QForm3D

Advanced software for forging simulation

The goals of forging technology :

- Make the parts of the required shape
- Provide required properties
- Do it in time and at the lowest cost

Forging process is a very complicated phenomenon,

Thus even the forger with the years of experience ...

still require expensive forging trials

for each new part to develope

The help can be found

in use of advanced simulation tool like QForm3D

QFORM3D

The most easy-to-use forging simulation software

QUANTOR FORM

QForm3D is created for forges
And to be used by the forgers

QForm3D is

- **Precise,**
- **Affordable**
- **Very simple in use**

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Case study: Large 6 Cylinder Crankshaft

Simulation Inputs:

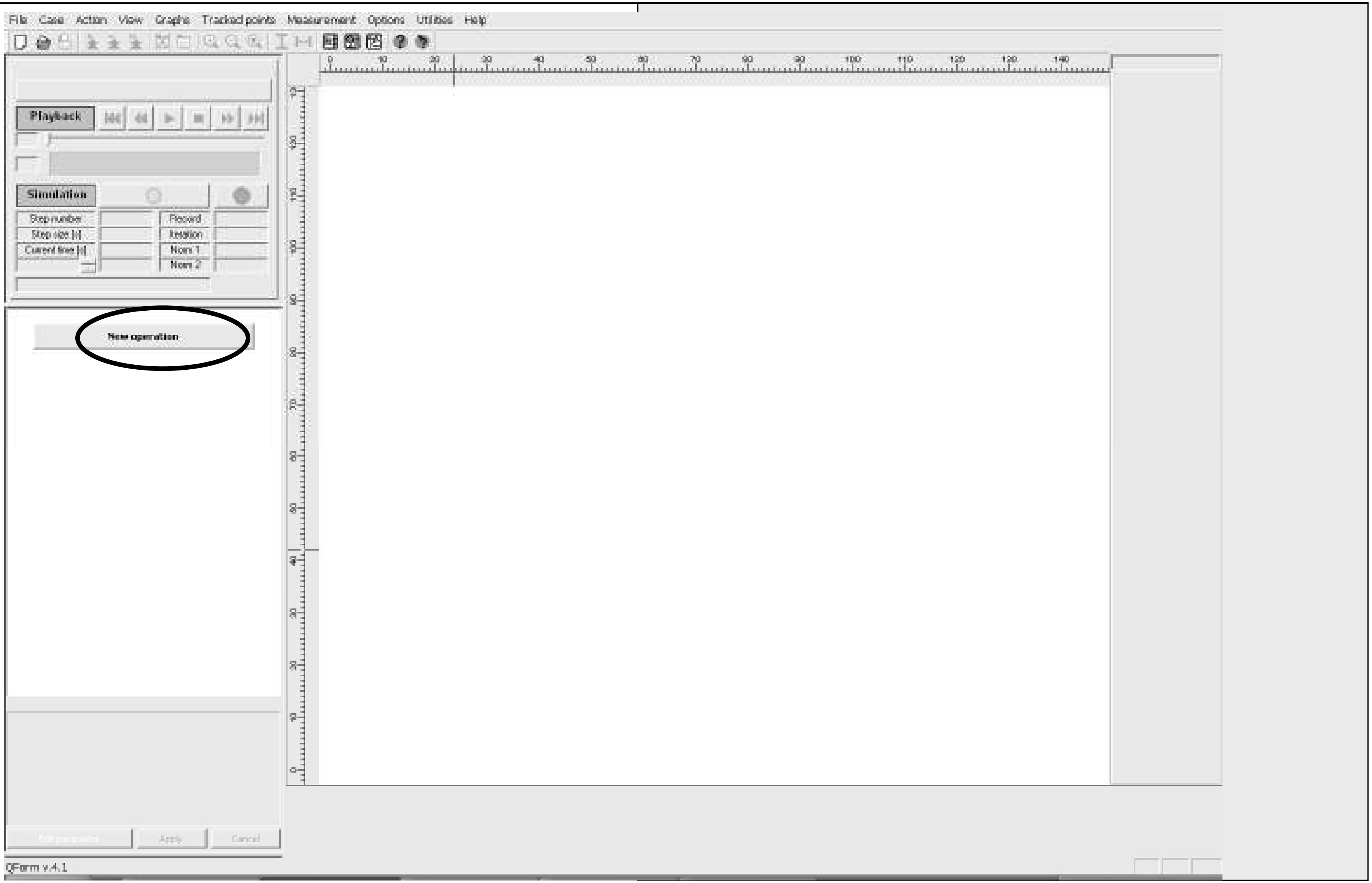
ProEngineer 6 Cylinder Crankshaft Stepped Dies Models
Billet 133mm Square, 1040mm Long
Micro Alloy Steel at 1280°C
9000T Press

The task - to predict

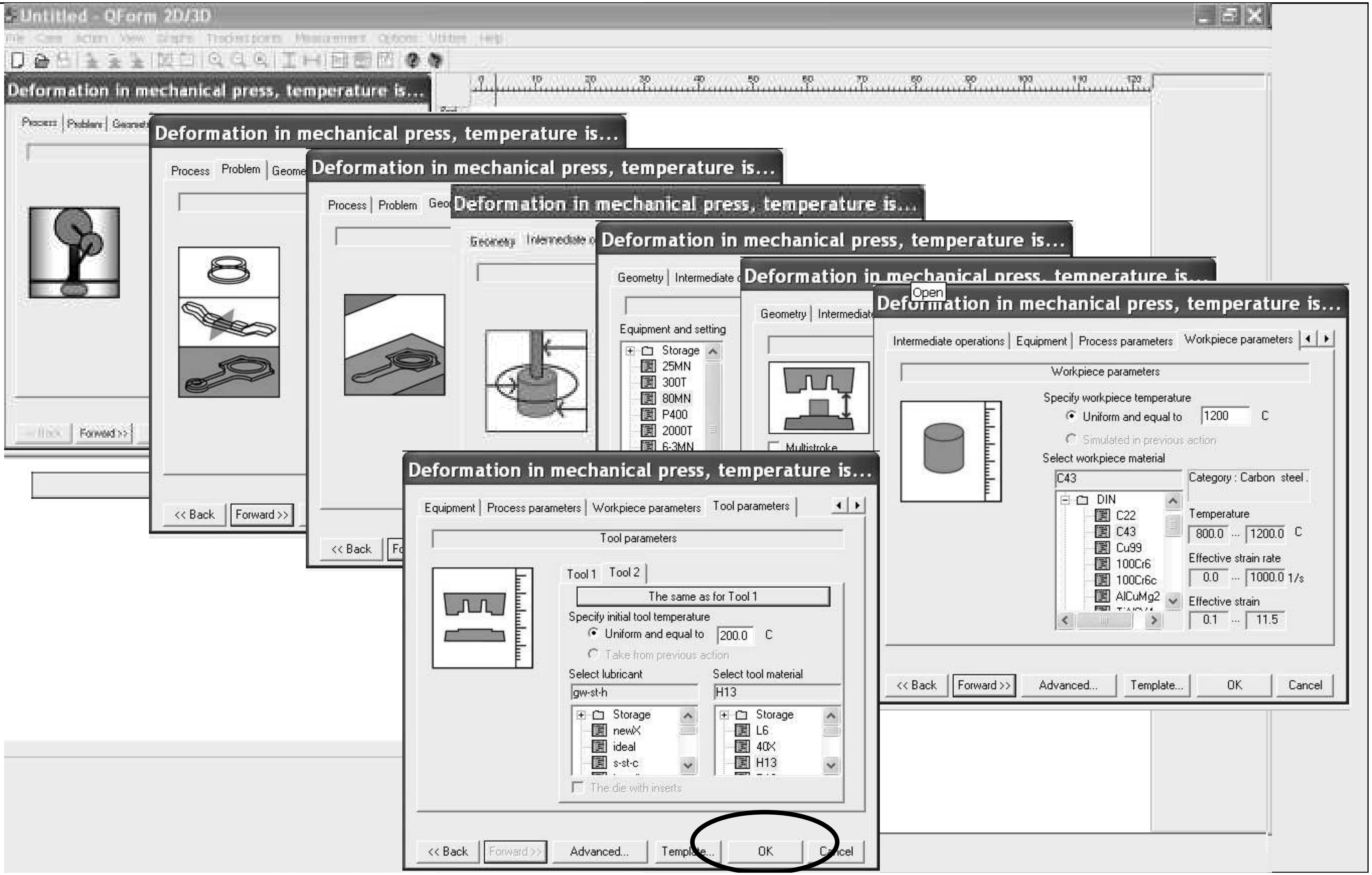
Press Capability
Die Filling
Material Flow
Forging Defects


