CASE 5: Forging an “inner race”

Simulation of the filling in the second operation (net shape forging)

Product: Inner race

Product Material: 16MnCr5

Tool Type: Rigid for the plastic analysis

Process Type: 3D, mechanical

Press Type: Eccentric vertical press

Software Used: eesy-form

Company: Acopecas Industria de Pecas de Aco Ltda., Brazil

Introduction

In this analysis the filling of the tooling was studied to avoid long and cost intensive development on the machine. The aim was to develop the first operation in a way that in the second operation the part could be made net shape.

The following picture shows a similar product during traditional process development. The first operation is shown.

Figure 1: Operation one of forming an inner race (during process development)

Key Points of Finite Element Model

Plastic simulation

The process was modelled in two separate models where the geometry result of the first operation was introduced into the model of the second operation.

The following data and/or information had to be provided:

- Geometry of the cut off
- Material data (measured yield stress – strain curves from the systems data base)
- Tool geometries (to be provided as STL file from a CAD system)
- Properties of the press in means of stroke and strokes per minute
- Friction coefficients

After putting in this information the system assembles the model and shows the assembled situation as shown below.

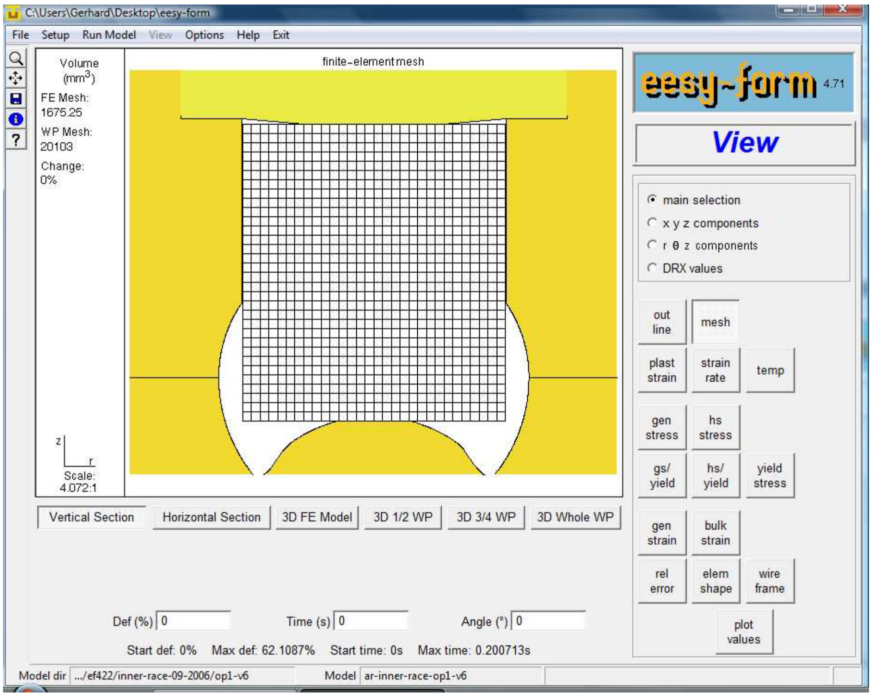

Figure 2: Model of operation one (in assembled position as vertical section)

The mesh generation is automatic. The user can influence the automatic re-meshing by setting specific parameters if wanted. To get a most precise result the mesh is homogeneous. No local refinement to safe computing time is used.

The increments are chosen and adapted by the system automatically. The user defines the final tooling position only.

The simulation was performed on an Intel ® Core ™ 2 Duo system running at 3 GHz.

The simulation time per operation was about 2 hours.

Analysis

The figures 3 and 4 show the results of a simulation of operation one.

