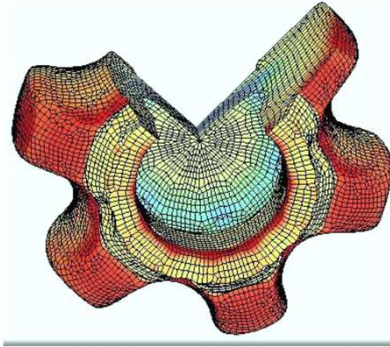
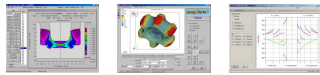


Application of FEA Simulation in Cold Forging



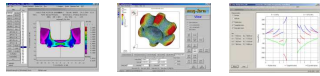
*Dr. Gerhard H. Arfmann, Dr. Michael Twickler
CPM GmbH, Herzogenrath, Germany*



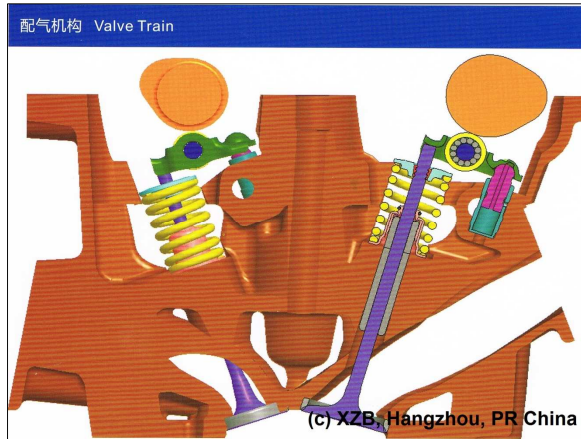
Application of FEA Simulation in Cold Forging



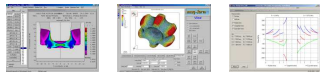
Automotive parts made by Forging



Application of FEA Simulation in Cold Forging

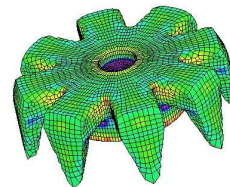


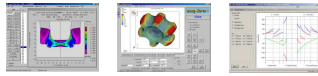
Interesting Automotive parts made by Cold Forging



Application of FEA Simulation in Cold Forging

How to design the right process
to produce a forged part?

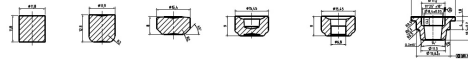




Application of FEA Simulation in Cold Forging

Starting from the product drawing the engineer has to

**design the forming sequence,
chose the machine and
designs the tooling.**

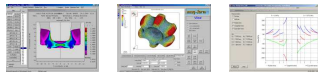


Traditionally he starts his work from **some initial design** and orders **the tooling**.

After arrival of them he starts with **the try out**.

After **some trial and error cycles** the engineer works out the **final process and tool design**.

Bild: XZB, Hangzhou, PR China



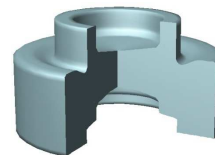
Application of FEA Simulation in Cold Forging

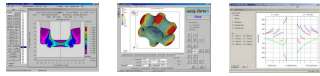
Process Idea

The process idea normally comes from the design engineer.

He may generate it from

- his own knowledge
- experience
- from books
- information from third parties.





Application of FEA Simulation in Cold Forging

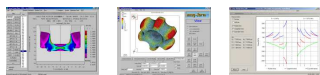
Initial Design

Normally the engineer adjusts existing designs to the requirements of the new part.

More rarely he develops a new process design from the roots.

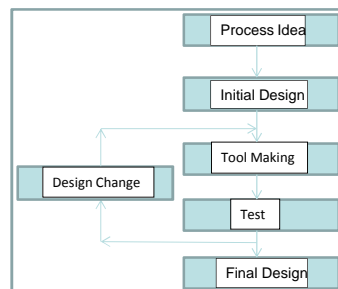
Available design packages based on empirical basic technology and/or on stored example progressions may help him as well.

However the engineer has to come up with an initial design layout.



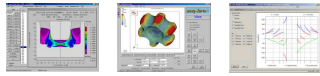
Application of FEA Simulation in Cold Forging

Principle of process design



As published by the author in the 1980's to explain how future CA techniques may help the engineer

In some cases all the testing is wasted and the product cannot be produced.



Application of FEA Simulation in Cold Forging

The role of Finite Element Analysis (FEA) in Process Design

FEA supports the engineer to generate better designs:

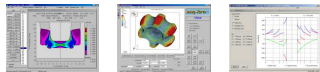
- the engineer models his ideas in FEA
- he finds out whether his process idea will work
- technological information (Stresses, Strain, Flowlines..) enables him to optimize his design
- he can try alternative ideas
- he can study the tool design and can optimize that as well.



Result: The Process is optimized before ordering the tools even.

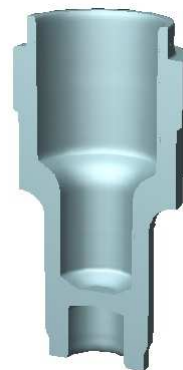
Further: In case of no success the development can be stopped before wasting time on endless trials.

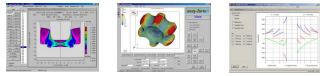
In any case FEA helps to avoid costs.



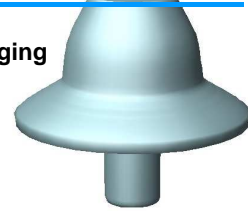
Application of FEA Simulation in Cold Forging

How good is FEA?





