CASE 4: Forging a “pancake”

Simulation failure due to non complete material data

Product: Pancake

Product Material: Aerospace alloy

Tool Type: Rigid for the plastic analysis

Process Type: 2D Axis-symmetric, Thermo-mechanically-coupled

Press Type: Hydraulic Press

Software Used: eesy-2-form

Company: Leistritz Turbinenkomponenten Remscheid GmbH, Germany

Introduction

In this analysis a process was analysed to find the correct layout before forging.

The real forging showed surprisingly a folding problem. Then the modelling was reviewed and the problem could be identified as using non-complete material data. The missing data was added and then the simulation showed the correct result. Then the simulation was used to optimize the process. A solution was found and verified.

Figure 1: Billet to be forged in a pancake

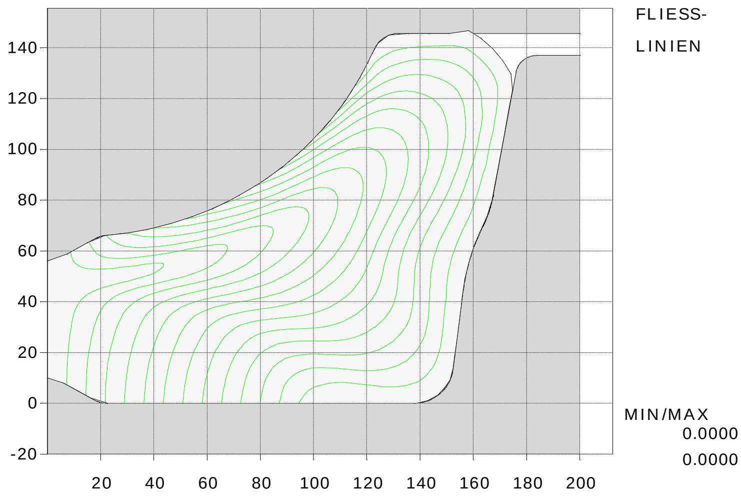

Figure 2: Result of the original simulation

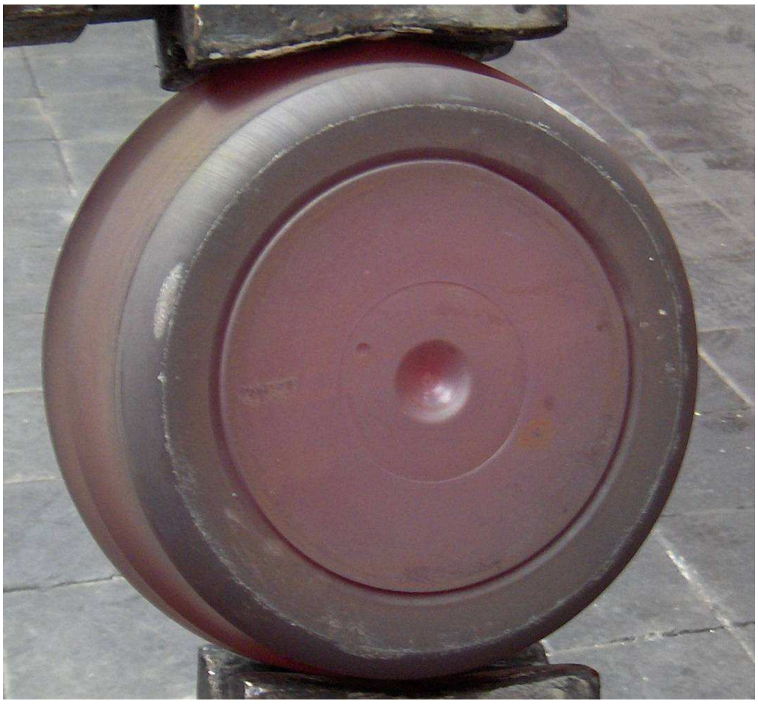
Figure 3: Result of the forging

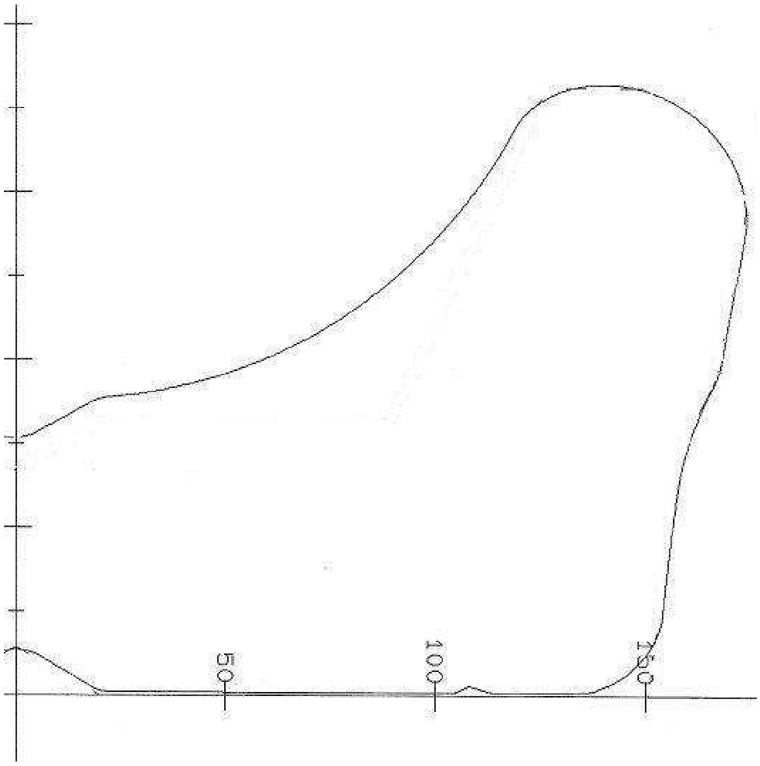

Figure 4: Measurement of the forged geometry

Key Points of Finite Element Model

Plastic simulation

The process was modelled in subsequent model files. The first simulation is the model to simulate the temperature distribution during the transport from the furnace to the forging machine. The result is the correct temperature distribution in the work piece before forging. To do so a standard thermal simulation was performed and parameters were set as known from the experience in application of the simulation system over some years.

Then the thermo-mechanical simulation of the forging operation was performed.

Again known data from experience and measured yield-stress strain curves were used.

The following data had to be put in for the modelling:

- Geometry of the billet (Volume of the piece, dimensions)
- Material Characteristics of the alloy (measured data provided from the systems database plus thermo physical data from literature/experience)
- Properties of the press to be used in means of stroke and machine characteristics
- Friction coefficients for the used combined Coulomb / shear law.
- All tooling dimensions

Any geometry can be created within the software's interface or imported via .iges files.

The mesh generation, the re-meshing options, the stepping (increments) of the simulation etc. are set by the system automatically.

With this information the plastic analysis of the process was performed. The simulation time is some minutes on modern Pentium 4 processors.

The results of the plastic simulation showed a perfectly formed part (figure 2).

But the result of the forging later was different (figures 3 and 4).

Problem analysis

As the results of the simulation did not match with the results of the forging the engineer had to find out why this difference appeared.

So the simulation results were studied carefully.