QUANTOR SOFT
QFORM3D
version
QForm2D3D
start

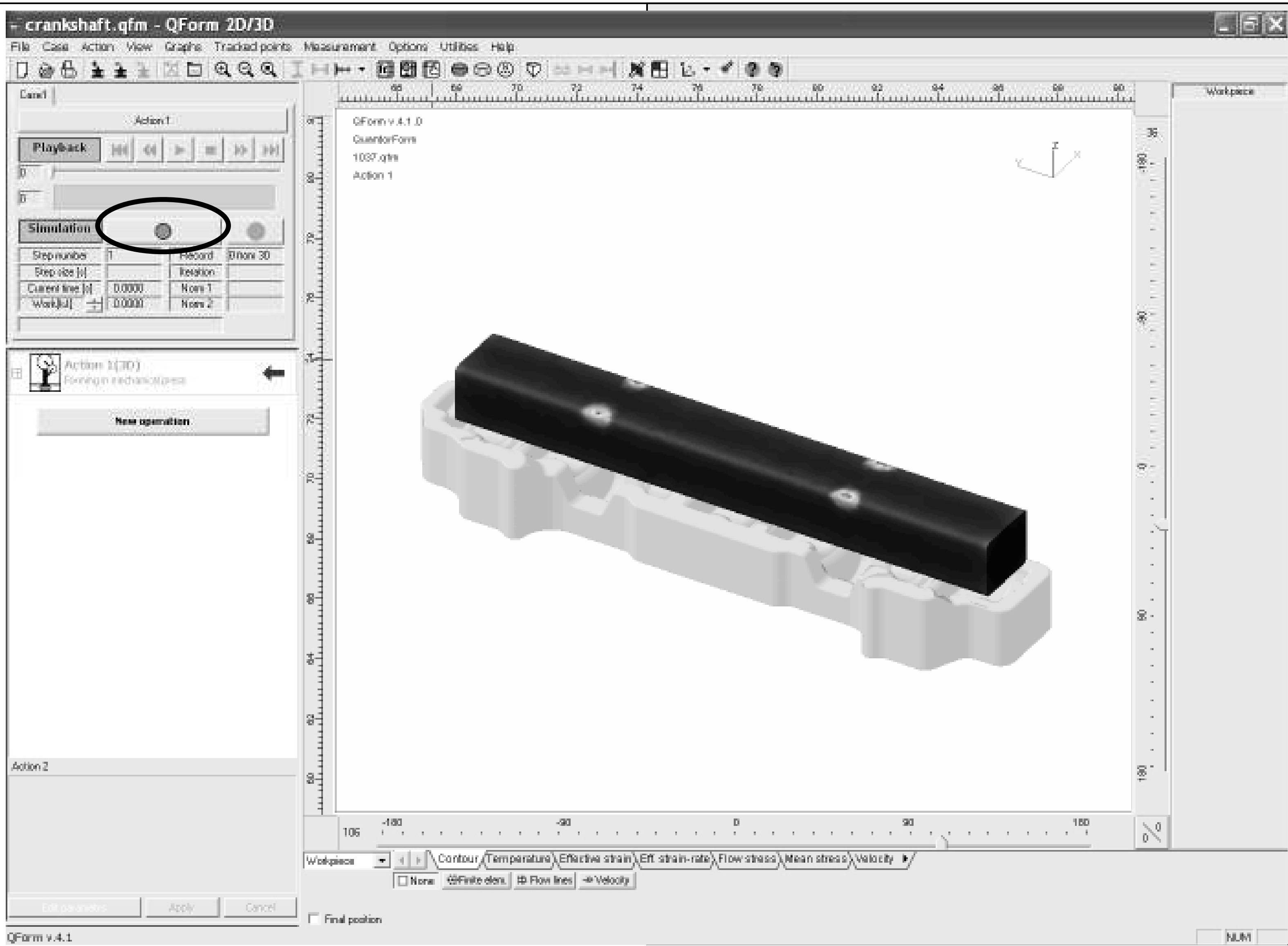
QForm window ready for new problem



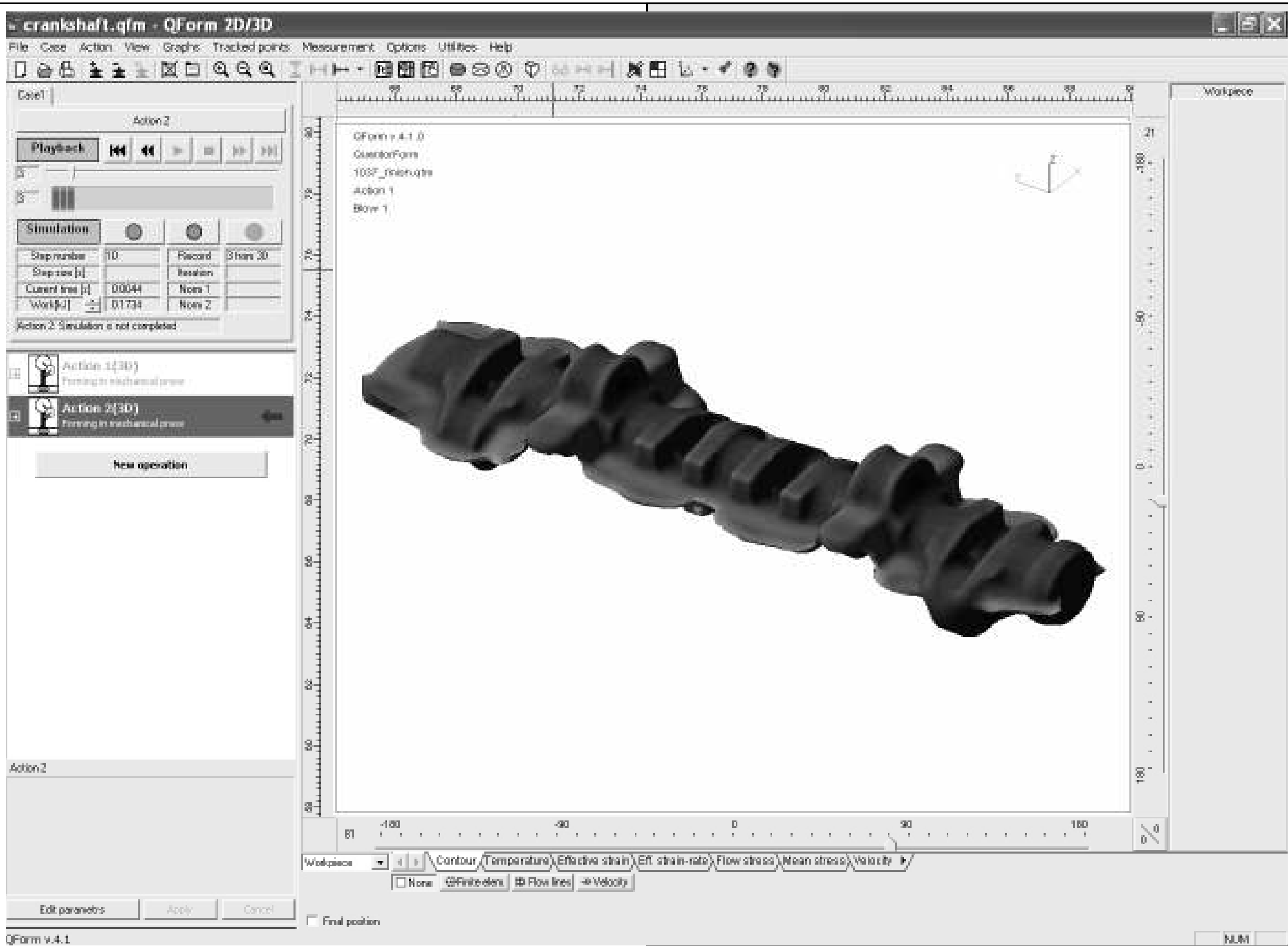
Data preparation Wizard



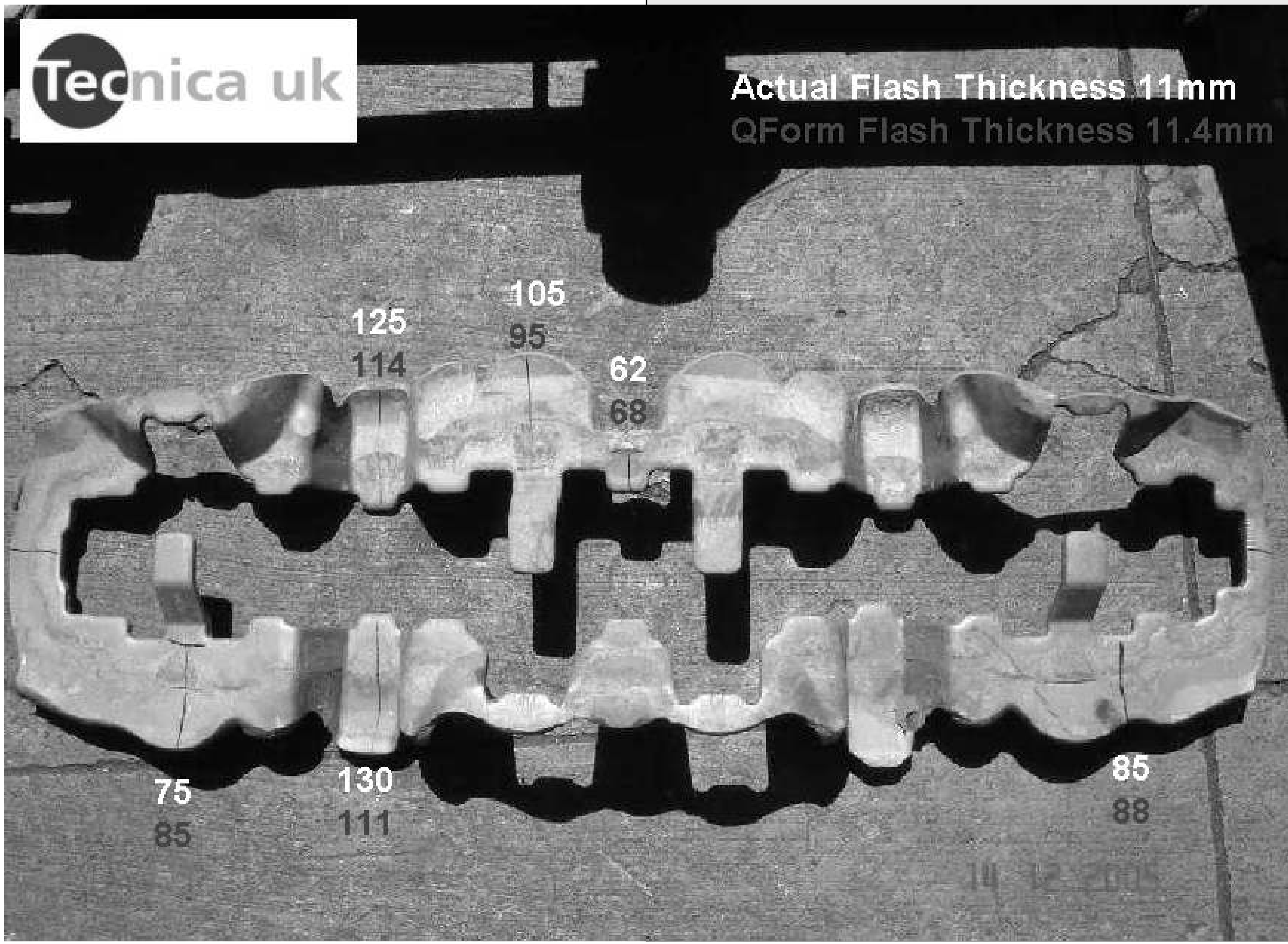
Simulation: Action 1 – Mould



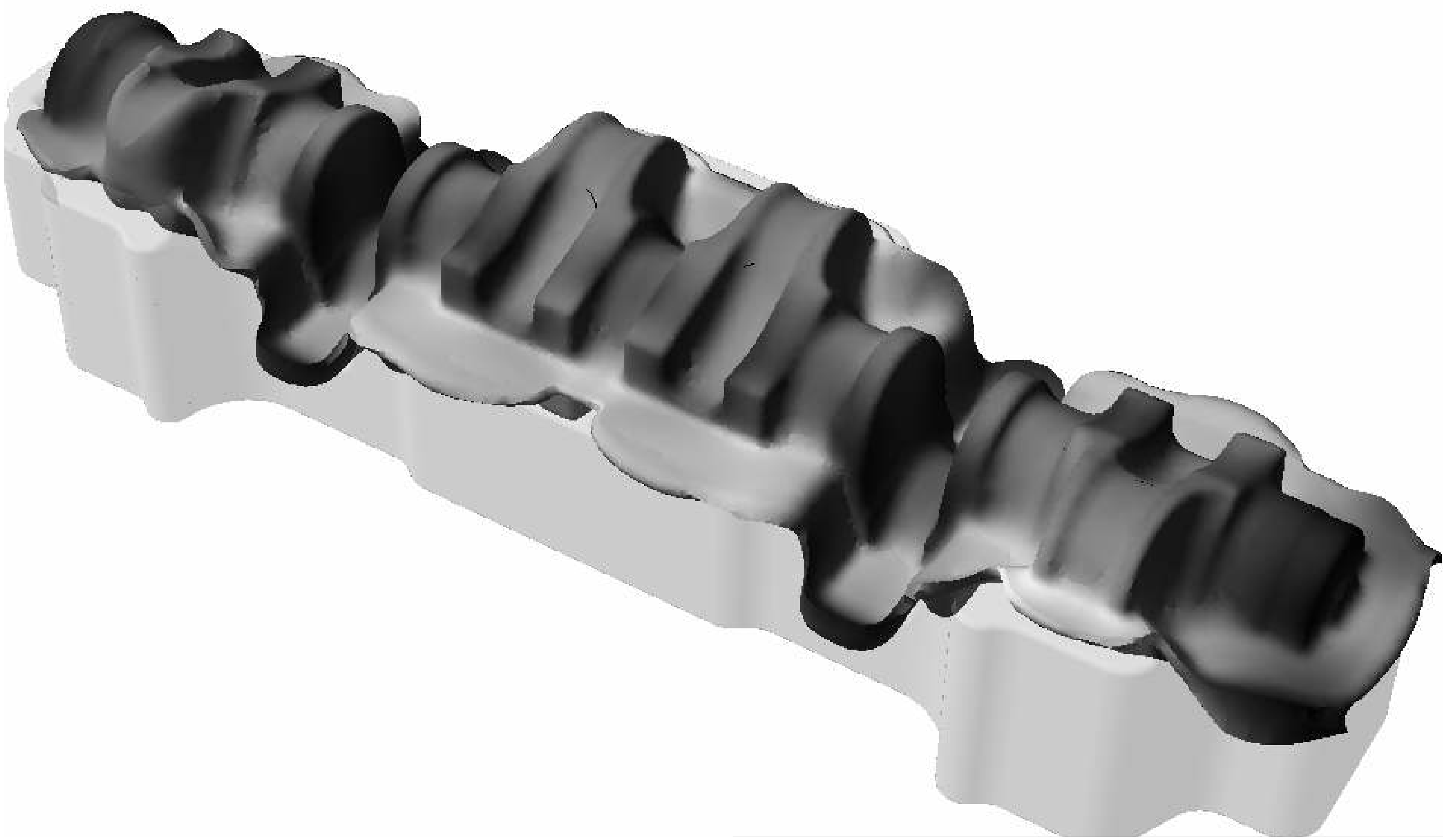
Simulation: Action 2 – Finish



Accurately Predicted Final Flash Thickness and Flash Widths



The temperature distribution



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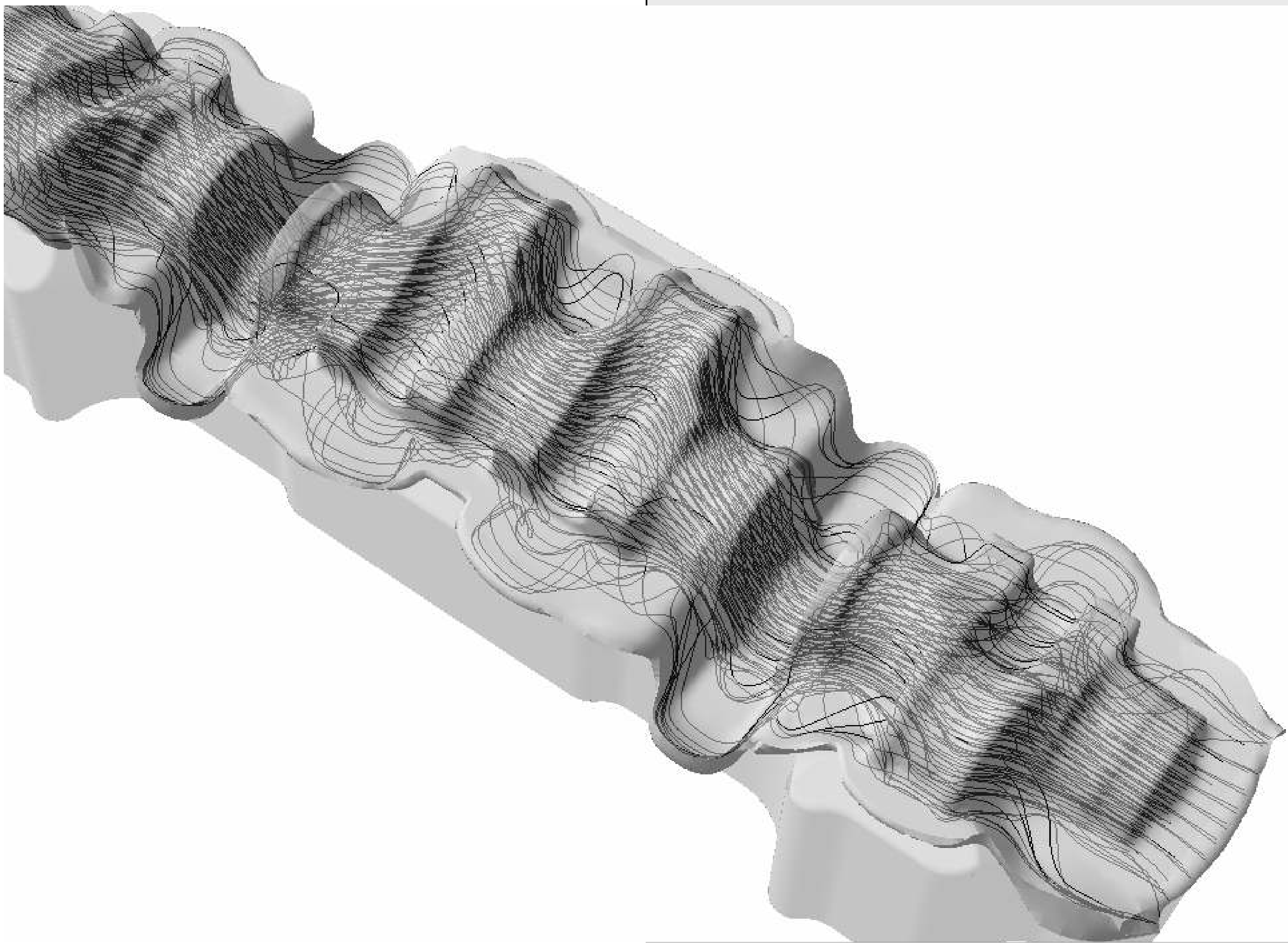
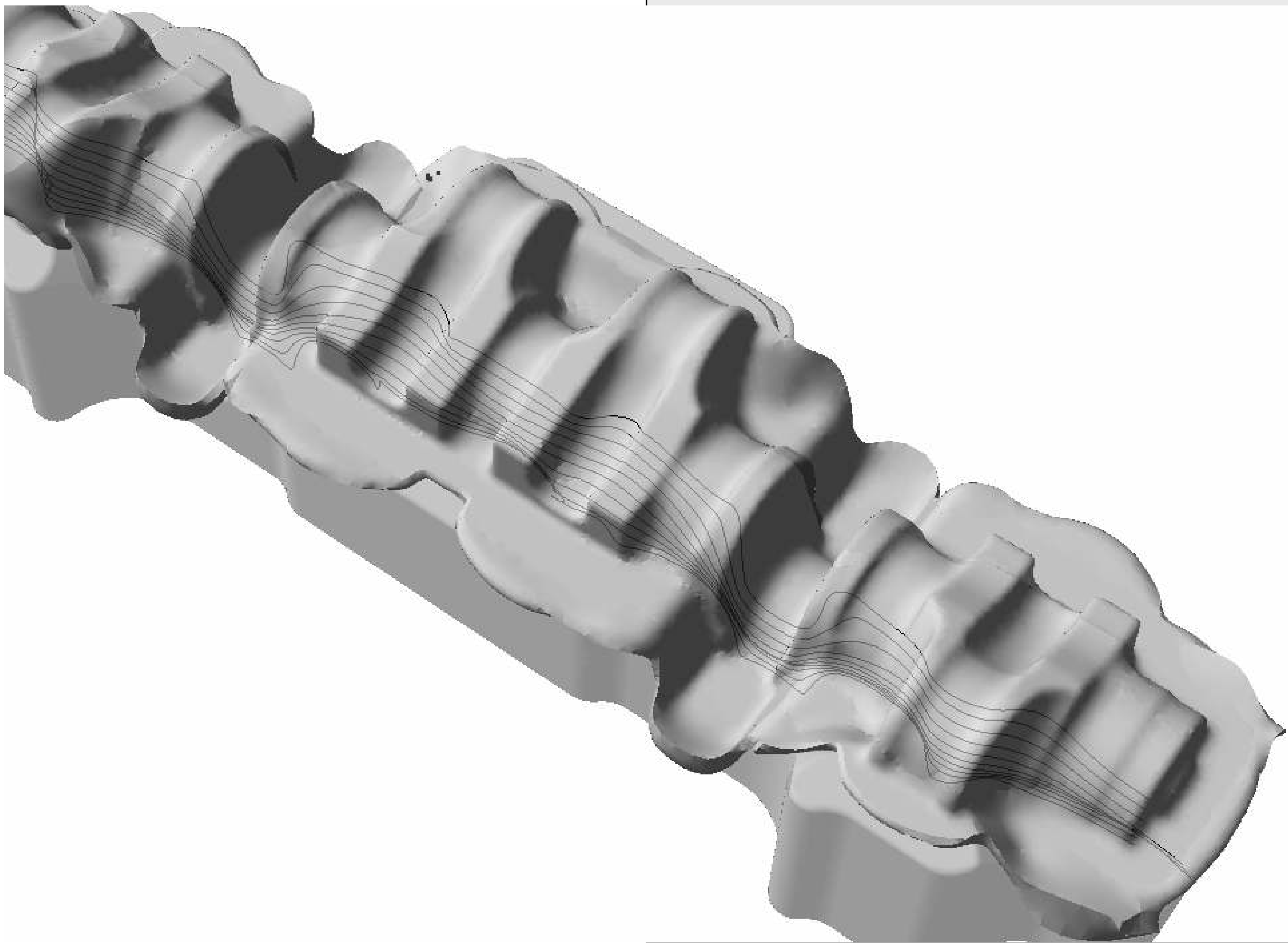
Look inside: the flow lines create the internal structure



One layer of the flow lines



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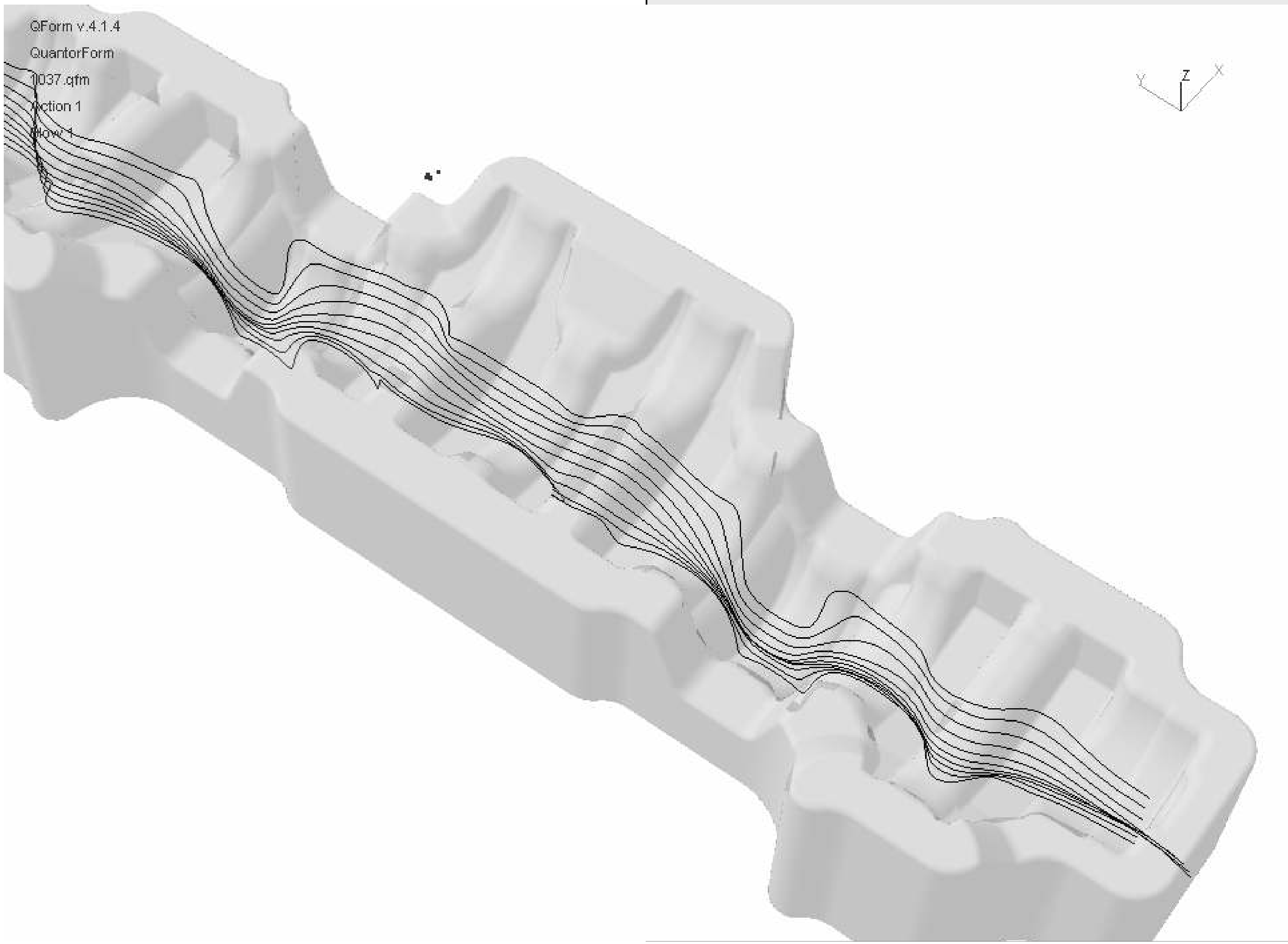
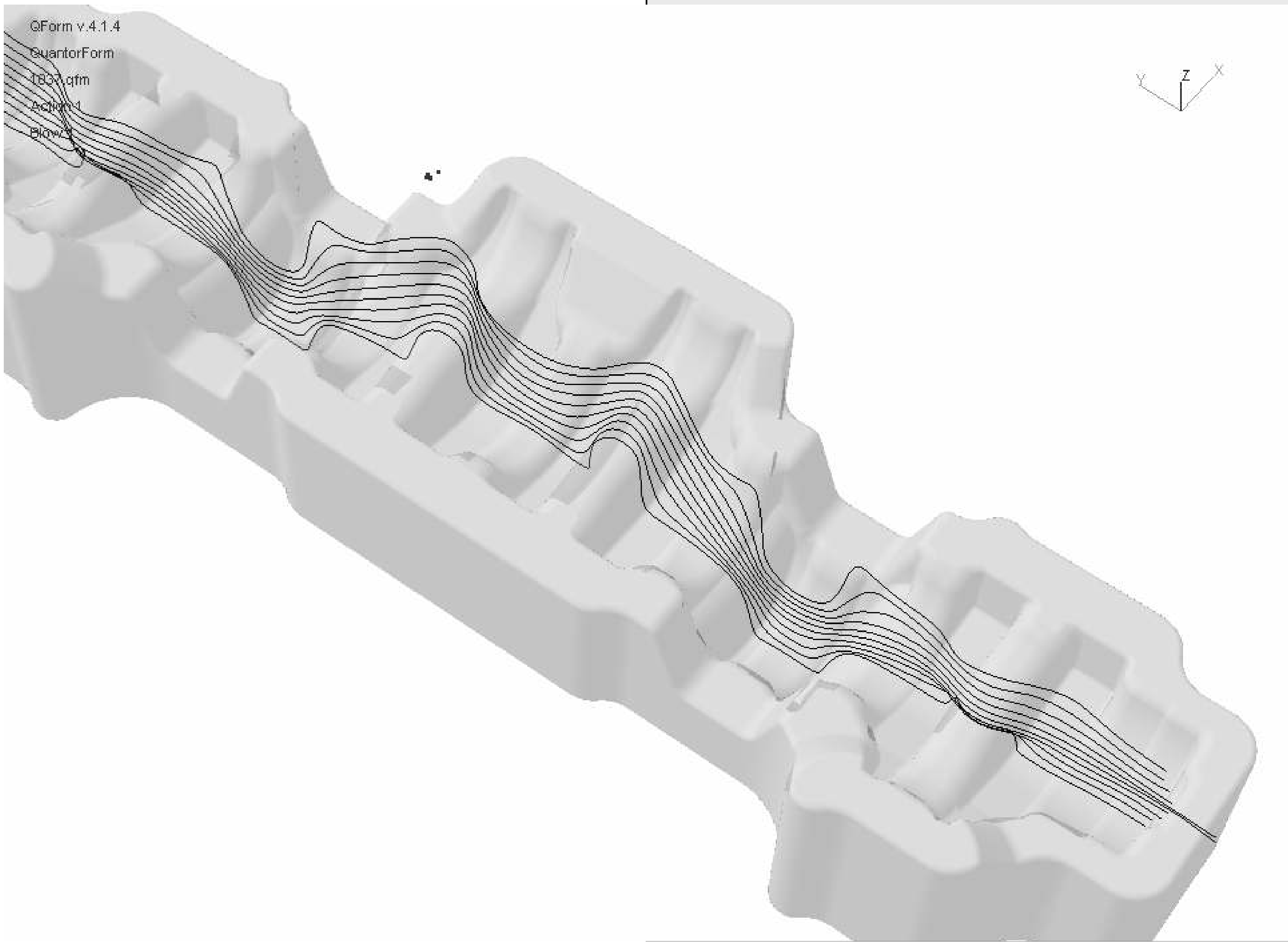
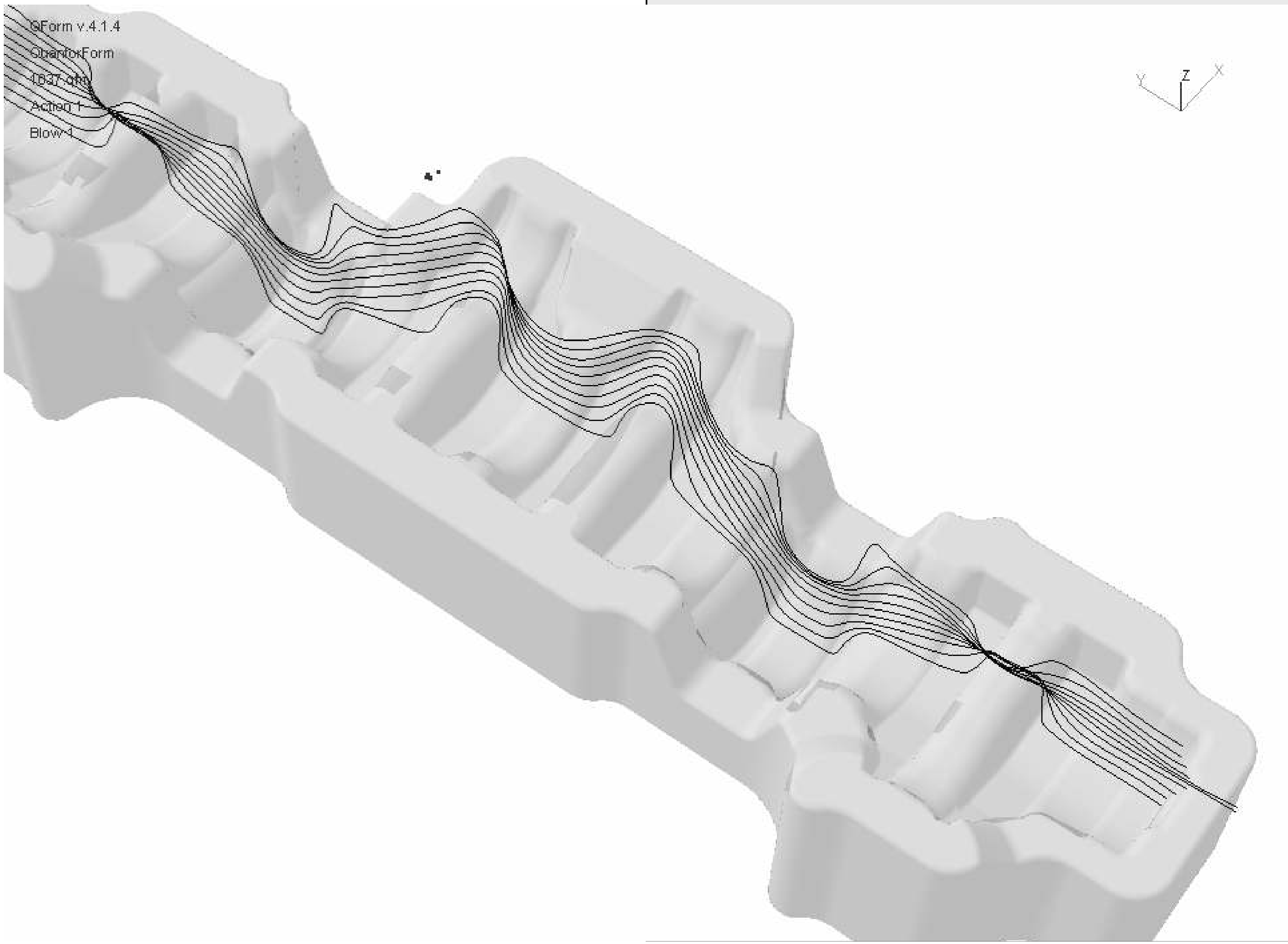
Analyze the grain flow layer by layer



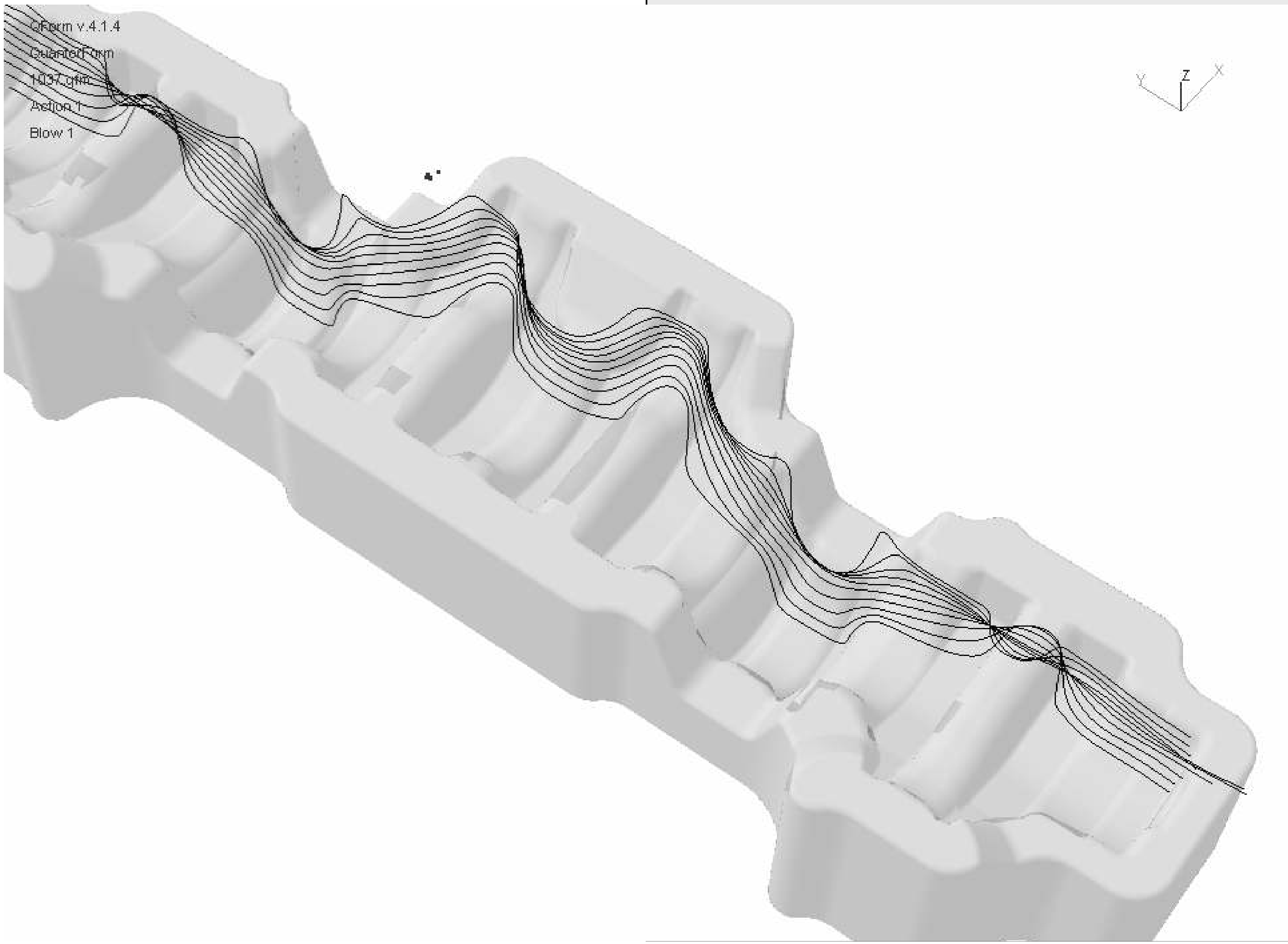
Analyze the grain flow layer by layer



Analyze the grain flow layer by layer



Analyze the grain flow layer by layer



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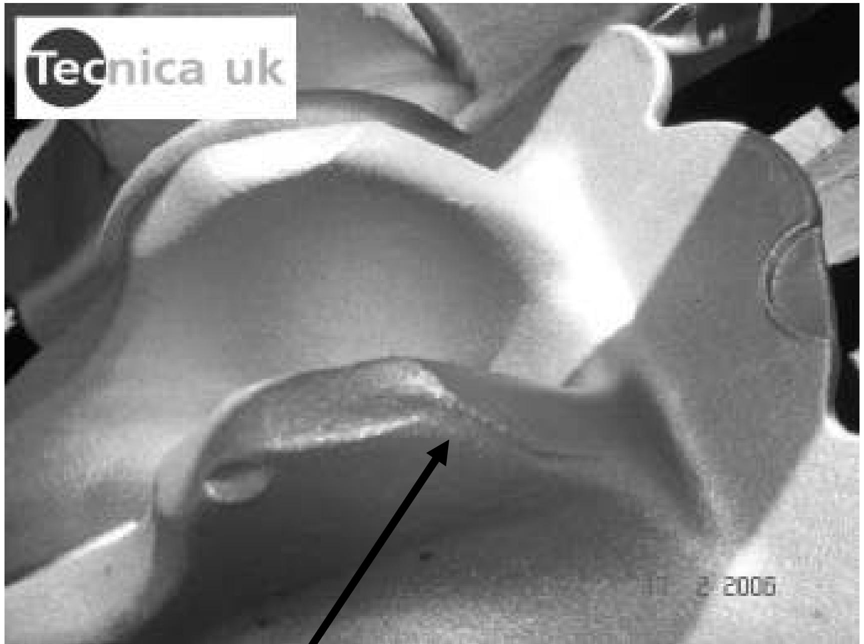
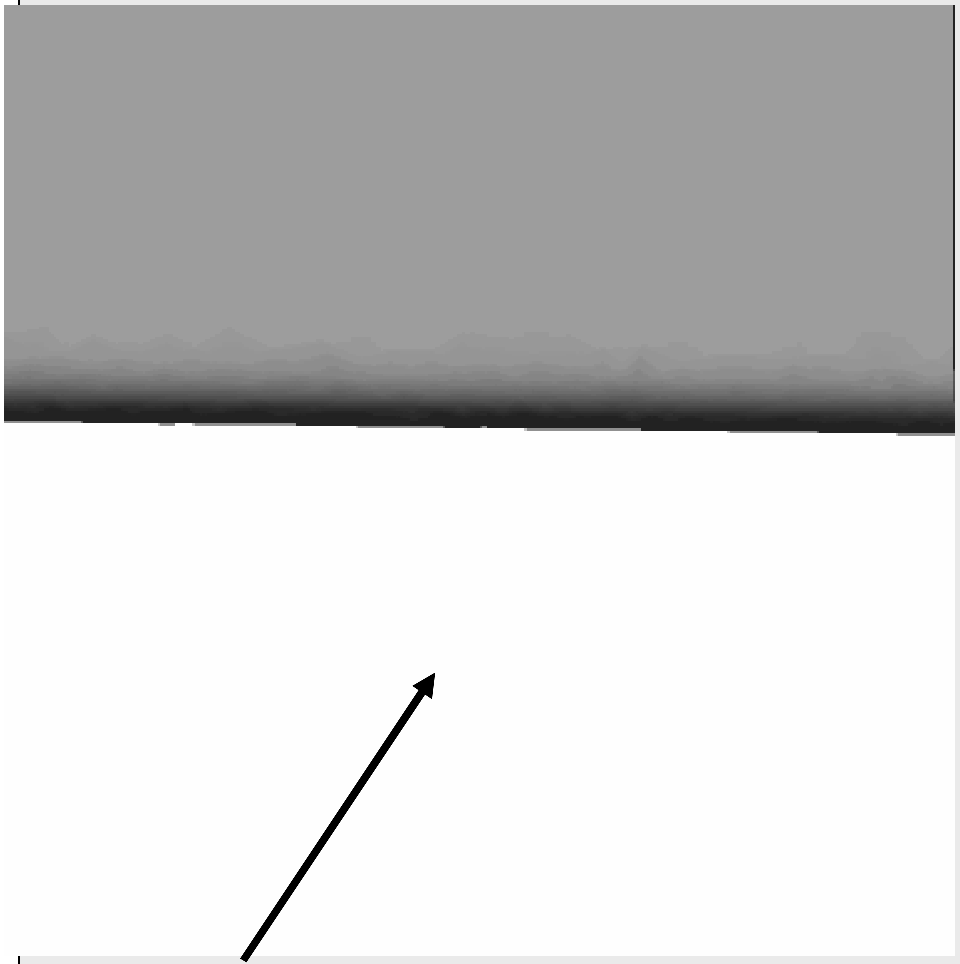
The evolution of the grain flow in certain location