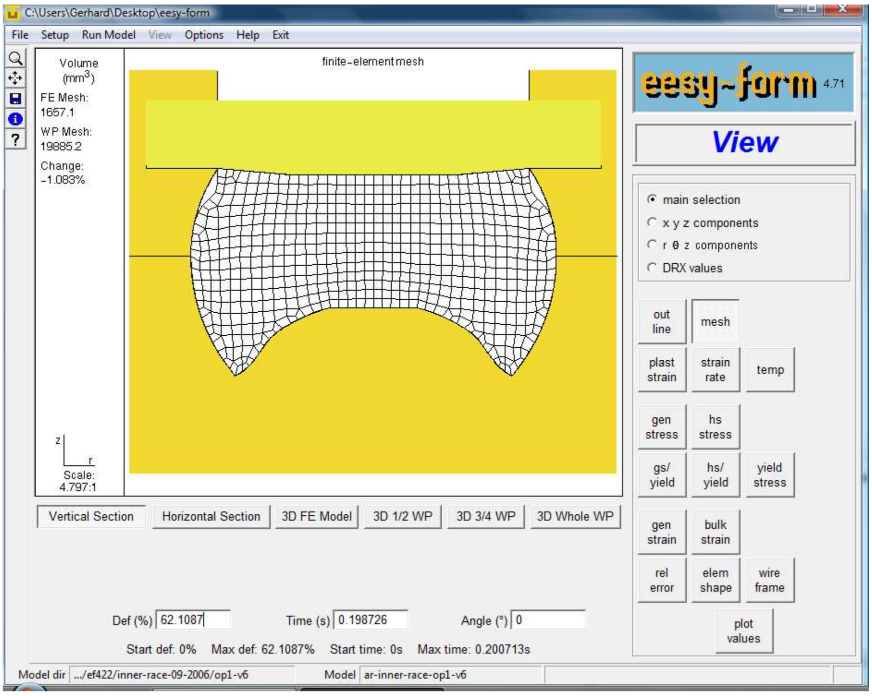

Figure 3: Model of operation one (in final position as vertical section)

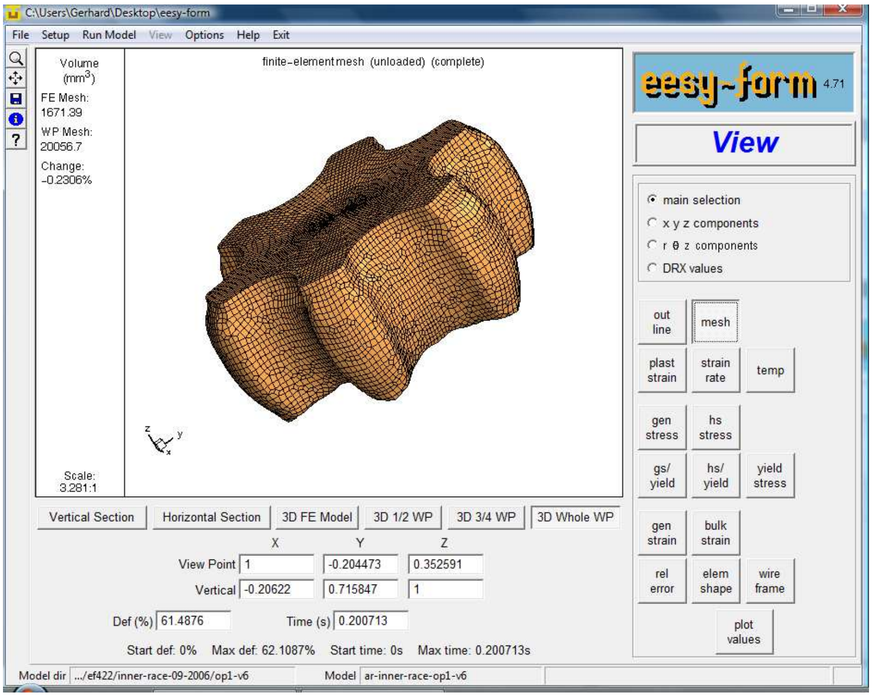

Figure 4: Model of operation one (in final position as 3D view)

The figures 5 and 6 show the beginning and the end of a simulation of operation two.

