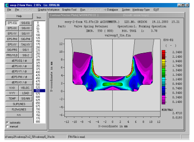
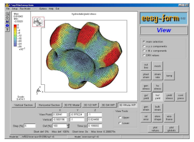
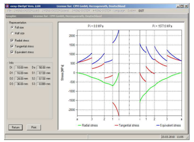
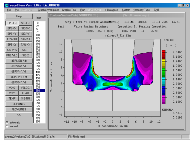
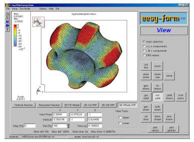
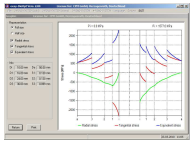




"The Use of Simulation to predict Tool Failure in Cold Forging Processes"

Dr. Gerhard H. Arfmann, Dr. Michael Twickler
CPM GmbH, Herzogenrath, Germany

Why to study FEA applications in metal forming processes under the aspect of tool failure?

Motivation:

The prediction of tooling failure is not a standardized application of simulation in industry.

Successful applications had to be studied to find out guidelines to support the design engineer.

By getting experience from these studies rules should be given to enable the design engineer to foresee problems in future and therefore avoid costs and development time.

The design engineer shall be enabled to develop long lasting tooling by using simulation instead of costly trial and error procedures.

The study focused on real applications in industry to give most practical guidelines.

The presentation shows such successful industrial applications.

Die failure in a multi station cold forming process

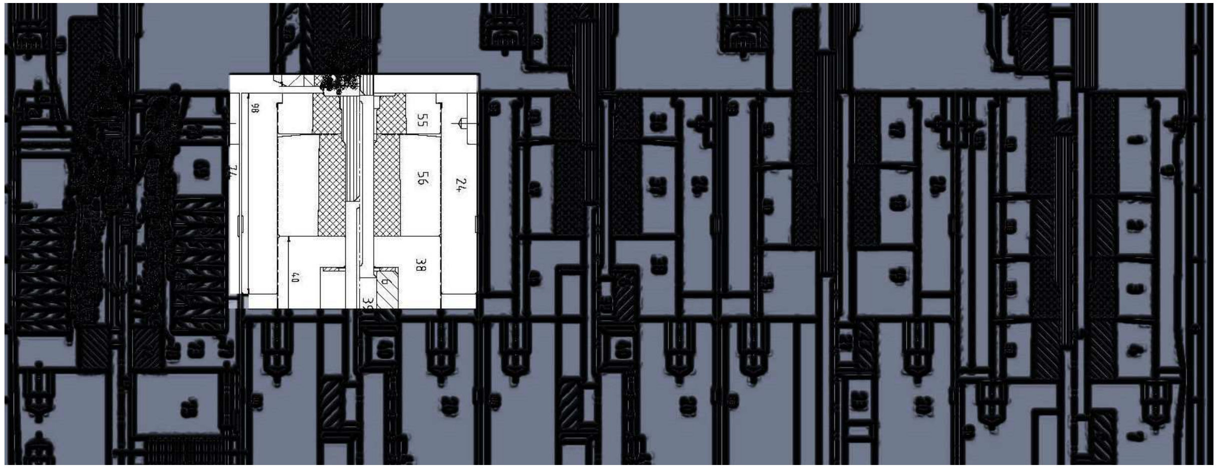
The customer faced severe tool failure in operation four of a five station process.

What can be optimized to get better tool life?

Die failure in a multi station cold forming process

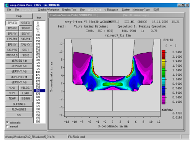
The five station cold forging process

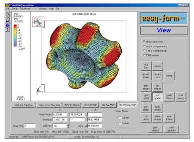
Die failure in a multi station cold forming process

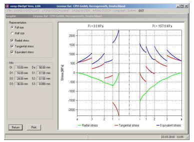


The five station cold forging process

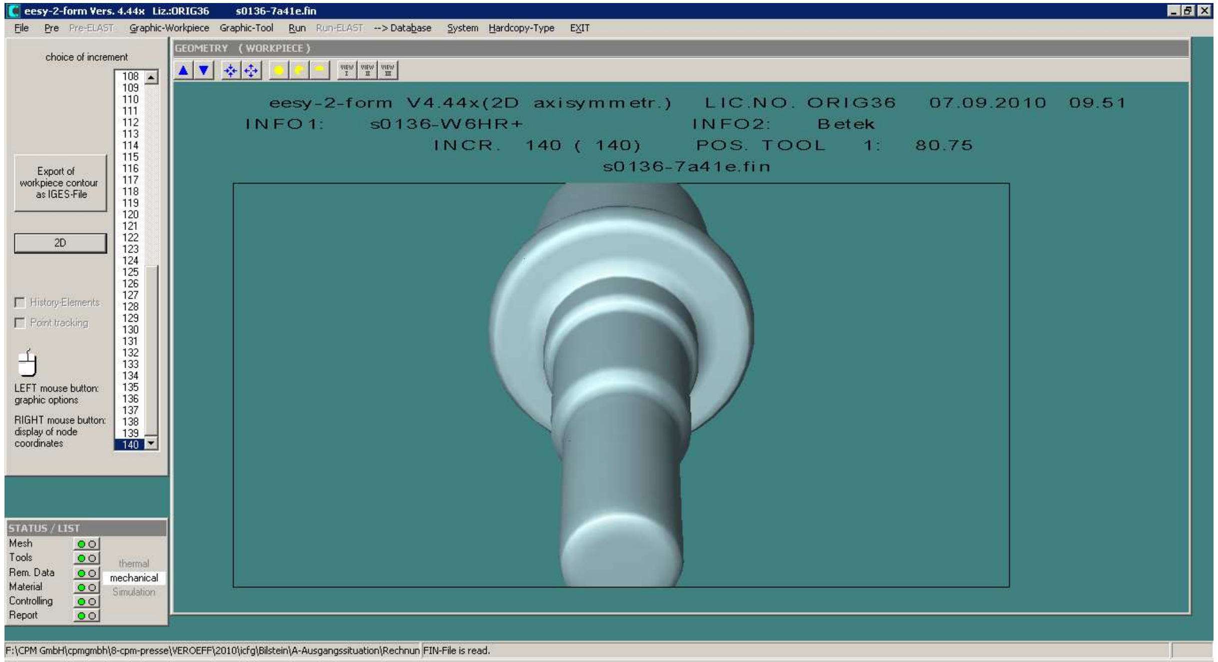
Initial tool design in operation 4







Die failure in a multi station cold forming process

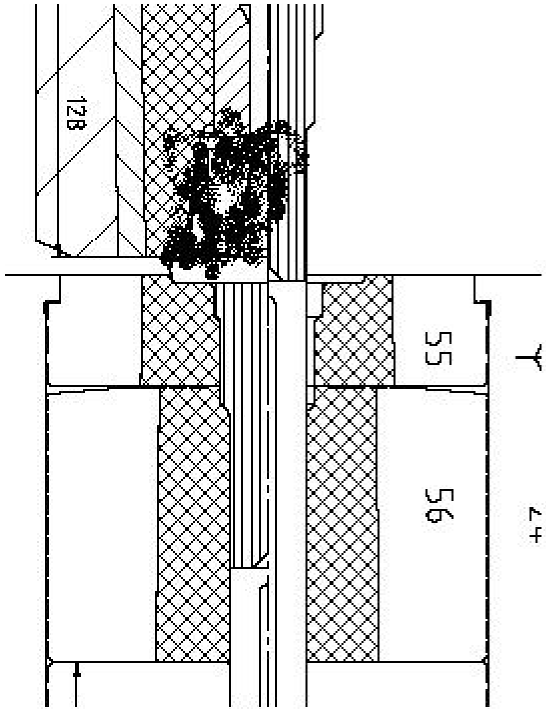


The five station cold forging process

Forming in operation 4

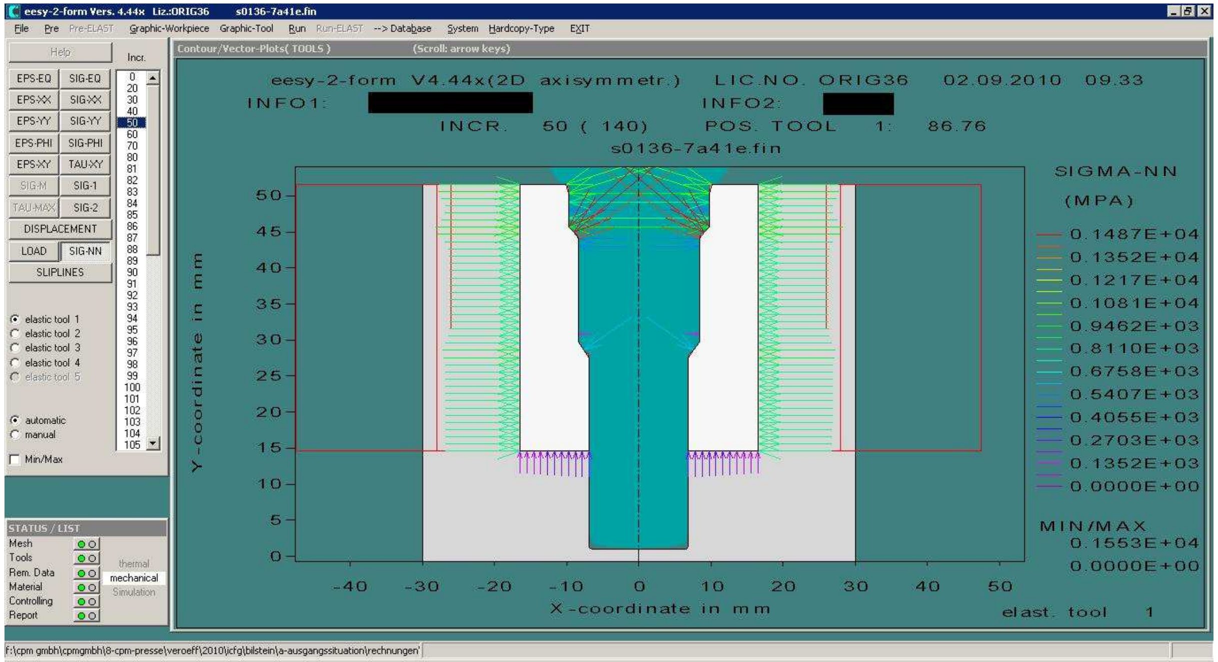
Die failure in a multi station cold forming process

Initial design of the die in operation 4 (carbide – pre stressed with a single ring)