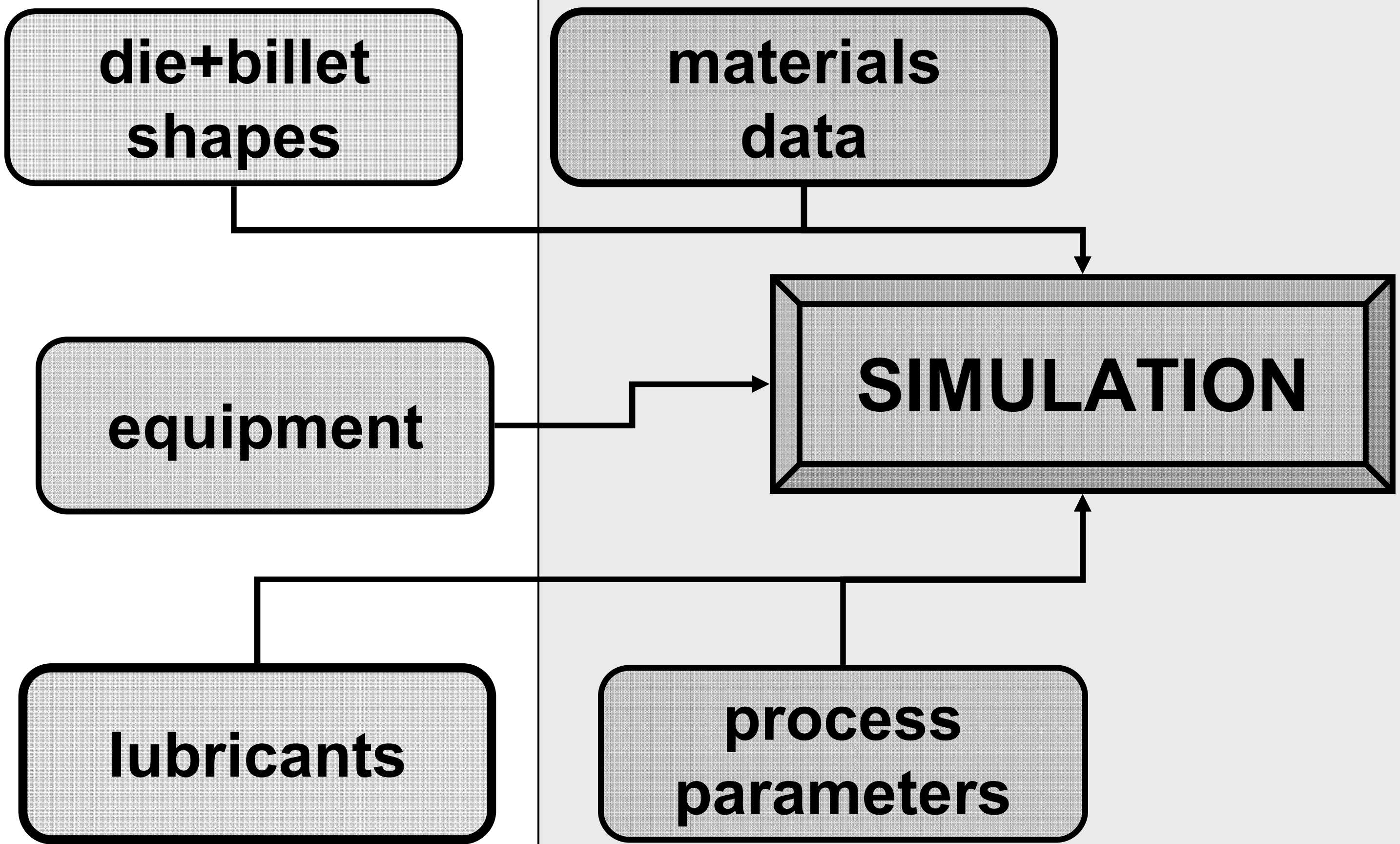
The lap formed on the web



The lap

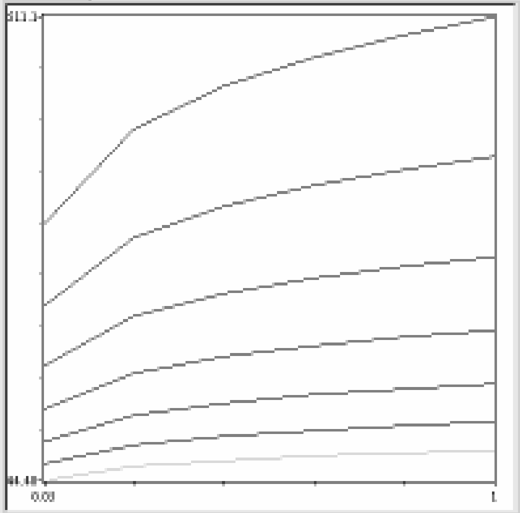


What is required for the simulation



Material & Lubricant: comprehensive Database

Flow Stress | Density | Thermal Cond. | Spec. Heat | Melting Temp. | Comment



SIGMA = F (strain, rate, theta) (MPa)
strain -- Strain (conventional)
rate -- Strain rate (1/sec)
theta -- Temperature (Degrees C)

theta (Degrees C): 800 — strain (conventional) — rate (1/sec)

800	0.05	0.24	0.43	0.62	0.81	1
0.001	44.484375	58.444477	64.685969	68.938667	72.22094	74.918091
0.01	61.264306	80.490268	89.086159	94.942986	99.463358	103.17791
0.1	84.373779	110.851962	122.6903	130.756378	136.981673	142.097595
1	116.200363	152.666397	168.970245	180.078918	188.65274	195.698151
10	160.032242	210.253616	232.707413	248.006393	259.814331	269.517334
100	220.397919	289.563263	320.486847	341.556732	357.818756	371.181824
1000	303.534119	398.768276	441.377533	470.395172	492.791382	511.195129

Example:

Flow stress depending on strain, strain-rate and temperature

QForm database contains flow stress for more than 430 steels, 30 copper alloys, 50 aluminum alloys, 20 titanium alloys, many nickel based alloys etc.

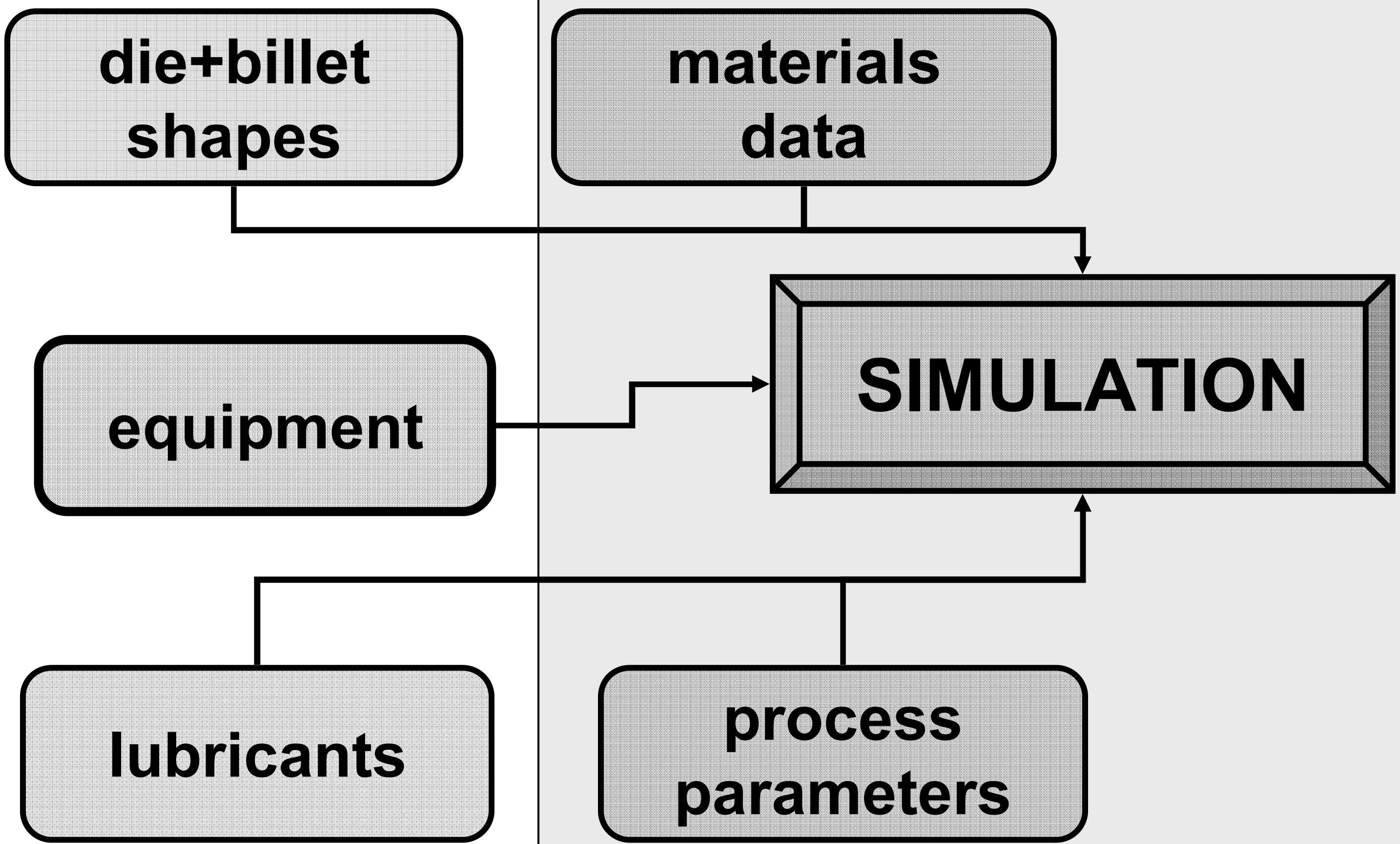
Next >>

Every user receives the

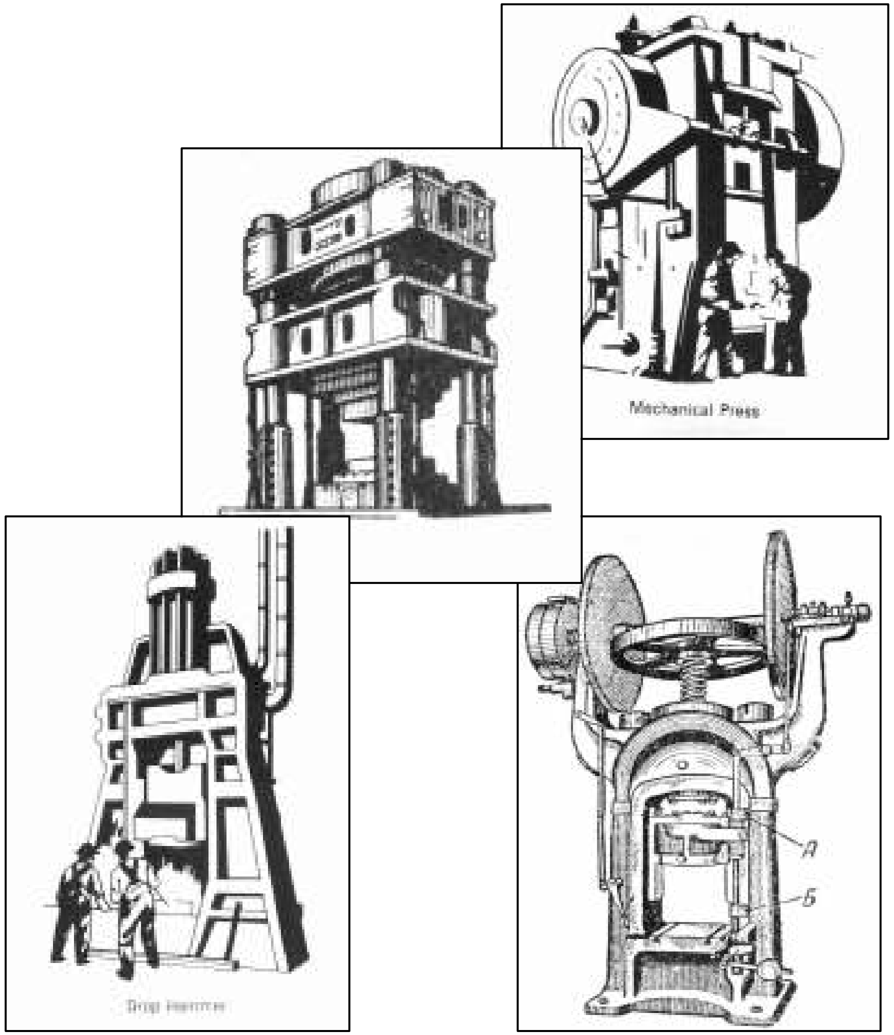
customized material and lubricant database

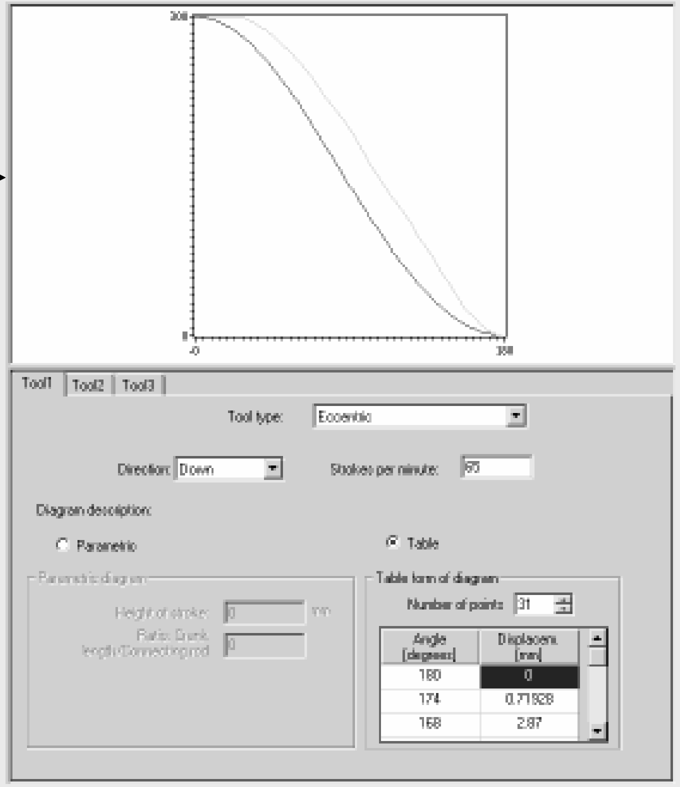
according to his specification

What is required for the simulation



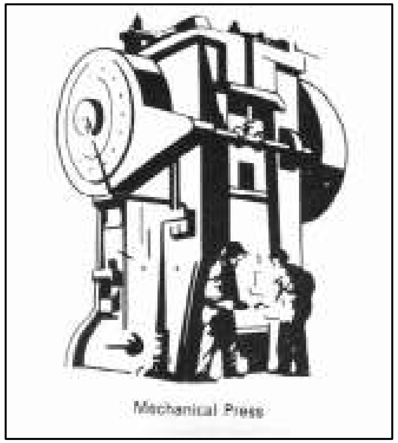
Simulation can be performed for any type of equipment



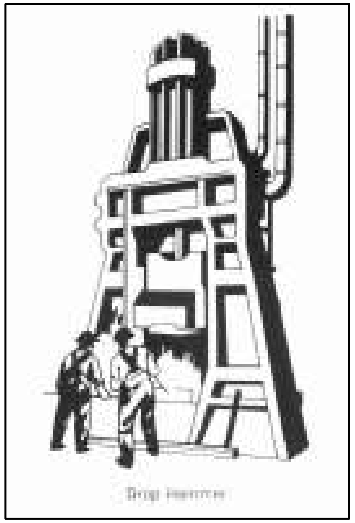


Example: Kinematics of the mechanical press with a holder

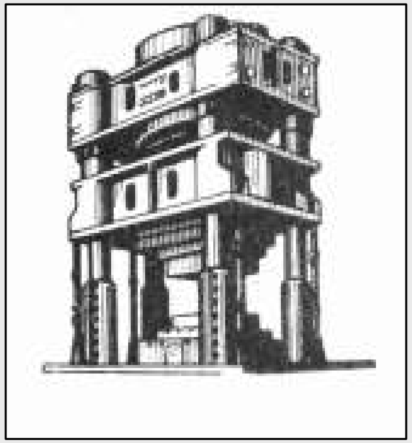
For every type of equipment the simulation gives you vital information:



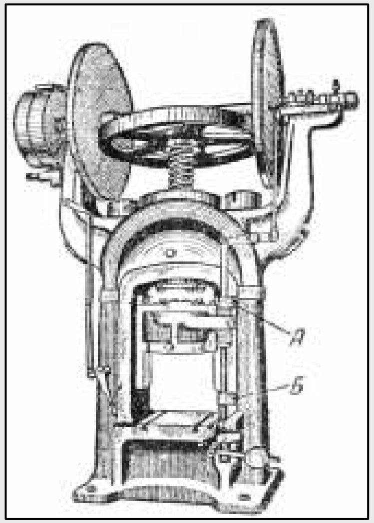
Critical load estimation



Required number of blows

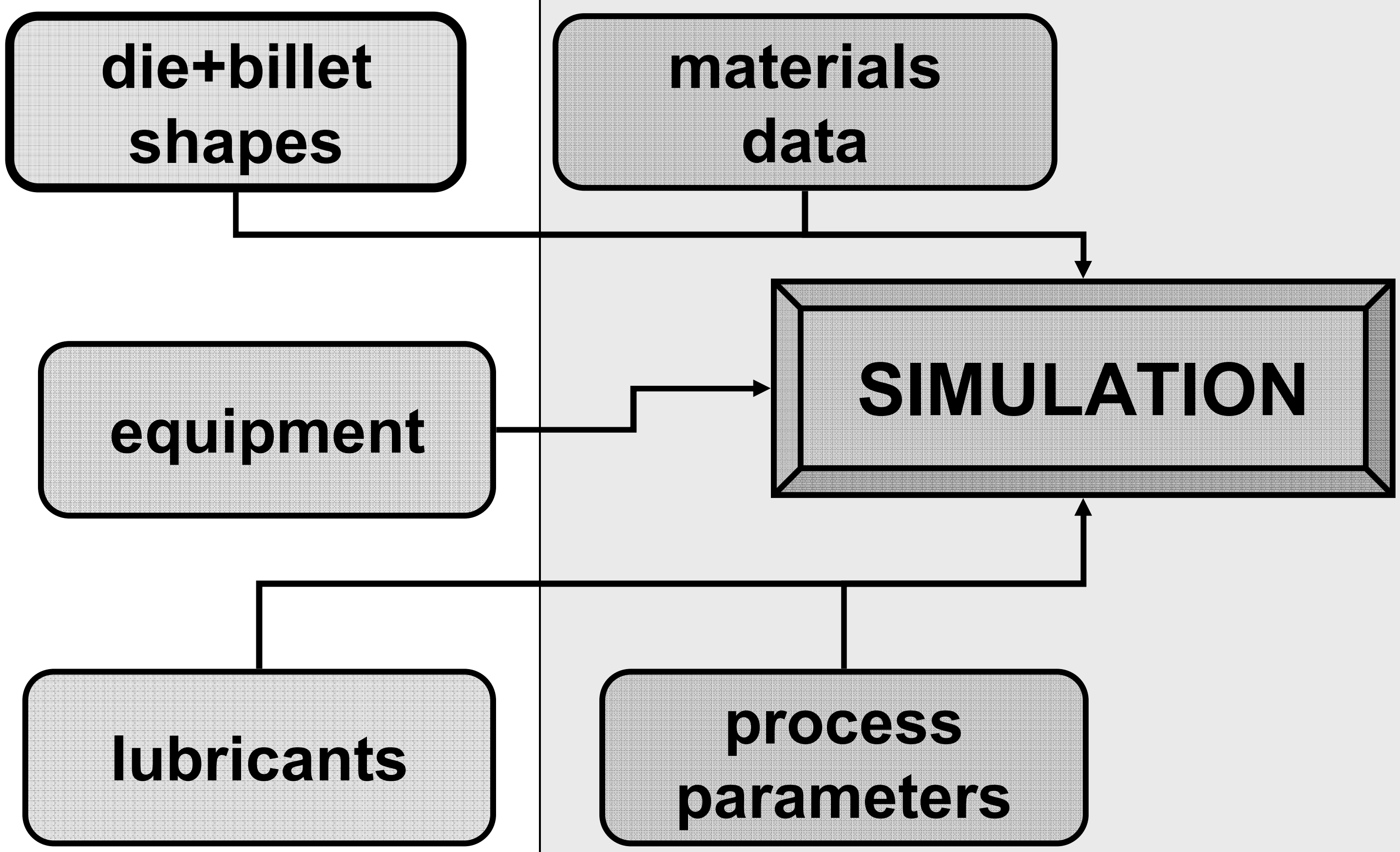


Energy and load requirements



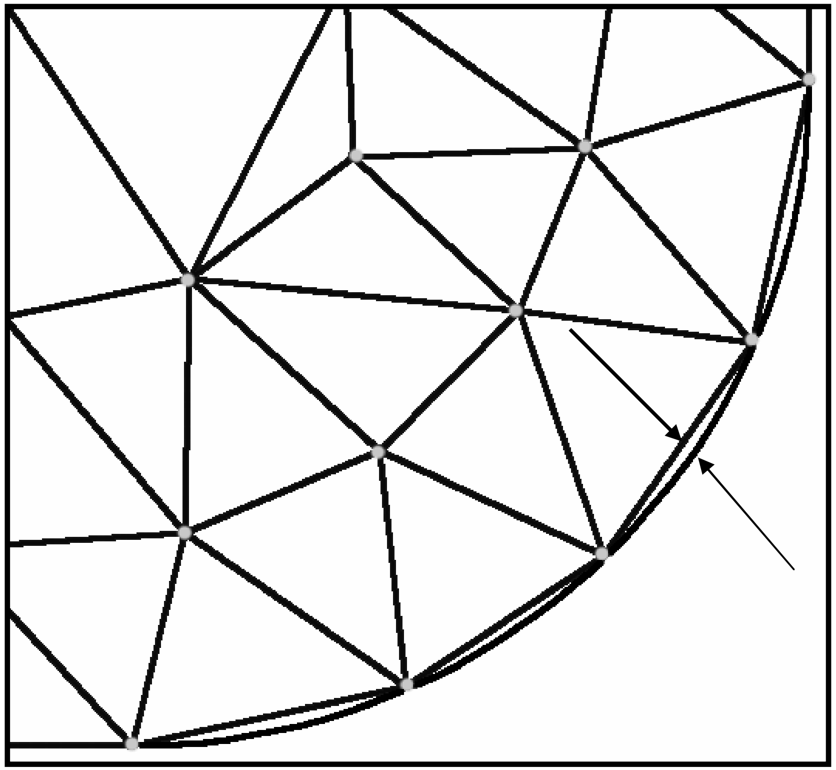
Optimal process parameter for safe use of press

