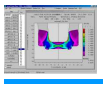
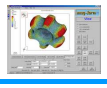
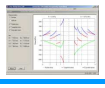
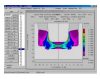
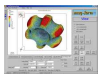




Examples of successful application of FEA in Fasteners Industry

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


CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Simulation technology is widely spread in Fasteners Industry today.
It is mainly used to check the geometry during progression design.
Also loads are checked to choose the right machine.

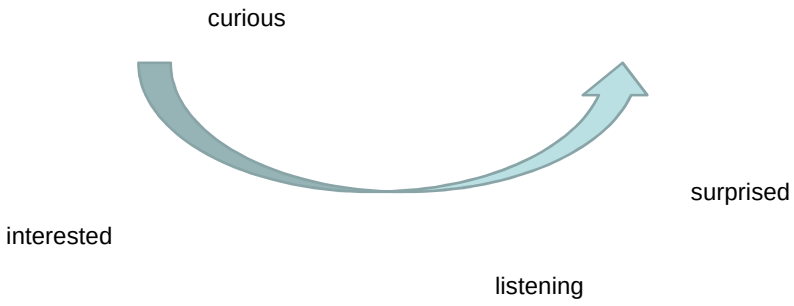
Detailed checks of local values to predict part properties or
to check for certain possible failures are only used on case to case basis.

Very often the detailed knowledge is missing to benefit from all information FEA can provide or the engineers simply do not check everything because they think it may not be necessary.

Sometimes even time pressure is the simple reason to not make the analysis in detail.

Examples of successful application of FEA in Fasteners Industry

This presentation will show successful examples to try to generate more interest in a proper way of usage of simulation technology.



CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

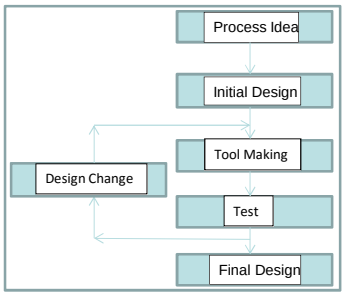
Examples of successful application of FEA in Fasteners Industry

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

Starting from the product drawing the engineer has to design the forming sequence, chose the machine and designs the tooling.
He may have an idea or he simply develops the new part out of existing progressions for other parts. He will then make the design and tool drawings and will order the tooling.
After arrival of the tools the try out on the machine will start. Very often the process will not work sufficiently. So the engineer has to run several trial and error loops to find out a suitable progression.

Examples of successful application of FEA in Fasteners Industry

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



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

Examples of successful application of FEA in Fasteners Industry

Using FEA the engineer will model his ideas in FEA and will find out first whether his process idea will work instead of ordering the tooling. In addition he will get useful technological information (Stresses, Strain, Flowlines etc) that will enable him to generate optimized designs. In case that his ideas will not lead to success for various reasons he can try other ideas or can give it up before wasting money for testing. In case of success he can study the tooling layout and can optimize that as well.

Like this he can find an optimized design before even making any try out. The first trail on the machine will normally be successful and only small adaptions may be necessary due to not perfect modeling /1/.

This is what most of the people talk about and hope that it will happen.

Examples of successful application of FEA in Fasteners Industry

In practice we have a lot of users reporting about big success.
But there are still others that are not so successful. The reasons may be very different and shall not be discussed in detail here.

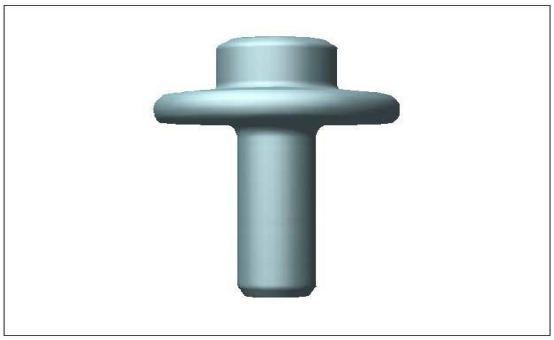
This presentation shall animate those who have problems
- to search for help and support to improve their level

and those who still do not use FEA at all
- to take a step forward soon.

CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt



Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt

Using his knowledge and/or some support tools the engineer came up with his approach to produce the fastener. He simulated his idea but he did not check the available information in total.

The loads looked ok and the form could be reached. So tools were ordered and the first tests were done.