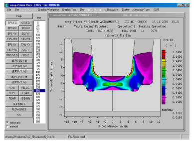
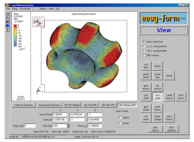
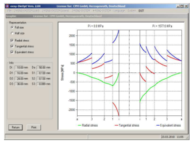
The five station cold forging process

Die failure in a multi station cold forming process

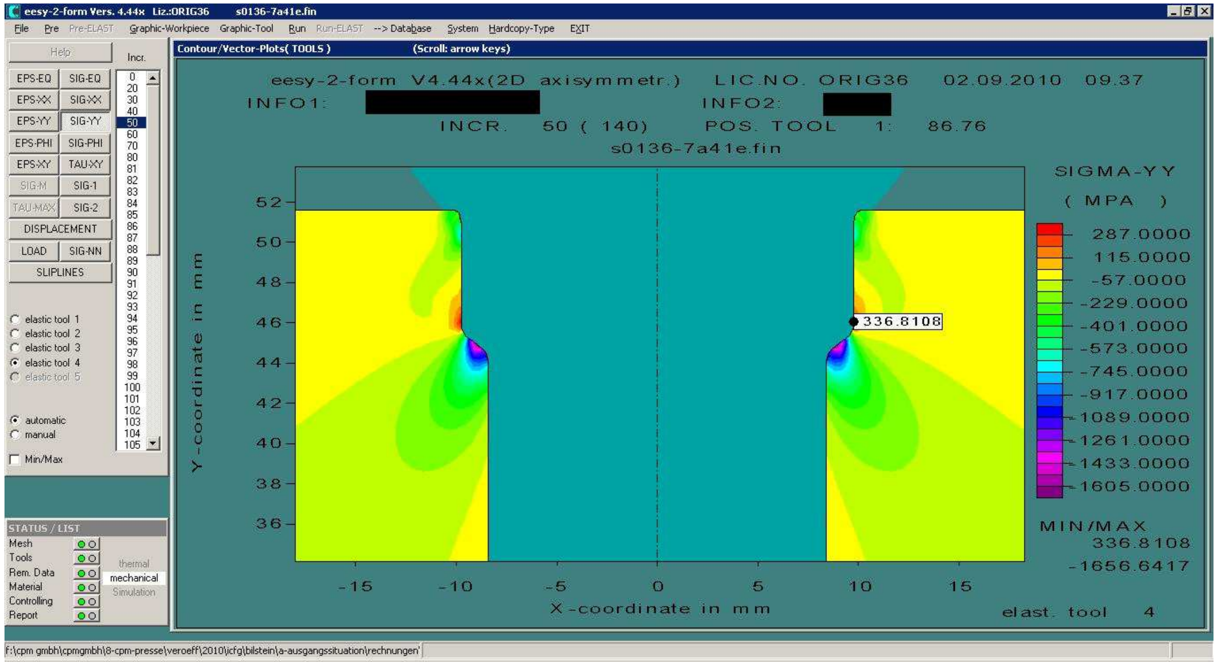


The five station cold forging process

Pressure on the carbide

Die failure in a multi station cold forming process

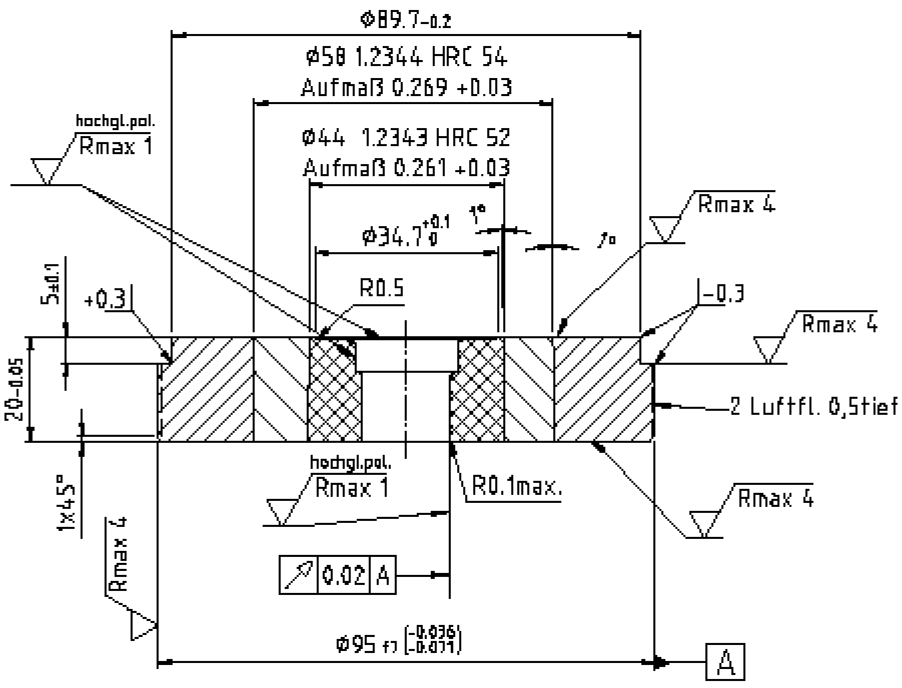


The five station cold forging process

Positive axial stress in the carbide => tool failure

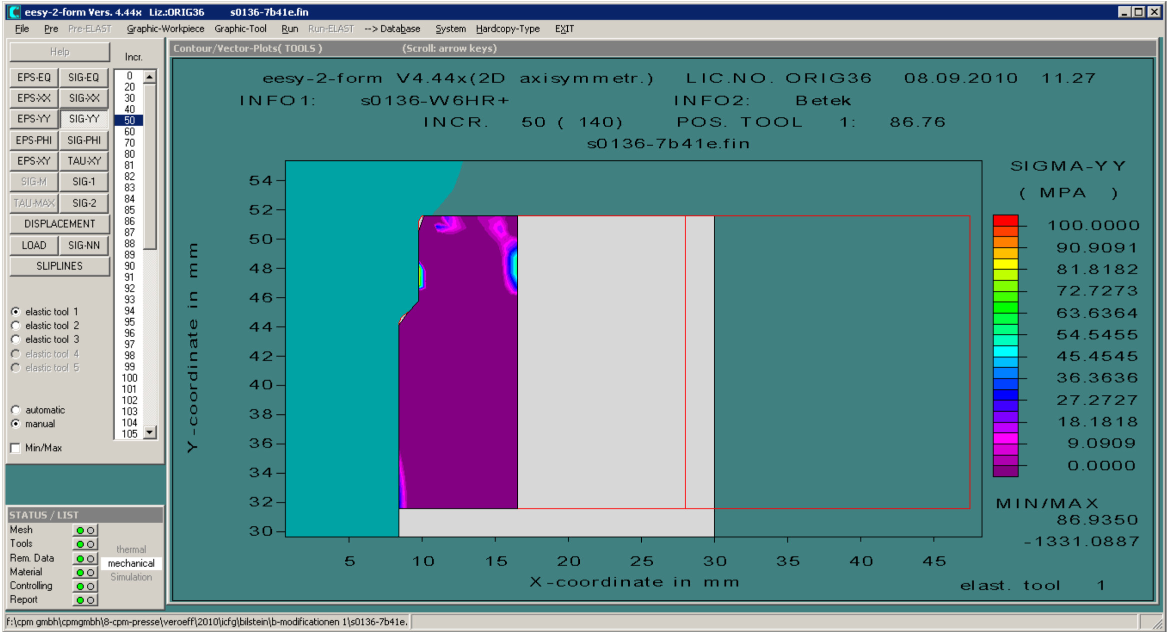
Die failure in a multi station cold forming process

new design of the die in operation 4 (carbide split – pre stressed with two rings)



The five station cold forging process

Die failure in a multi station cold forming process



The five station cold forging process

Still positive axial stress in the carbide => tool failure

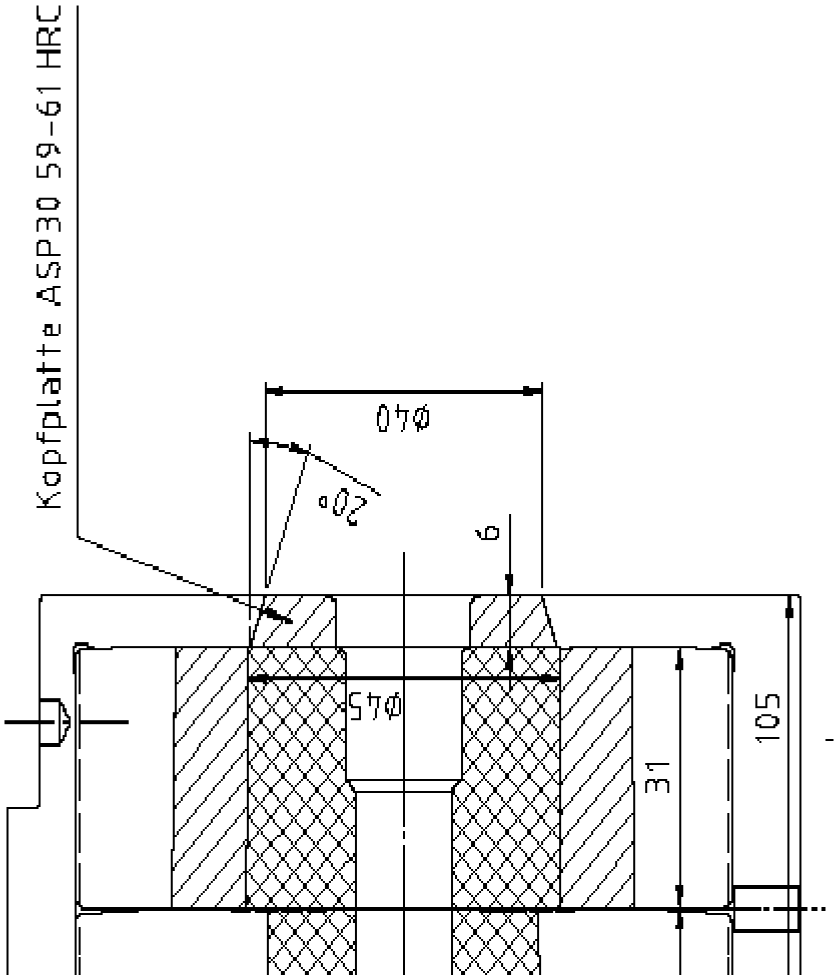
Die failure in a multi station cold forming process