What is required for the simulation

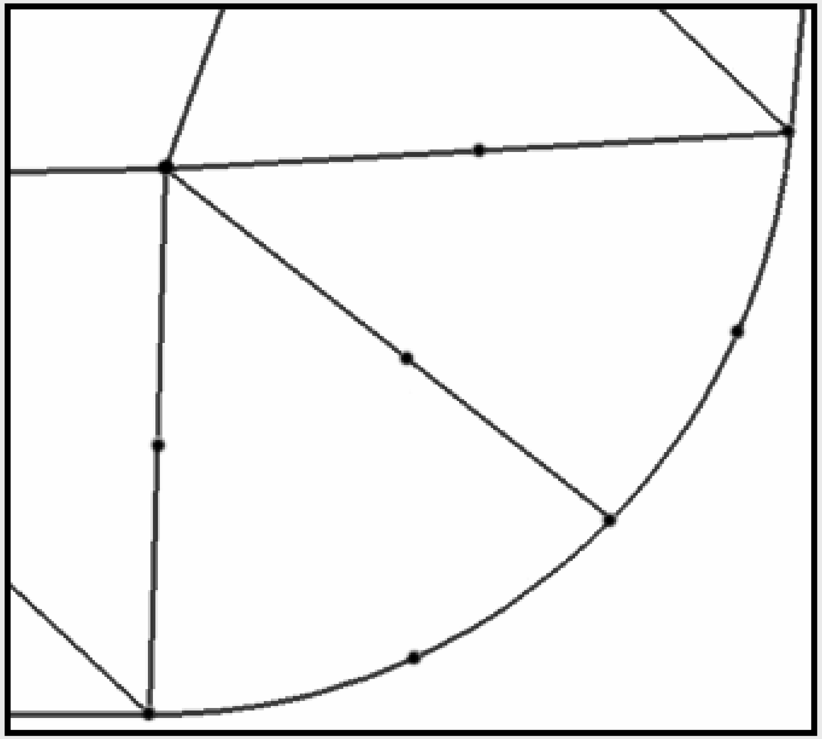


Quadratic approximation provides accurate solution for 2D

Linear (left) and quadratic (right) FE approximation of the surface with the same number of nodes



Error of the surface approximation



As in QForm 2D

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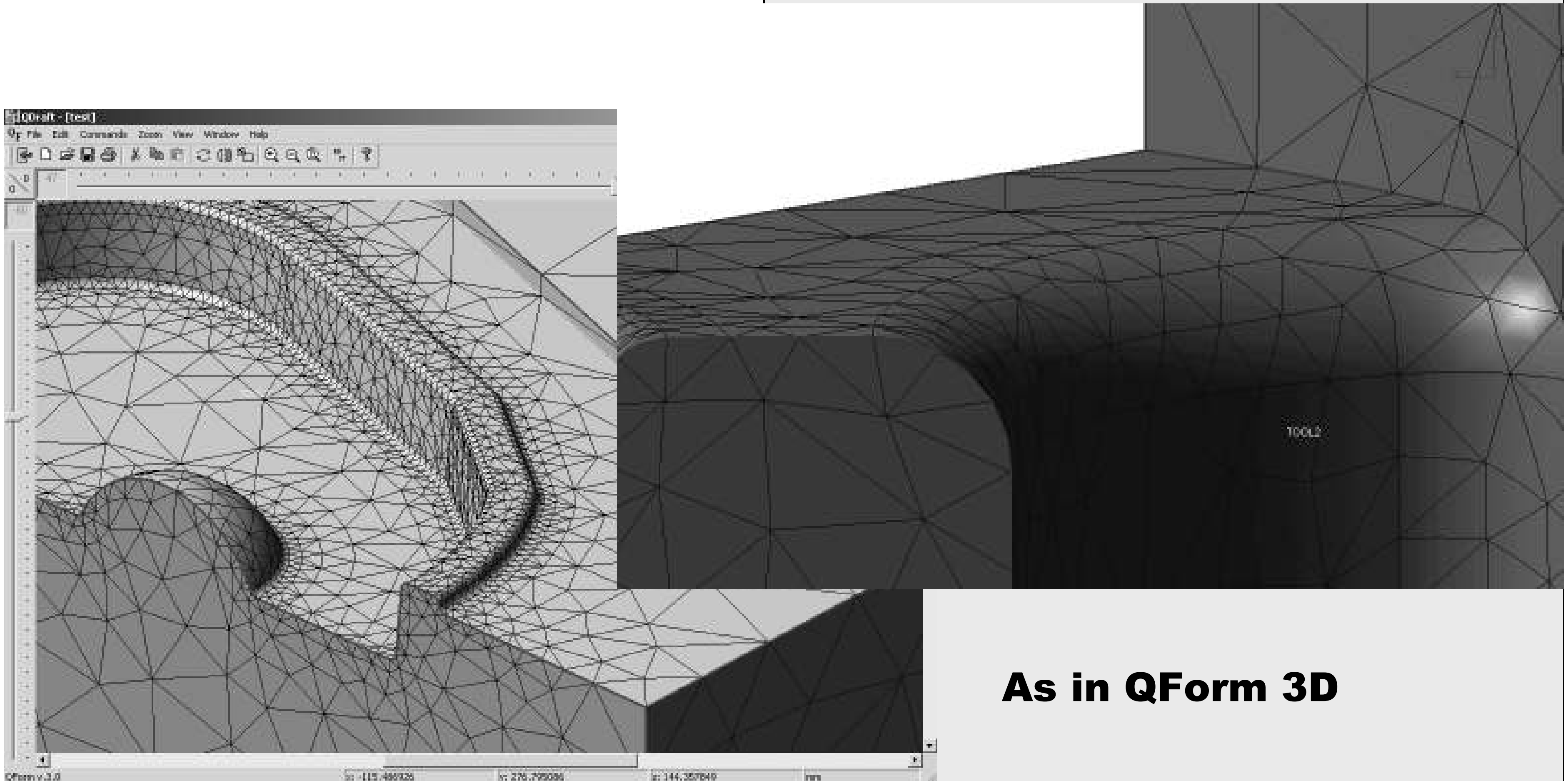
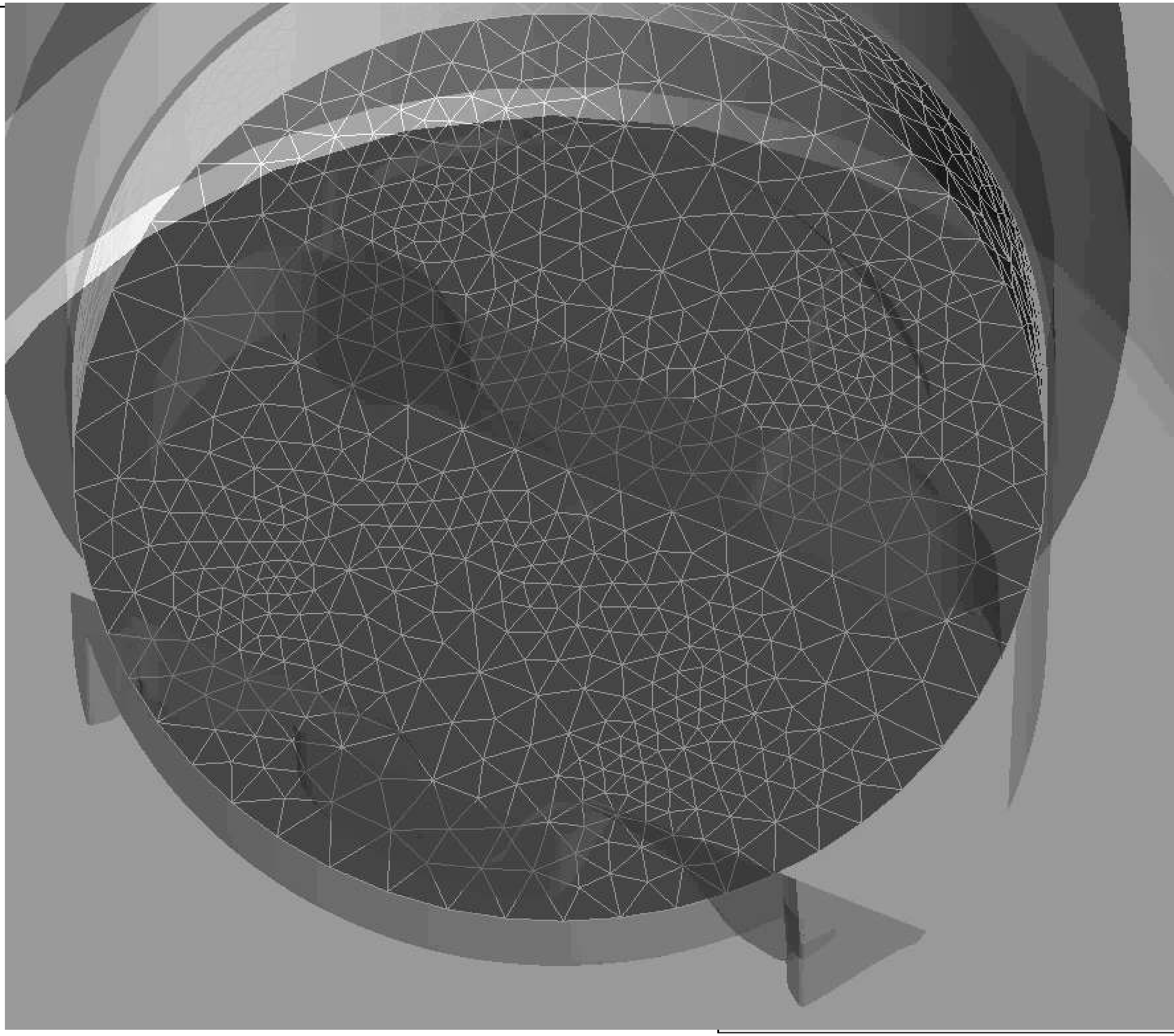
Accurate representation of the 3D source geometry



As in QForm 3D

How simulation runs?

QForm makes optimal meshes in 2D and 3D without user`s interference



Piston forging:

Automatic generation of the mesh

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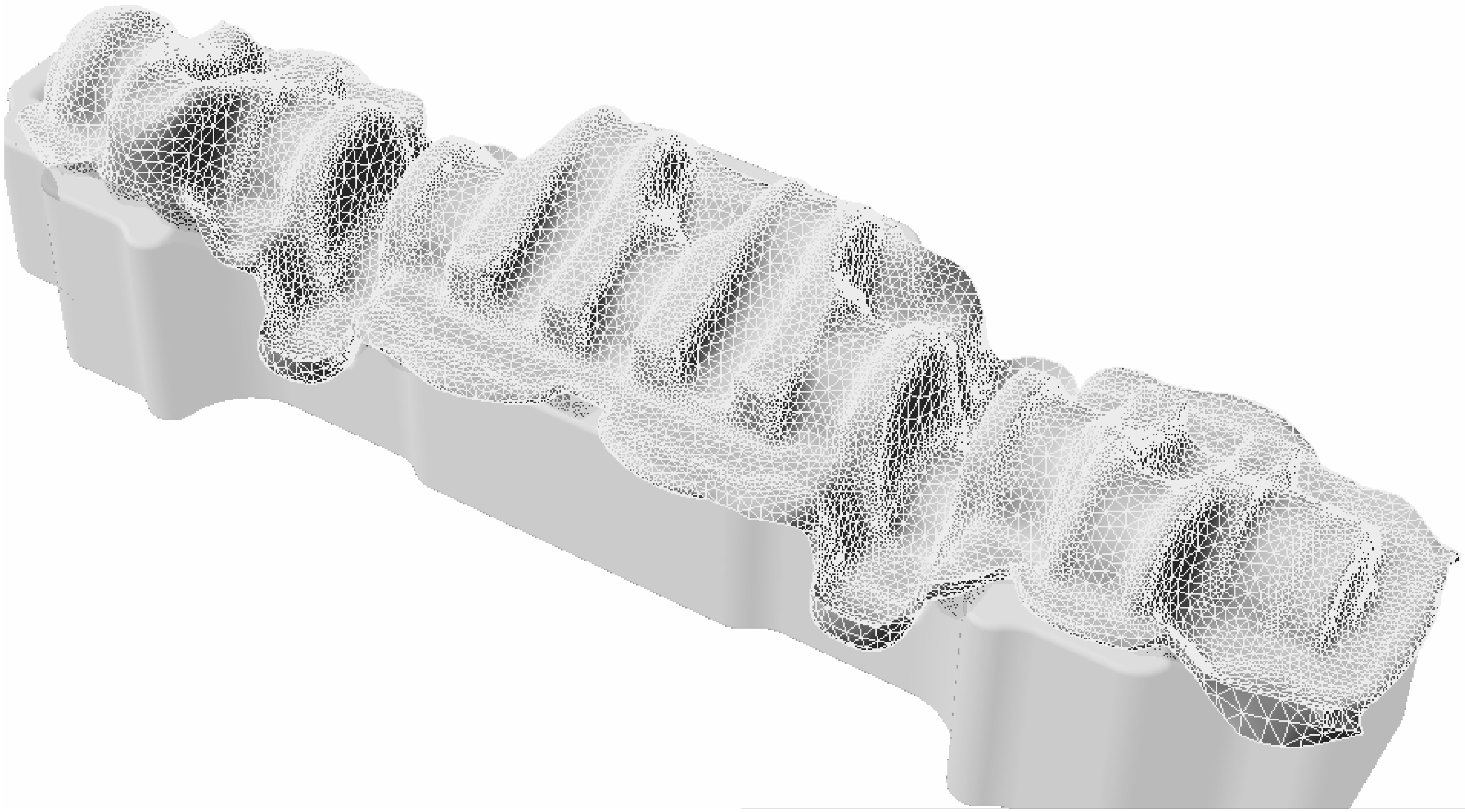
The models with up to 100 000 nodes runs on a PC with single, dual or two double core processors in parallel mode



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Practice of forging simulation

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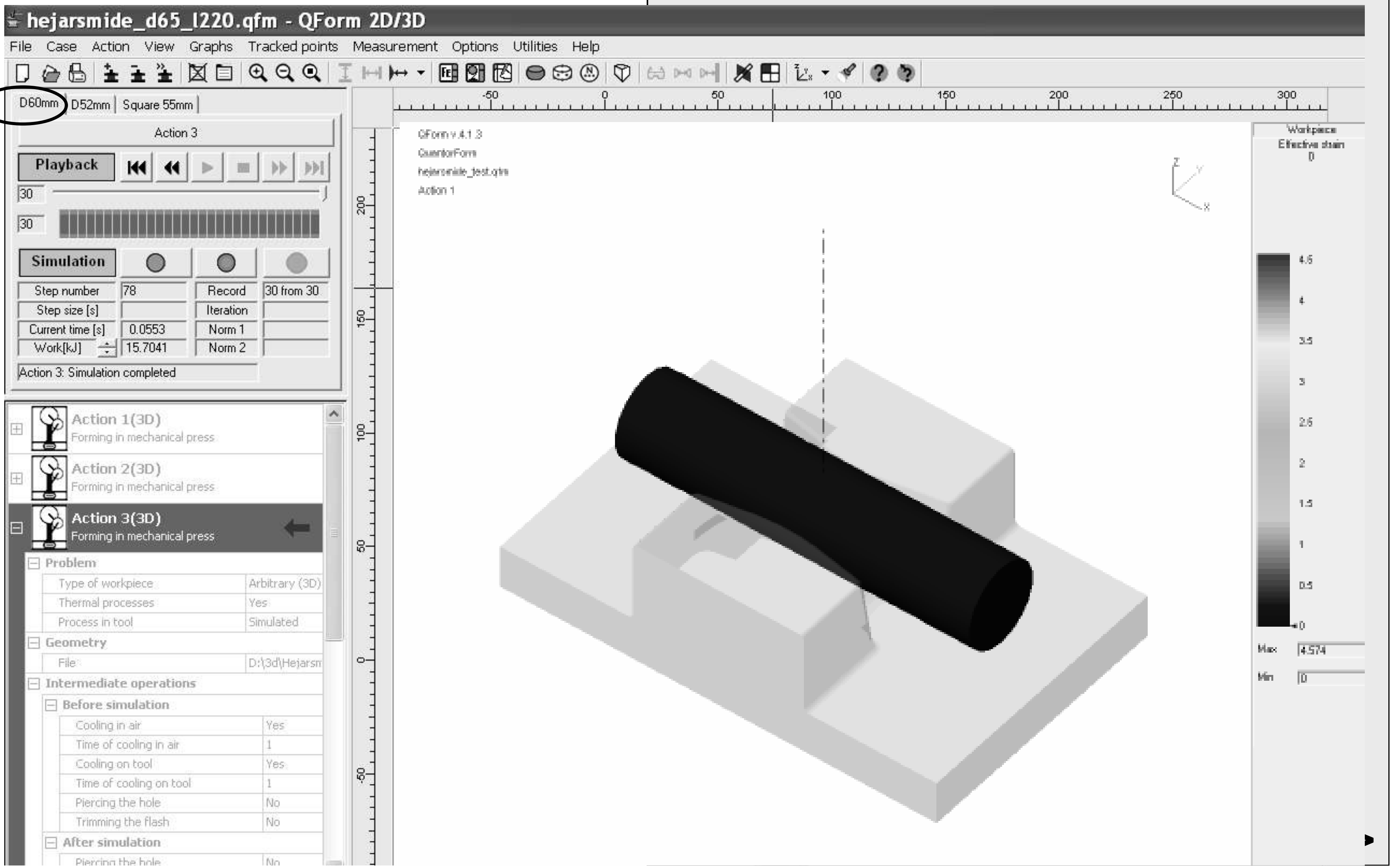
Hot closed die forging: the project, the cases, the actions



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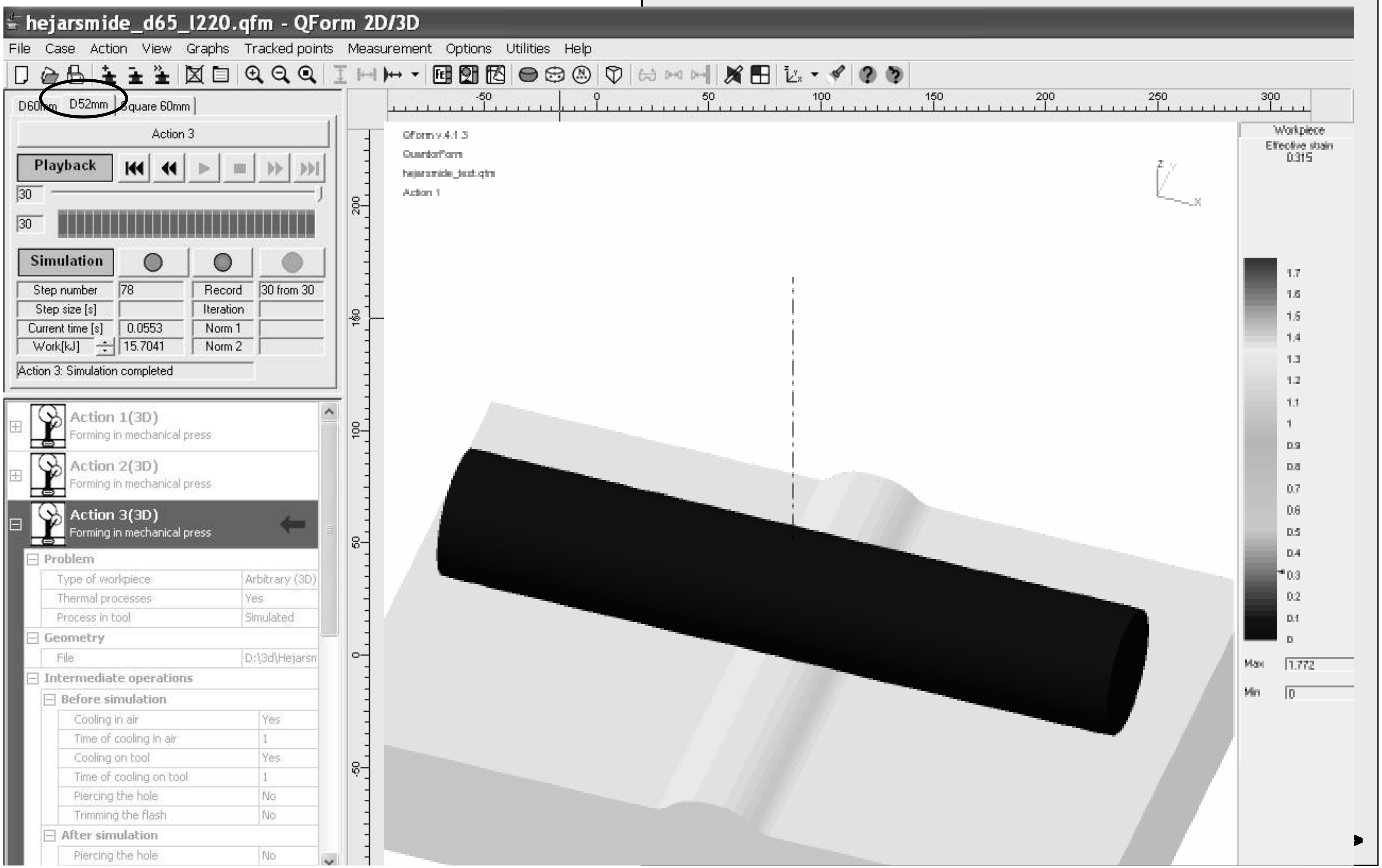
Hot closed die forging: the project, the cases, the actions



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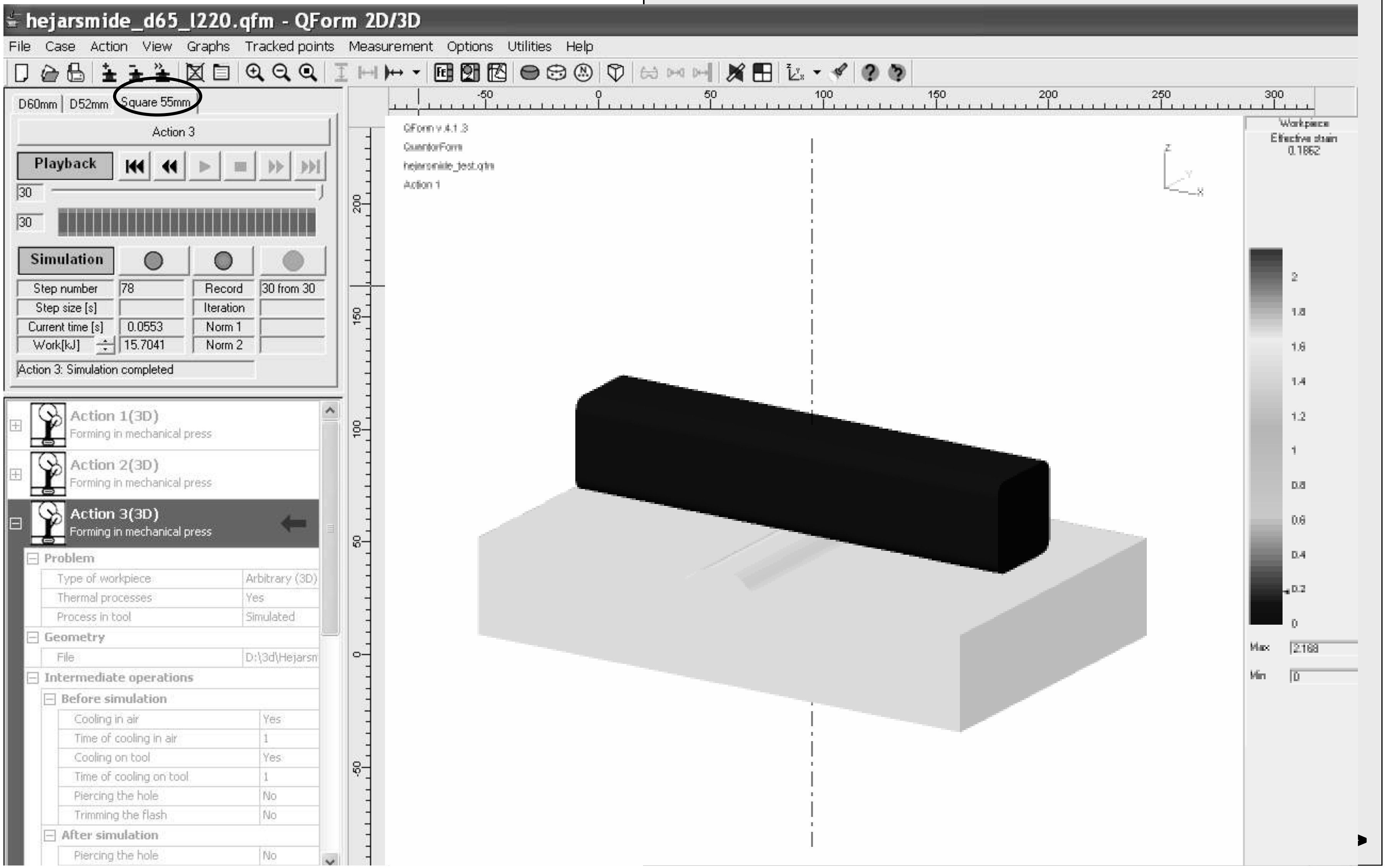