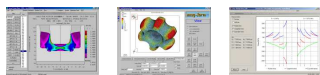
Application of FEA Simulation in Cold Forging



FEA is:

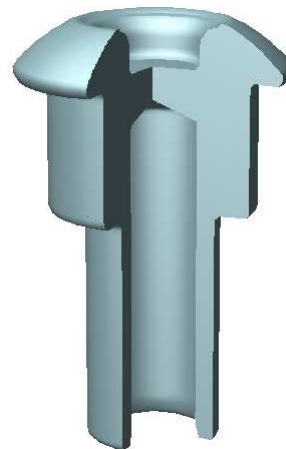
- precise enough to avoid trial and error
- quick enough to accelerate developments significantly (reduce the dev. Time)
- is more precise than the "firm" knowledge of experienced stuff
- helping to close the gaps in knowledge of the stuff
- having the required data (material, friction etc) available and proved
- practically exact even so scientifically not 100% precise
- providing the stuff much more insight in the process than any imagination of an experienced stuff
- best used by experienced stuff and will help to improve their technology
-

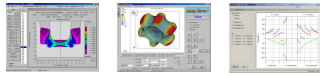
FEA is the ideal tool fro the good engineer!



Application of FEA Simulation in Cold Forging

For what to use FEA?





Application of FEA Simulation in Cold Forging

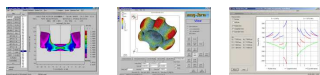
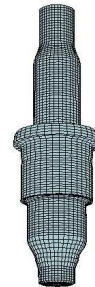
The following examples deal with very real cases to show the advantage of the use of FEA.

They are of different complexity and therefore show that the use of FEA is not only beneficial for complex applications.

All cases are recent applications of customers.

All of customers are long time in the market and have a sound reputation as good technology companies.

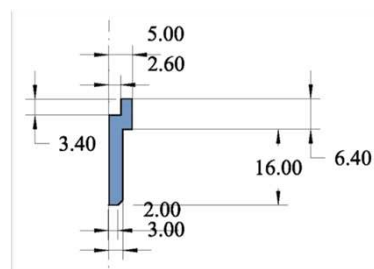
They provided these examples to show that consequent and continuous usage of FEA is a “must” in state of the art cold forging.

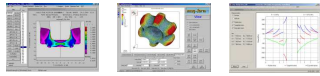


Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

The following bolt had to be produced:

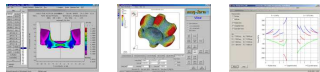
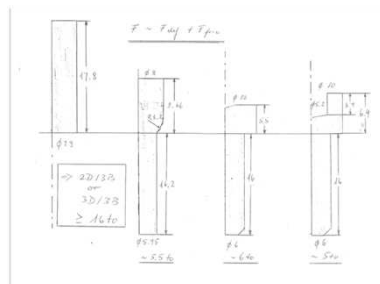




Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

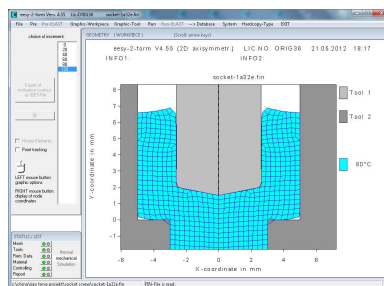
Using his knowledge and/or some support tools the engineer came up with his first approach to produce the fastener.

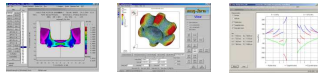


Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

Simulations performed showed a bad (but typical) result:

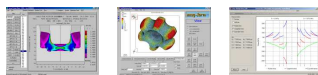
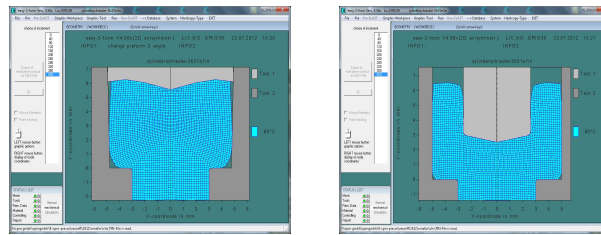




Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

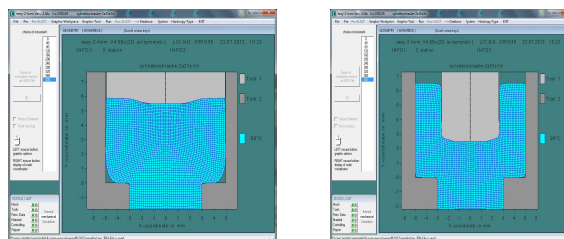
Simulation based on empirical knowledge showed a bad result as well:

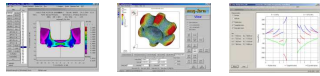


Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

Detailed studies of the material flow in several variations let to a good result:



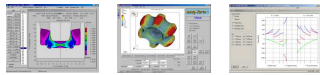
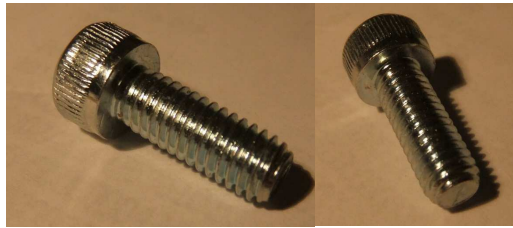
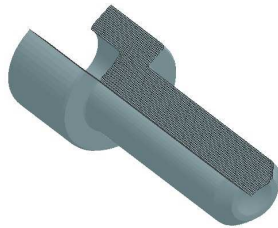


Application of FEA Simulation in Cold Forging

Design of a Process to form a Cylinder Head Bolt

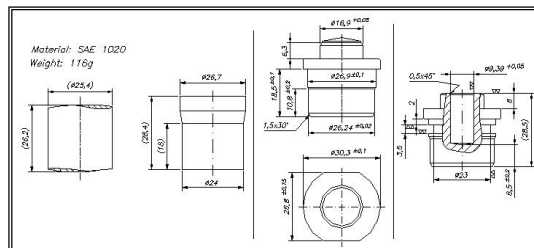
Simulation

Real part.