The five station cold forging process

Tool breakage persists

Die failure in a multi station cold forming process

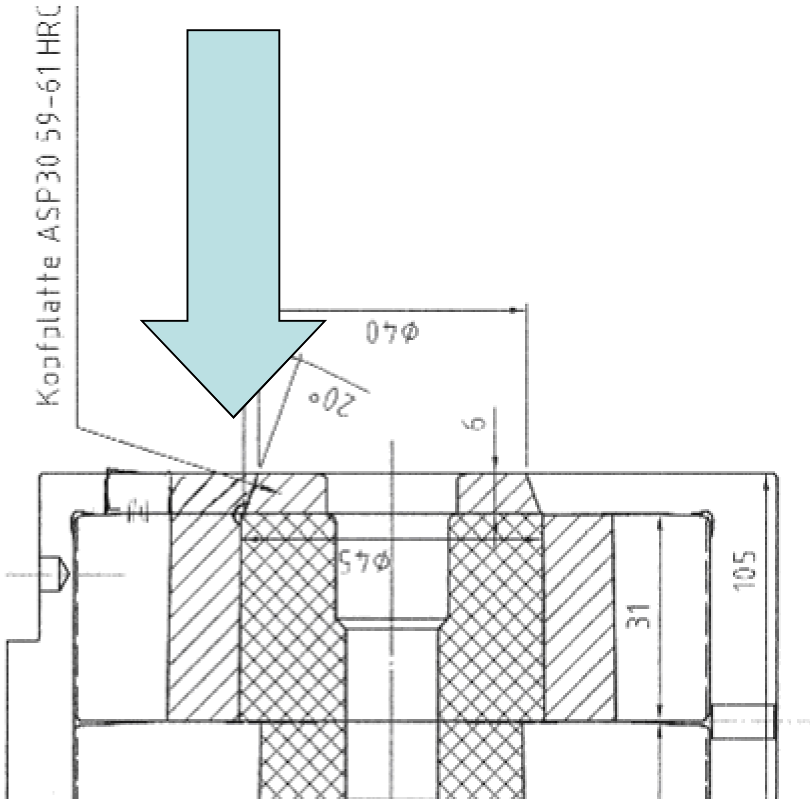
new design idea of the die in operation 4 (Disc made of ASP 30 – carbide pre stressed with two rings)



The five station cold forging process

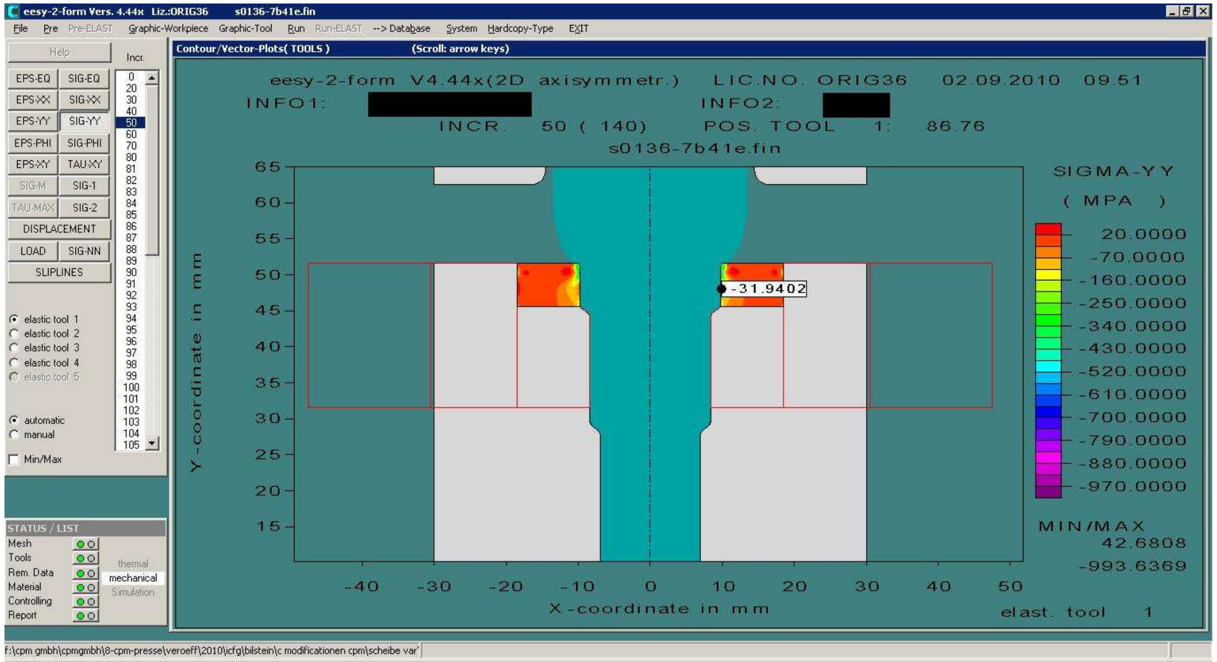
Die failure in a multi station cold forming process

corrected new design of the die in operation 4 (Disc made of ASP 30 – carbide and disk pre stressed with two rings)- corrected by toolmaker



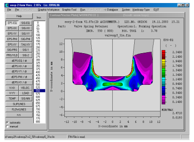
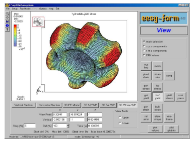
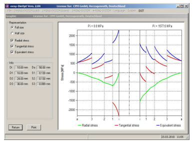
The five station cold forging process

Die failure in a multi station cold forming process



The five station cold forging process

Simulation shows compressive stress
- tool life increased from 1.000 to 25.000 pieces

Die failure in a multi station cold forming process

Result:

Systematic analysis of the various design ideas leads to better tool design and better understanding of the design.

Testing on the machine can be avoided.

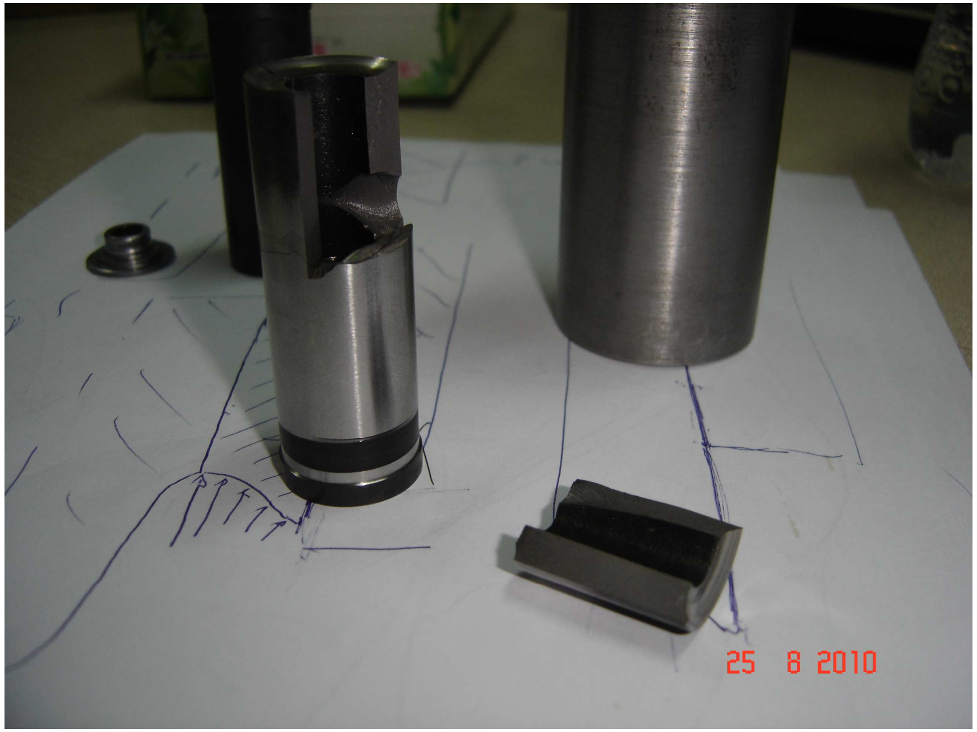
Design rules could be reviewed.

Future designs can be made better by using FEA from the beginning and considering the new design rules.

The five station cold forging process

Punch failure in a multi station process

Punches of operation 5 fail premature



Five station cold forging process to form a valve spring retainer

Punch failure in a multi station process

Punches of operation 5 fail premature

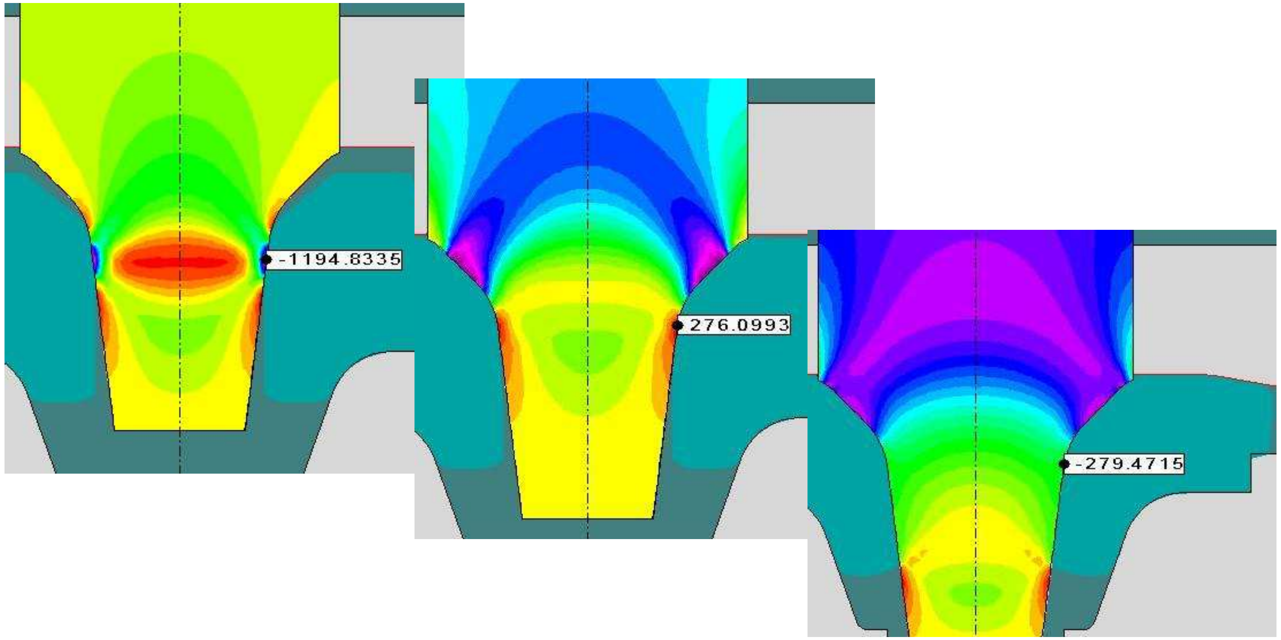
Five station cold forging process to form a valve spring retainer