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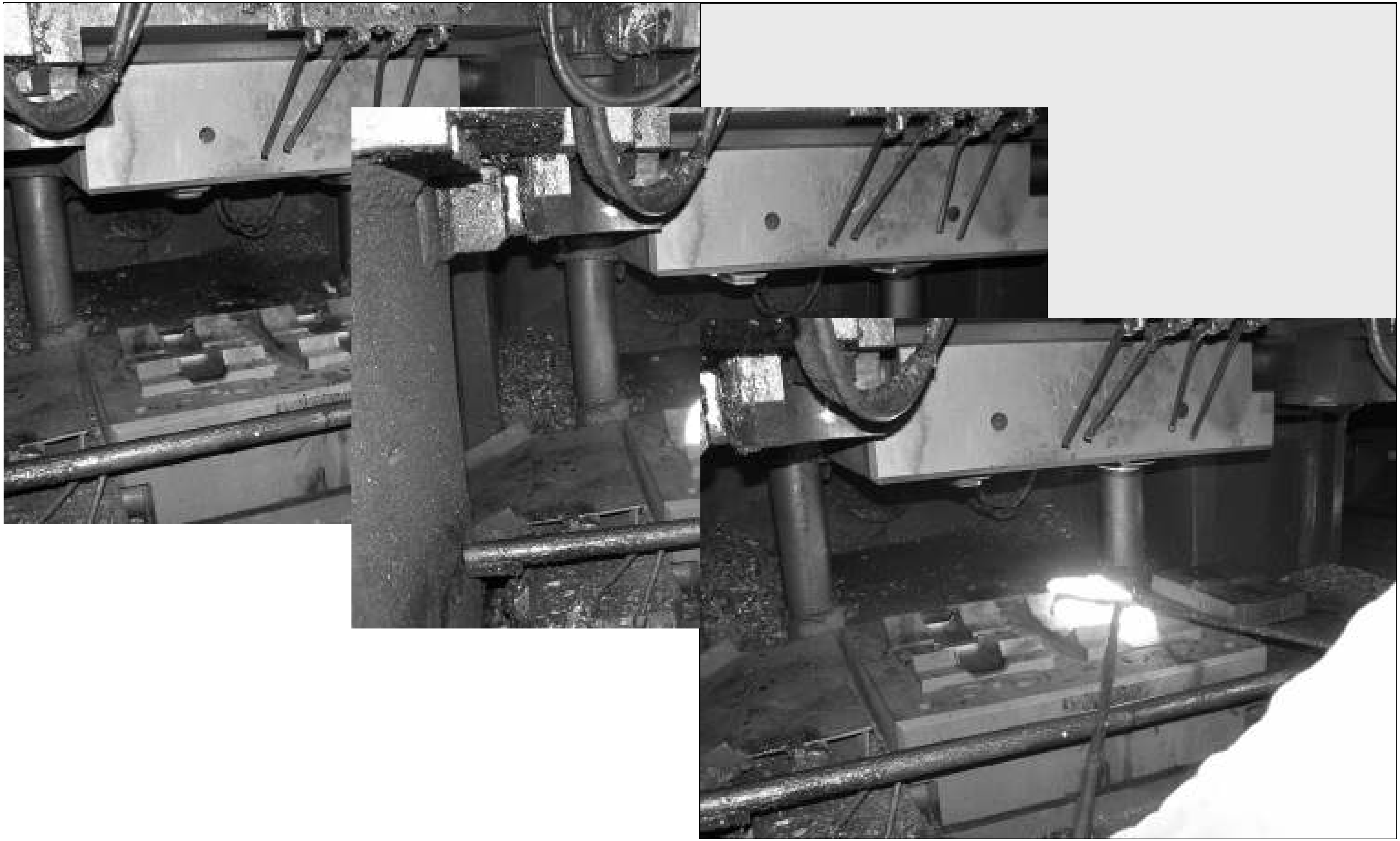
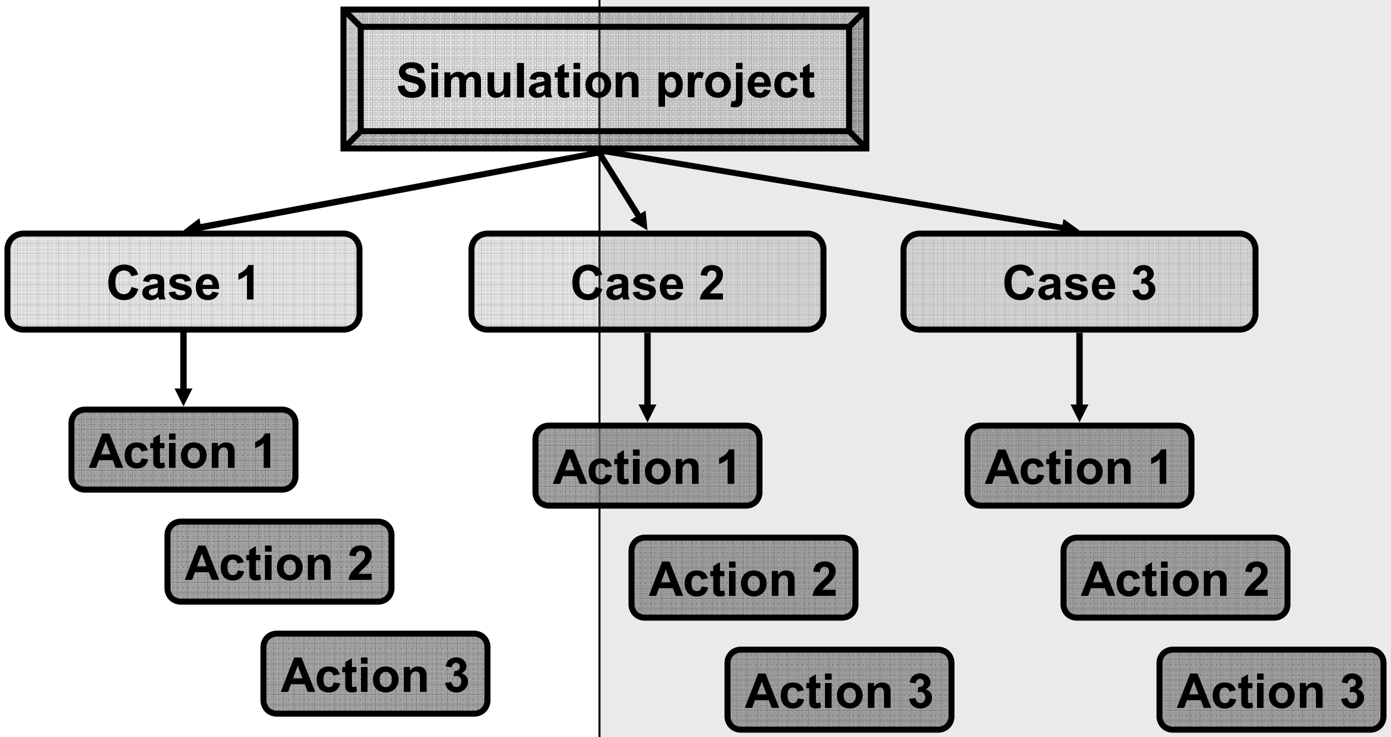
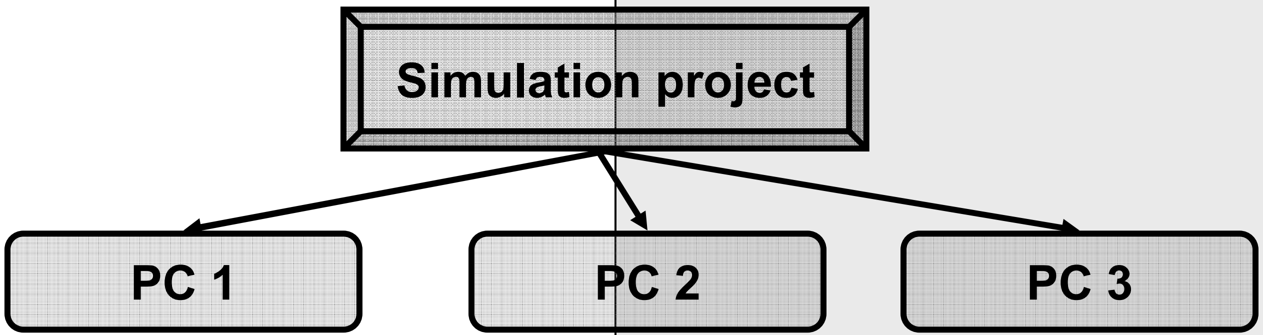
Hot closed die forging: quick feedback



The project, the cases, the actions



Splitting the project for parallel simulation on several PCs in a network



Simulation of preforming operations

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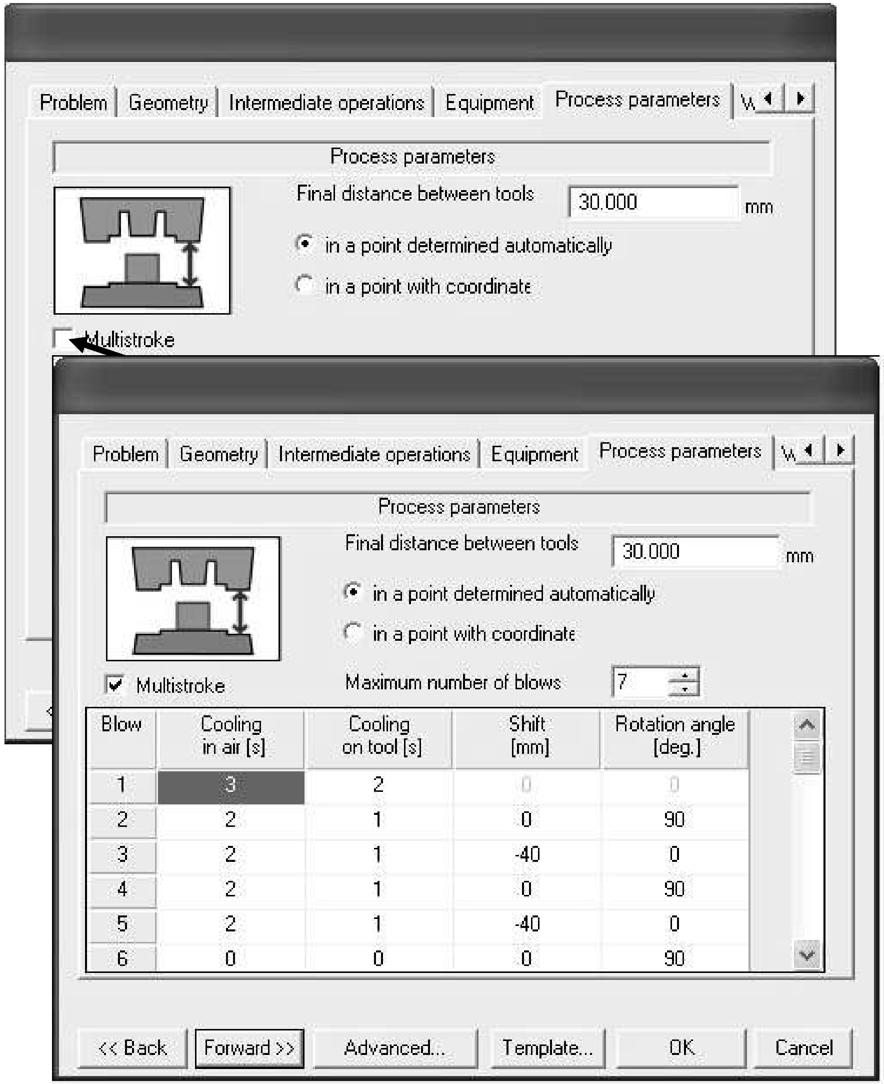
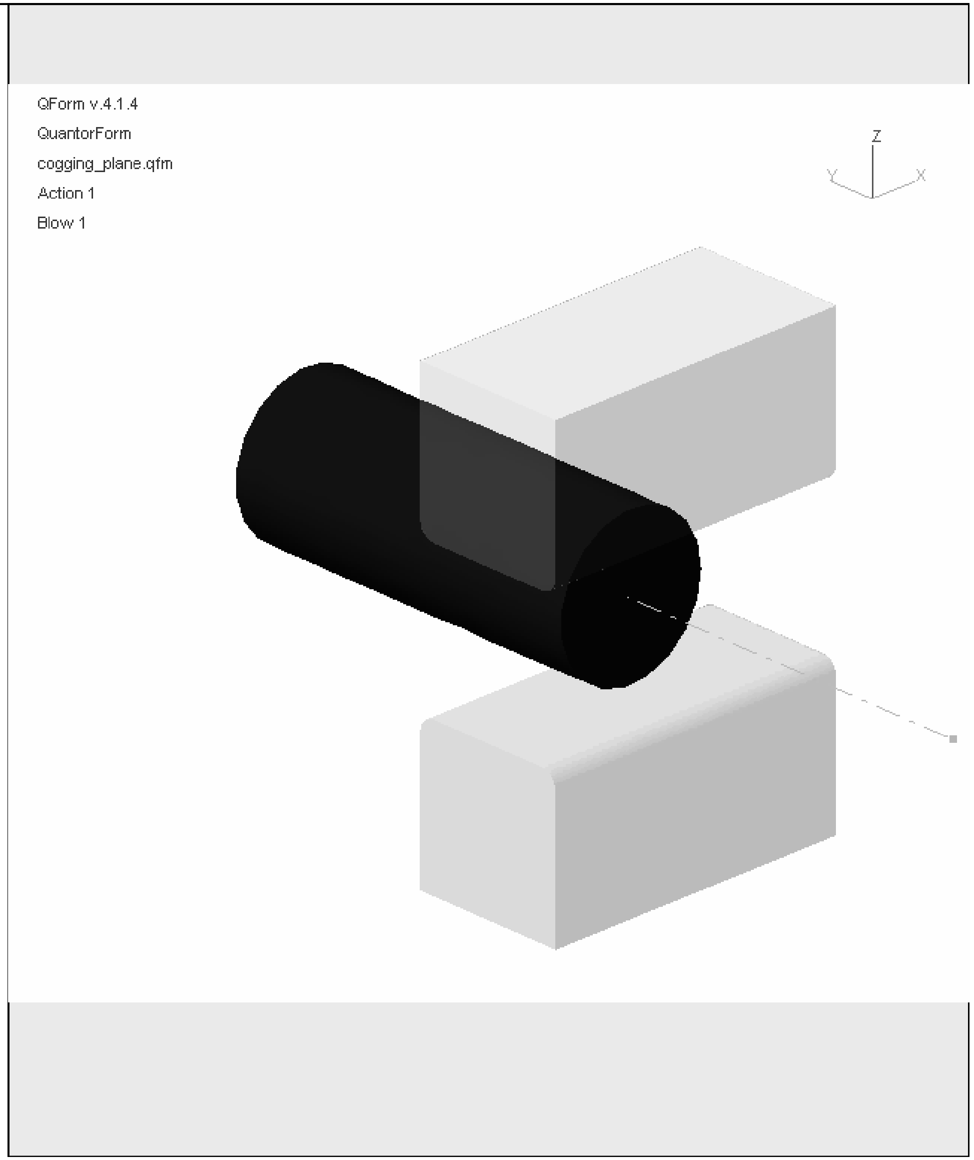
Programmed simulation of cogging operation in a single action





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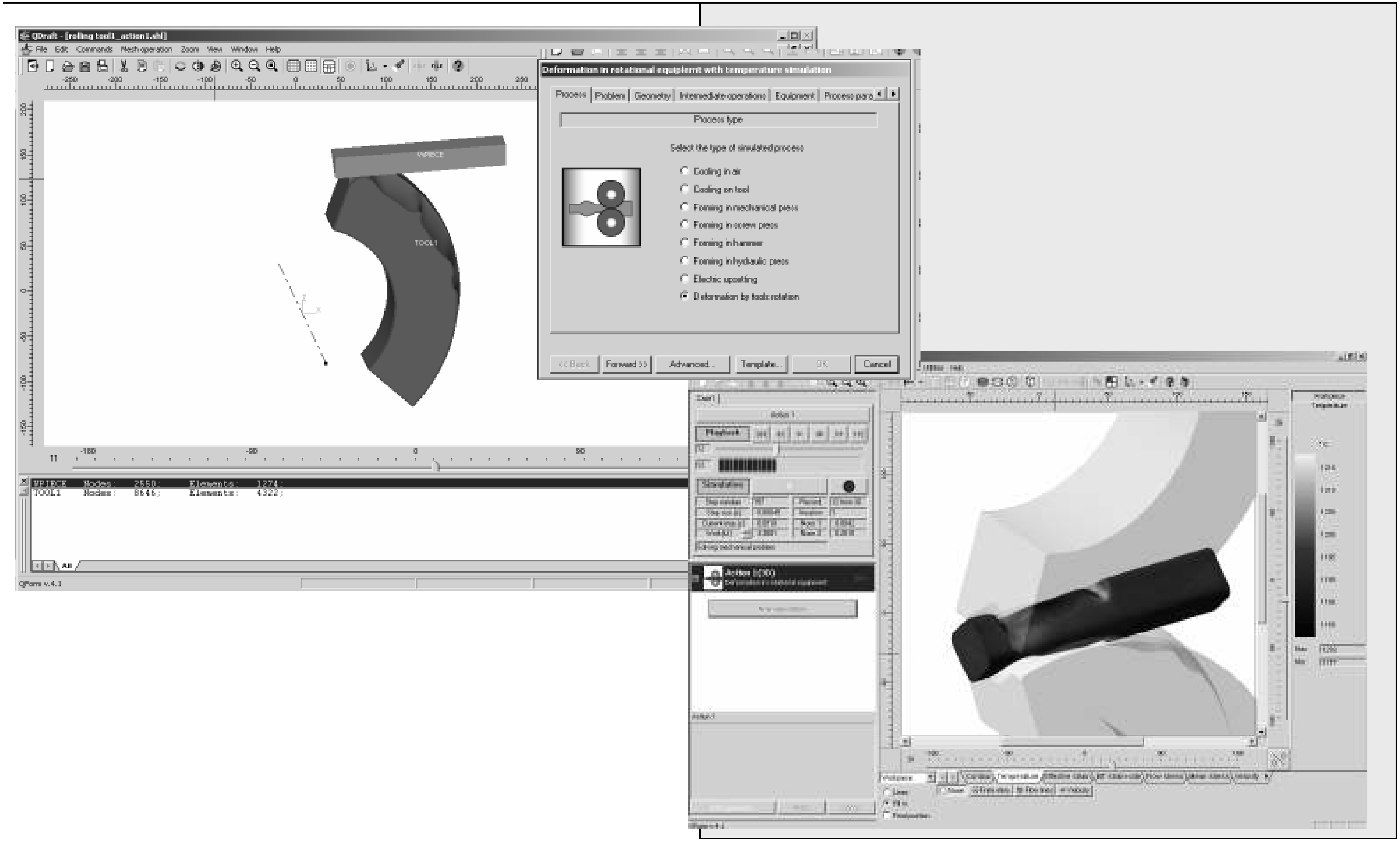
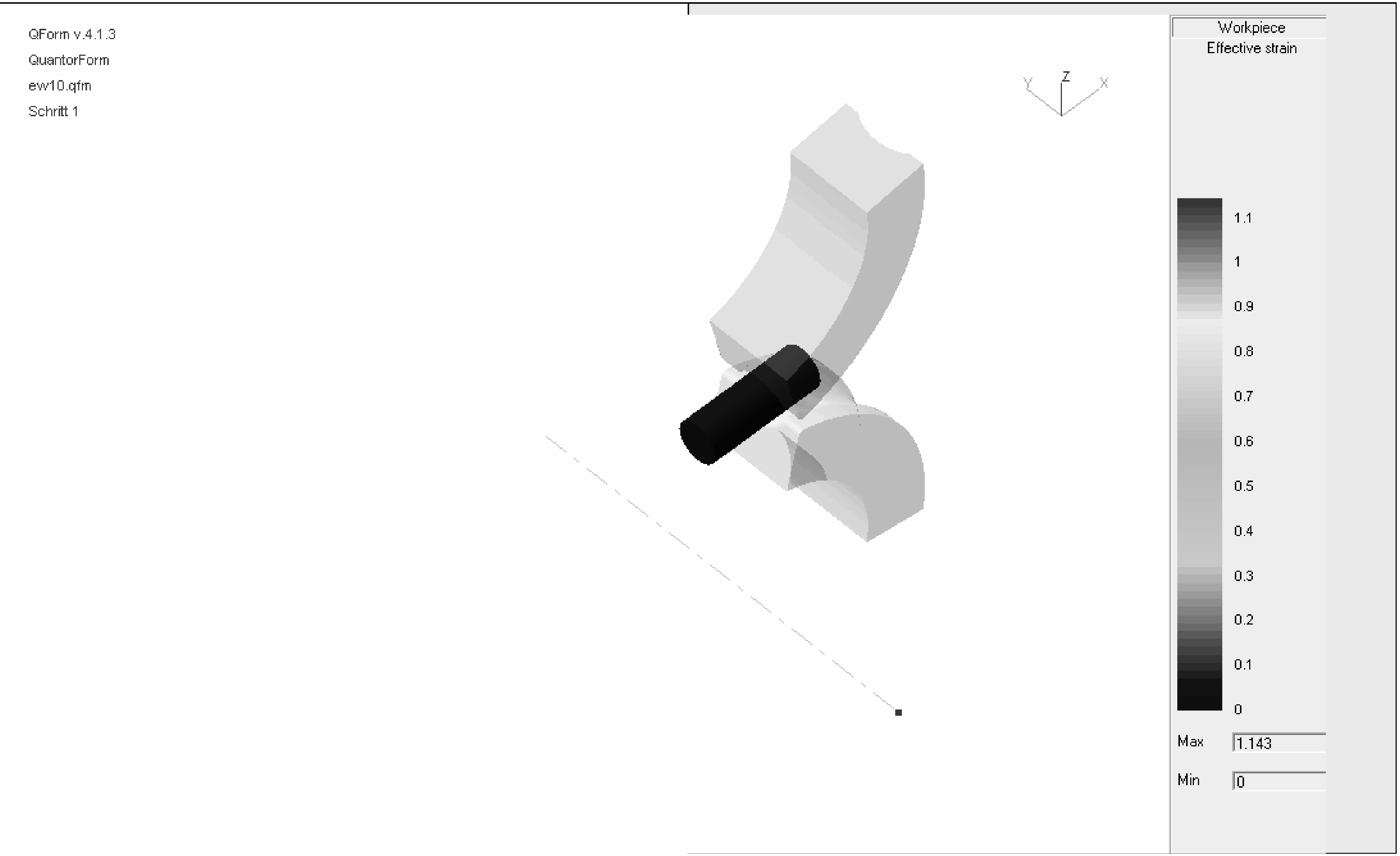
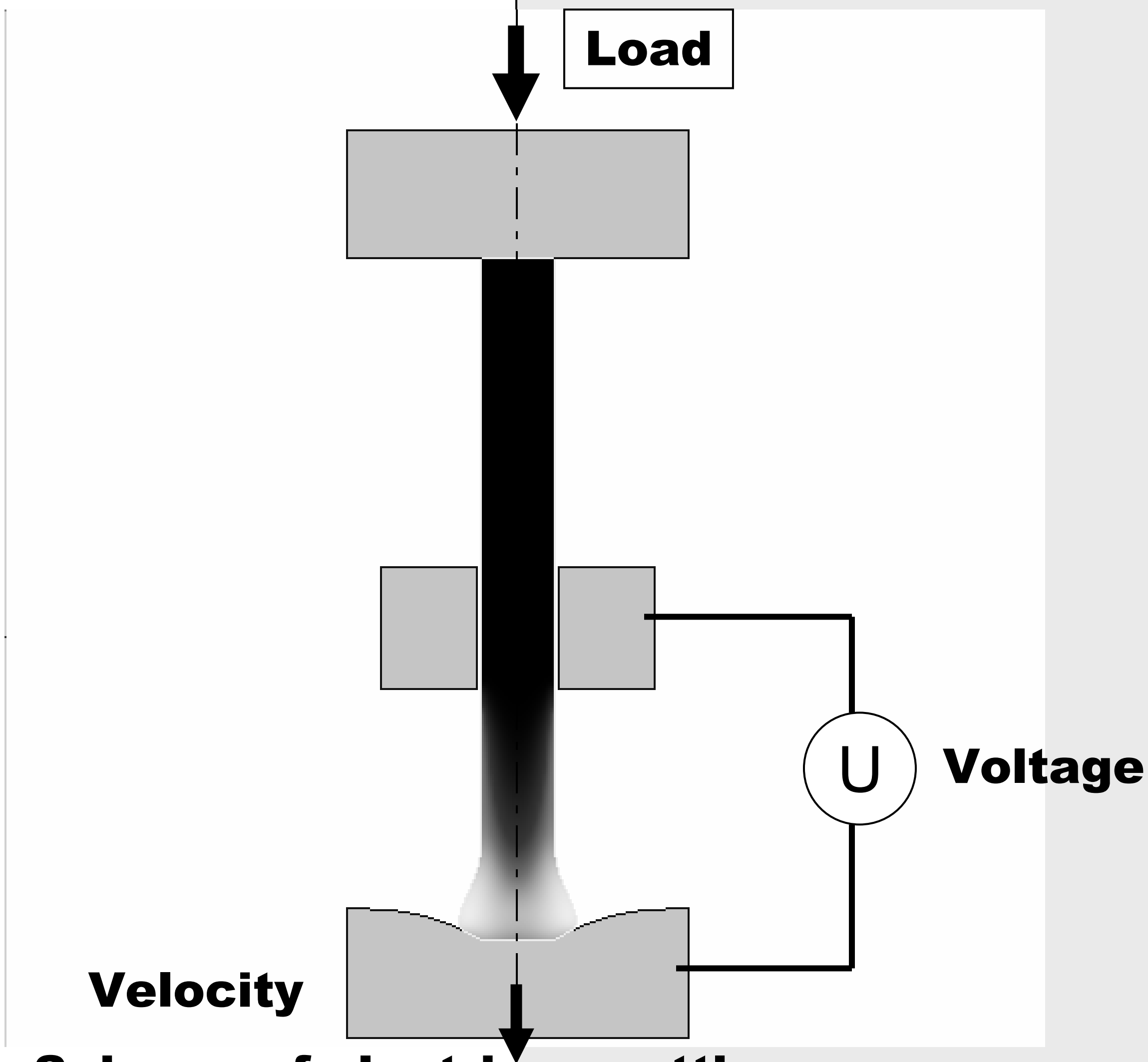
Simulation of reducer rolling



