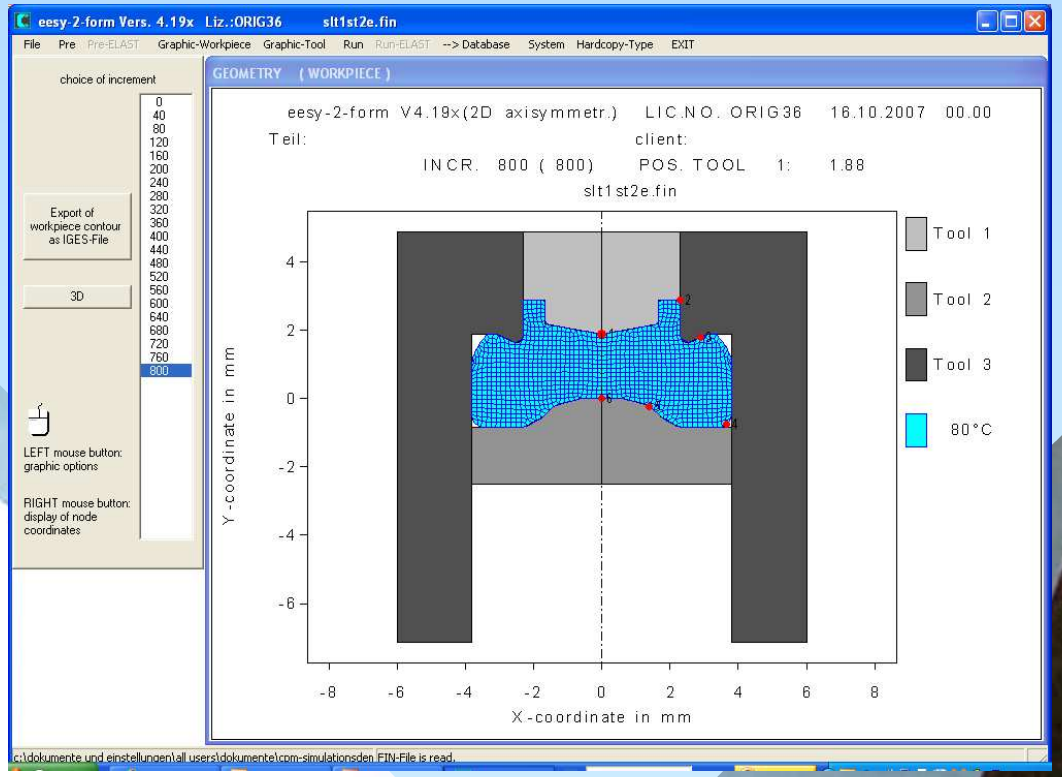
Forming station with spring loaded die

Layout of the spring loaded die system for a complex operation

Final position



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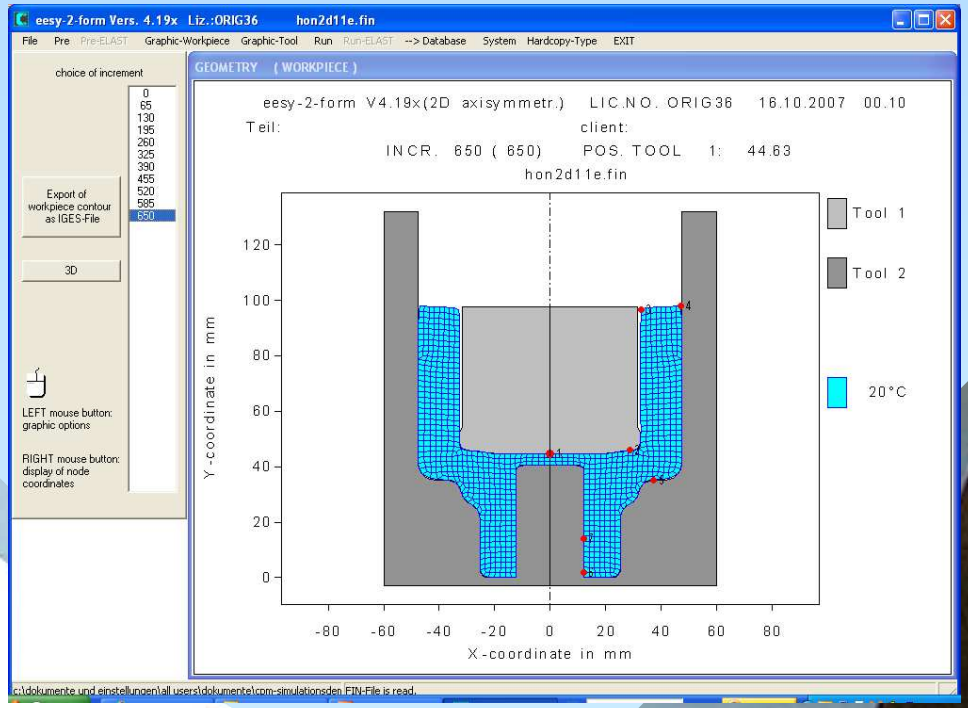
Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