Punch failure in a multi station process

Punches of operation 5 fail premature

Five station cold forging process to form a valve spring retainer

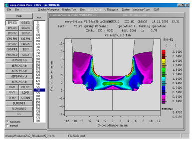
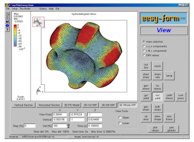
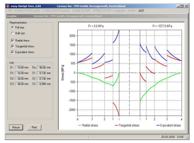
Punch failure in a multi station process



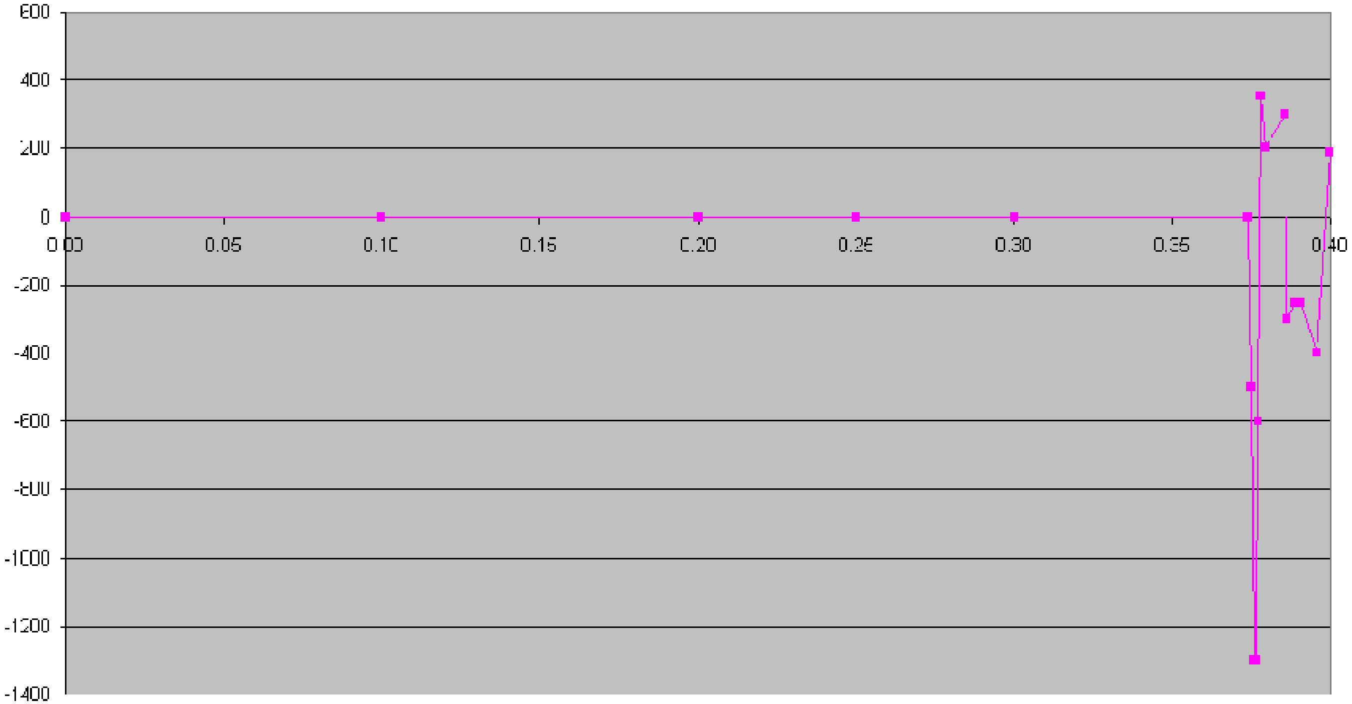
Five station cold forging process to form a valve spring retainer

Alternating Stress

Failure due to fatigue

Punch failure in a multi station process

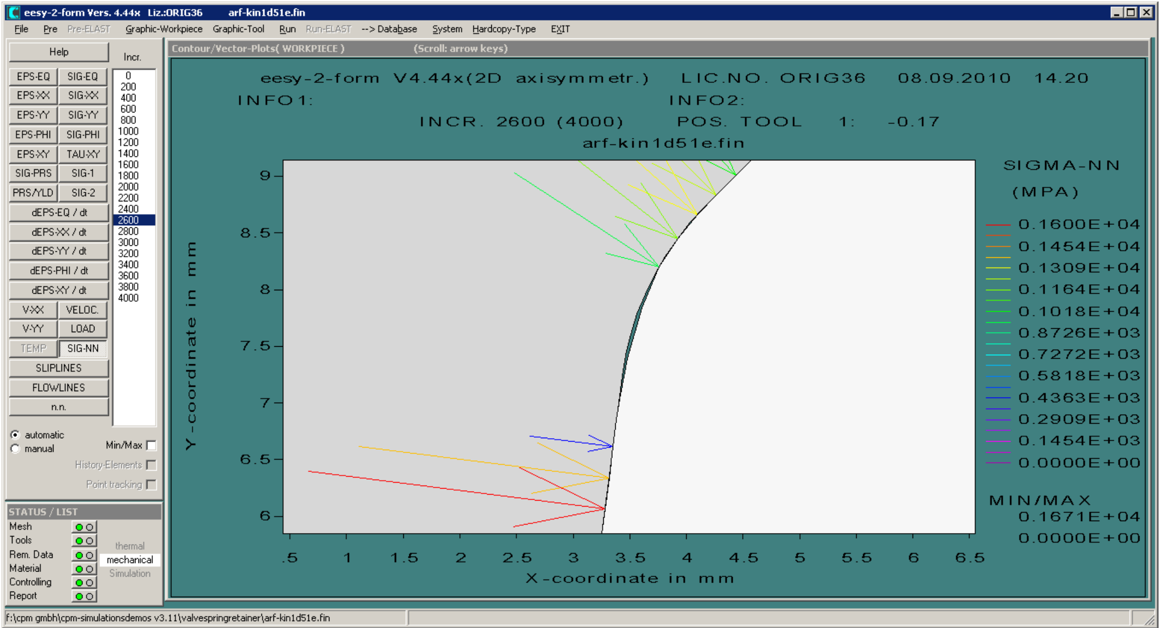


Five station cold forging process to form a valve spring retainer

Alternating Stress in short time period

Failure due to fatigue

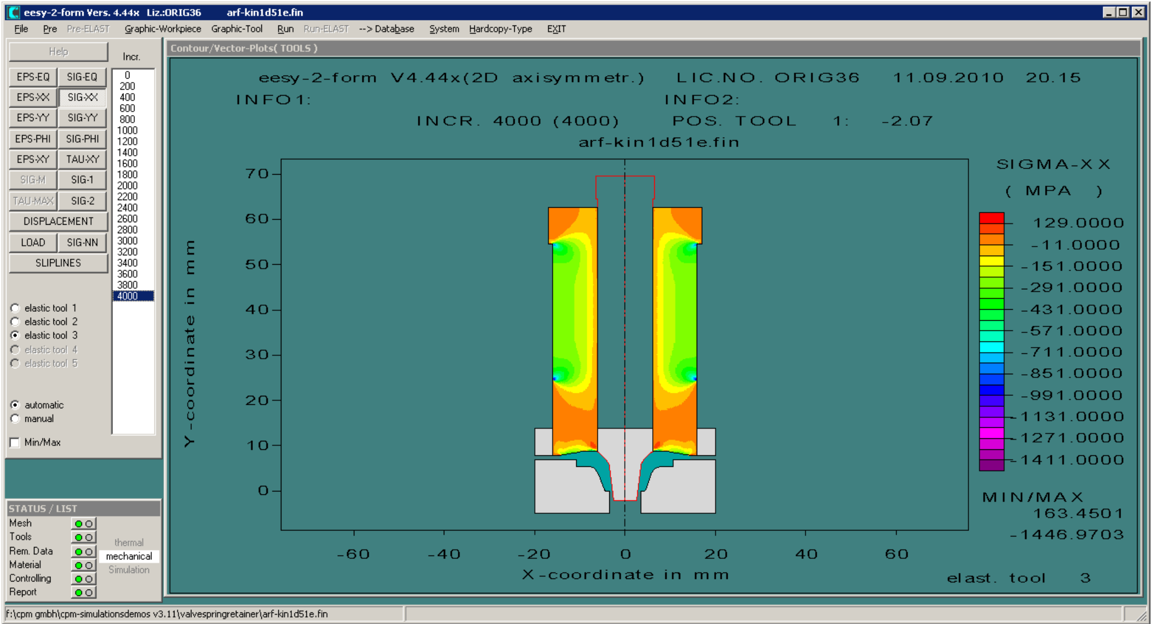
Punch failure in a multi station process



Five station cold forging process to form a valve spring retainer

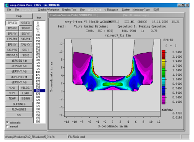
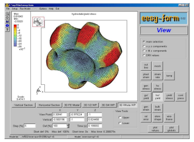
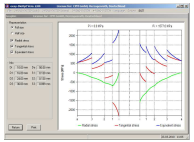
Reason for failure: material lost contact to the tooling

Punch failure in a multi station process

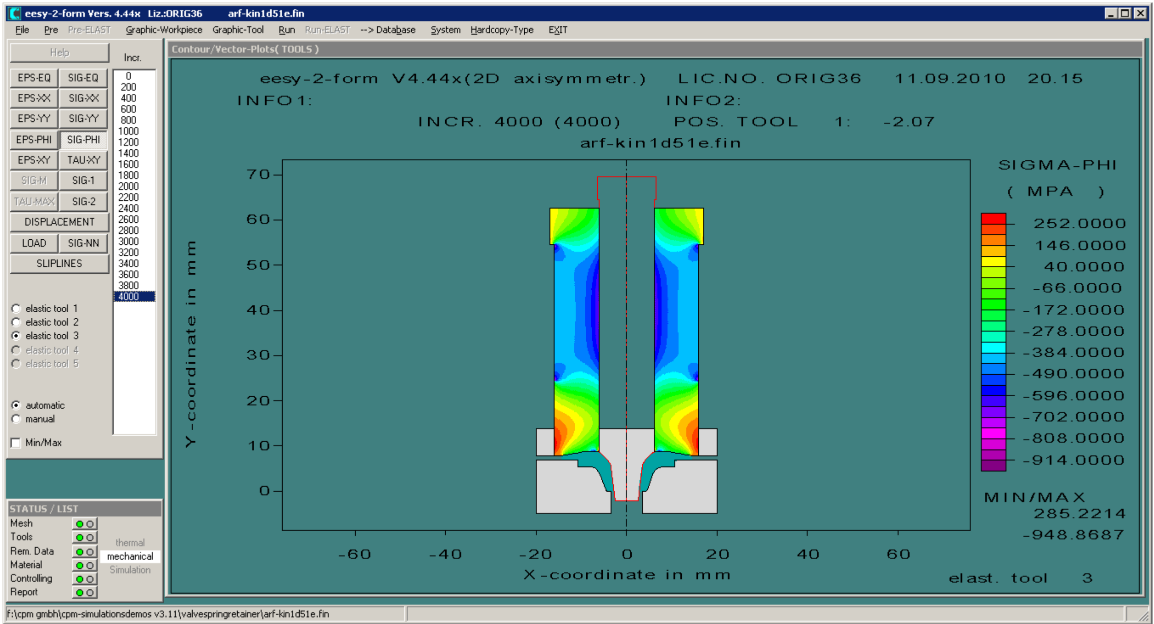


Five station cold forging process to form a valve spring retainer

High stress concentration at the point of breakage (Sig xx)