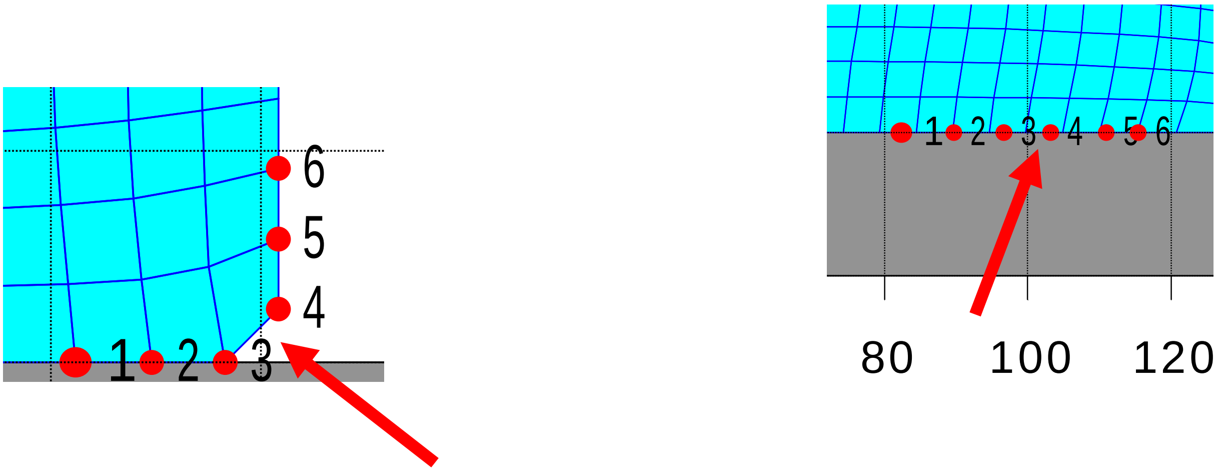

Figure 5: Point tracking feature to be used

The point tracking feature of the system was used to find out any inconsistency.

But the result showed nothing indicating any irregularity.

So consequently the physical properties were checked like temperature distribution.

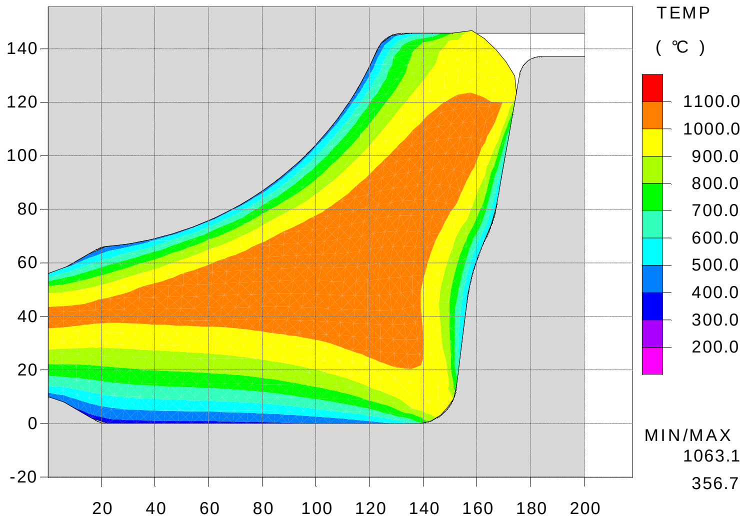

Figure 6: Temperature distribution

This analysis showed that in the area of question there is a significant cooling down in the forging. Temperatures are only about some 600℃.

So the engineer came up to check for the input data to be valid in that temperature range.

As found the material data was only provided at higher temperatures.