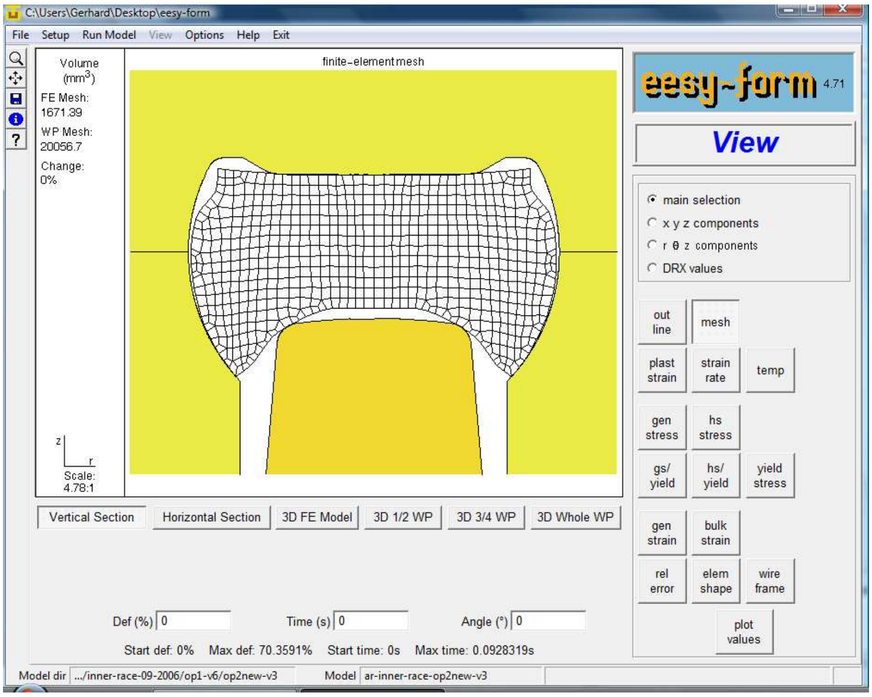

Figure 5: Model of operation two (initial position as vertical section)

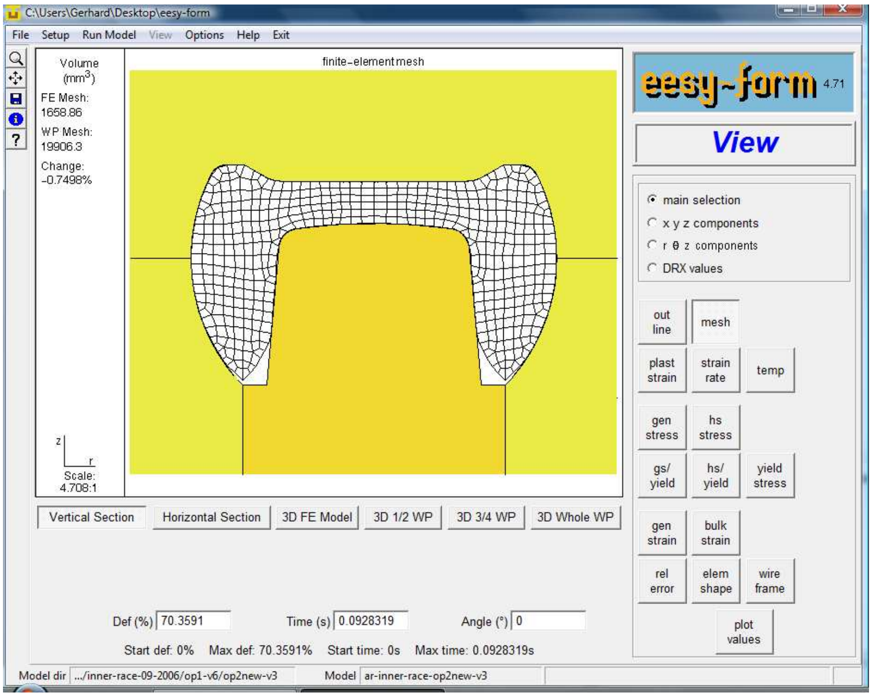

Figure 6: Model of operation two (final position as vertical section)

Now it was important to find out whether the product is properly forged.