Punch failure in a multi station process

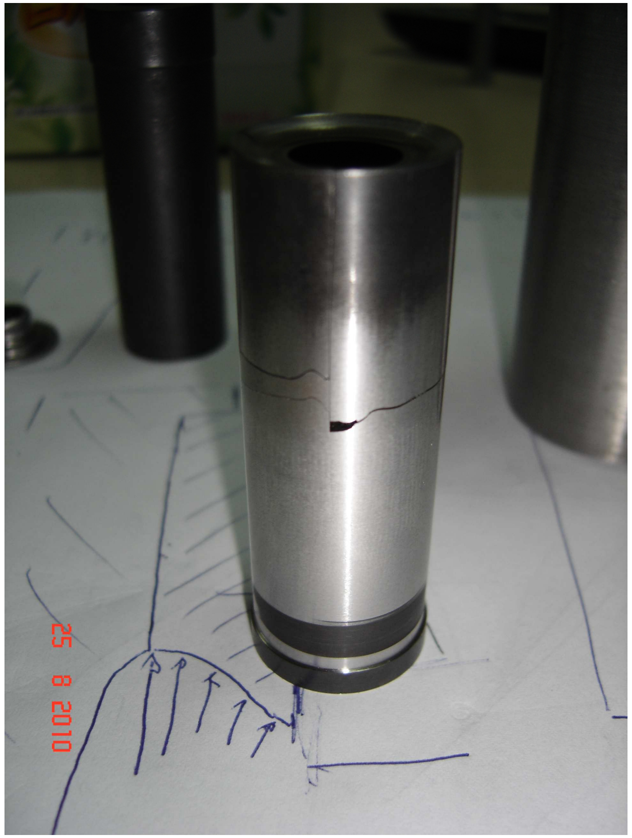


Five station cold forging process to form a valve spring retainer

positive tangential stress below the point of breakage

Punch failure in a multi station process

Crack initialization



Five station cold forging process to form a valve spring retainer

Punch failure in a multi station process

Result:

The change of the progression design to get the material in contact to the pin during all the process solved the problem.

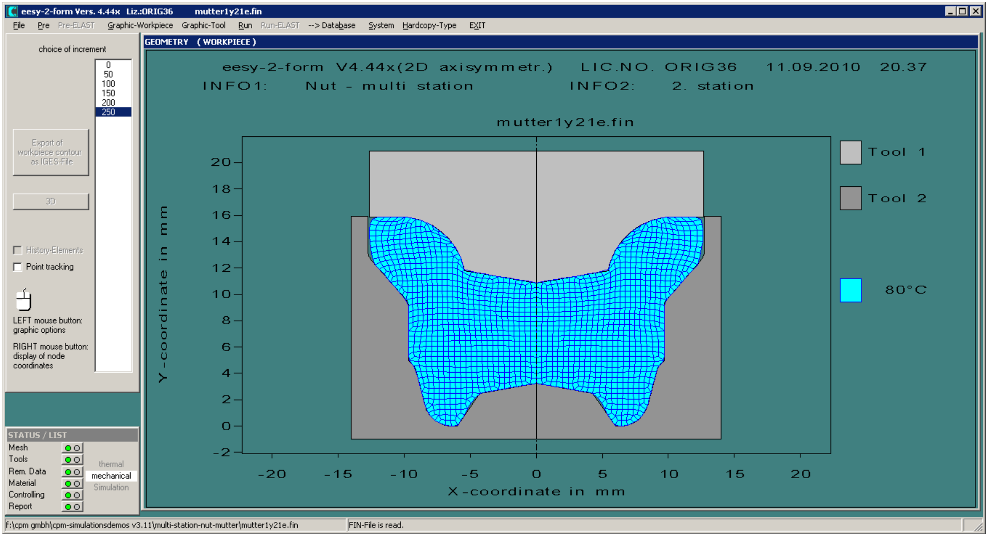
A longer housing of the punch to avoid the upsetting in the front solved the problem.

Related design rules could be revievised.

Five station cold forging process to form a valve spring retainer

Punch failure in a multi station process

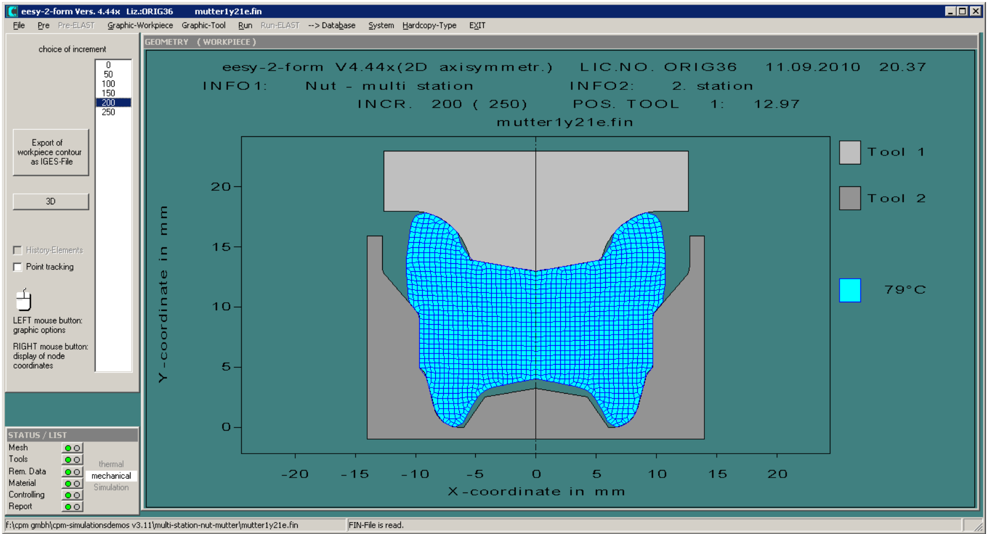
Punch of operation 3 fails



Nut making cold forging process

Punch failure in a multi station process

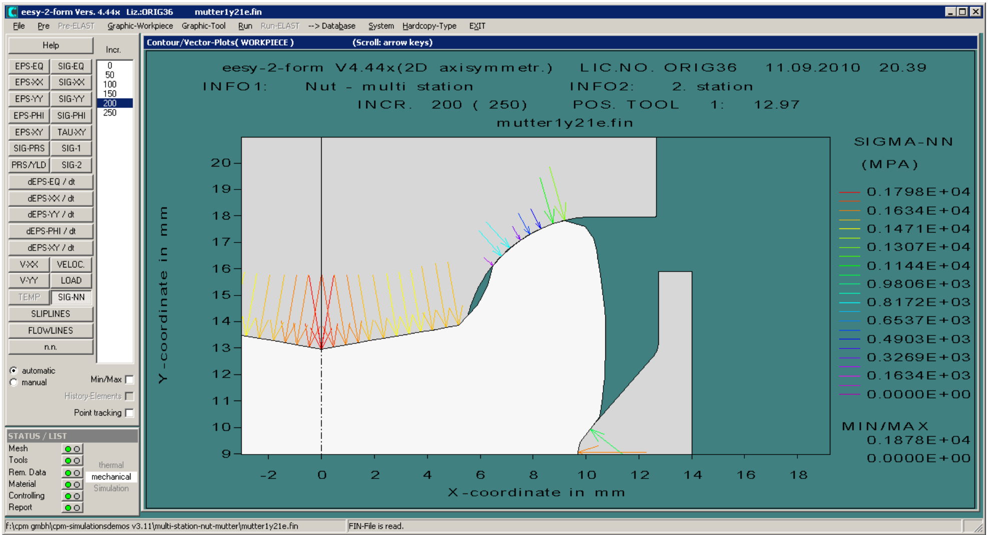
Punch of operation 3 fails



Nut making cold forging process

Punch failure in a multi station process

Material flow causes severe stress distribution



Nut making cold forging process

Result: positive stress in the punch -> punch failure

Punch failure in a multi station process

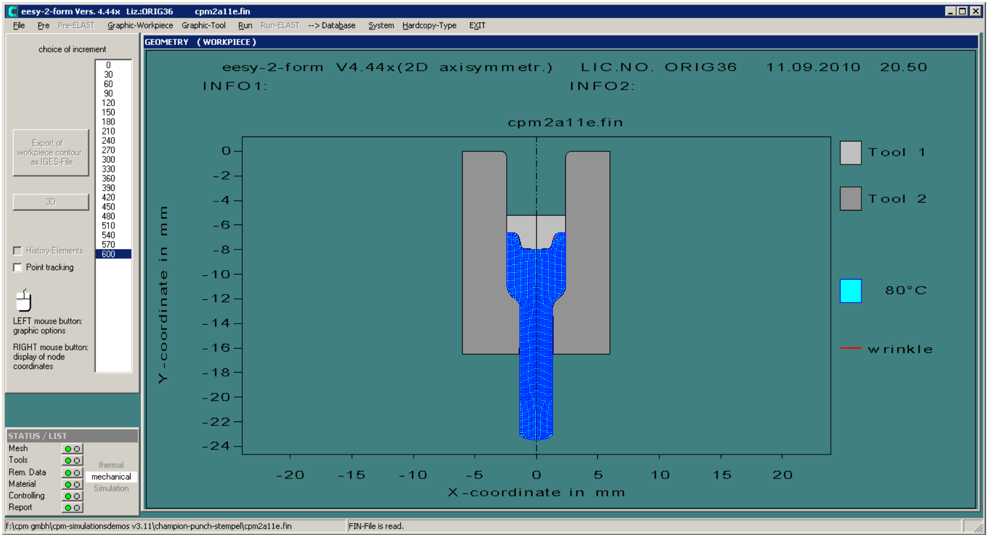
Material flow causes severe stress distribution