But the fastener failed in testing. There appeared cracks at the outer diameter.

CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

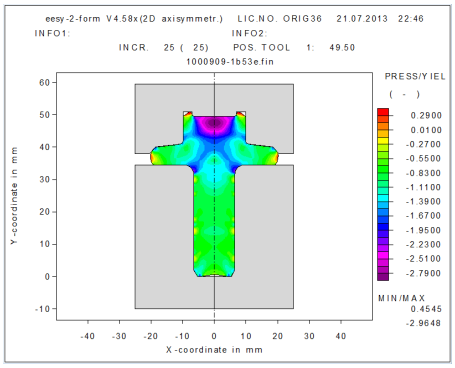
Examples of successful application of FEA in Fasteners Industry

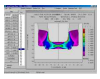
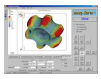
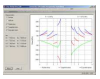
Design of a Process to form a Hex bolt

Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt

The engineer re-checked his simulations and found the very clear indication that his part would fail by interpreting the stresses correctly.

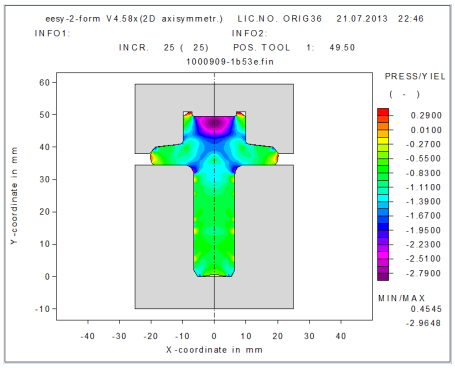


  
CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt

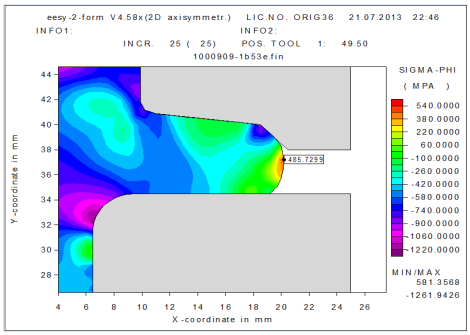
The ratio between hydrostatic pressure and yield stress shows critical areas at the top of the hex and at the flansh. (This ratio should be negative – values of 0.45 indicate that locally nearly all stresses are positive – this is indicating the danger of material cracking)



Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt

The tangential stress reaches 485 MPa at the surface.
It is the main stress because the others (Sig xx and Sig yy) are about 0 MPa. The yield stress is about 530 MPa. So the single tangential stress is the dominating stress.

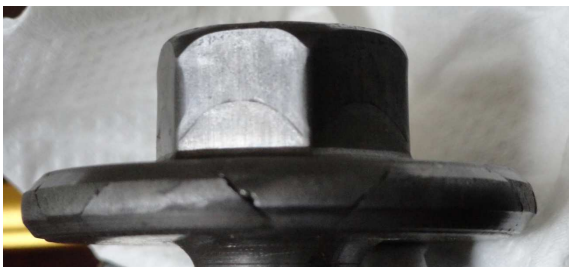


CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Design of a Process to form a Hex bolt

As the screw material is a ductile material it will fail at an angle of 45° to the direction of the main stress (this is the direction of maximum shear stress). This is exactly what the screw did. Due to the asymmetry of the hexagon head the cracks appear perfectly orientated to the hexagon asymmetry



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

Examples of successful application of FEA in Fasteners Industry

Failure of a screw that is not caused by wrong progression

CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Failure of a screw that is not caused by wrong progression

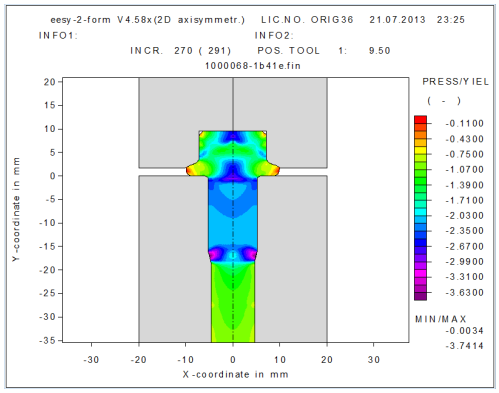
The next example shows a failure in a screw that is not caused by a wrong progression. The search for a better progression was not successful.