On one hand the typical plasto-mechanical results like plastic strain or hydrostatic pressure have to be check for avoiding breakage and / or reduce pressure to avoid tooling problems.

Figures 7 and 8 show such results.

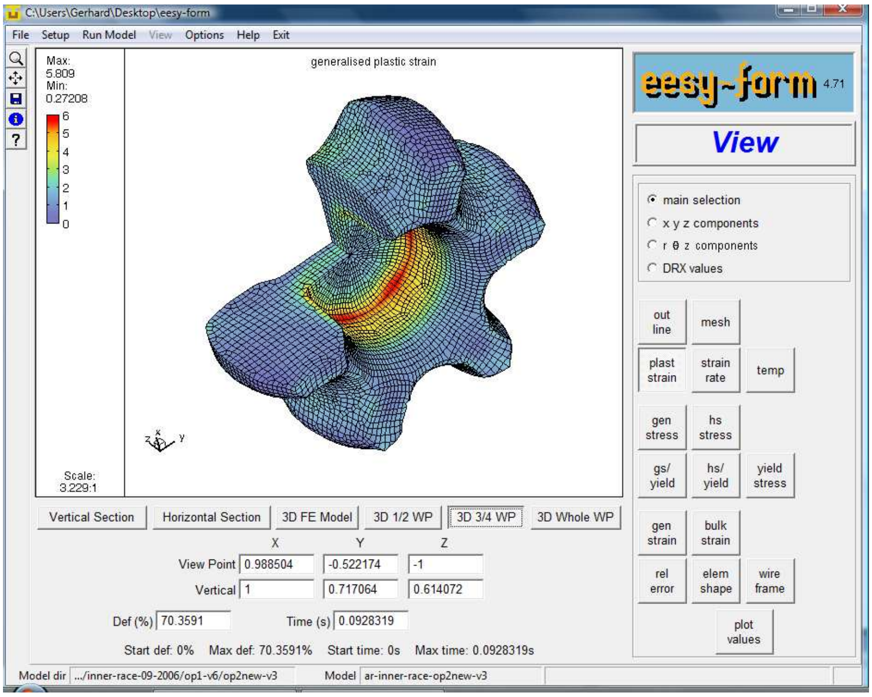

Figure 7: distribution of plastic strain after operation two

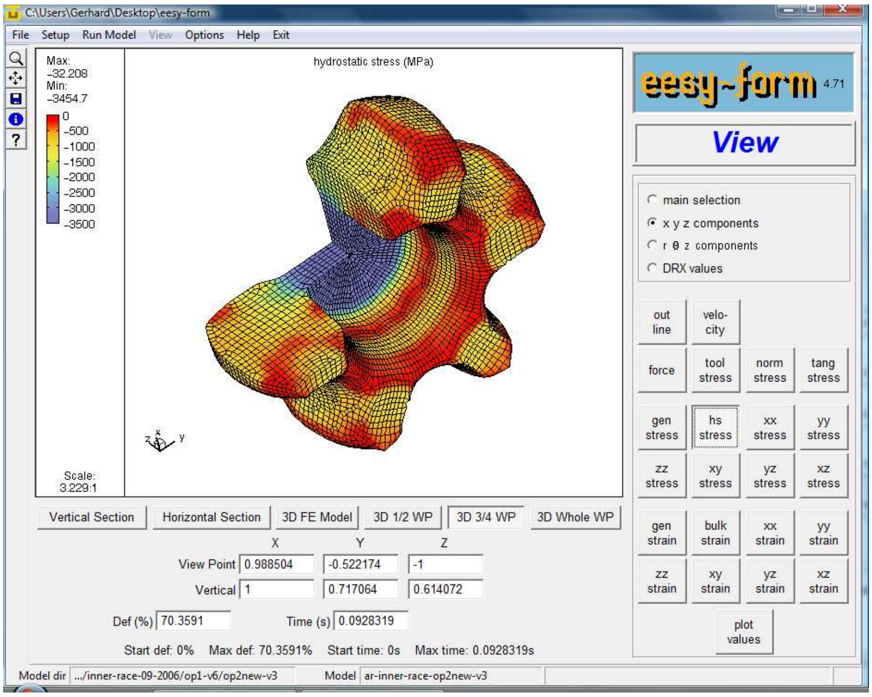

Figure 8: distribution of hydrostatic pressure after operation two

More important for the general process layout was first of all the perfect filling of the piece.