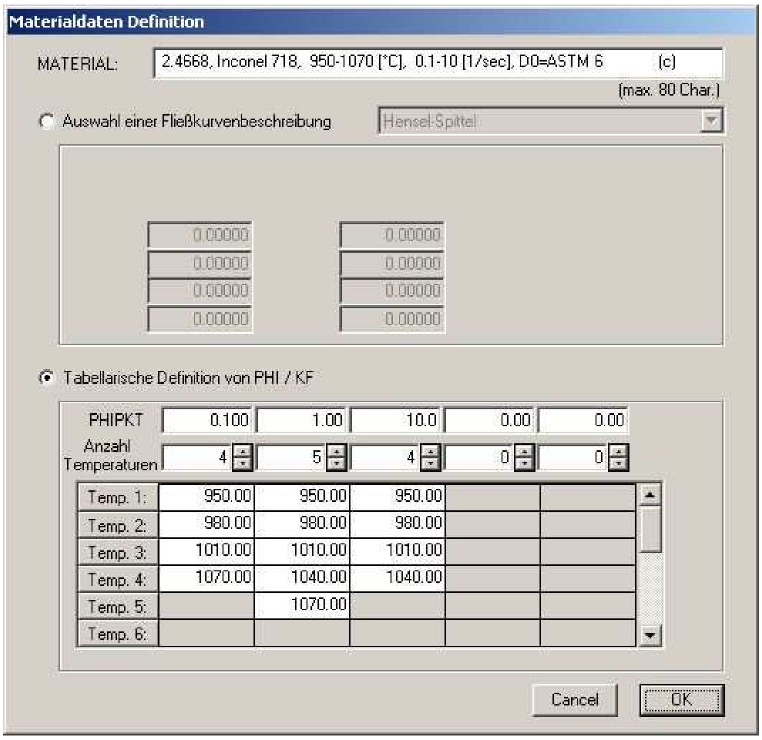

Figure 7: Yield stress-strain curve definitions

The finding was that the data provided in the system was not sufficient.

The supplier provides measured data and indicates the range of validity. This is the normal area of forging. But in this case the real process was not in the expected area of temperature. The actual temperature of the process was out of that range. So after consulting with the supplier additional data could be provided and added.

Then the simulation was performed again.

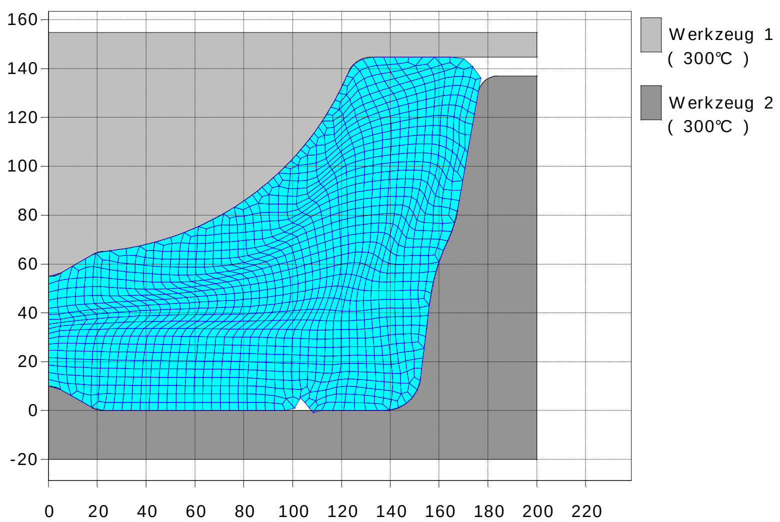

Figure 8: Simulation with extended data

Now the simulation showed the correct result.

After verifying the results of the new modelling the engineers performed several simulations to work out a good process design.