By learning from the simulation the engineers can avoid costly trails in future and in the dispute with the supplier there will be no discussions anymore.

Examples of successful application of FEA in Fasteners Industry

Failure of a screw that is not caused by wrong progression

The ratio between hydrostatic pressure and yield stress shows values that are even negative.

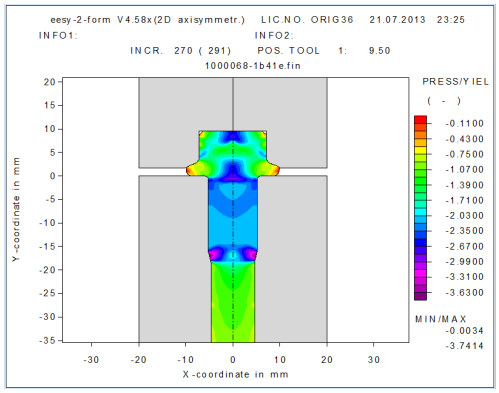


CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

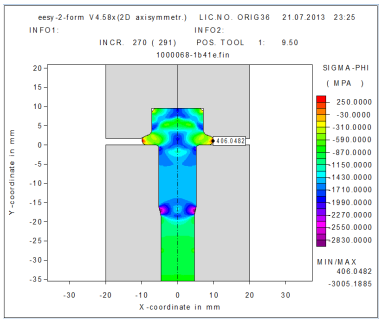
Failure of a screw that is not caused by wrong progression

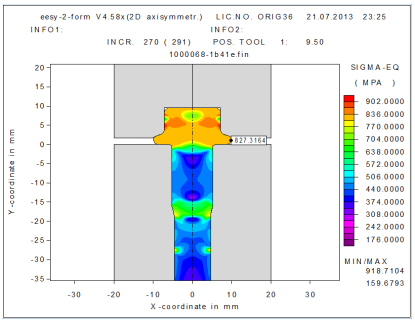
This means that the biggest positive stress is less than half of the yield stress. Even so the tangential stress is positive it cannot lead to cracking of the part. Furthermore the part would have cracked under 45° to the tangential stress if the crack is due to tangential stress.



Examples of successful application of FEA in Fasteners Industry

Failure of a screw that is not caused by wrong progression

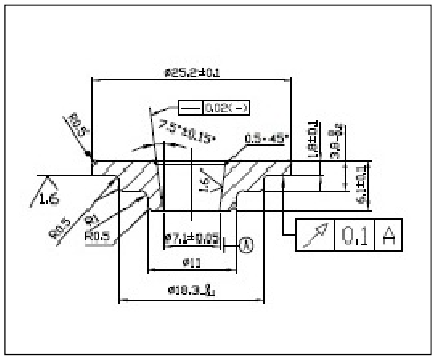




In this case the engineer can call the supplier to replace the material directly.
This kind of failure is provable a material problem.

Examples of successful application of FEA in Fasteners Industry

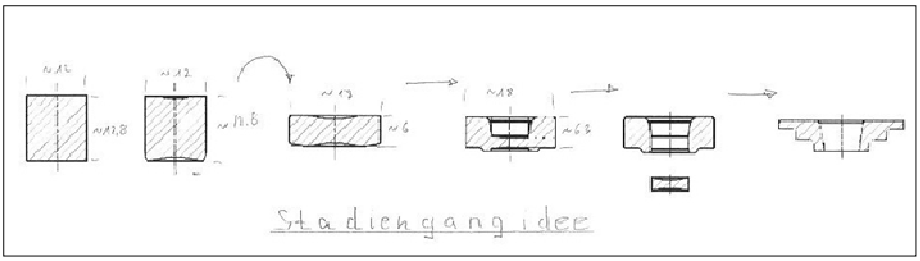
Production of a valve spring retainer: ***unusual tool design***



Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer

Progression idea

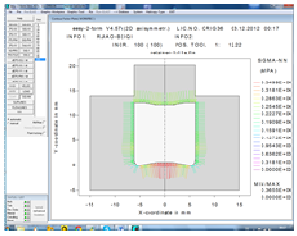


CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

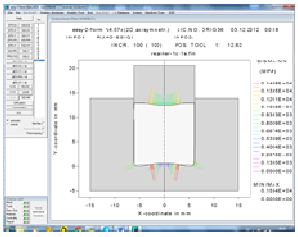
Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer

By means of simulation the material flow and the fine adjustment of the tools was studied to get the right shape at low loads.