Application of FEA Simulation in Cold Forging

Production of a shock absorber

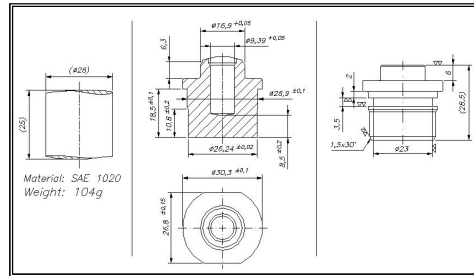


Conventional process

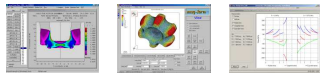


Application of FEA Simulation in Cold Forging

Production of a shock absorber

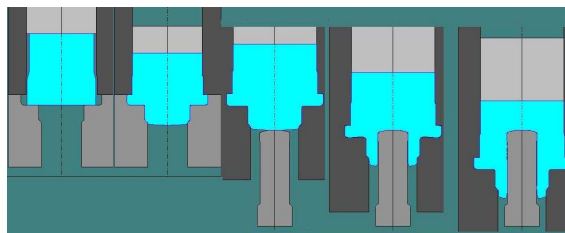


Single stage process

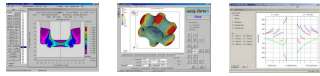


Application of FEA Simulation in Cold Forging

Production of a shock absorber

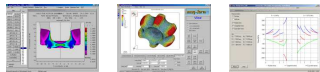
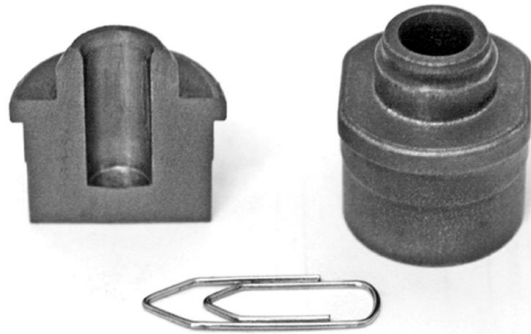