Nut making cold forging process

Result: positive stress in the punch -> punch failure

Punch failure in extrusion process

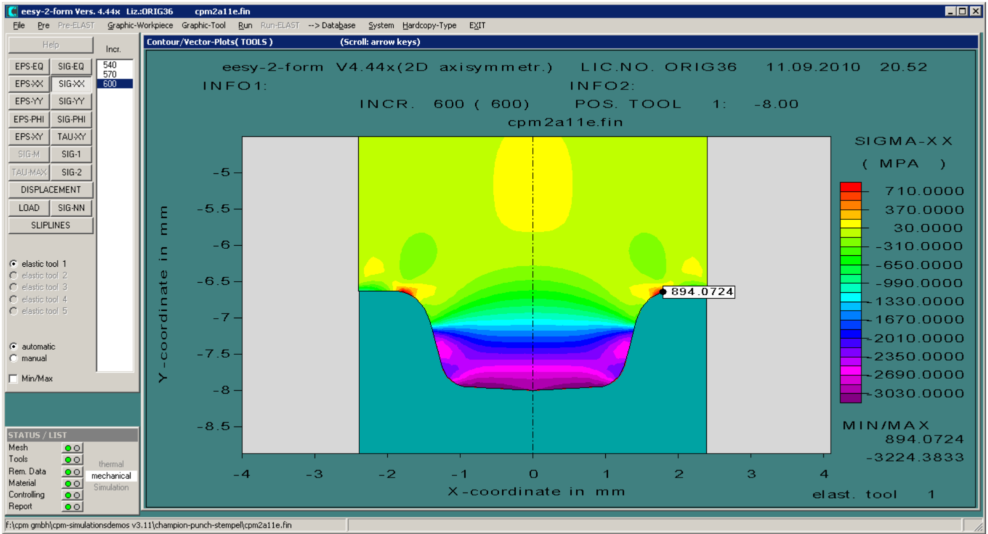
Punch of operation 2 fails



Cold forging extrusion process

Punch failure in extrusion process

Punch of operation 2 fails



Cold forging extrusion process

High local positive radial stress -> punch failure

Punch failure in extrusion process

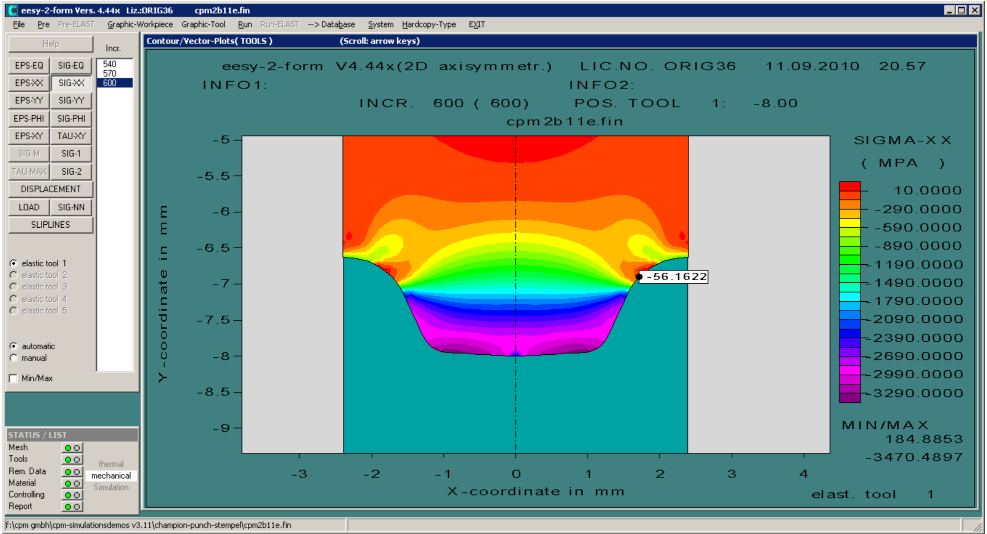
Punch of operation 2 fails

Cold forging extrusion process

Picture of a similar failure (picture from ICFG)

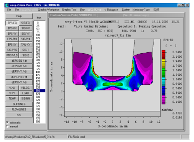
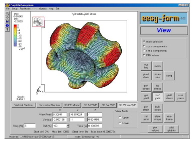
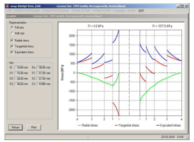
Punch failure in extrusion process

Punch of operation 2 changed



Cold forging extrusion process

No high local positive radial stress after change of radius

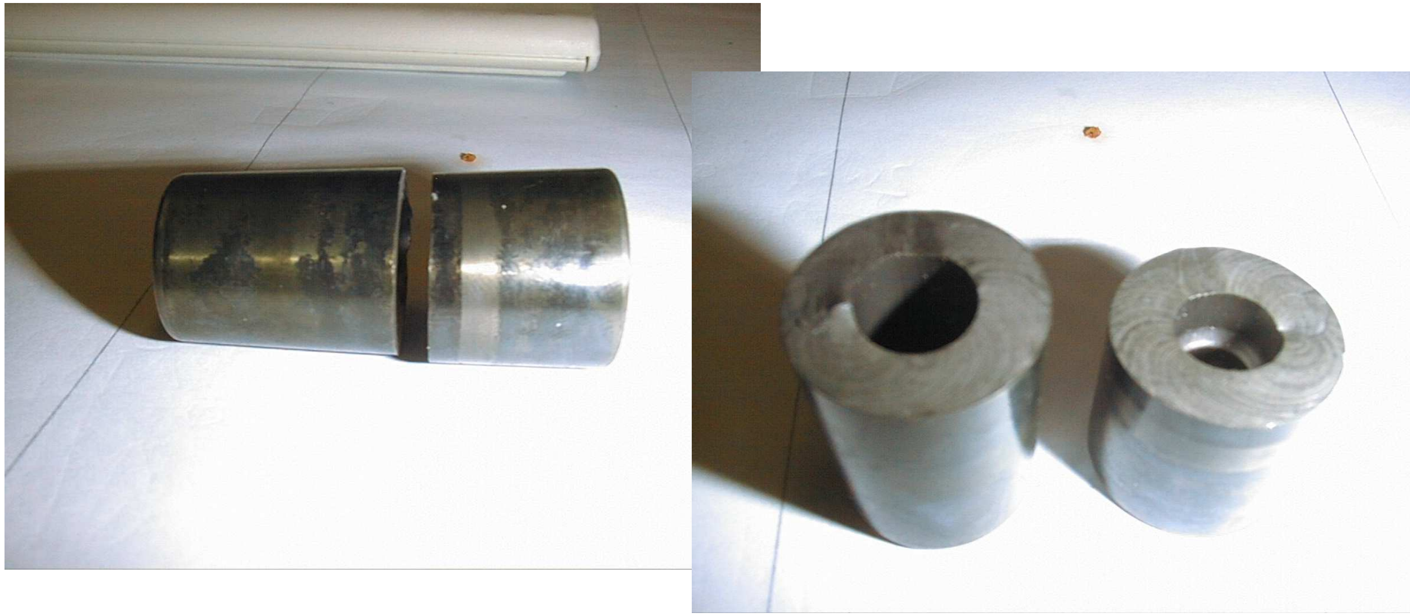




Die failure in extrusion **Using a hybrid approach to optimize the tool design**

Cold forging
extrusion
process

Die failure mainly due to overloading

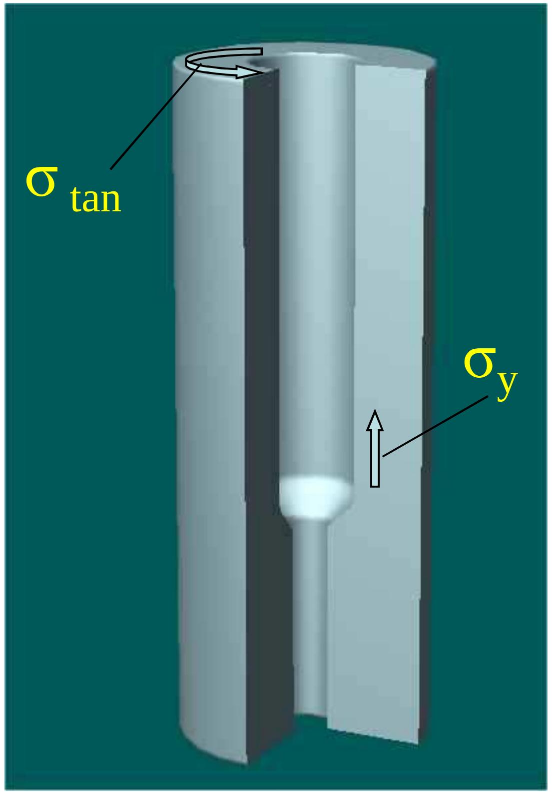
Die failure in extrusion **Using a hybrid approach to optimize the tool design**