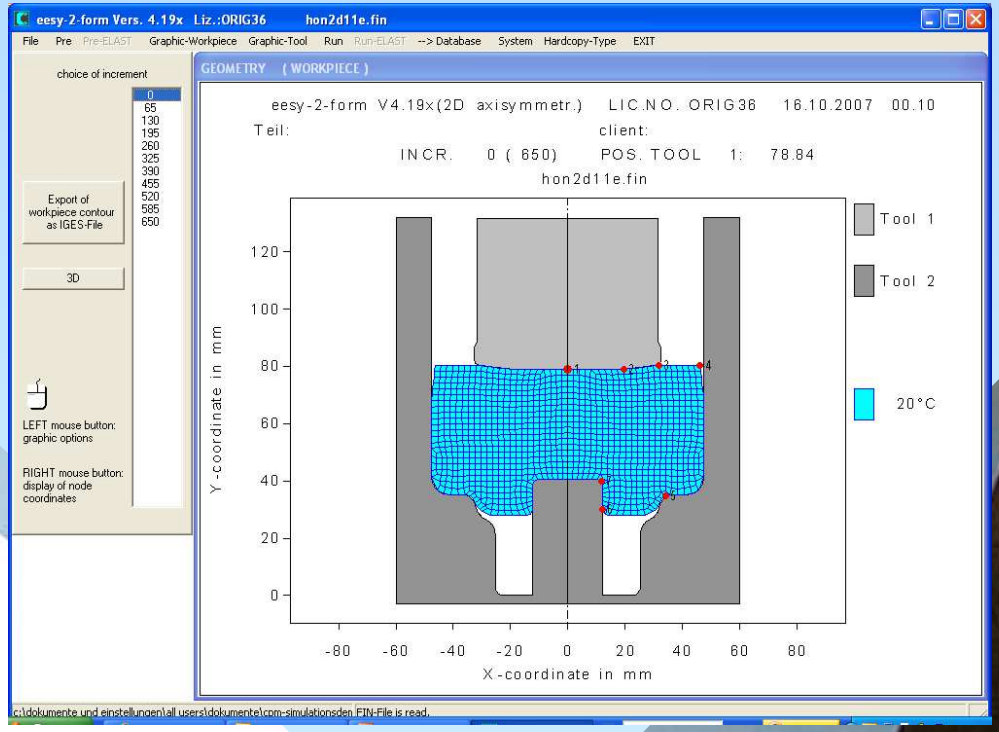


Korea Metal Week 2007

Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

Initial position

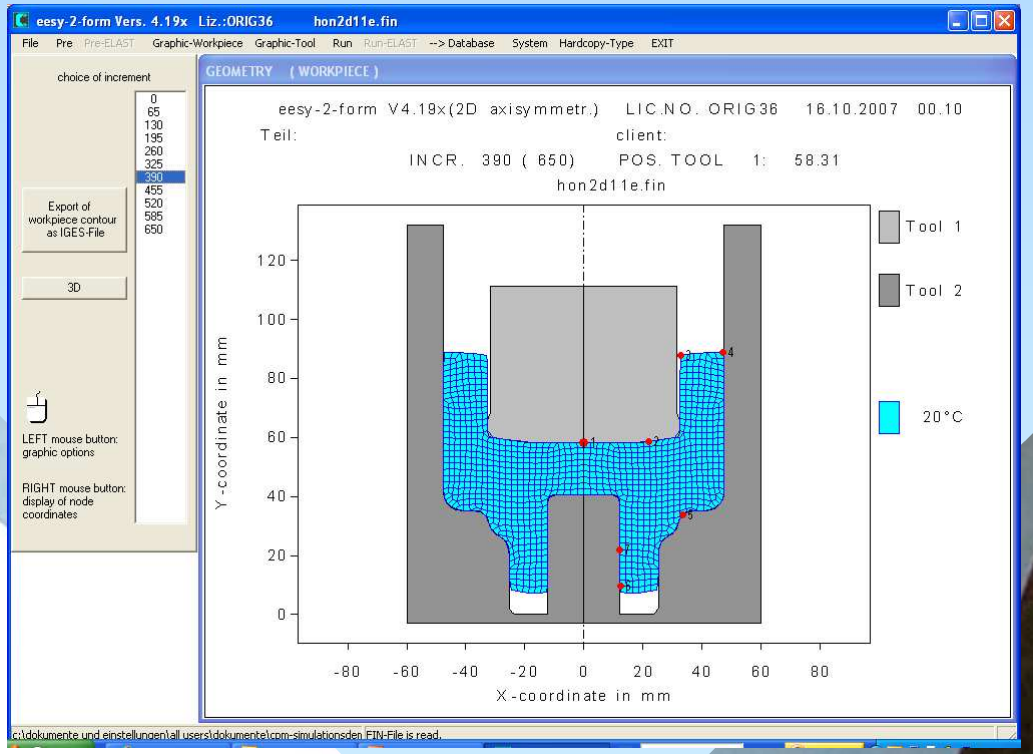


Korea Metal Week 2007

Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

intermediate position

