Examples of successful application of FEA in Fasteners Industry

-Actual examples from around the world-

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Abstract:

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.

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

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In the traditional procedure the engineer will order tooling and after arrival will start with the try out on the machine. 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. This cost time and tooling and is therefore quite expensive. In some cases all the testing is wasted and the product cannot be produced.

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

The FEA helps the engineer to generate process designs.

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.

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.

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 problemsl to search for help and support to improve their level or those how still do not use FEA at all to take a step forward soon.

2. Examples of FEA Application in Process Design

2.1. Design of a Process to form a Hex bolt could have been improved

The following bolt had to be produced:

Figure 1: Bolt to be produced (Hex shape simplified)

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 test were done.

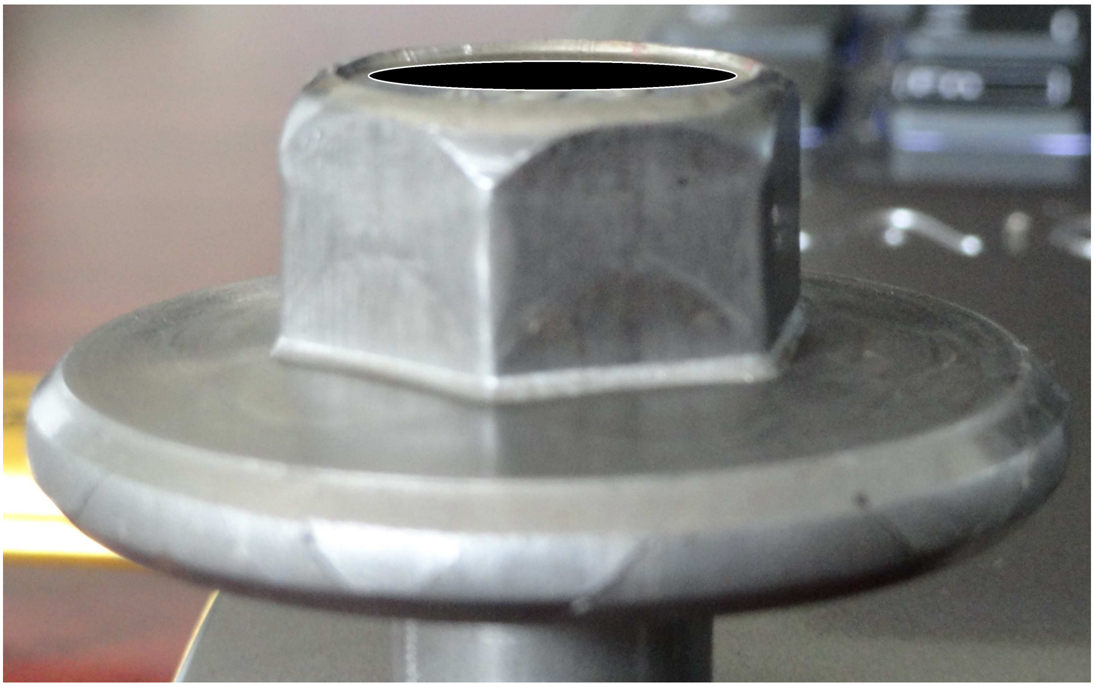

Figure 2: Resulting product from first progression

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

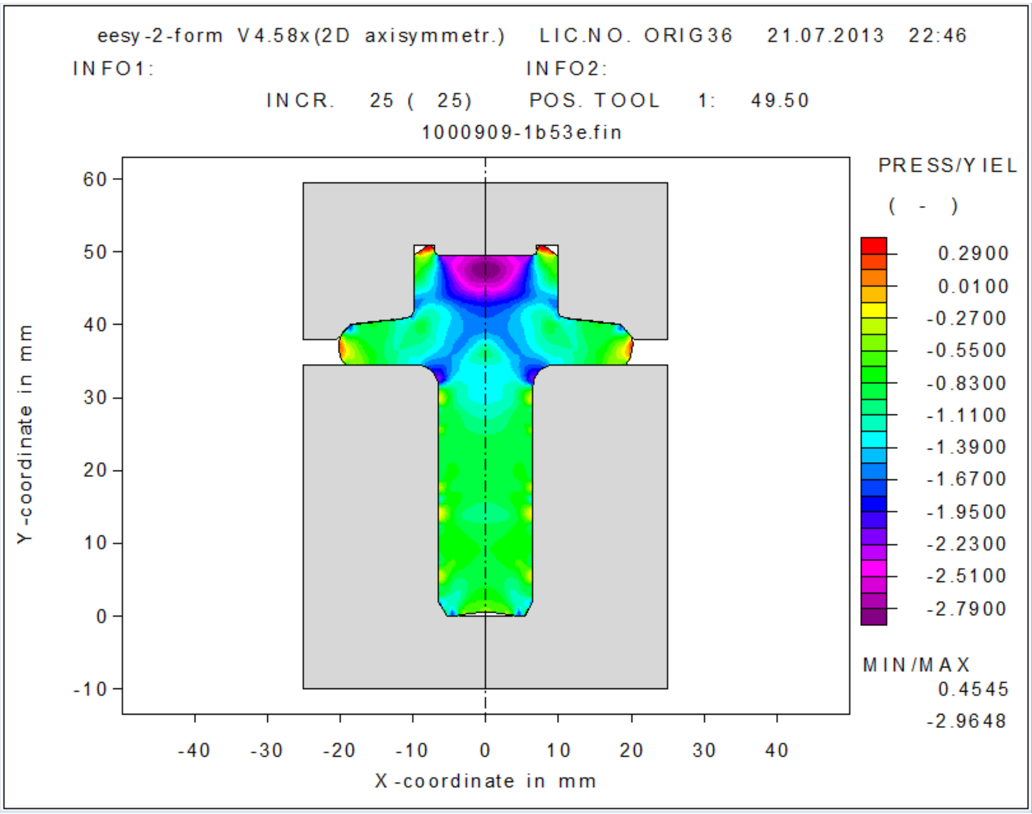

Figure 3: The ratio between hydrostatic pressure and yield stress

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)