Cold forging extrusion process

Die failure mainly due to axial stress in the insert

Die failure in extrusion **Using a hybrid approach to optimize the tool design**

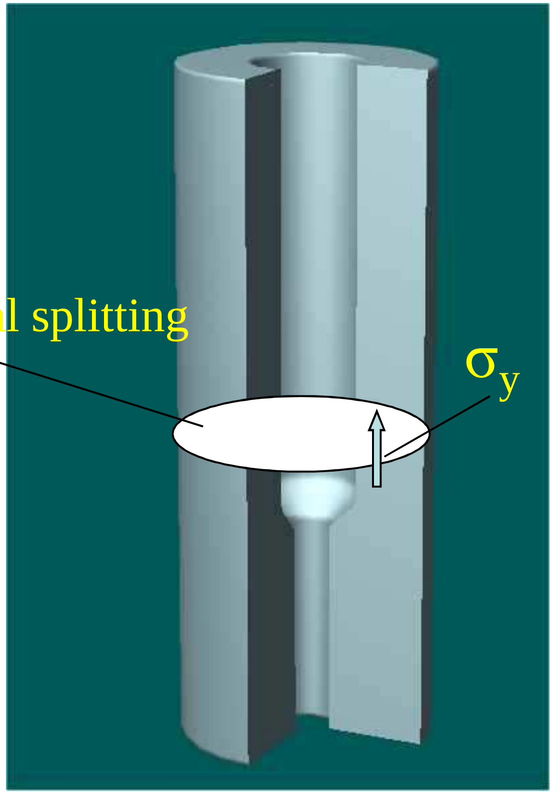


σ_{tan}: critical for axial cracks

σ_y: critical for horizontal cracks

Cold forging extrusion process

Die failure in extrusion **Using a hybrid approach to optimize the tool design**

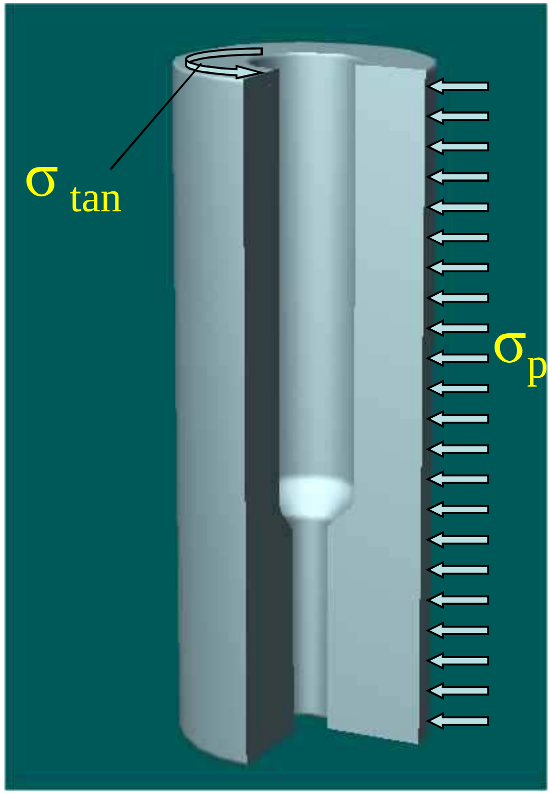


σ_y: critical for horizontal breackage

splitt the insert

Cold forging extrusion process

Die failure in extrusion **Using a hybrid approach to optimize the tool design**

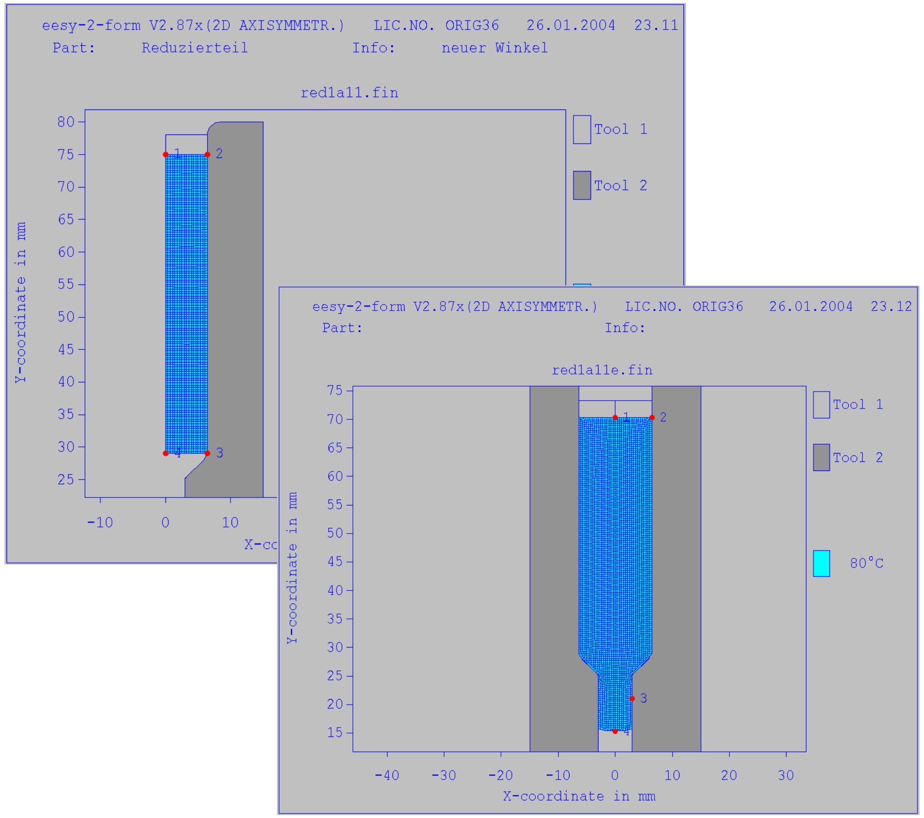


σ_{tan}: critical for radial cracks

⇒ pre-stress the insert

Cold forging extrusion process

Die failure in extrusion **Using a hybrid approach to optimize the tool design**

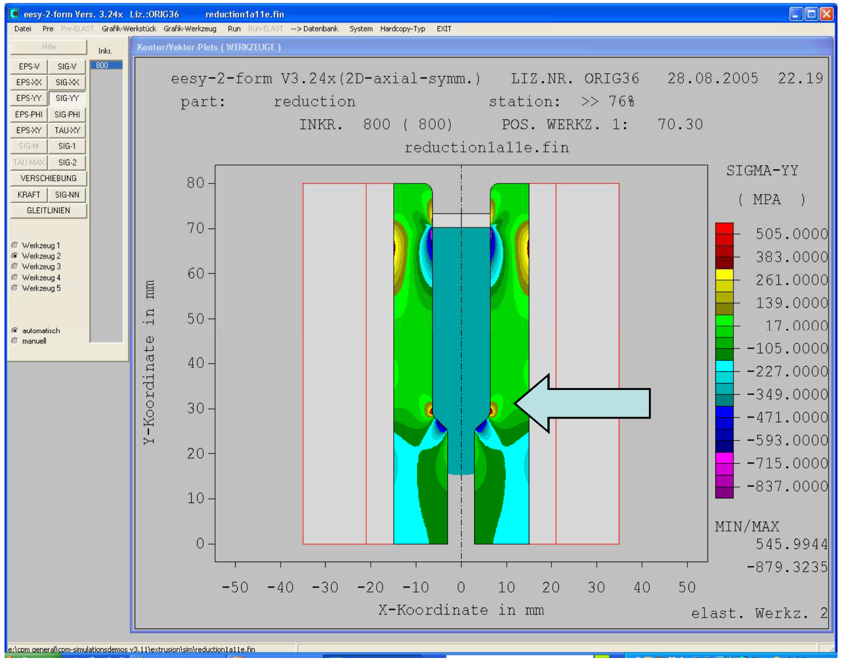


Process

material flow

Cold forging extrusion process

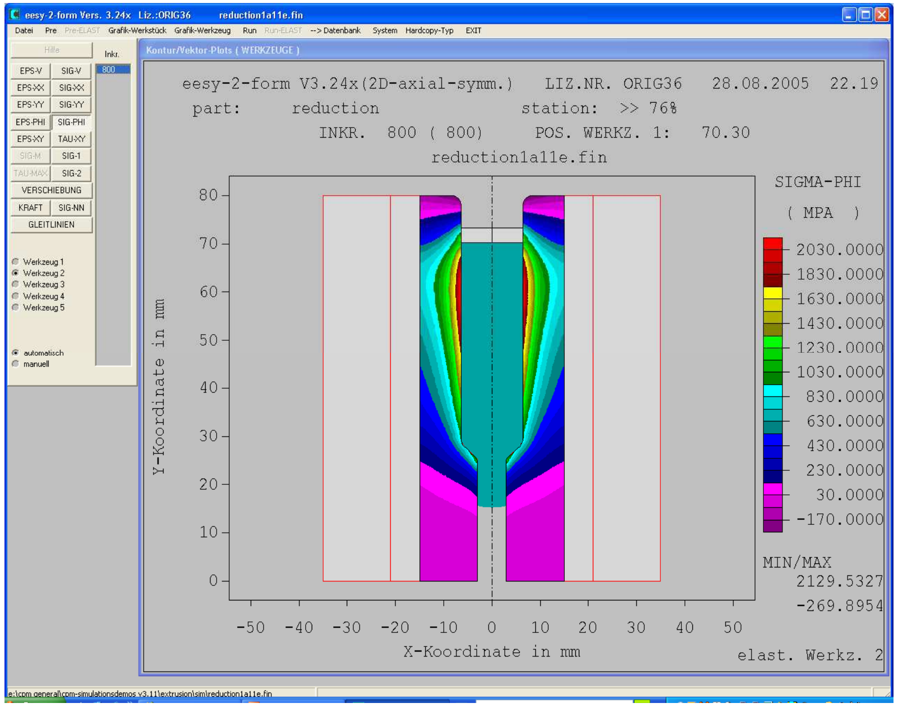
Die failure in extrusion **Using a hybrid approach to optimize the tool design**



Cold forging
extrusion
process

Axial stress in the insert => split the carbide insert

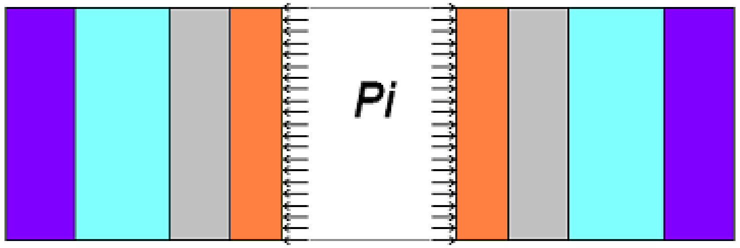
Die failure in extrusion **Using a hybrid approach to optimize the tool design**



Cold forging extrusion process

High tangential stress => improve the pre-stressing

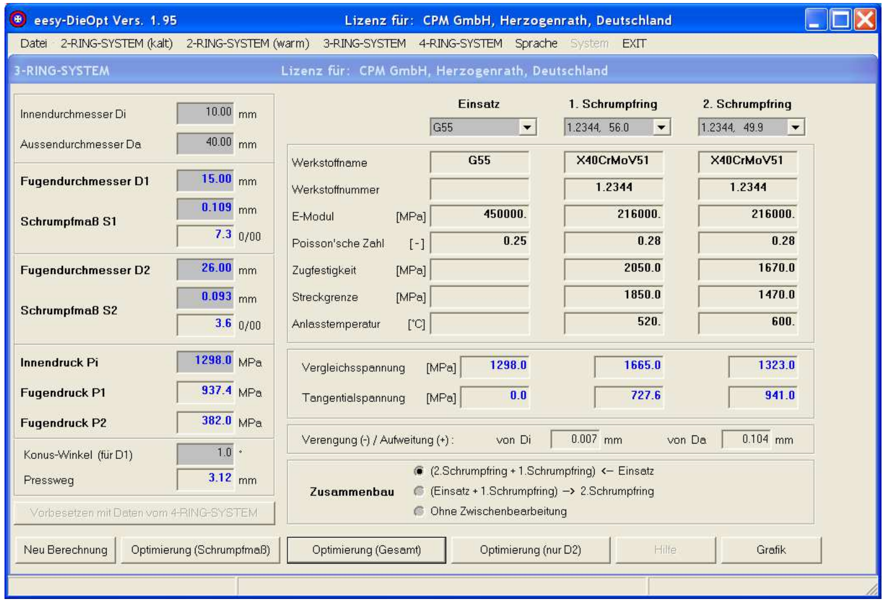
Die failure in extrusion **Using a hybrid approach to optimize the tool design**