Simulation of the single stage process



Application of FEA Simulation in Cold Forging

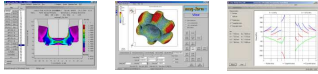
Production of a shock absorber



Application of FEA Simulation in Cold Forging

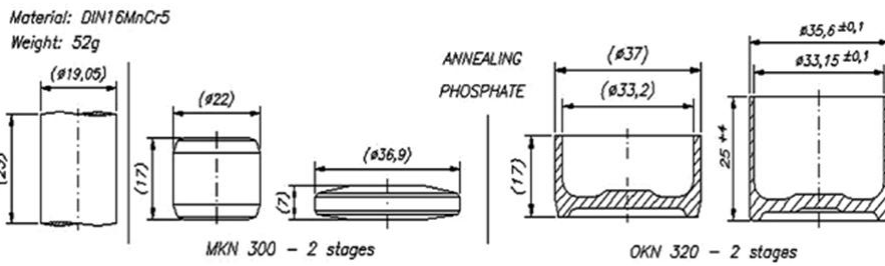


Test of new processes

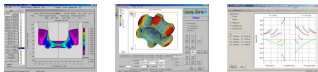


Application of FEA Simulation in Cold Forging

Simulation of a „valve tappet“

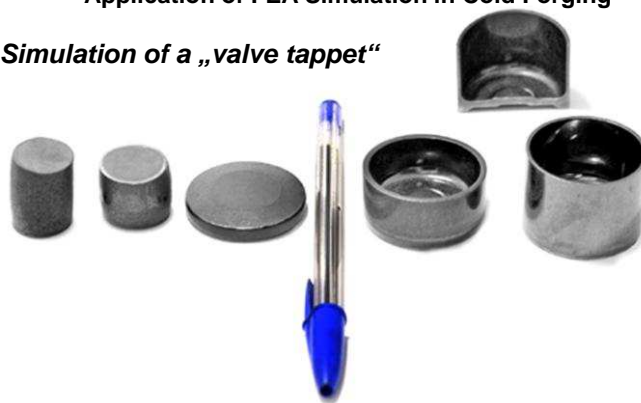


Traditional process

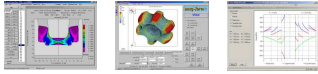


Application of FEA Simulation in Cold Forging

Simulation of a „valve tappet“

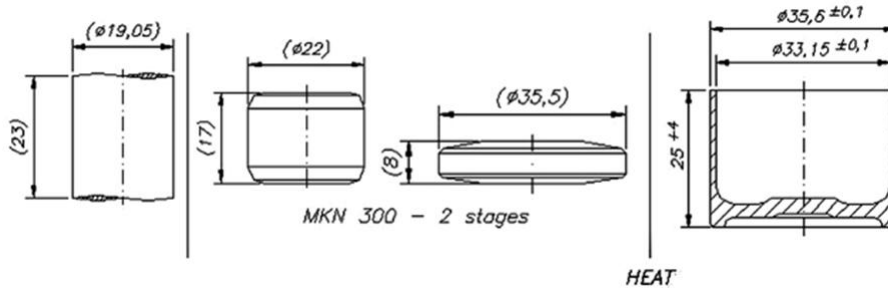


Traditional process

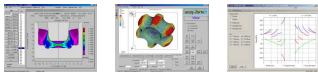


Application of FEA Simulation in Cold Forging

Simulation of a „valve tappet“



New process

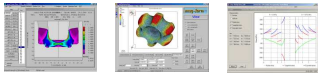


Application of FEA Simulation in Cold Forging

Simulation of a „valve tappet“

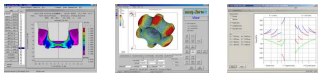


New process



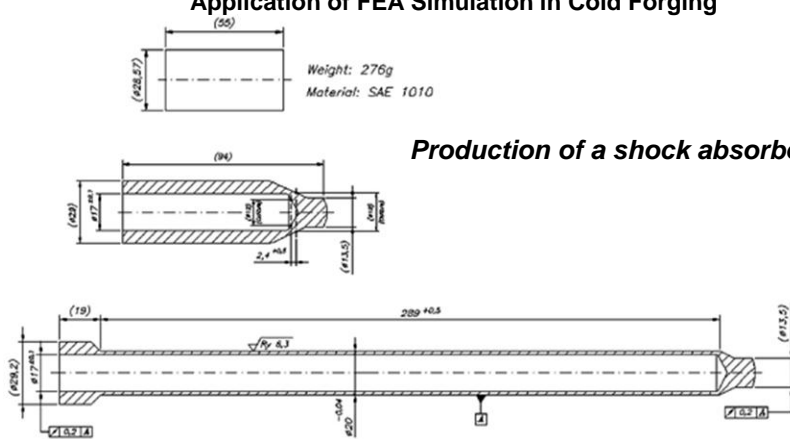
Application of FEA Simulation in Cold Forging

Production of a shock absorber body

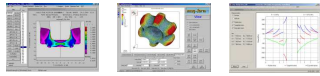


Application of FEA Simulation in Cold Forging

Production of a shock absorber body

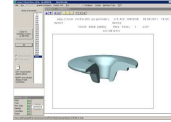


Weight: 276g
Material: SAE 1010



Application of FEA Simulation in Cold Forging

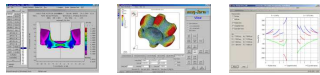
Production of a valve spring retainer – tool failure



Progression

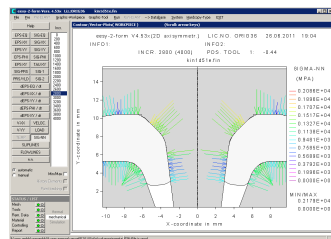
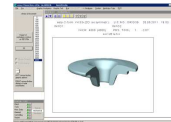


Premature tool failure

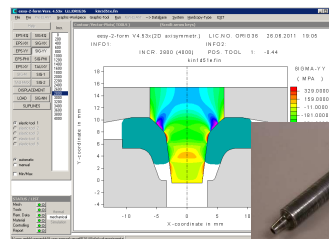


Application of FEA Simulation in Cold Forging

Production of a valve spring retainer – tool failure

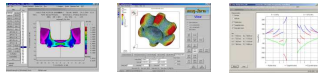


Normal Stresses



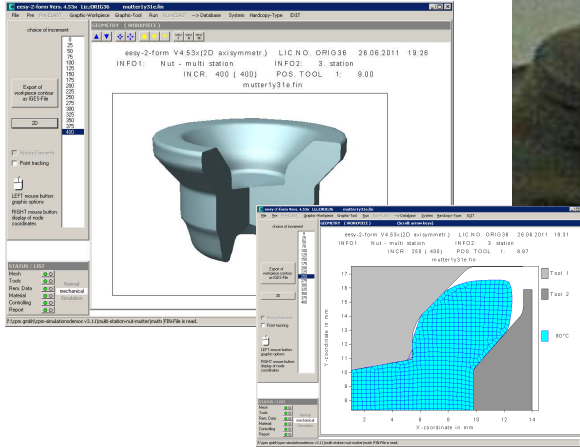
Axial Stress in the punch



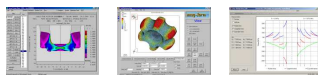


Application of FEA Simulation in Cold Forging

Production of a nut

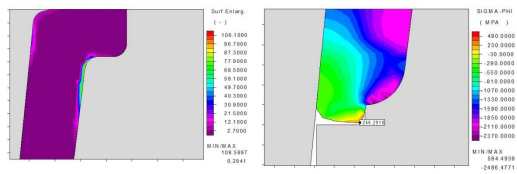


Premature tool failure



Application of FEA Simulation in Cold Forging

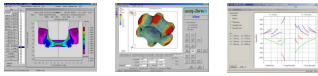
Roughness and cracking on a valve spring retainer