Figure 9 shows the geometrical result of the simulation. The geometry looks well but has to be checked in detail for under filling.

This can be done by checking the tool contact on the piece surface and / or the velocity of the material (material flow).

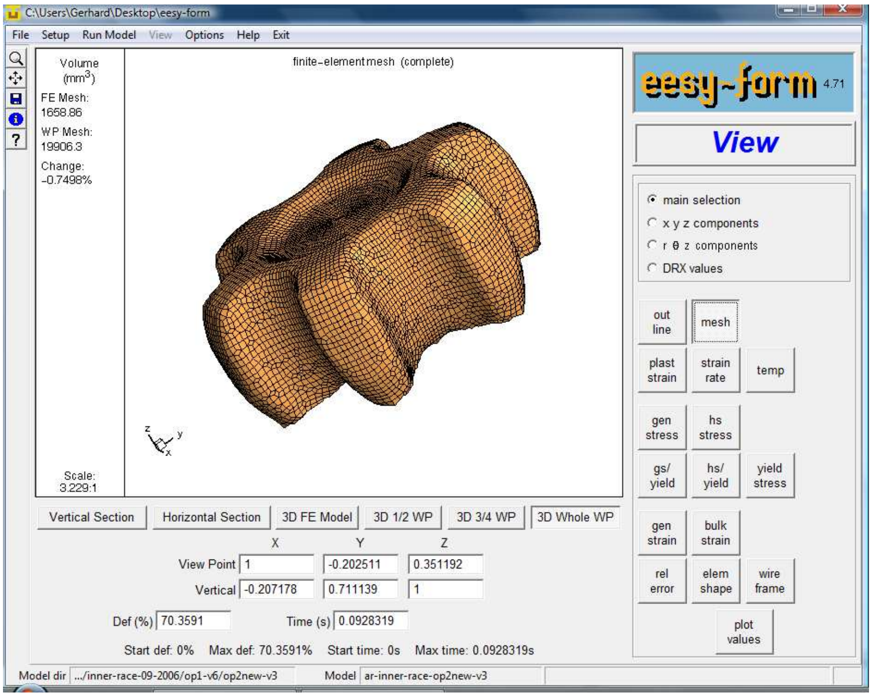

Figure 9: geometry after operation two

Eesy-form provides the possibility to show “normal pressure” on the piece surface. This is done by displaying some vectors at the mash nodes in case of contact. This may indicate that there is no contact or at least no contact pressure on the surface.

Figure 10 and 11 show such pictures of “normal pressure” distribution.