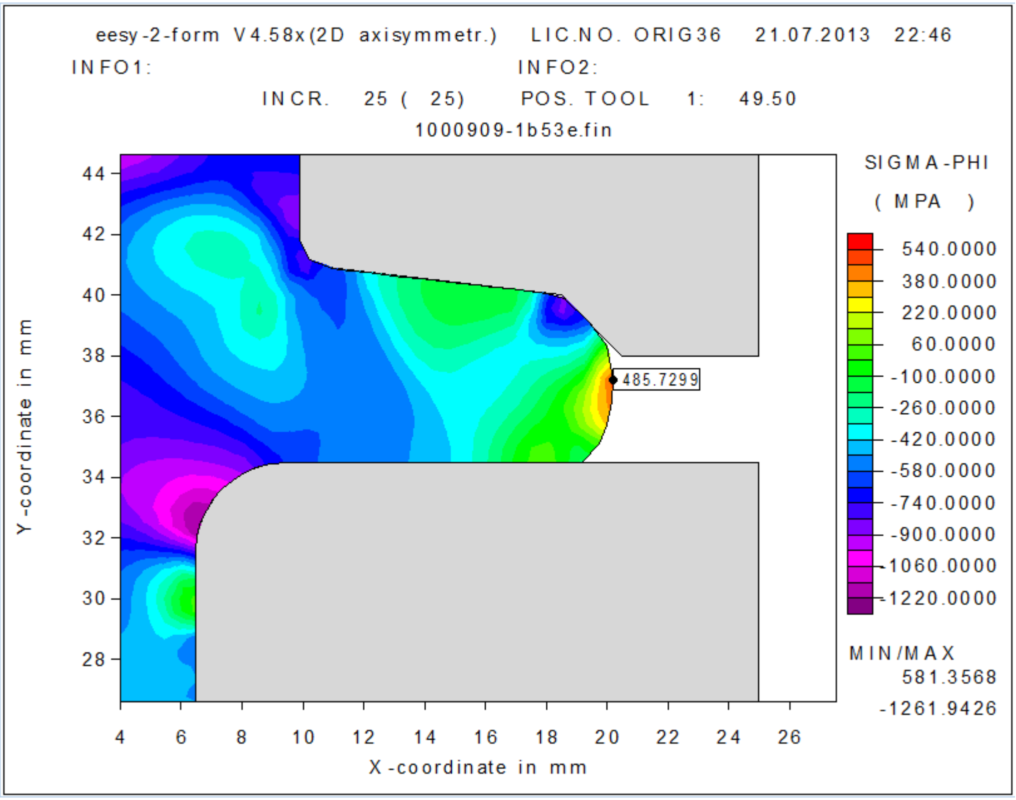

Figure 4: The tangential stress is too high

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. As the screw material is a ductile material it will fail under 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. Do to the asymmetry of the hexagon head the cracks appear perfectly orientated to the hexagon asymmetry

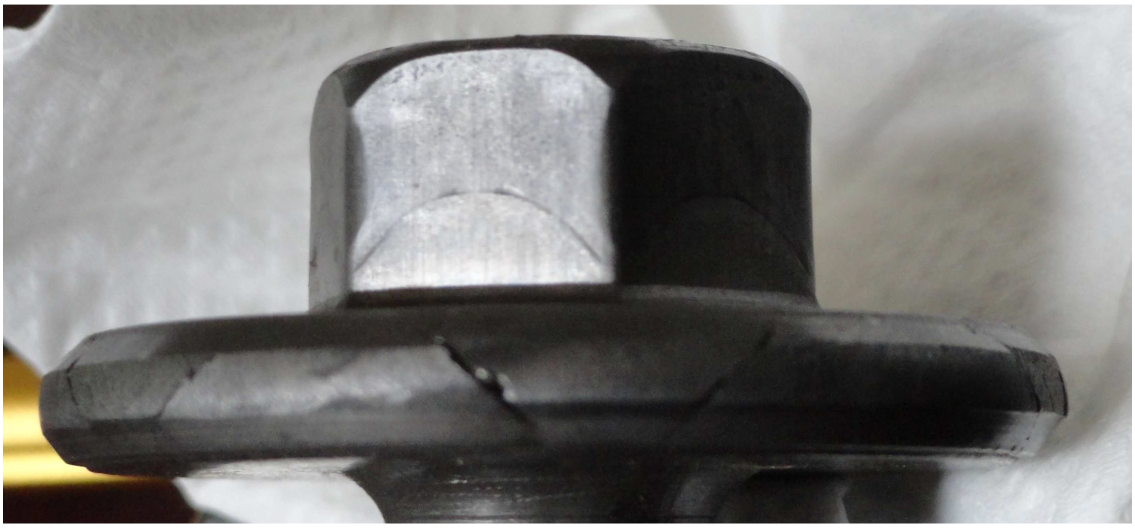

Figure 5: Screw failure under 45° to the main stress orientated to the hex head

This un-successful trail could have been avoided if the engineer would have checked in detail before ordering the tooling.

These kind of problems happen quite often if experience is considered to be above simulation or to make simulation un-necessary.

Experience is important to not make stupid simulations but a detailed analysis of simulation can not be replaced by experience.

2.2. Failure of a screw 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.

Figure 6: Cracks on a screw

Again this problem (the searching without success) could have been avoided if the engineer would have simply checked his layout more in detail in simulation.