surface enlargement

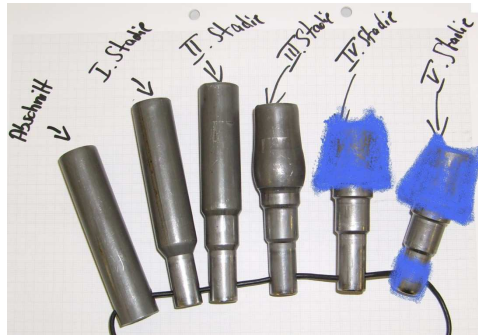
high tangential stress



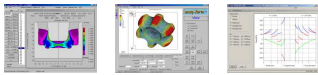


Application of FEA Simulation in Cold Forging

Production of a „bolt“

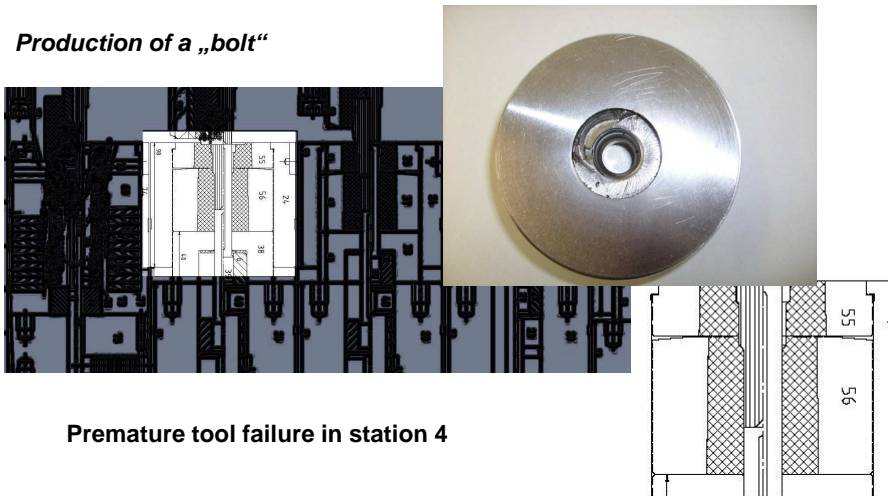


Premature tool failure in station 4



Application of FEA Simulation in Cold Forging

Production of a „bolt“

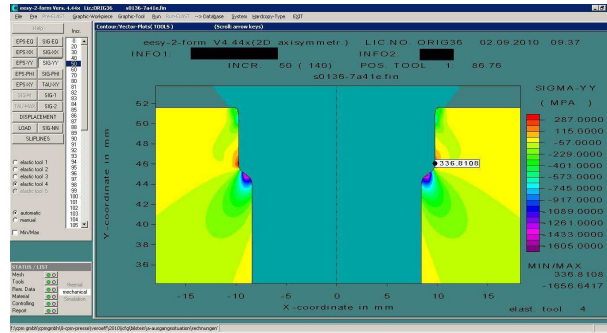


Premature tool failure in station 4

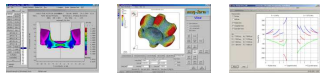


Application of FEA Simulation in Cold Forging

Production of a „bolt“

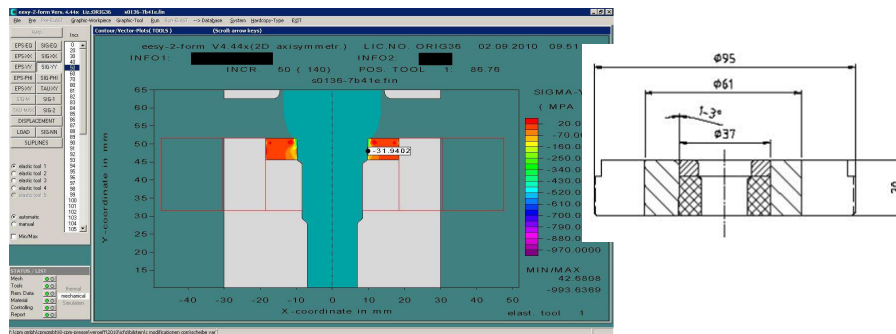


Positive stress in station 4 – 5.000 pieces tool life

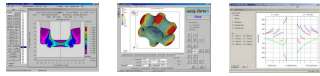


Application of FEA Simulation in Cold Forging

Production of a „bolt“

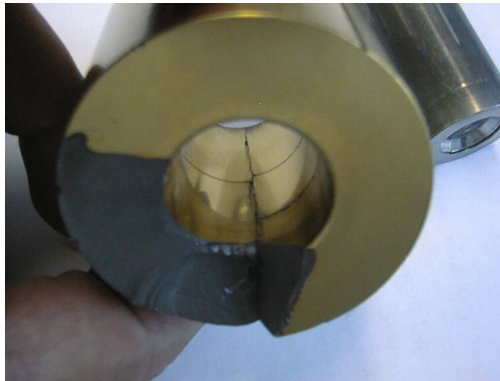


Compressive stress in station 4 – new design – 100.000 pieces tool life

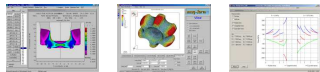


Application of FEA Simulation in Cold Forging

Design of an extrusion die

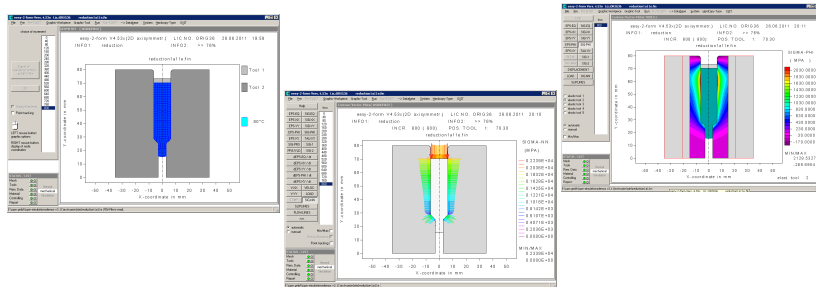


Overloaded die insert

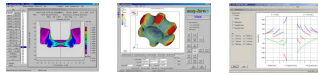


Application of FEA Simulation in Cold Forging

Design of an extrusion die

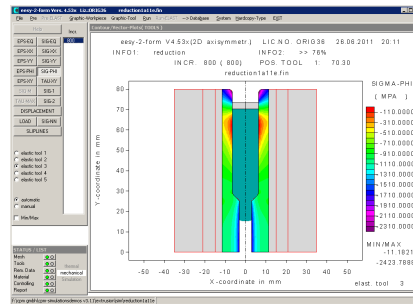