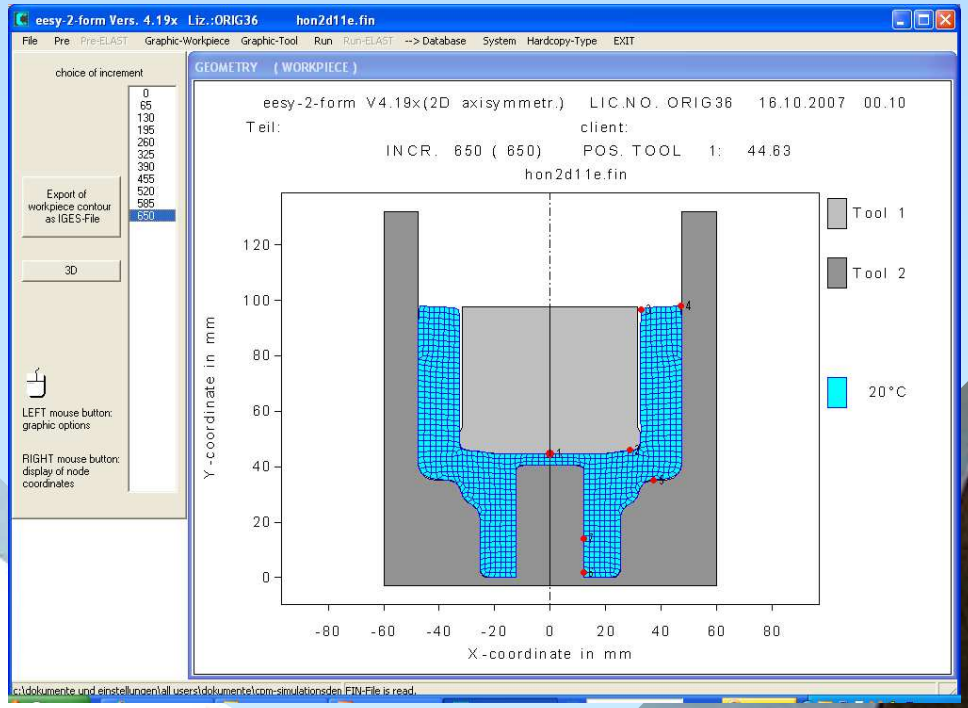


Korea Metal Week 2007

Difficult tool design for a combined forward and backward extrusion

Extreme deformations during extrusion with tight tolerances

Final position



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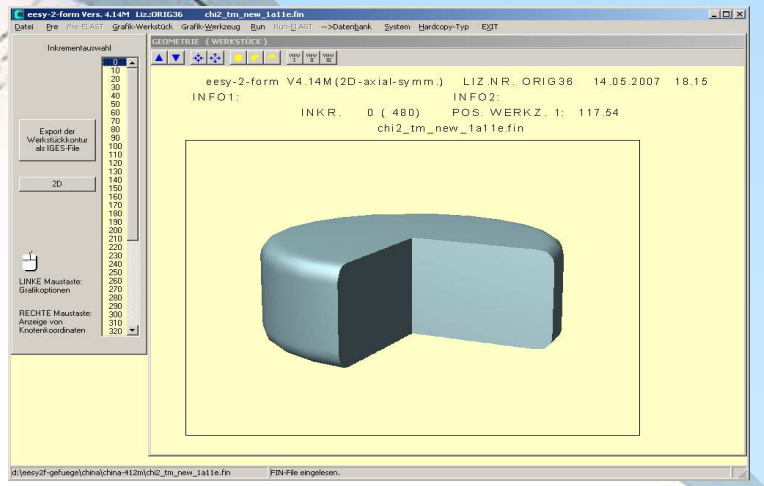