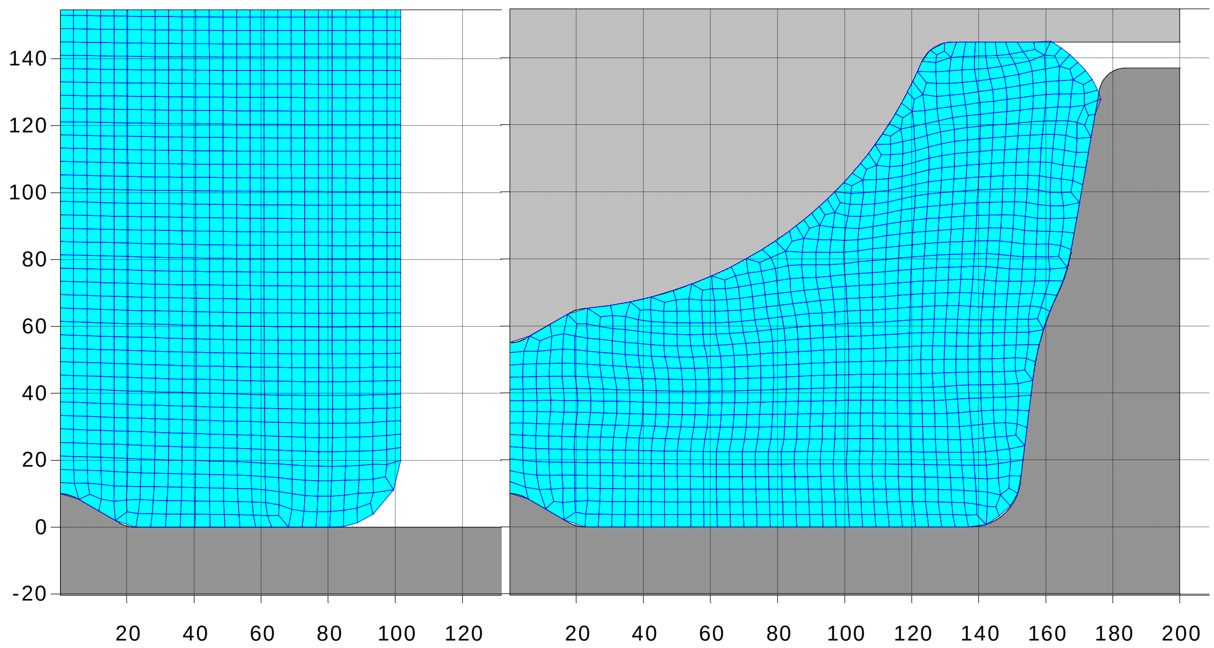

Figure 9: New design with revised model

The simulation showed no further problems.

The process was tested and showed good results.

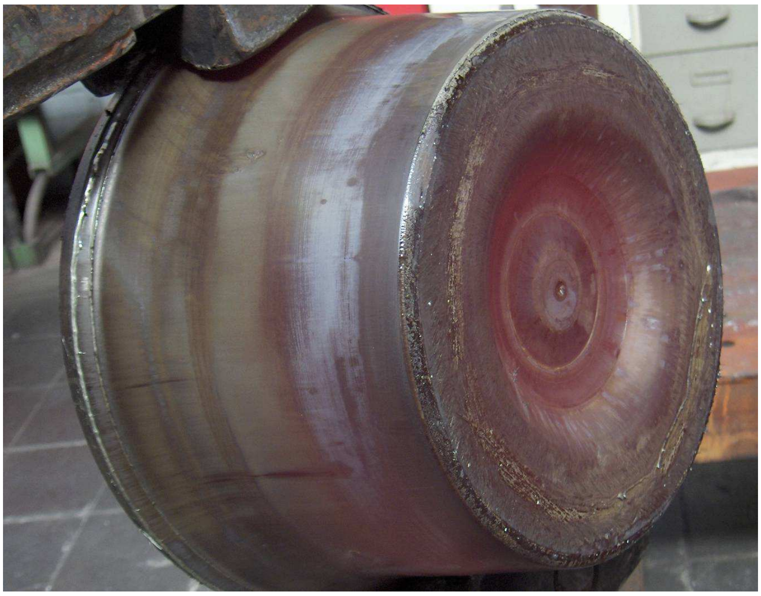

Figure 10: New design with revised model – result in forging

The process could be performed successfully.

Conclusions

The application of FEM does not only require a good simulation system. It requires also a good support of the supplier to support the customer to analyse problems that may show up and to guide him to find solutions. In this case the problems were the non-complete set of data that was used. The system provided data in the typical range of forging of the specific material. But in some cases the real application may be out of that range. So data had to be added. This is a good example that shows that the support and knowledge in simulation and forging of the supplier of the simulation system and the knowledge of the user is required to be very good.

Similar experience of some users of simulation codes lead to a project of the German Cold Forging Group (GCFG) and the “Industrieverband Massivumformung” (IMU) to initiate a project to enable industries to get reliable material data along guidelines of best practice from any source.

This project was performed under the guidance of CPM GmbH, Germany and results can be asked form the GCFG or the IMU or CPM GmbH (www.cpmgmbh.com).