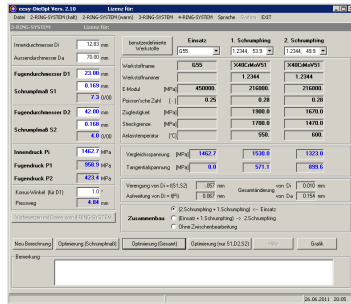


Stress analysis – Normal stresses on surface – Tangential stresses in the die

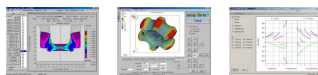


Application of FEA Simulation in Cold Forging

Design of an extrusion die

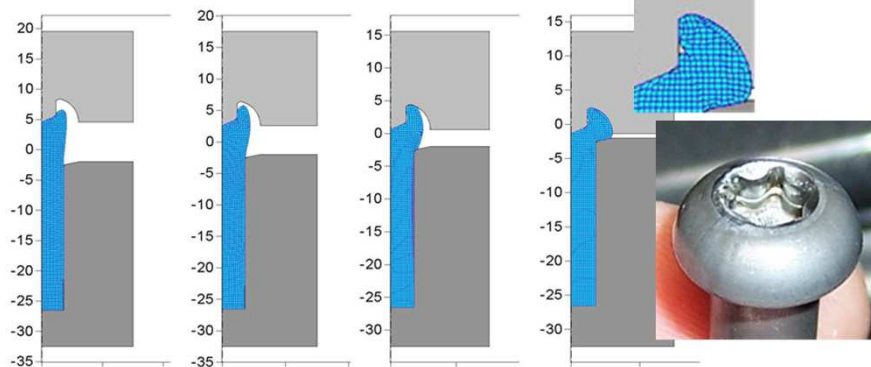


Optimization of the die design – resulting Tangential stresses in the die

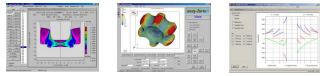


Application of FEA Simulation in Cold Forging

Production of a bolt

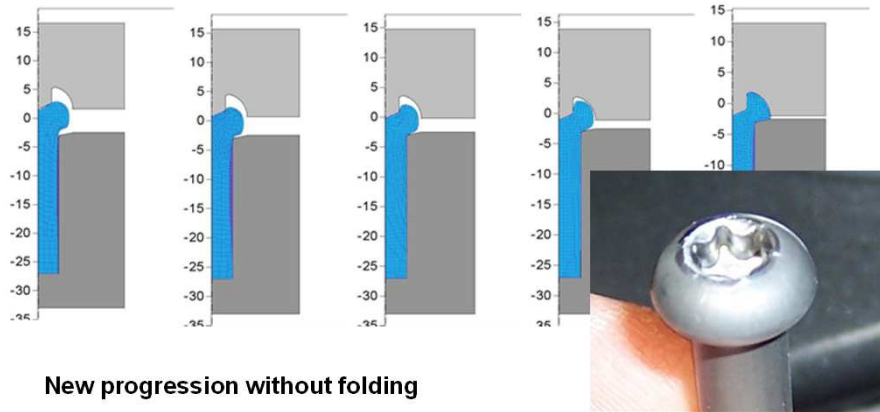


Original progression with folding

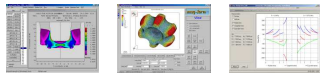


Application of FEA Simulation in Cold Forging

Production of a bolt

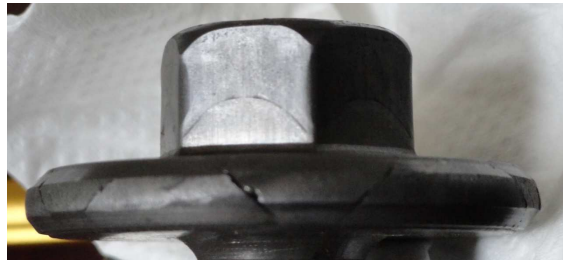


New progression without folding

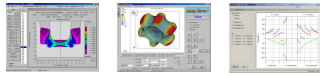


Application of FEA Simulation in Cold Forging

Production of a hex bolt

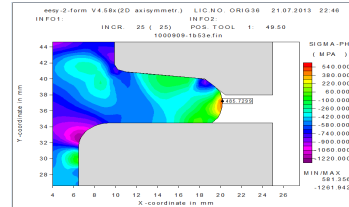
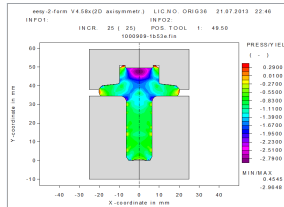


The hex bolt shows cracks on the surface



Application of FEA Simulation in Cold Forging

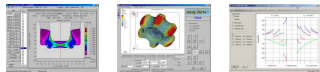
Production of a hex bolt



Stress analysis

After the stress analysis the engineer understands the reason and can change the design to avoid the failure.