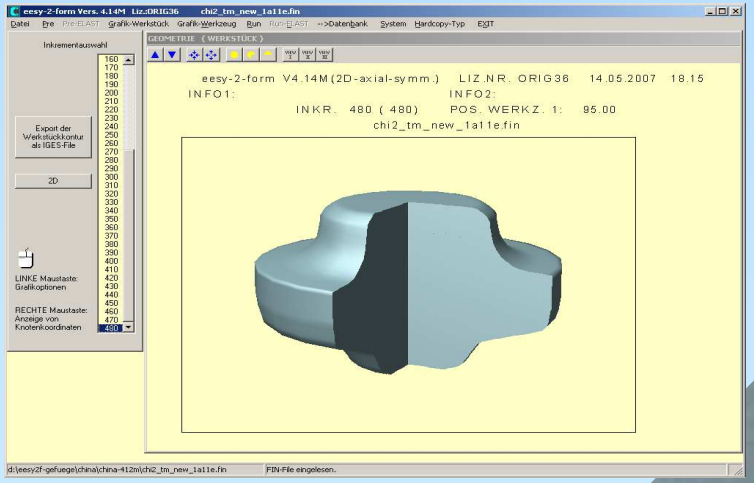
Microstructure prediction in forging



Initial blank



Final shape

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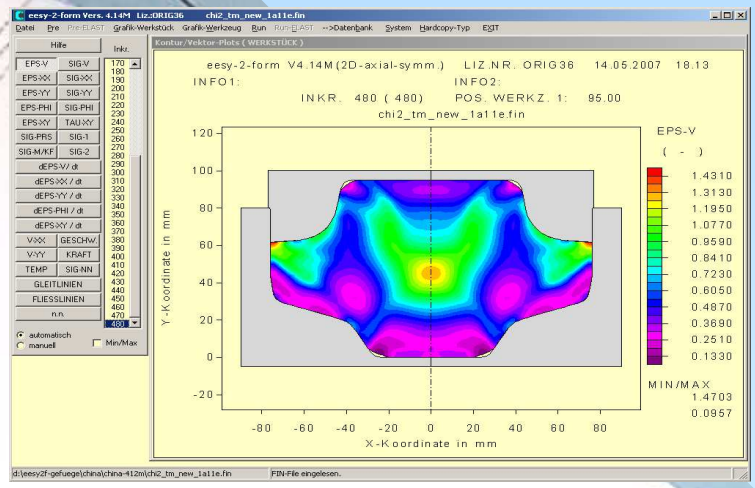
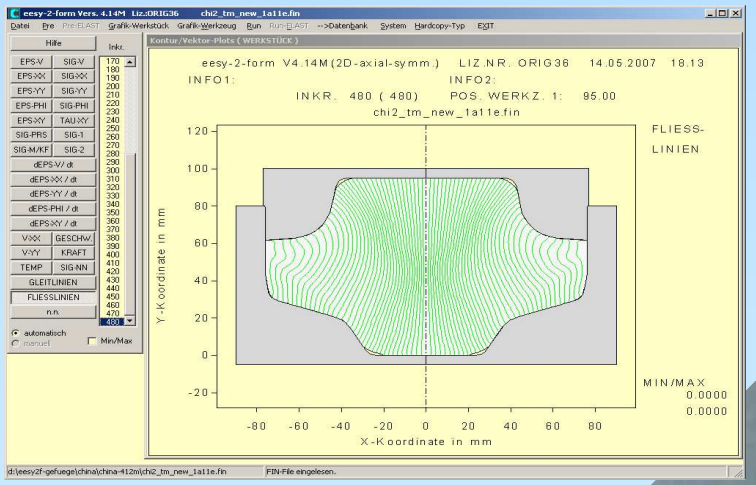
Microstructure prediction in forging