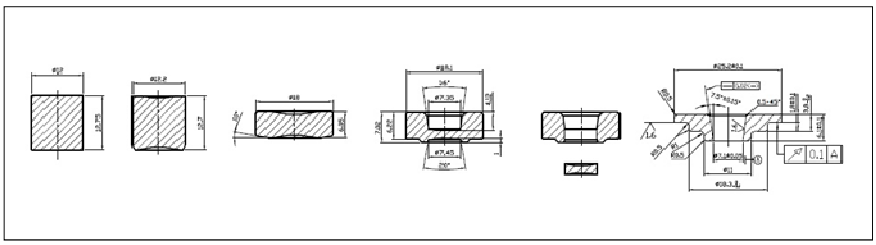
Too much filling-> high loads



Symetrical forming at low load

Examples of successful application of FEA in Fasteners Industry

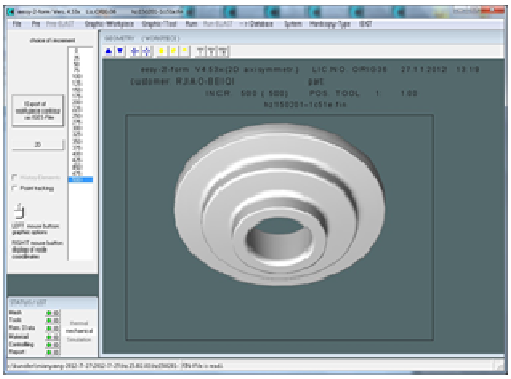
Production of a valve spring retainer



Final progression design

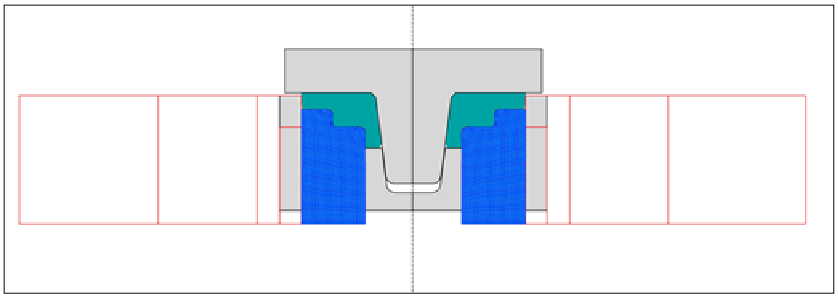
Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer – expected product geometry



Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer



Usual design with insert, pre-straining ring and body

Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die

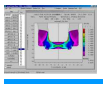
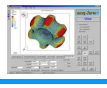
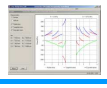
Usually the insert is made from carbide. Typical would be G55.

The carbide will be pre-strained by a ring.

Both together will be pressed into the body.

The insert has to be pre-strained in a way that it does not have to take any positive tangential stresses und load. At the inner surface shear stresses have to be avoided as well. In critical areas the tool could be split as well to avoid such local stresses.

The split between carbide insert and pre-straining ring is often chosen at the outer diameter to avoid positive stresses there as well.
In general three ring systems are chosen to not make the tooling too complex.

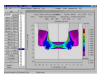
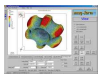
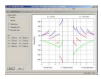
Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die

By using adequate software the engineer is able to make an optimal dimensioning of the die layout.

The layout he will investigate by FEA again to find eventually critical stresses.

In doing so he can vary the chosen materials, their heat treatment, the interference and the construction to find the best design for a reliable tooling.

Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die

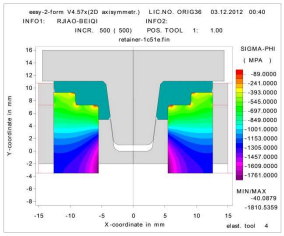
The following pictures show the analysis of the tool layout.
The analysis of the insert shows negative tangential stresses but the shear stresses reach a critical level.

The layout was calculated for G55 as insert material and DIN 1.2344 with HRC 50.

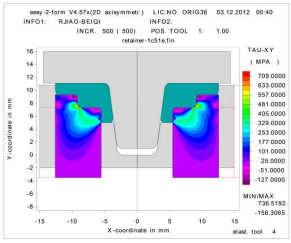
To avoid these stresses the engineer can „play“ with different layouts and/or other materials.