Simulation of reducer rolling

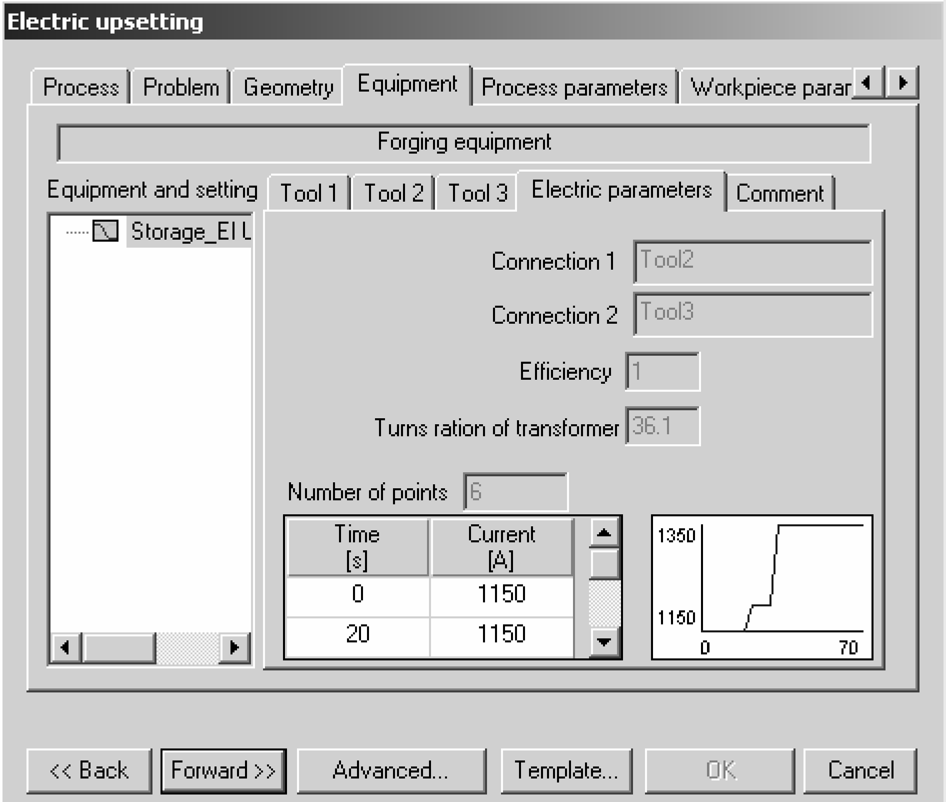


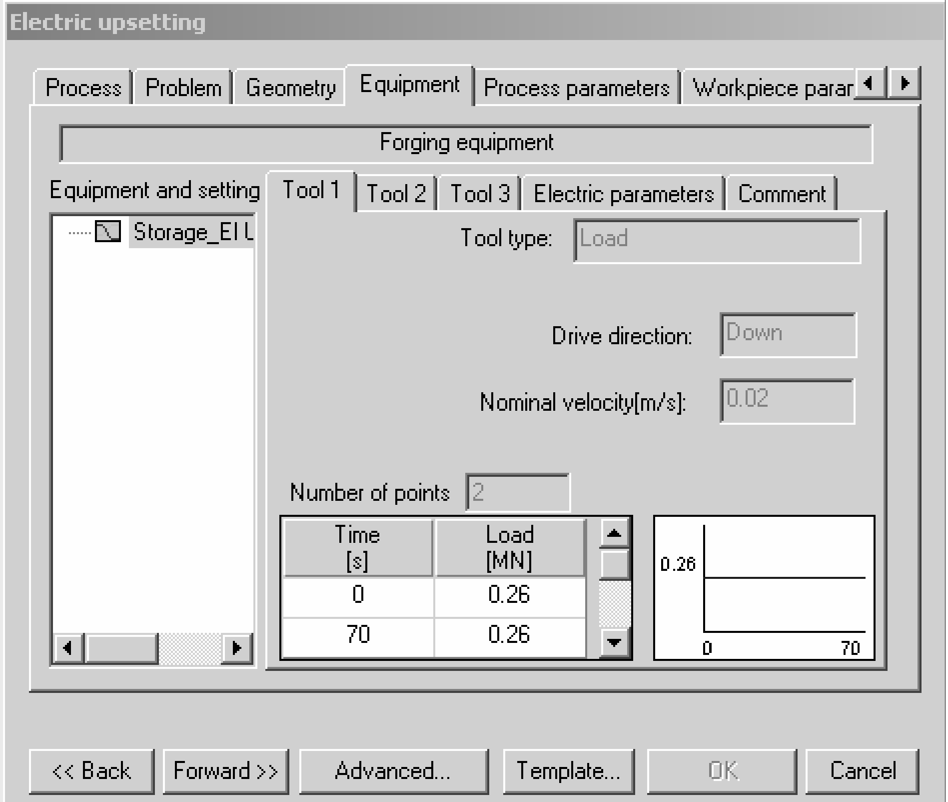
Simulation of electric upsetting



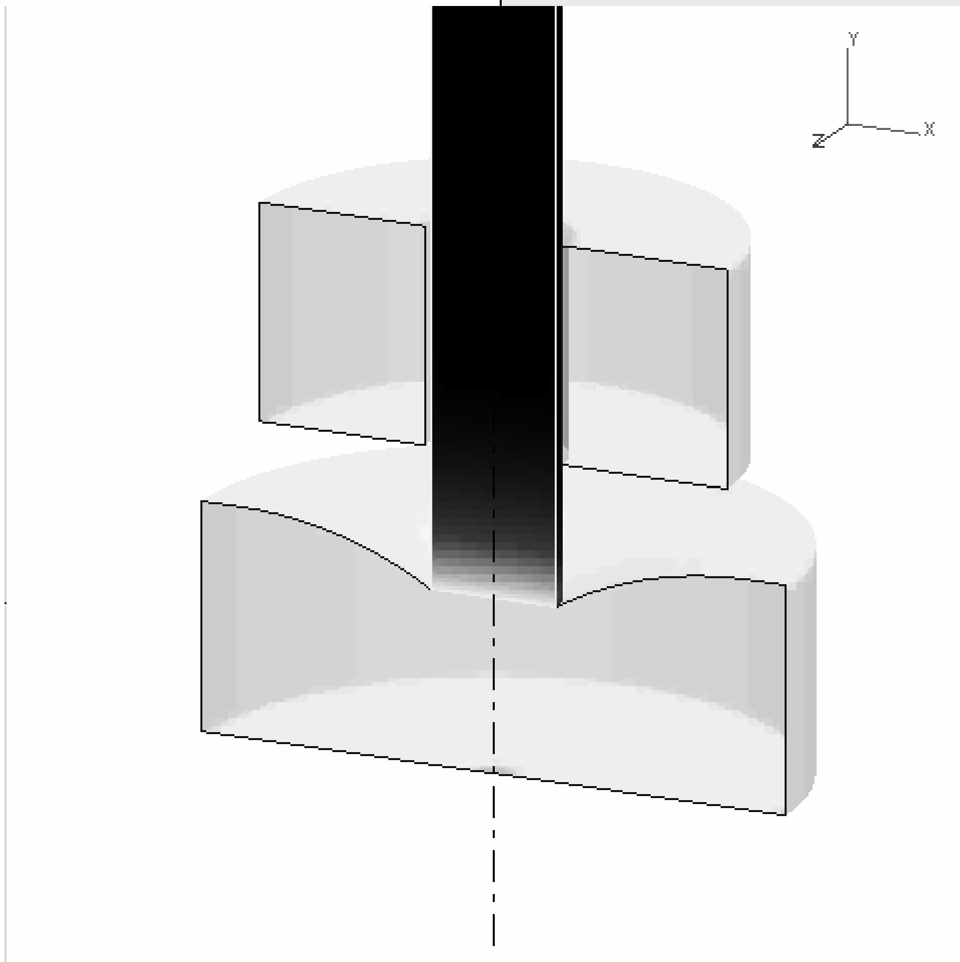
Scheme of electric upsetting process

Specific data required for electric upsetting simulation



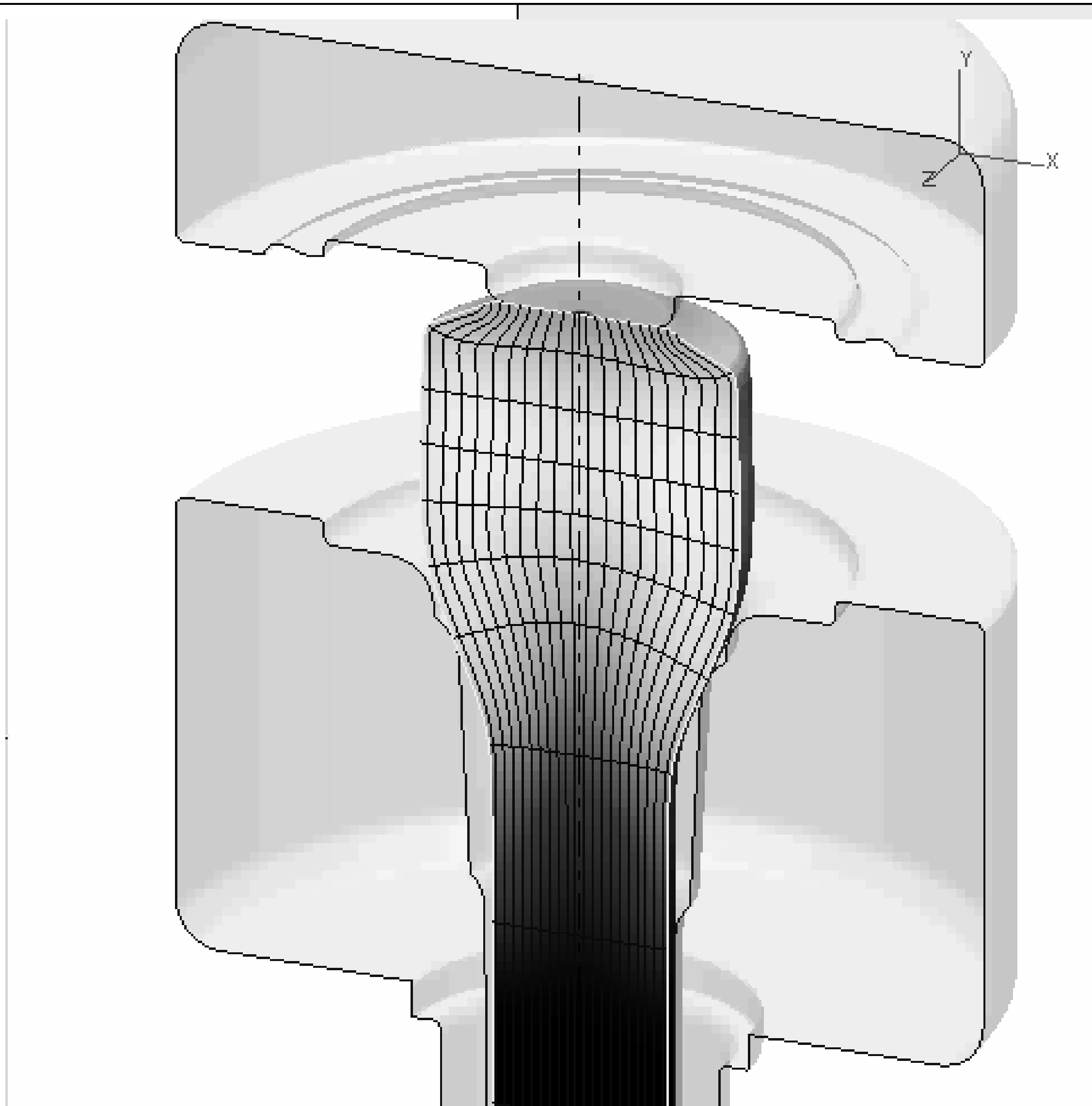


Electric upsetting simulation



Electric Upsetting

Forging of the shaft in a screw press



Closed die Forging

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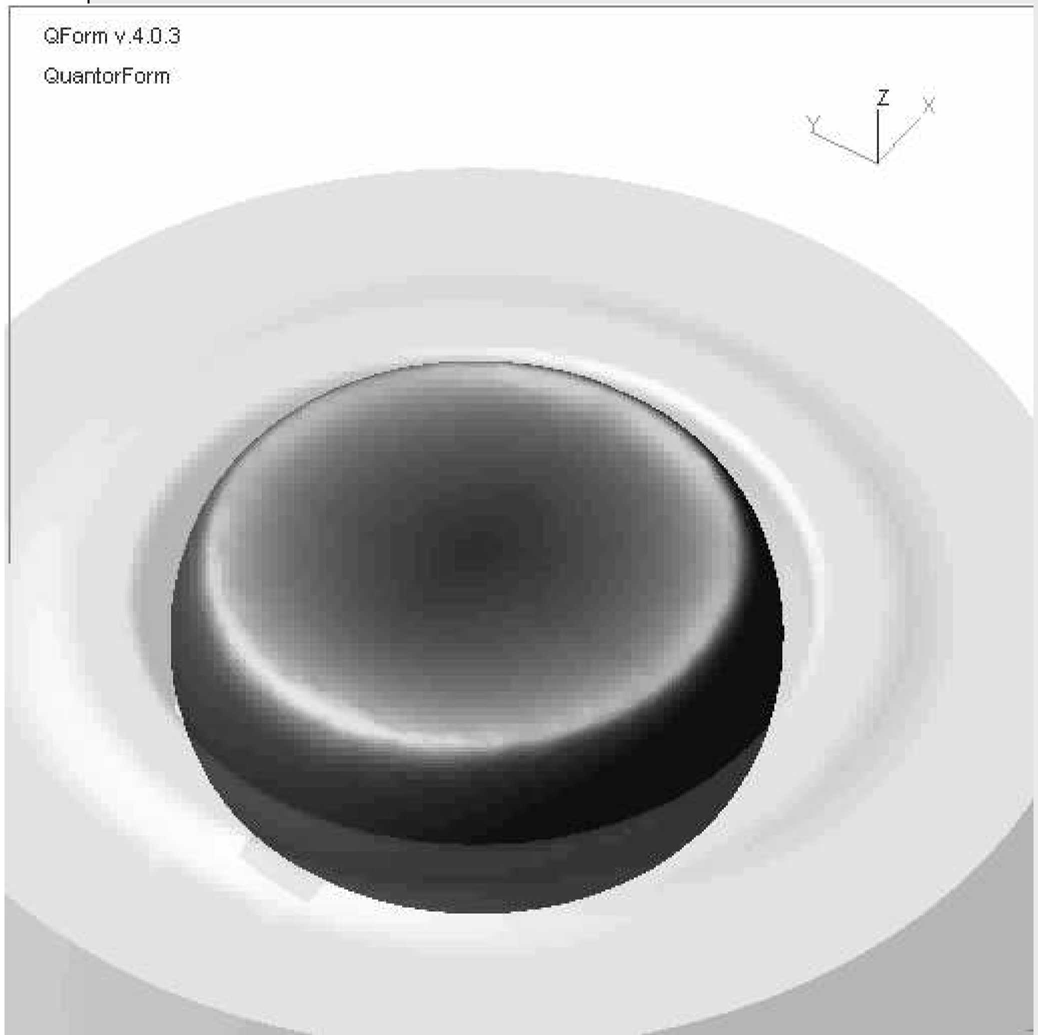
Intermediate operations to be simulated:

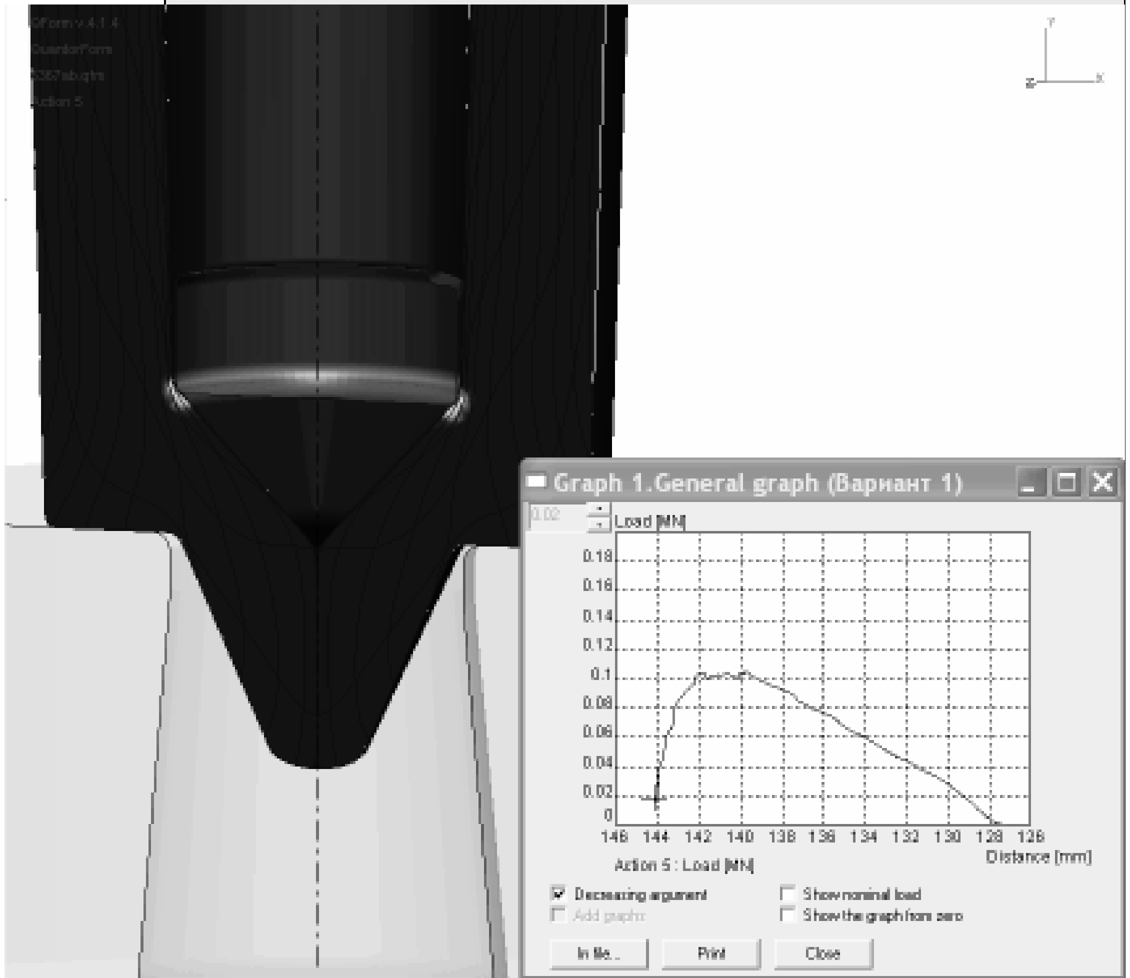
- **Piercing the holes and trimming the flash by clipping contour**



Next >>

Intermediate operations to be simulated:

- **Piercing the hole by the punch**



Control of the dimensions after piercing

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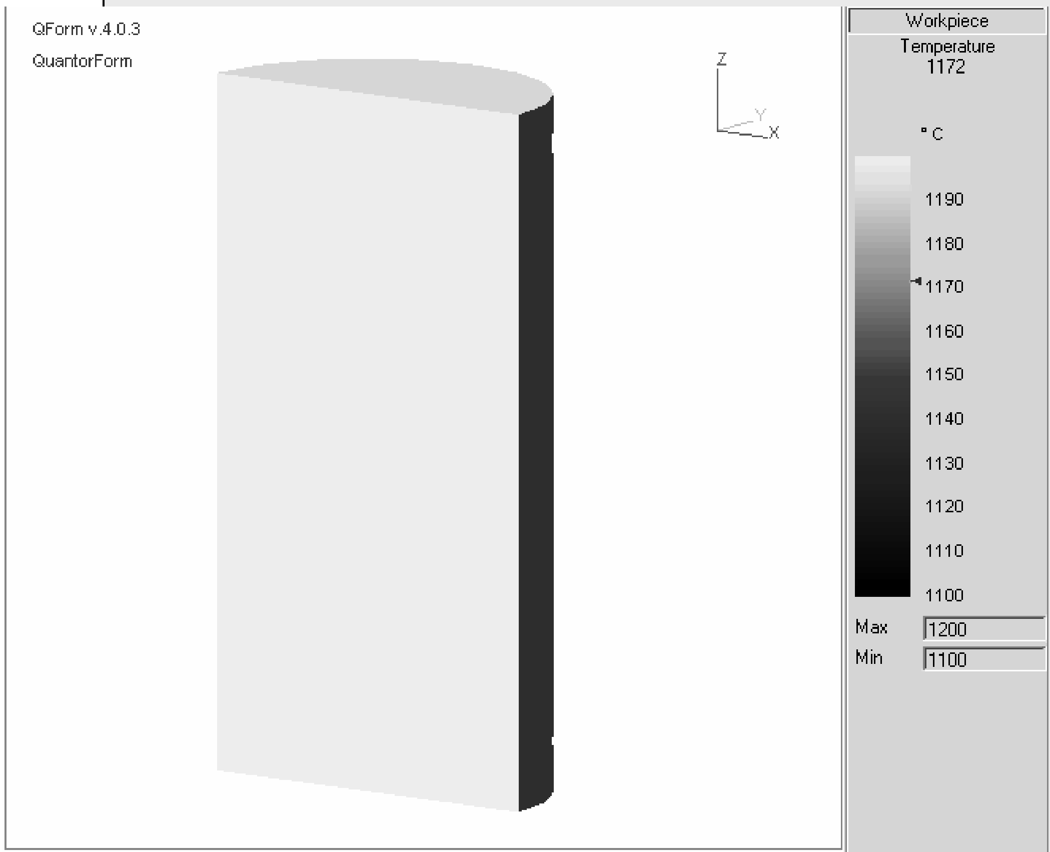
Intermediate operations to be simulated:

- Piercing the holes and trimming the flash
- Cooling in air
- Cooling in tool
- Rotation and gravitational positioning



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Intermediate operations to be simulated:

- Piercing the holes and trimming the flash
- Cooling in air
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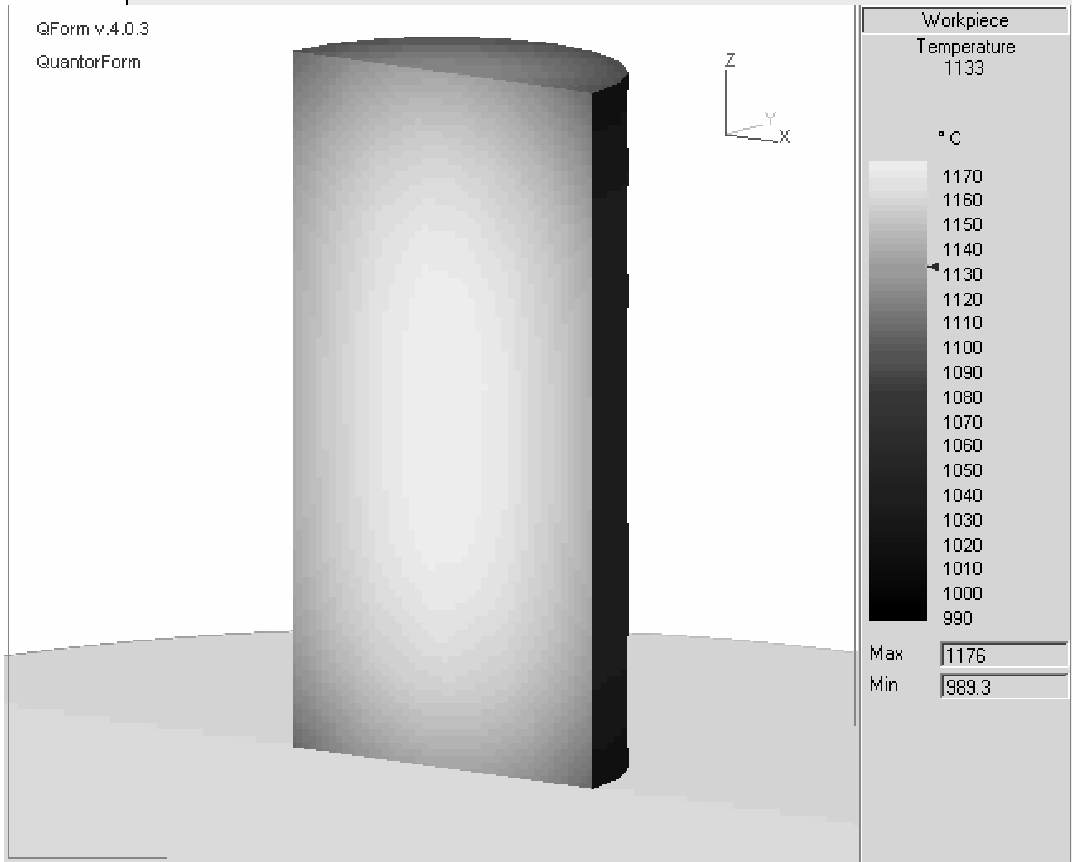
- Rotation and gravitational positioning



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Intermediate operations to be simulated:

- **Piercing the holes and trimming the flash**
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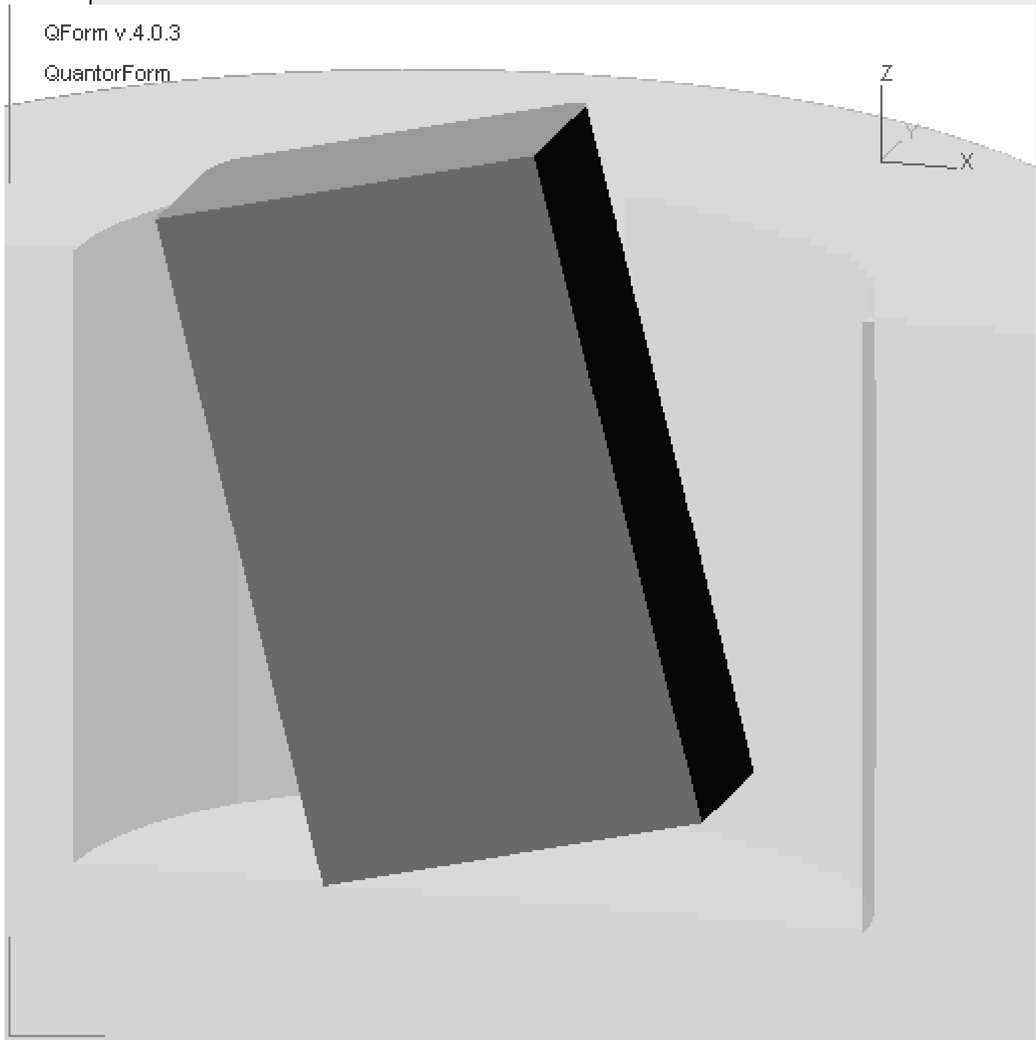
- **Cooling in tool**
- **Rotation and gravitational positioning**



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What benefits do we get from simulation?

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Solving technological problems

1. **Die filling analysis**
2. **Saving the material**
3. **Prediction of material flow defects**
4. **3-tools-simulation**
5. **Simulation of multi-stroke forging**
6. **Positioning and gravity**

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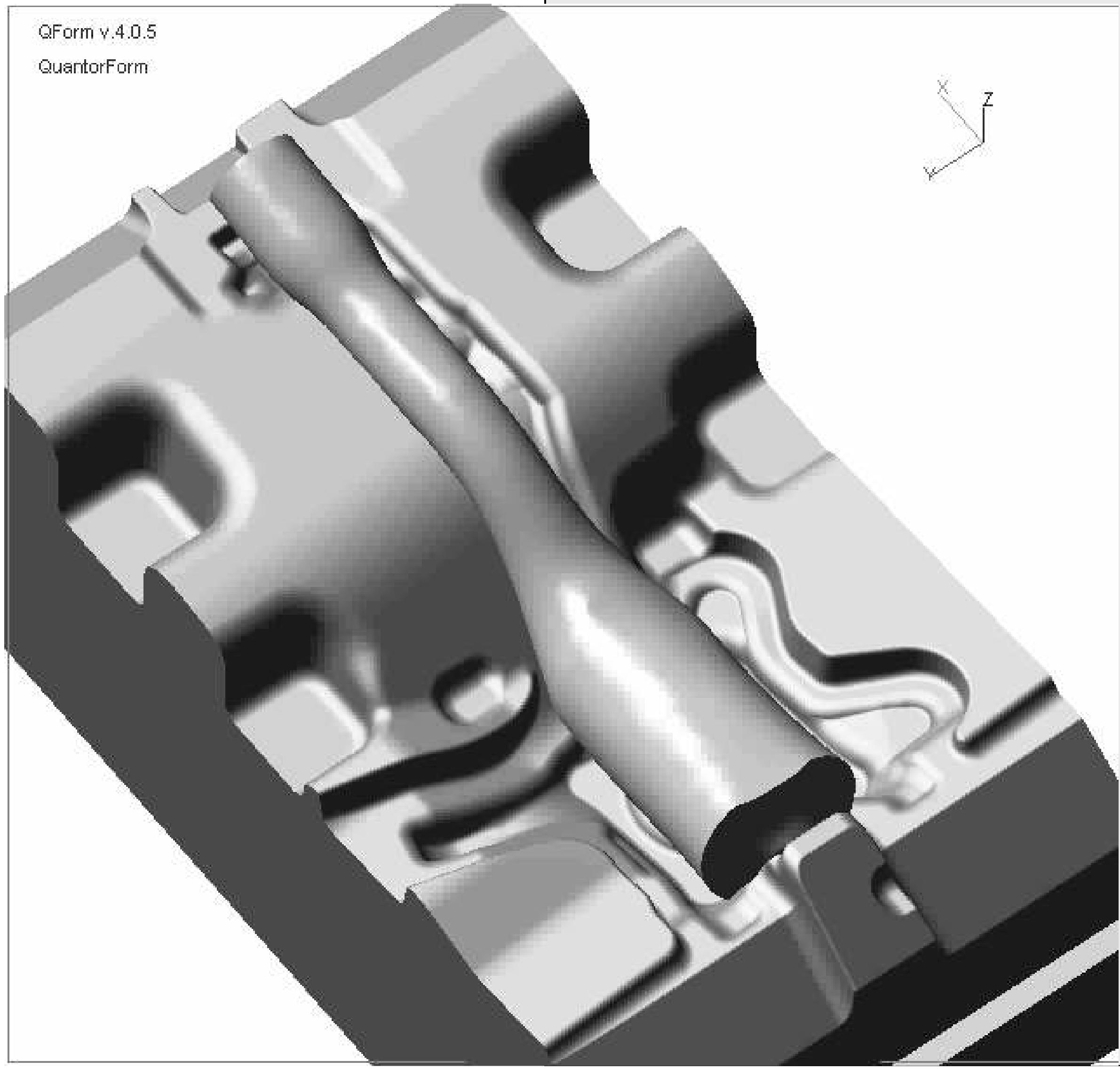
Forging simulation (the die filling is shown)

Making 5 pieces of equal high quality at a time

Forging simulation (the die filling is shown)

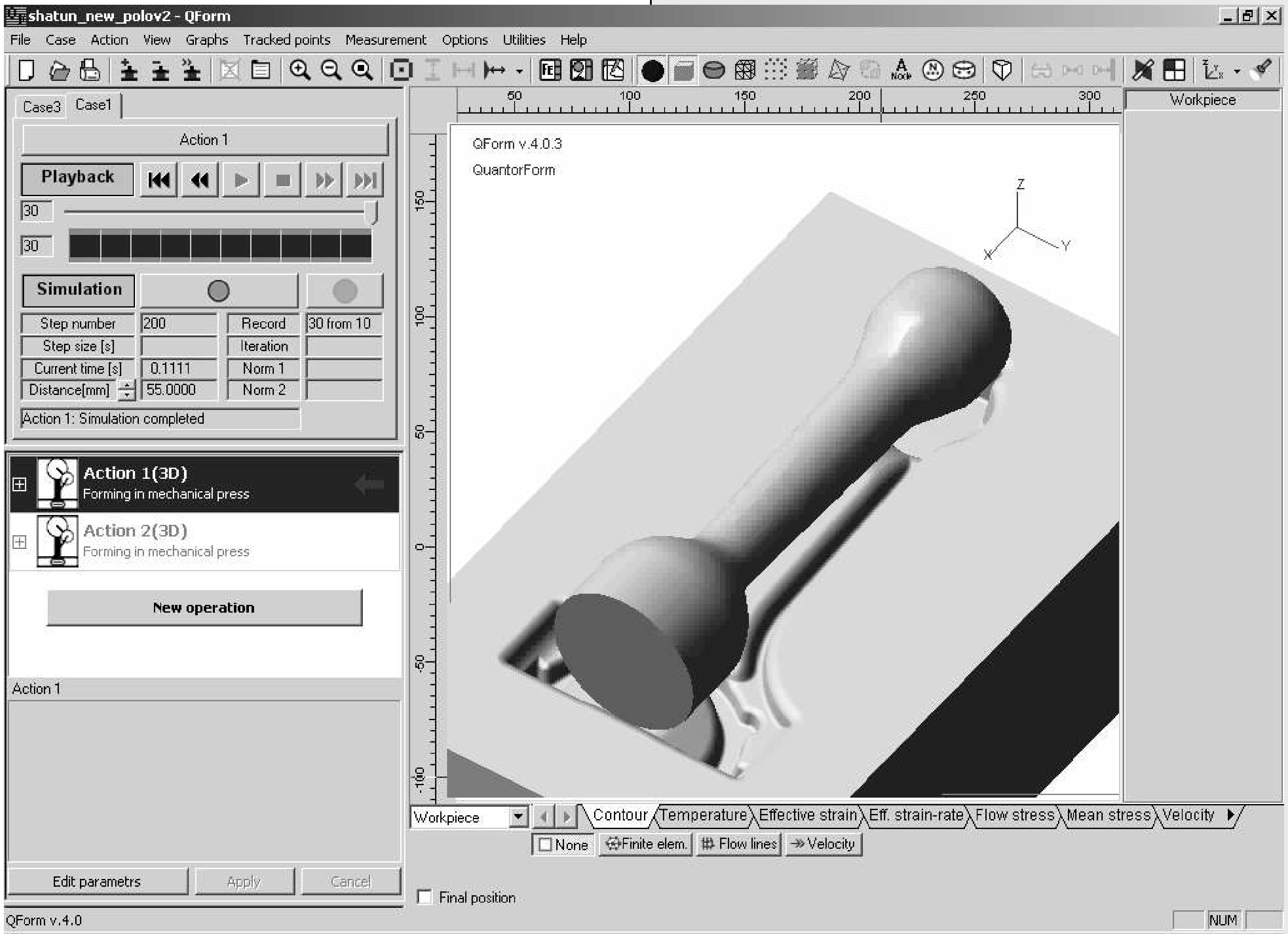


Saving the material

1. **Filling the dies at lower load**
2. **Saving the material**
3. **Prediction of material flow defects**
4. **3-tools-simulation**
5. **Simulation of multi-stroke forging**
6. **Positioning and gravity**

Next >>

Initial preform shape



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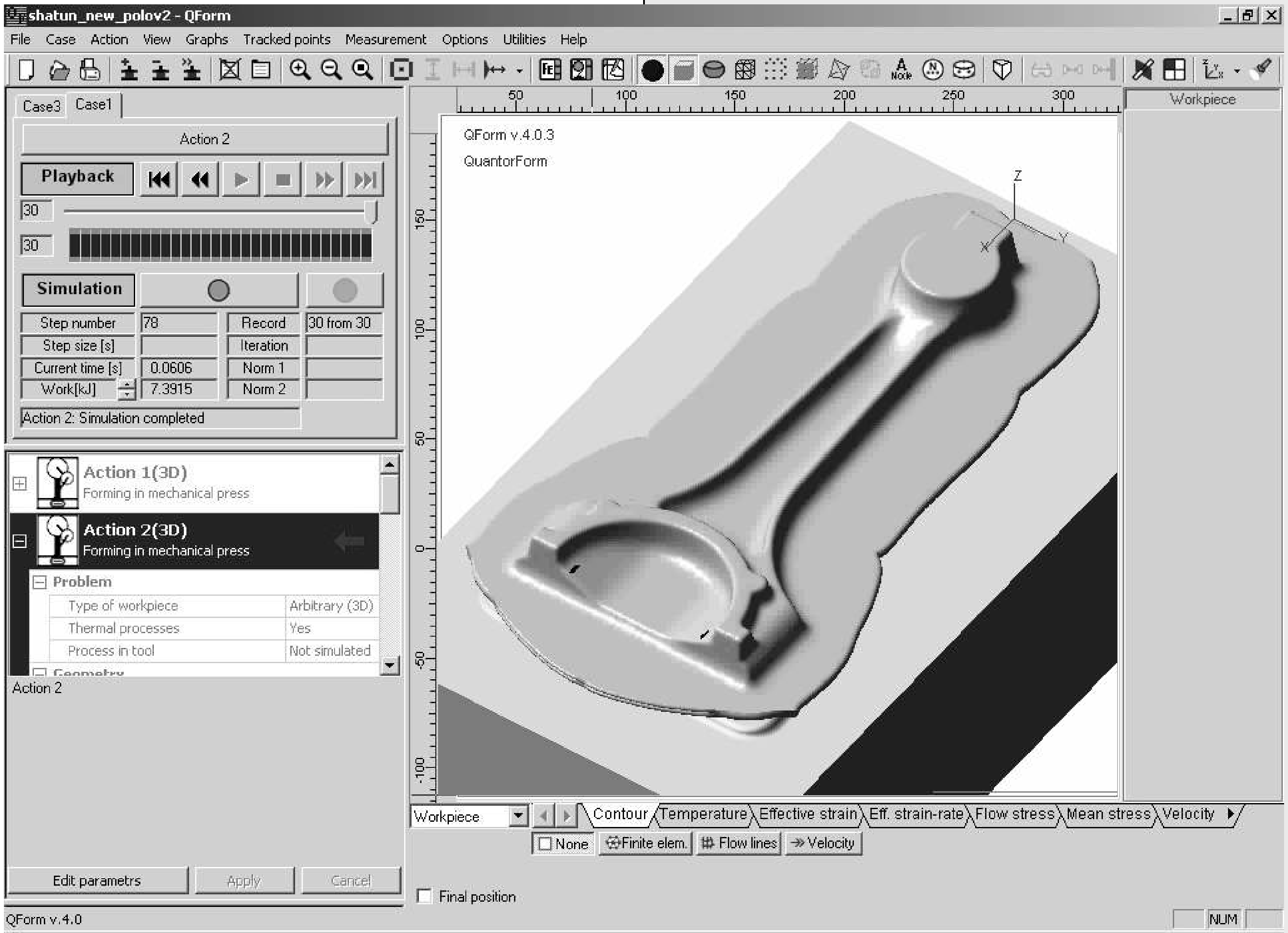
Initial preform shape



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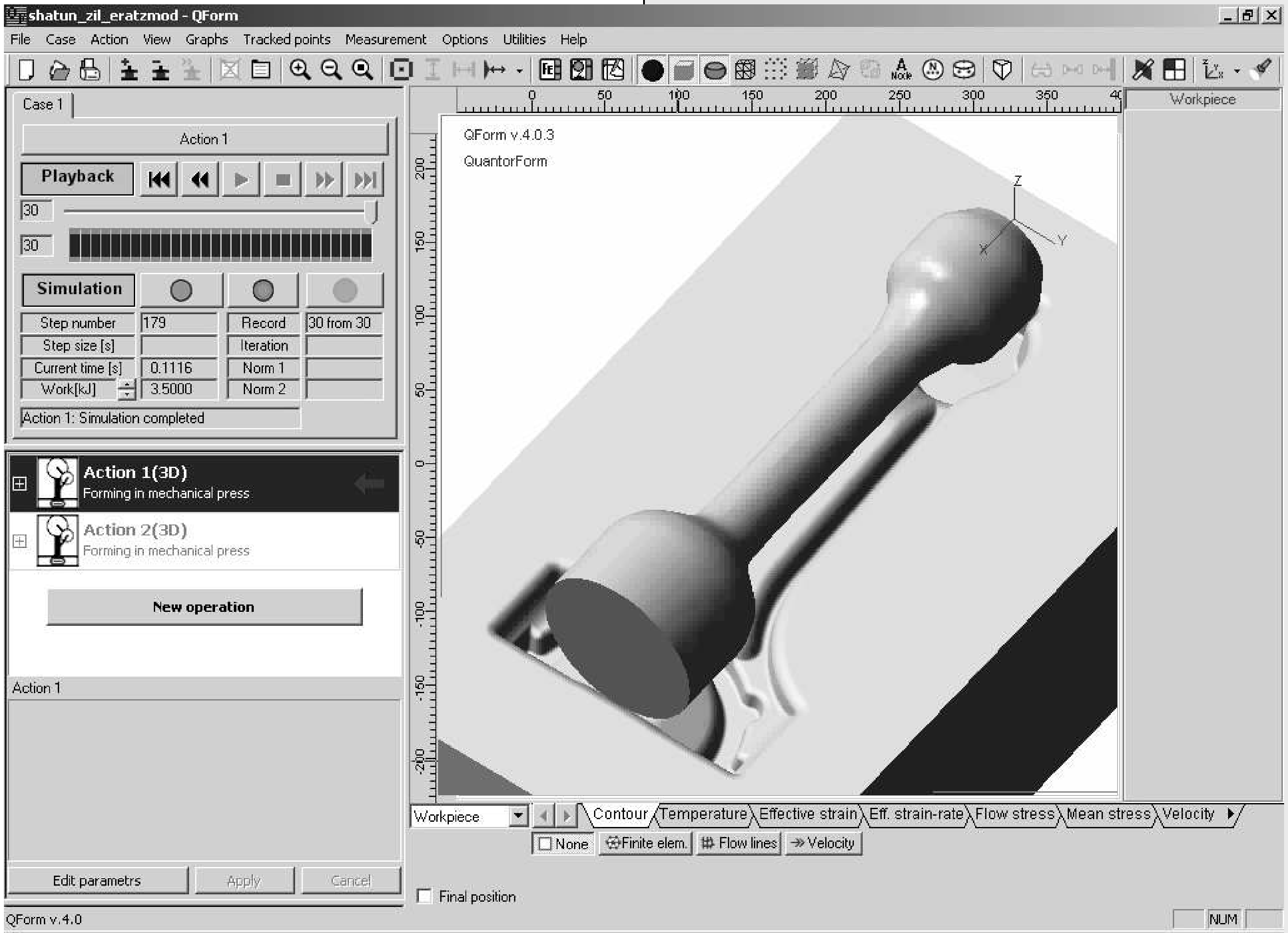
Optimized preform shape



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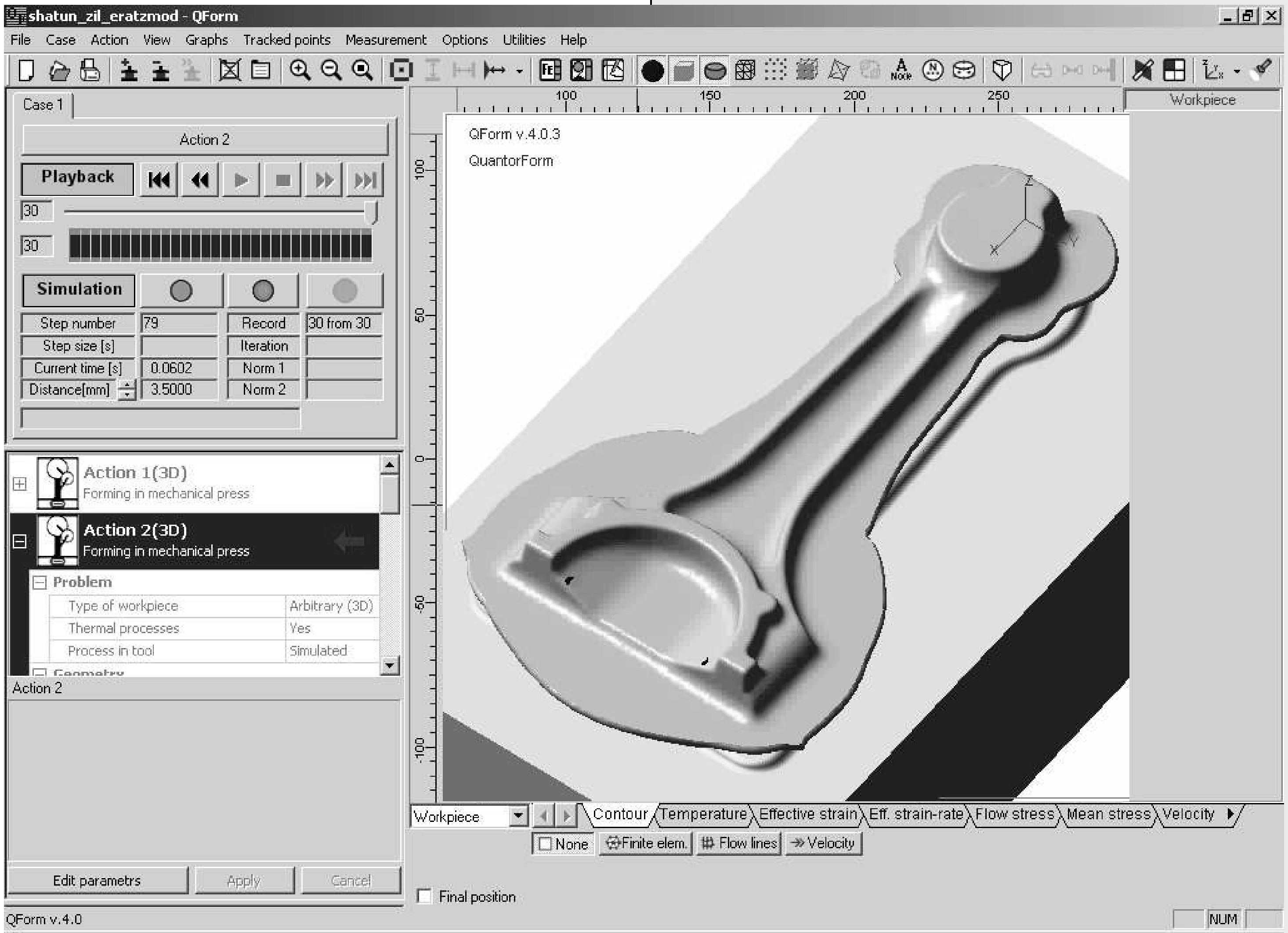
Optimized preform shape