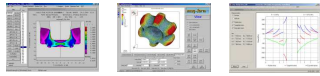
Learning this once the engineer will not make this mistake again.



Application of FEA Simulation in Cold Forging

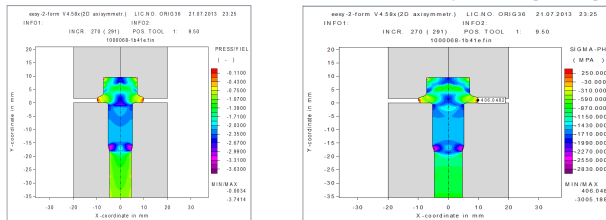
Failure of a screw that is not caused by wrong progression





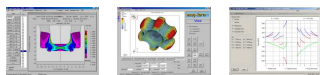
Application of FEA Simulation in Cold Forging

Failure of a screw that is not caused by wrong progression



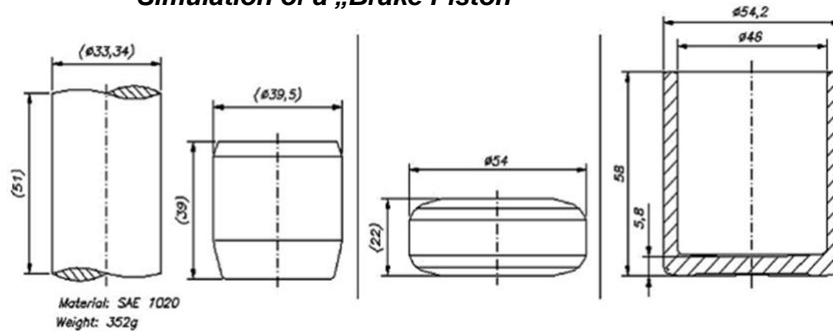
Stress analysis – all values (tangential stress and ration of hydrostatic pressure to yield stress) are safe

In this case the engineer can call the supplier to replace the material directly. This kind of failure is provable a material problem.

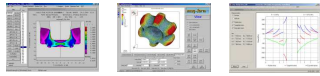


Application of FEA Simulation in Cold Forging

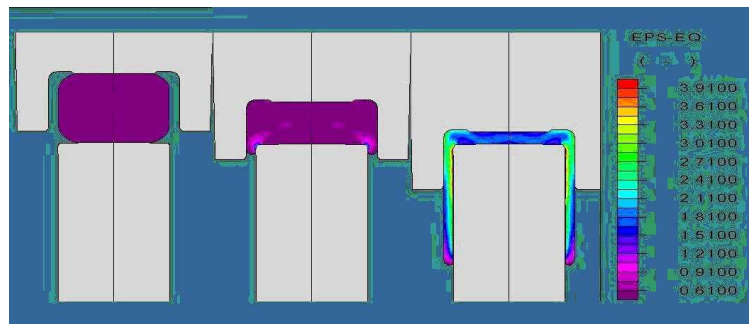
Simulation of a „Brake Piston“



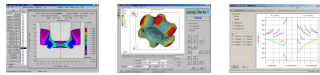
traditionel process



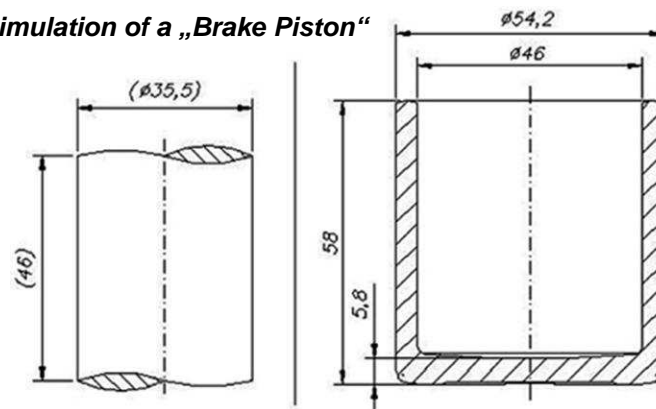
Application of FEA Simulation in Cold Forging
Simulation of a „Brake Piston“



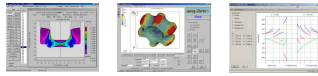
traditionell process



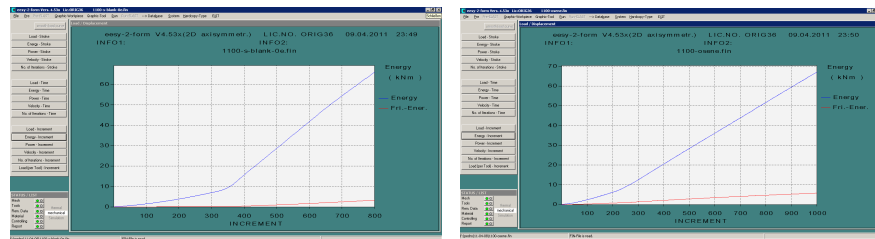
Application of FEA Simulation in Cold Forging
Simulation of a „Brake Piston“



new process – osen-



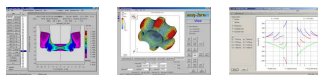
Application of FEA Simulation in Cold Forging Simulation of a „Brake Piston“



Comparison – work Backward Osen

Since both processes need the same work (besides small differences in friction etc) the Osen process requires less load.