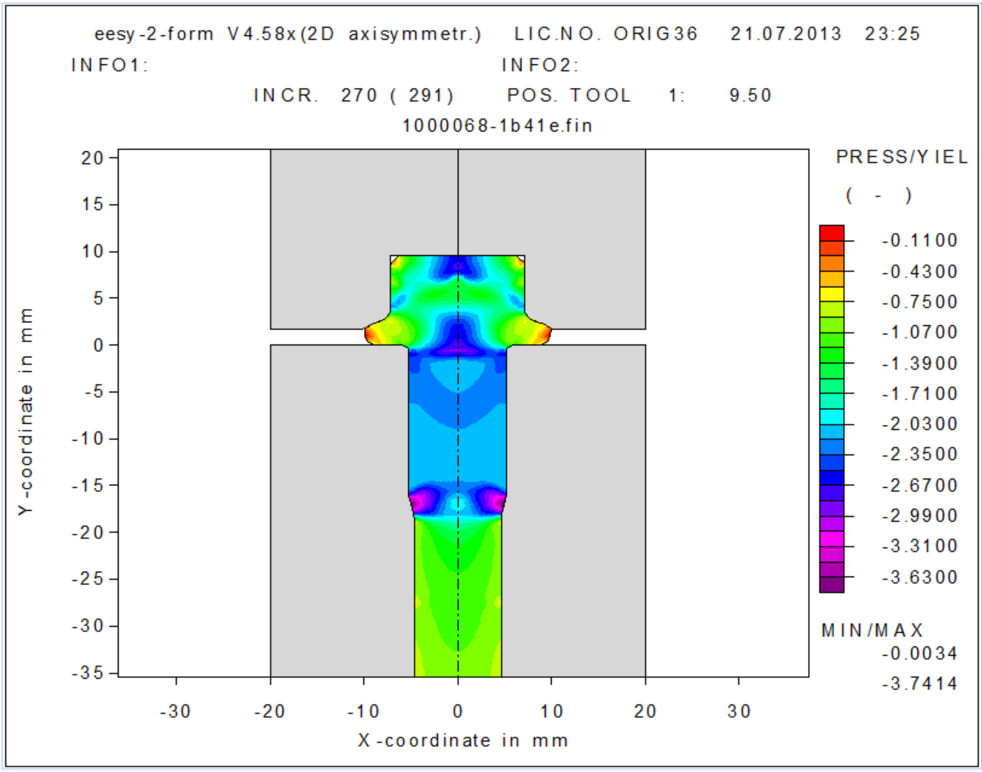

Figure 7: The ratio between hydrostatic pressure and yield stress

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

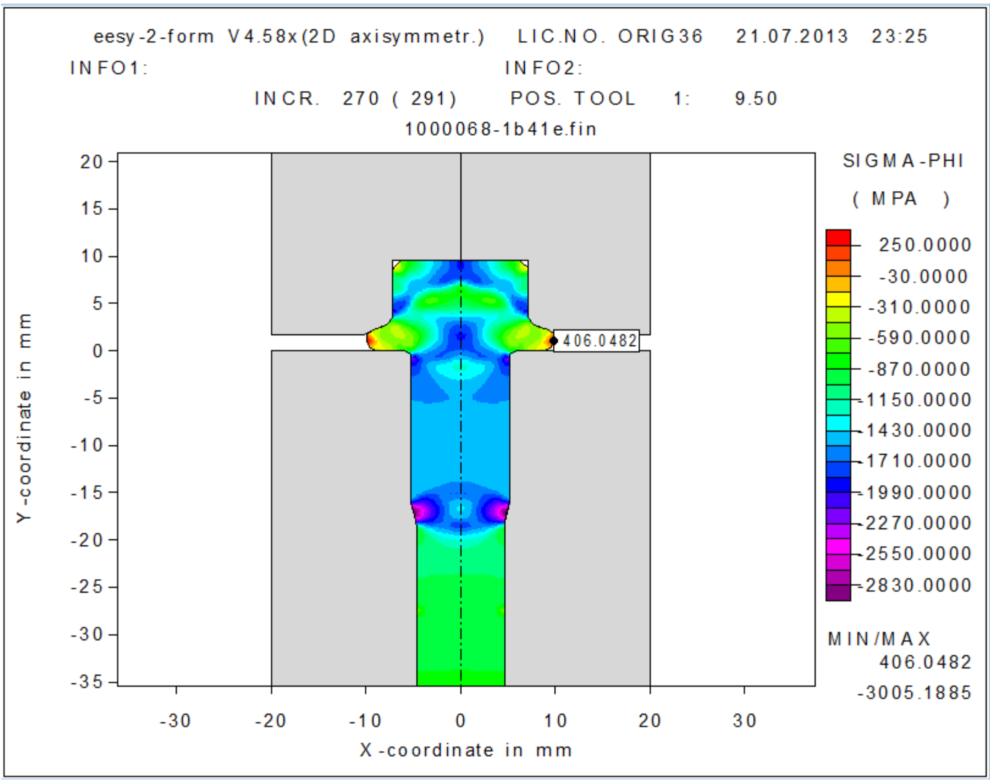

Figure 8: The tangential stress

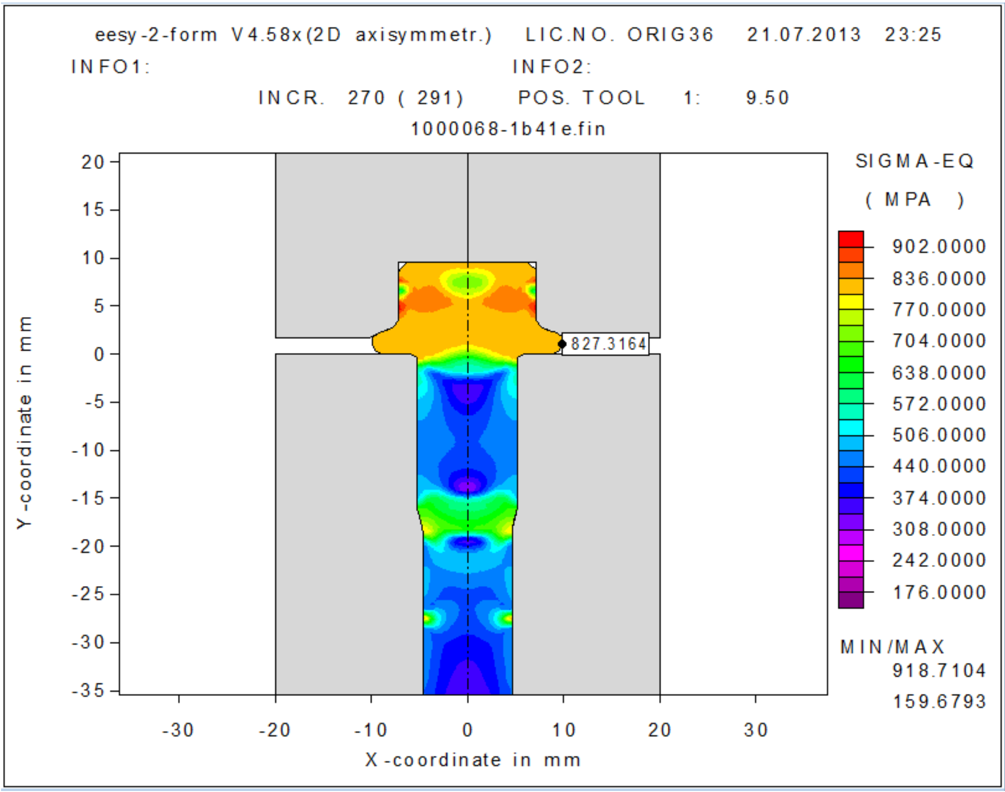

Figure 9: Yield Stress

In this case the engineer would have called the supplier to replace the material directly.

This kind of failure is provable a material problem.

3. Conclusion

After 25 years of usage of FEA software to analyze progression designs there is still a discussion about the sense or nonsense of using simulation in forging industry. Some argue that the systems are too complex to be used others think that they are not precise enough still. Scientists often mention that the data and algorithm used are scientifically not really correct.

Despite all these discussions FEA is a very useful tool for industry. It helps to avoid a lot of costs. It helps to improve technology.

And it does all this if it is used consequently in a proper way.

The examples were successful ones because these users will use FEA in a much better way in future.

4. 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 /1/. This information and the comments are very helpful to improve FEA software and promote its use in articles like this.

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