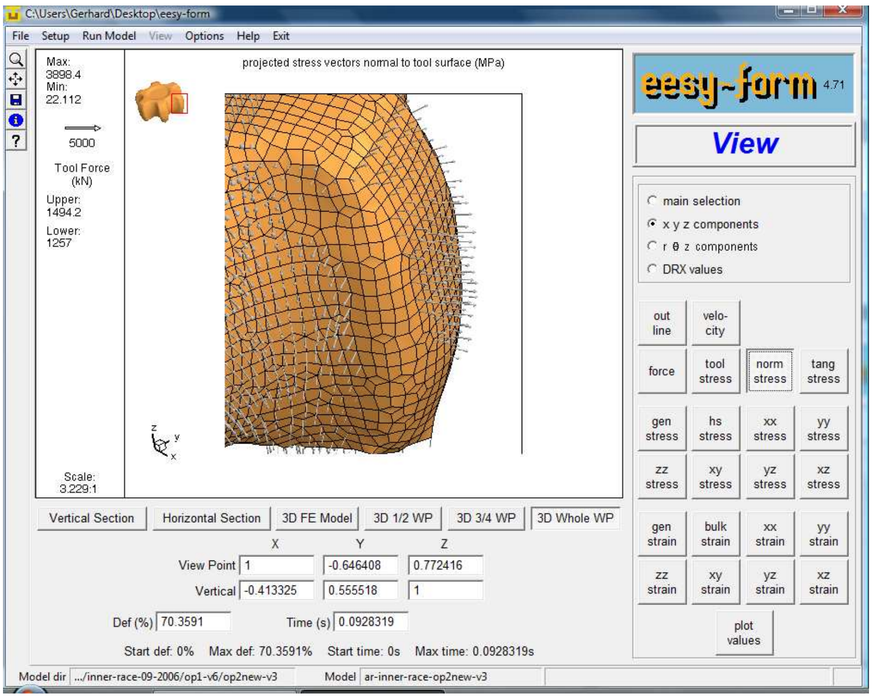

Figure 10: distribution of “normal pressure” at the end of operation two

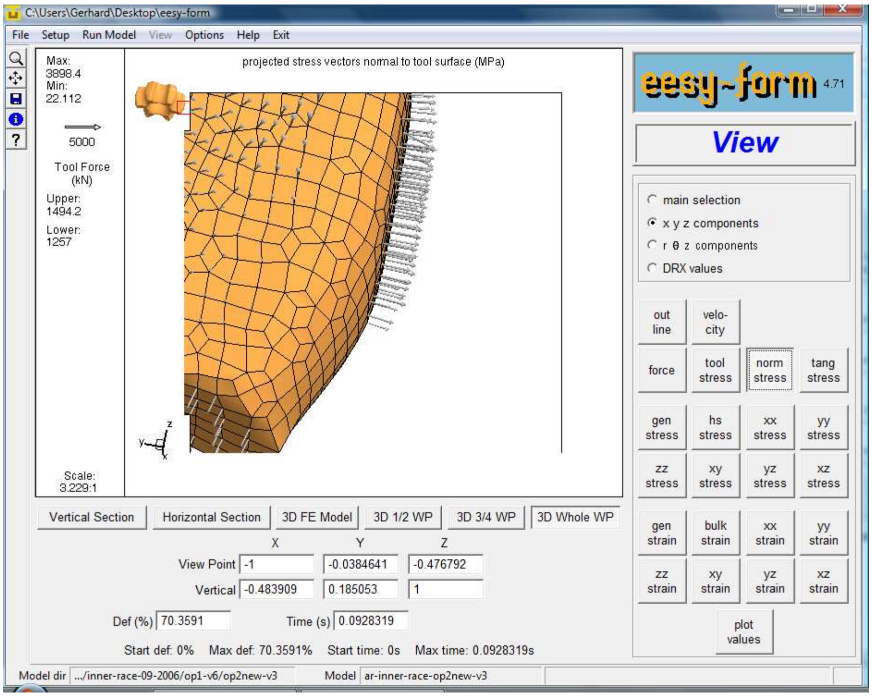

Figure 11: distribution of “normal pressure” at the end of operation two

Besides checking the “normal pressure” the material velocity had to be checked as well to be sure that the material is not only sliding on the tool surface but still has movement towards the tool surface. In that case it is obvious that the piece is not formed properly and the tool cavity is not filled.