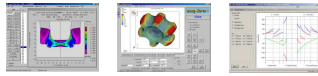
The Osen process requires about 180 to while the backward extrusion requires 450 to.



Application of FEA Simulation in Cold Forging Production of an „inner race“

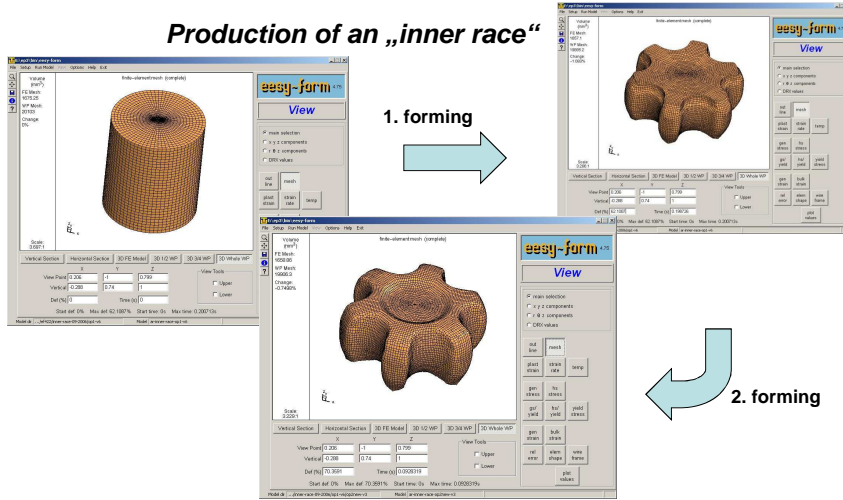


Inner race – process development



Application of FEA Simulation in Cold Forging

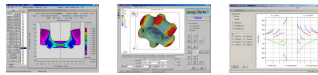
Production of an „inner race“



(c) 2014 Dr. Gerhard H. Arfmann, Dr. Michael Twickler

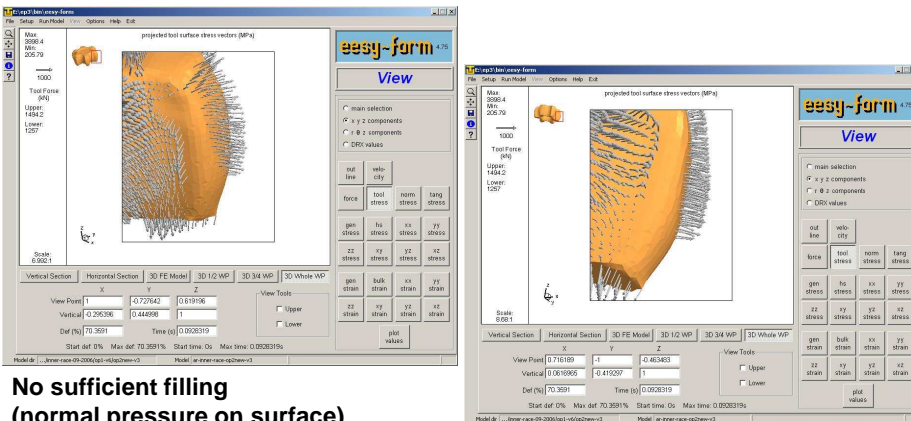
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2nd GAF Advanced Fastener Technology Development International Forum, 11./12.09.2014, Shanghai, PR China



Application of FEA Simulation in Cold Forging

Production of an „inner race“

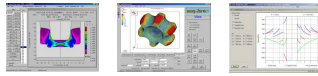


No sufficient filling
(normal pressure on surface)

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2nd GAF Advanced Fastener Technology Development International Forum, 11./12.09.2014, Shanghai, PR China



Conclusion Application of FEA Simulation in Cold Forging

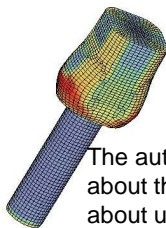
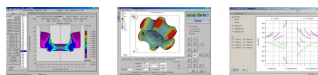


After 25 years of usage of FEA software to analyze plastic material flow there is still some discussion about the sense or nonsense of using simulation in forging industry. Still some argue that the systems are too complex to be used others think that they would be not precise enough still. Scientists sometimes mention that the data and algorithm used are scientifically not really correct.

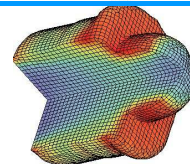
Despite all these discussions FEA is established as a very useful tool for industry. The examples showed a part of the wide range of **successful application in industry**.

It helps to avoid a lot of costs. It helps to improve technology. And finally despite of some certain “weakness” of FEA it opens the user areas of technology that he would not reach otherwise.

Today FEA is a “must” for companies who want to be in the lead
– who want to win.

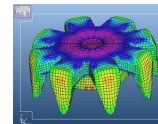


Acknowledgements



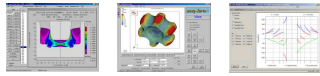
The authors thank their customers for providing them with relevant information about the practical cases and about their general comments about using FEA in their daily work.

This information and the comments are very helpful to improve FEA software and promote its use in presentations like this.



Besides others we would like to mention:

Acopecas,Brasil; XZB, PR China; Barton Cold Forging,UK; Fuchs, Germany;
Bilstein und Sikermann,Germany; Hema,Germany; Philidas,UK; SQB,PR China;
Manzato,Brazil; General Screw, PR China; CQB, PR China; Nedschroef, Belgium



Trust in “eesy” simulation



**Customers are happy to solve their daily problems
with simulation**