Distribution of strain



Fibre distribution

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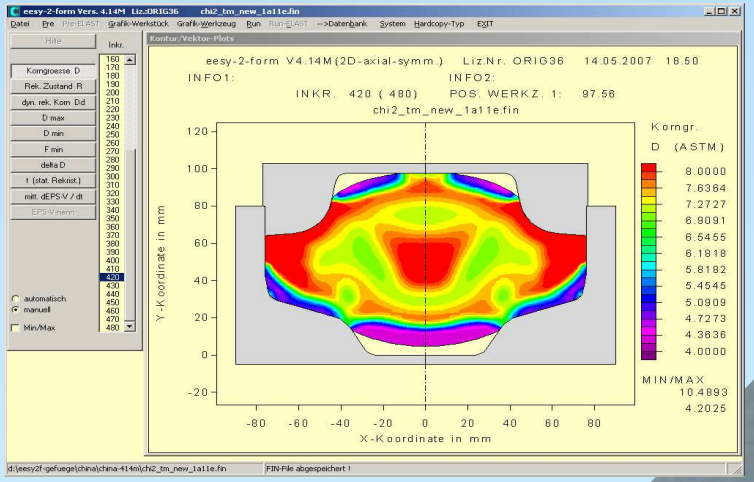
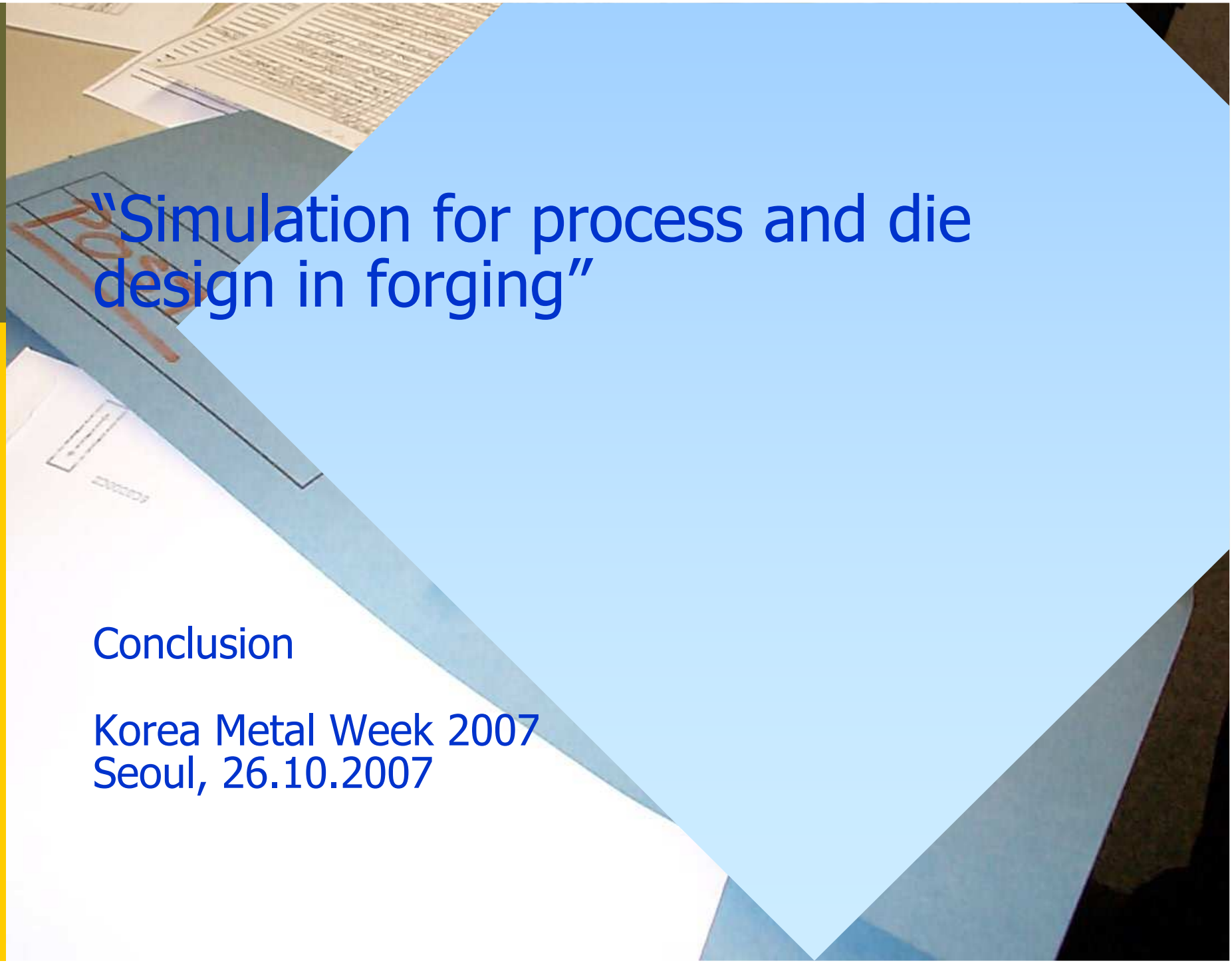
Microstructure prediction in forging