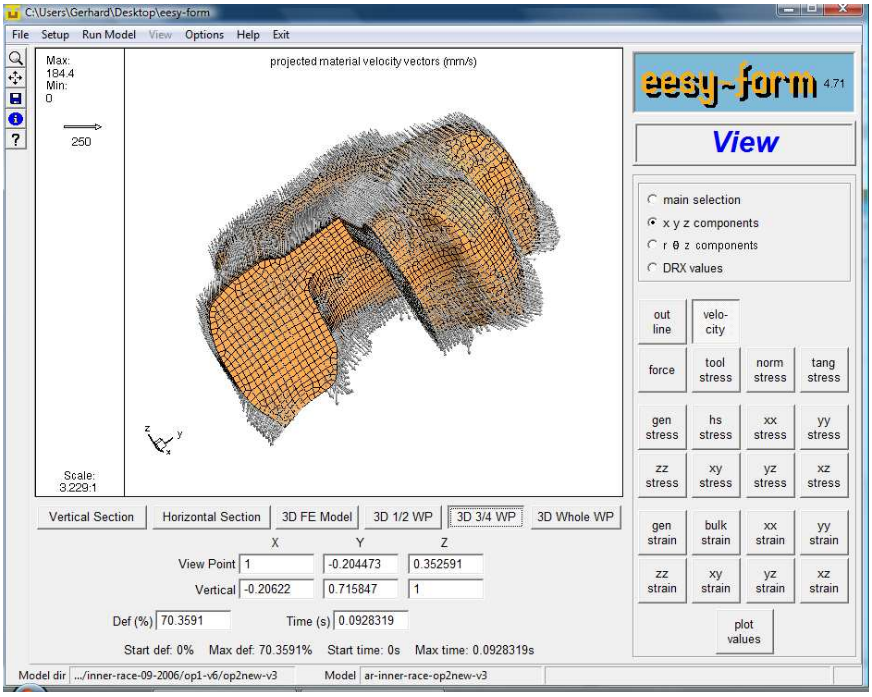

Figure 12: Material movement (velocities) at the end of operation two

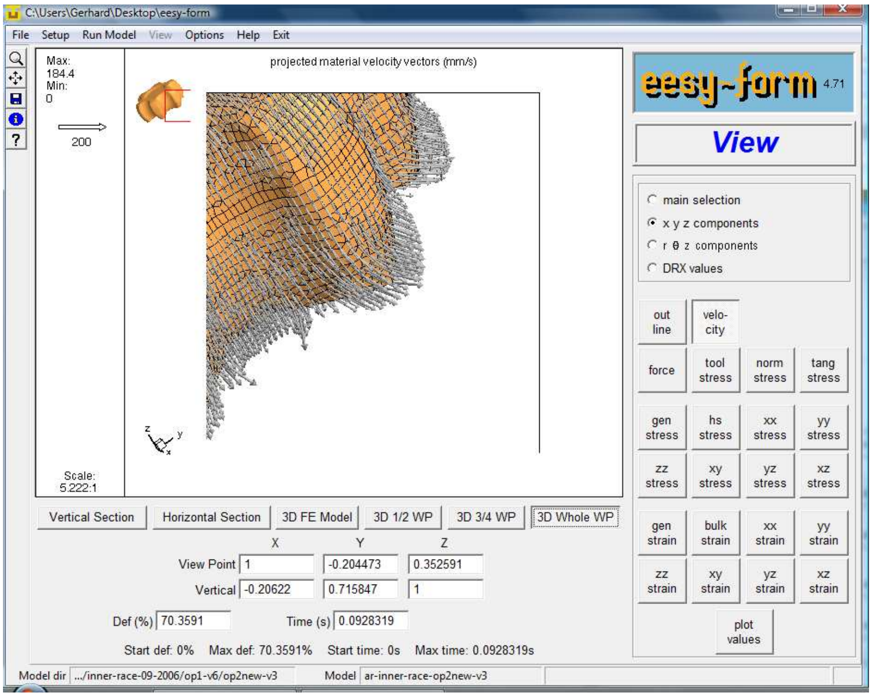

Figure 13: Material movement (velocities) at the end of operation two

Conclusions

The application of FEM has enough precision to provide the required information of under filling.

The model was generated with high precision using a high number of elements. Therefore the computing time was some hours. But the results were so precise that with some variations of pre forms a good design could be found that later in the production could be verified.

The investment in some hours computing time and several days (total project time) of engineering to perform the simulations and to find the solutions is justified compared to longer development time (weeks!) and high tooling costs by working the traditional way of development.