Cold forging extrusion process

Simplified pre-stress analysis to optimize the design

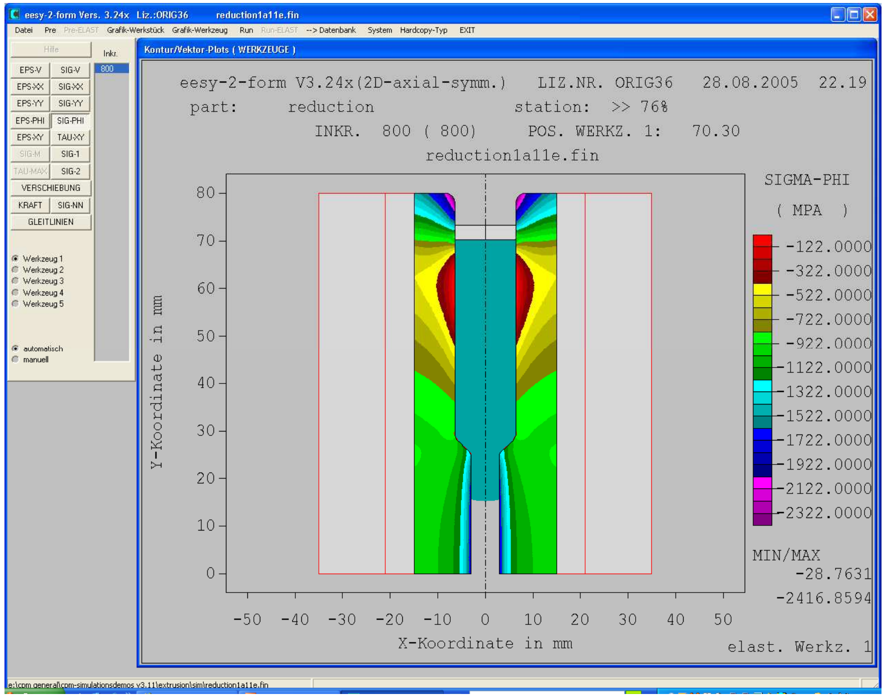
Die failure in extrusion **Using a hybrid approach to optimize the tool design**



Cold forging extrusion process

Simplified pre-stress analysis to optimize the design

Die failure in extrusion **Using a hybrid approach to optimize the tool design**

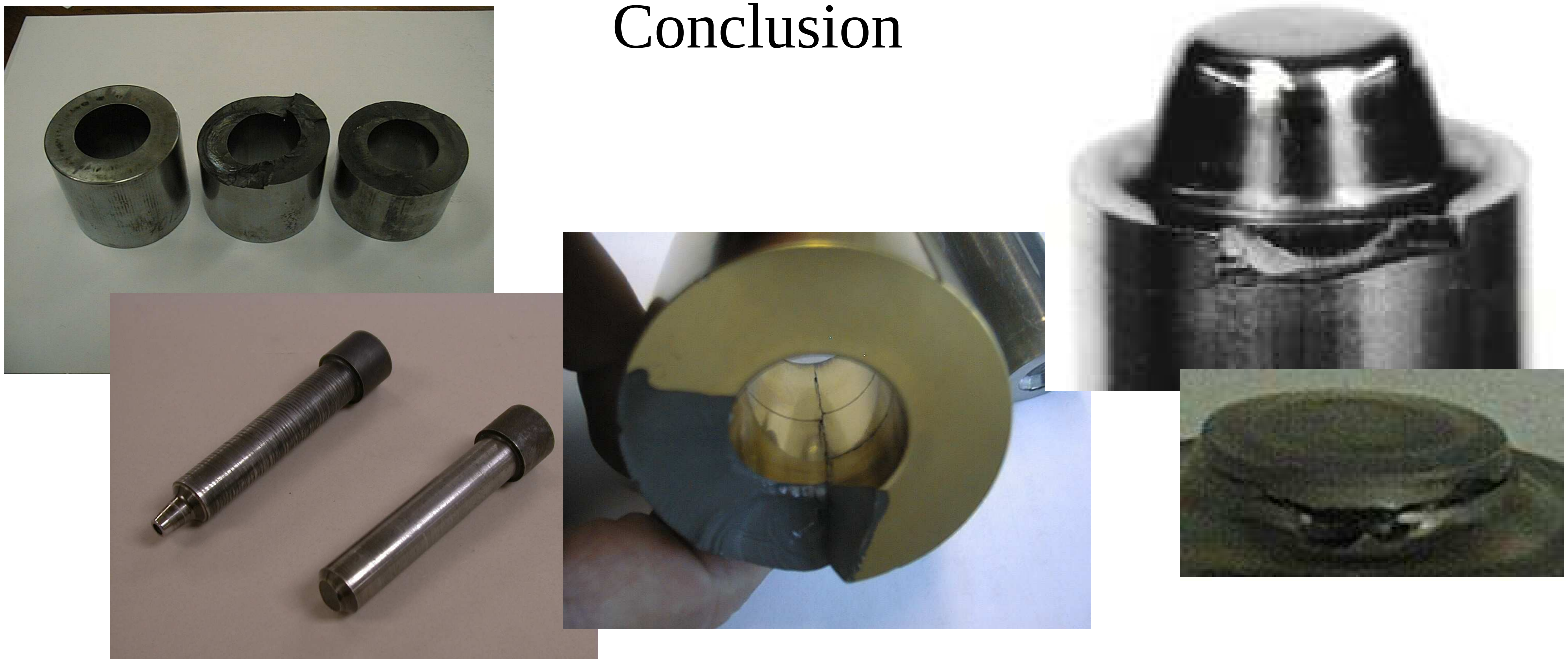


Cold forging
extrusion
process

Checking the optimized design in FEA

Study of FEA applications in metal forming

Conclusion



A lot of tooling problems can be solved or avoided by consequent use of FEA during the design stage

Why to study FEA applications in metal forming processes under the aspect of tool failure?

Result:

The prediction of tooling failure is still not a standard application of simulation.

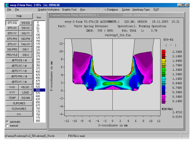
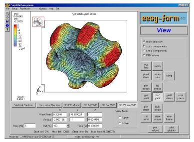
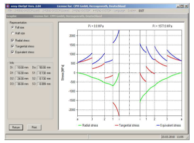
Successful applications allowed to find out guidelines to support the design engineer based on reliable simulation results.

By getting experience from the studies rules could be given to enable the design engineer to foresee problems and therefore avoid costs.

The design engineer is enabled to develop longer lasting tooling by using simulation instead of costly trial and error procedures.

The study focused on real applications in industry and gave most practical guidelines.

The research has to go on to provide more sound and reliable models on a higher level to better predict not only tool failure but tool live as well.

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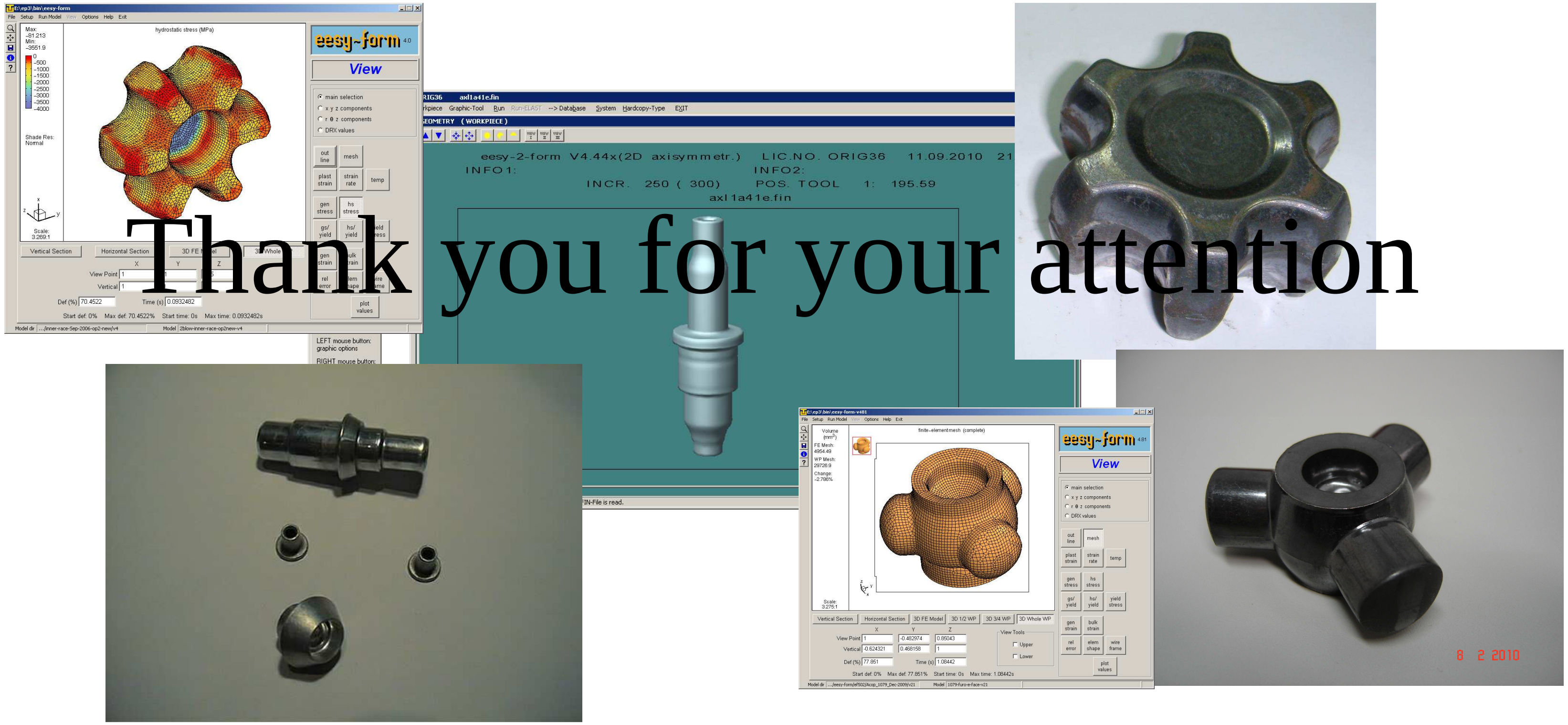
Study of FEA applications in metal forming



Thank you for your attention