- **Grain size**
  - **degree of re-cristallisation**
    - **dynamic re-crist. fraction**
      - **static re-crist. fraction**
        - **grain-groth**
          - **timing and recovering**

Aims of simulation



Gain size distribution



“Simulation for process and die design in forging”

Conclusion

Korea Metal Week 2007
Seoul, 26.10.2007

Korea Metal Week 2007

Conclusion

Most of the daily problems in design of a metal forming proce
can be supported by today simulation technology.

Some special application need further development still.

Simulation is generally established as a design tool.

Hurry up to not miss the train .. But choose your simulation partner carefully …… he has to be expert in forging as well!

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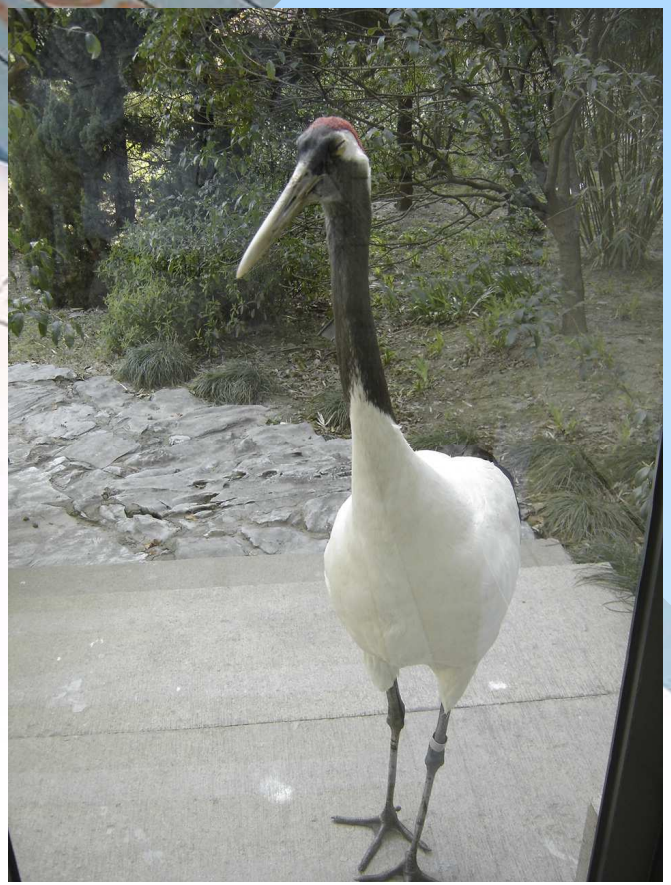

Thank you for your attention !

You are most welcome to contact CPM or Jin-A.

Like this bird knocking at my door at a Hotel in China in the early morning……

I do not know whether he wanted support or knowledge or simulation….