Examples of successful application of FEA in Fasteners Industry

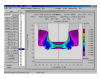
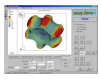
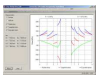
Production of a valve spring retainer - Design of the die



Tangential Stresses

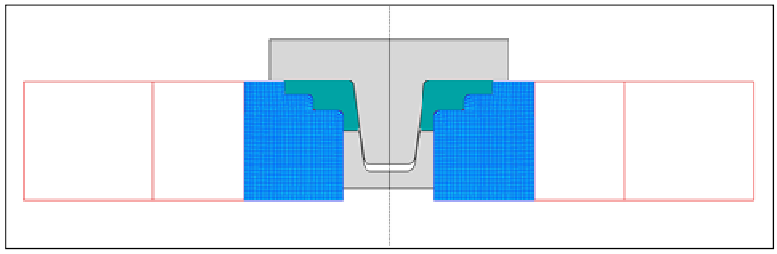


Shear Stresses

  
CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

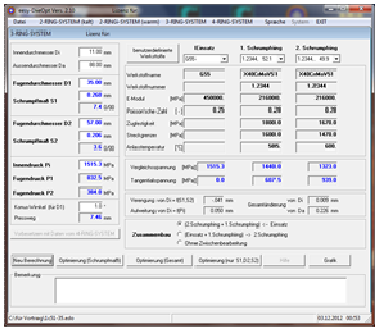
Production of a valve spring retainer - Design of the die



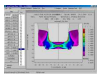
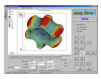
The engineer had the idea to design the inner tools as one block
- against usual design rules

Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die



The outer diameter of the insert was chosen even bigger than the outer diameter of the product..
The design system allows to calculate the optimum values for the outer diameter of the pre-straining ring, the interferences, the right material and the right hardness of the pieces.

  
CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die

Using these values the tool analysis was performed and surprisingly the results were much better than all other layouts studied before.

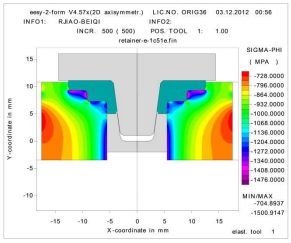
In this case the choice of a solid big insert was much better than a structured die layout.

The practical test proved the results. This design was by far much better than all other alternative layout.

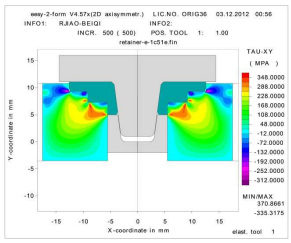
:O !

Examples of successful application of FEA in Fasteners Industry

Production of a valve spring retainer - Design of the die



Tangential Stresses



Shear Stresses

Zusammenfassung

Despite all ongoing discussions FEA is a very useful tool for industry.
It helps to avoid a lot of costs. It helps to improve technology.
The examples show that FEA can be used in a much better way as some discussions make believe.

To get the best results FEA has to be used continuously and it has to be used for material flow analysis as well as for tool studies or material considerations.

Unconventional approaches are allowed and wanted even to extend the technological knowledge. Used by the experienced engineer in the right way FEA is perhaps the strongest weapon to stay ahead in the daily competition.

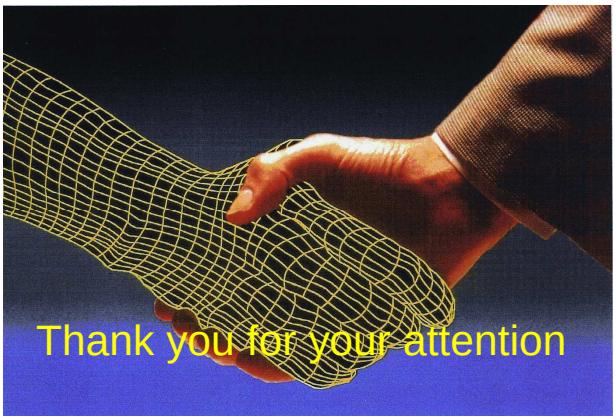
Acknowledgements

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 articles like this.

CPM Gesellschaft für Computeranwendung,
Prozeß- und Materialtechnik

Trust in “eesy” simulation



Customers are happy to solve their daily problems with simulation