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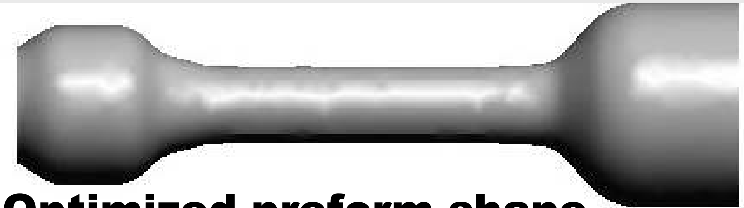
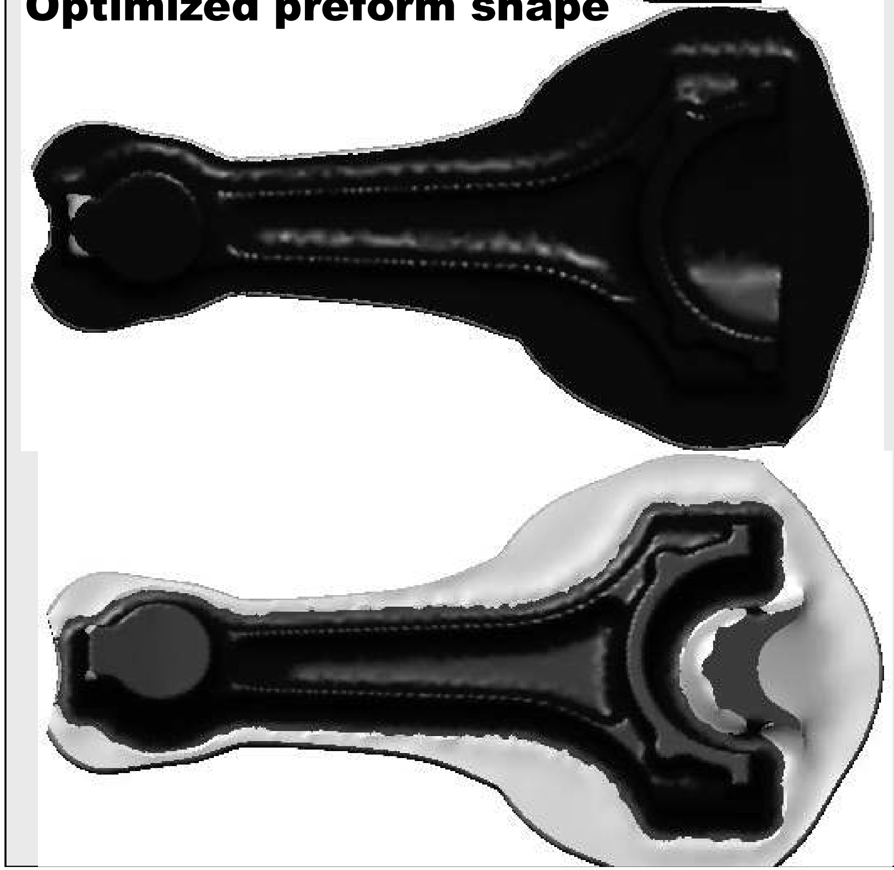
Material saving: billet weight reduced by 12%

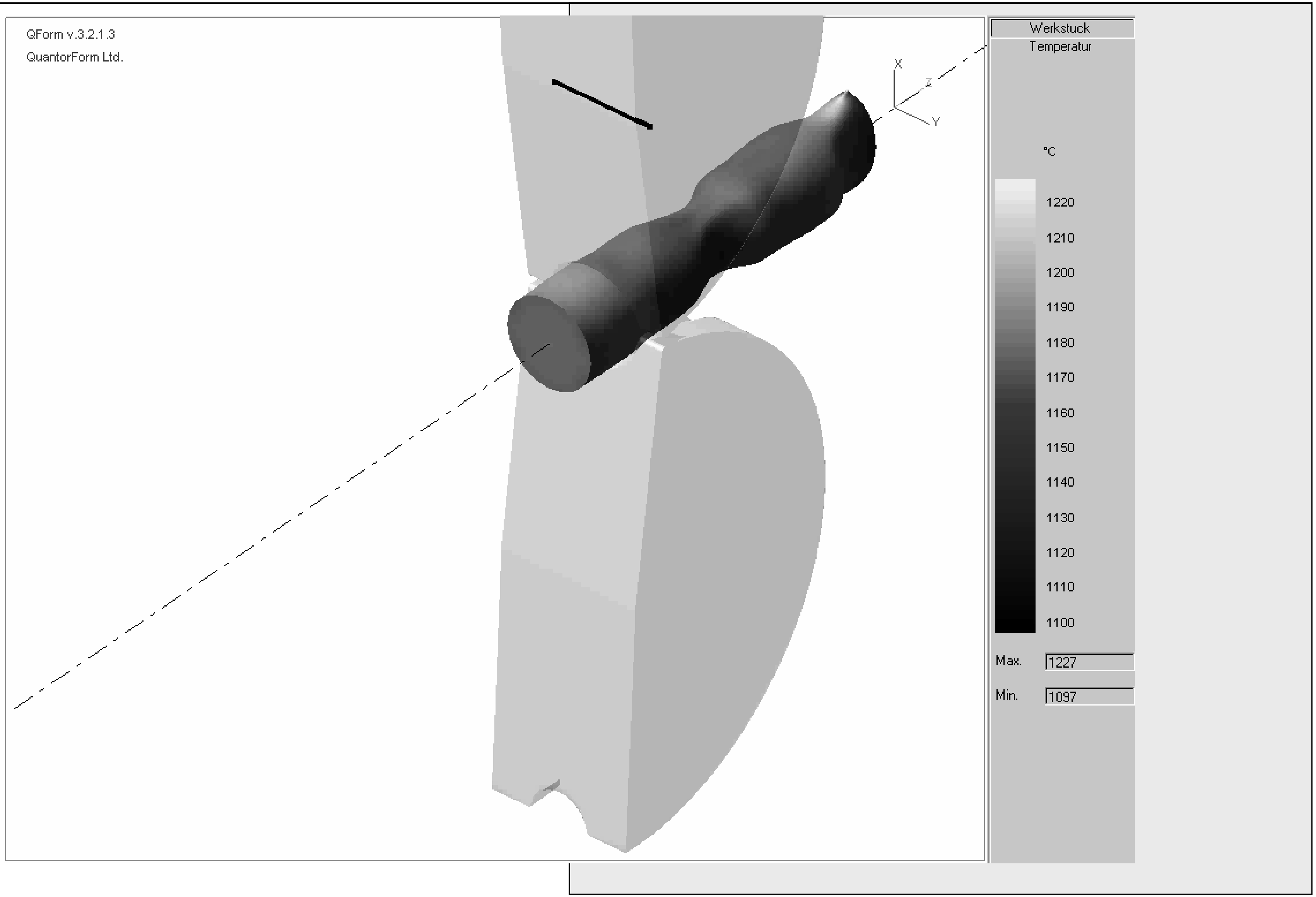
Initial preform shape



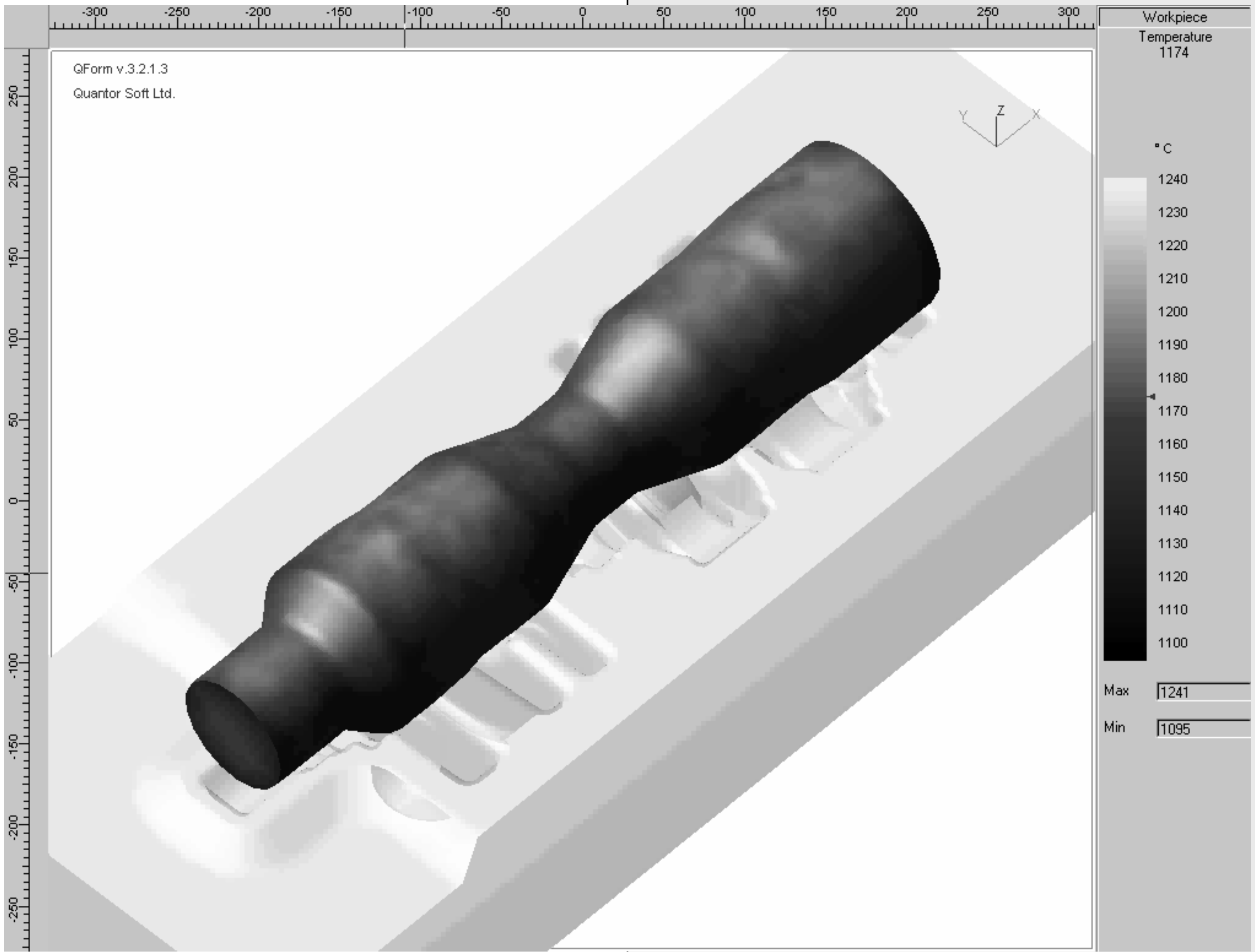
Optimized preform shape



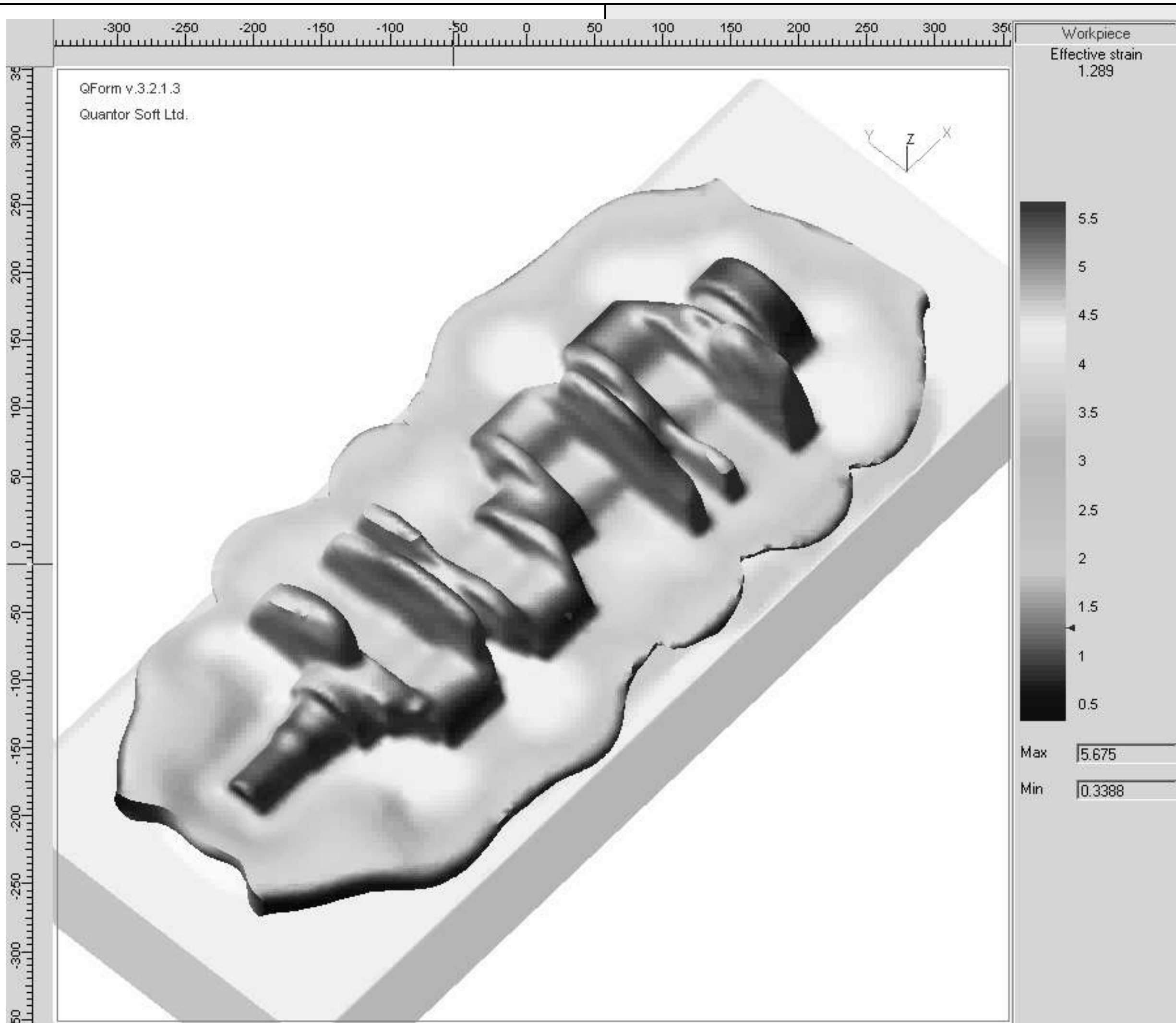
Distance 35 mm in front of center line in 3rd pass



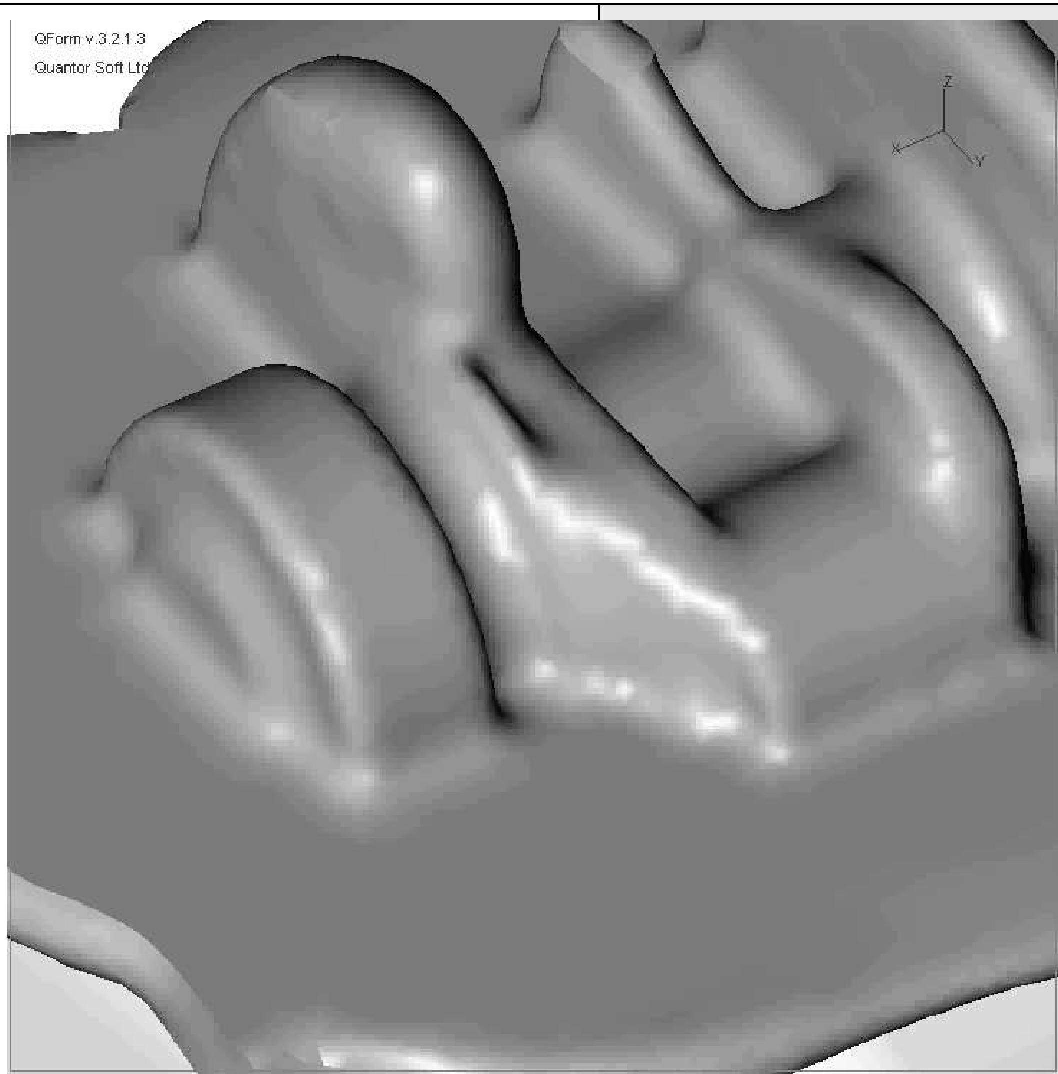
Crankshaft forging simulation (the first blow, temperature shown)



The second forging blow (strain distribution)



The lap formation in second forging blow

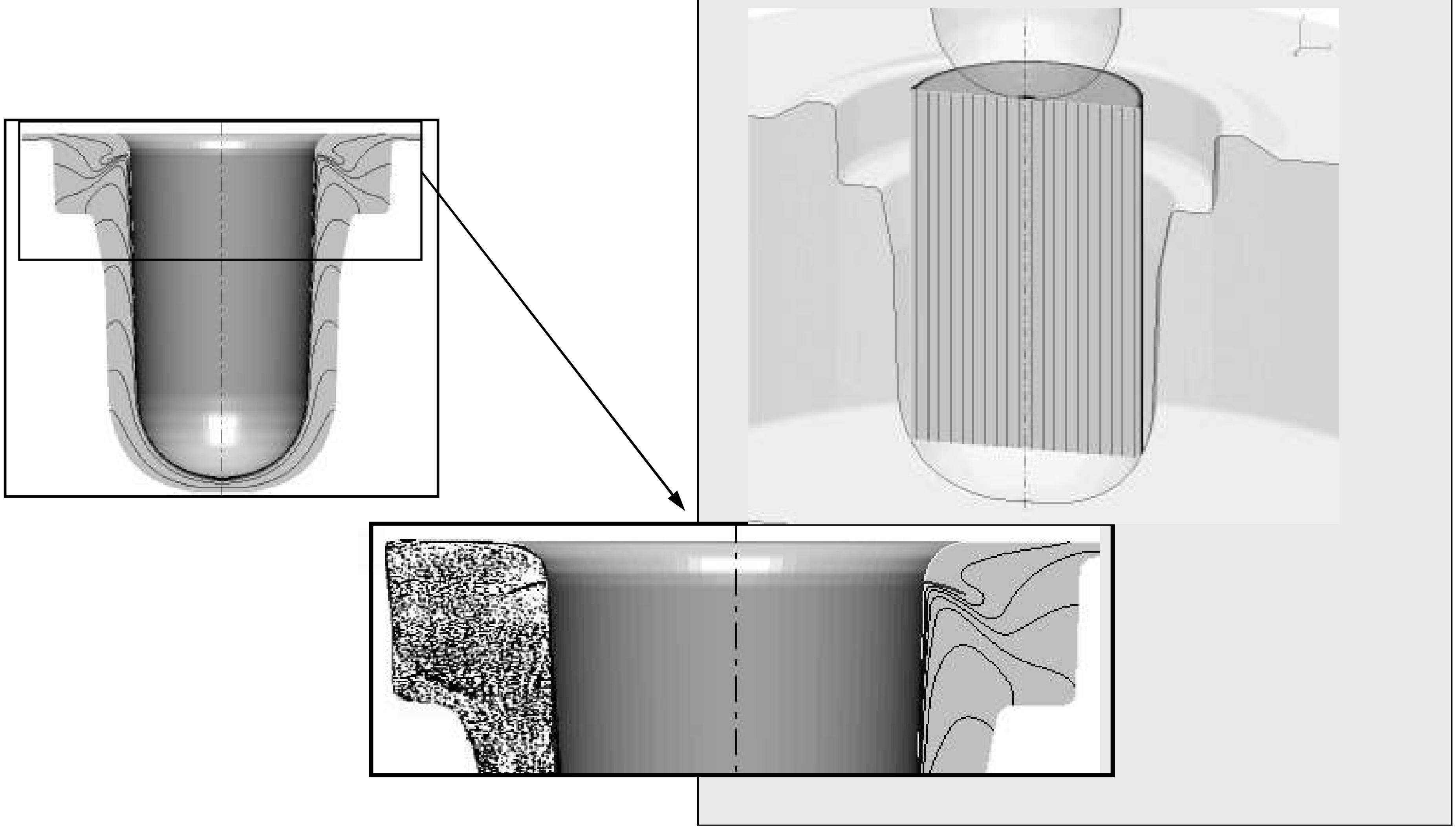


Part 2. Solving technological problems using QFORM3D

1. **Filling the dies at lower load**
2. **Saving the material**
3. **Prediction of material flow defects**
4. **3-tools-simulation**
5. **Simulation of multi-stroke forging**
6. **Positioning and gravity**

Prediction of material flow defects

Identification of the laps in simulation in QForm2D



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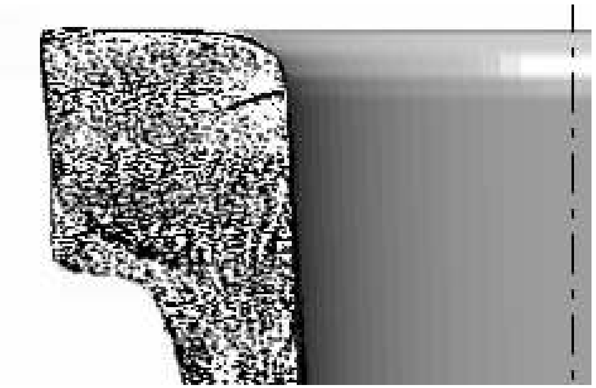
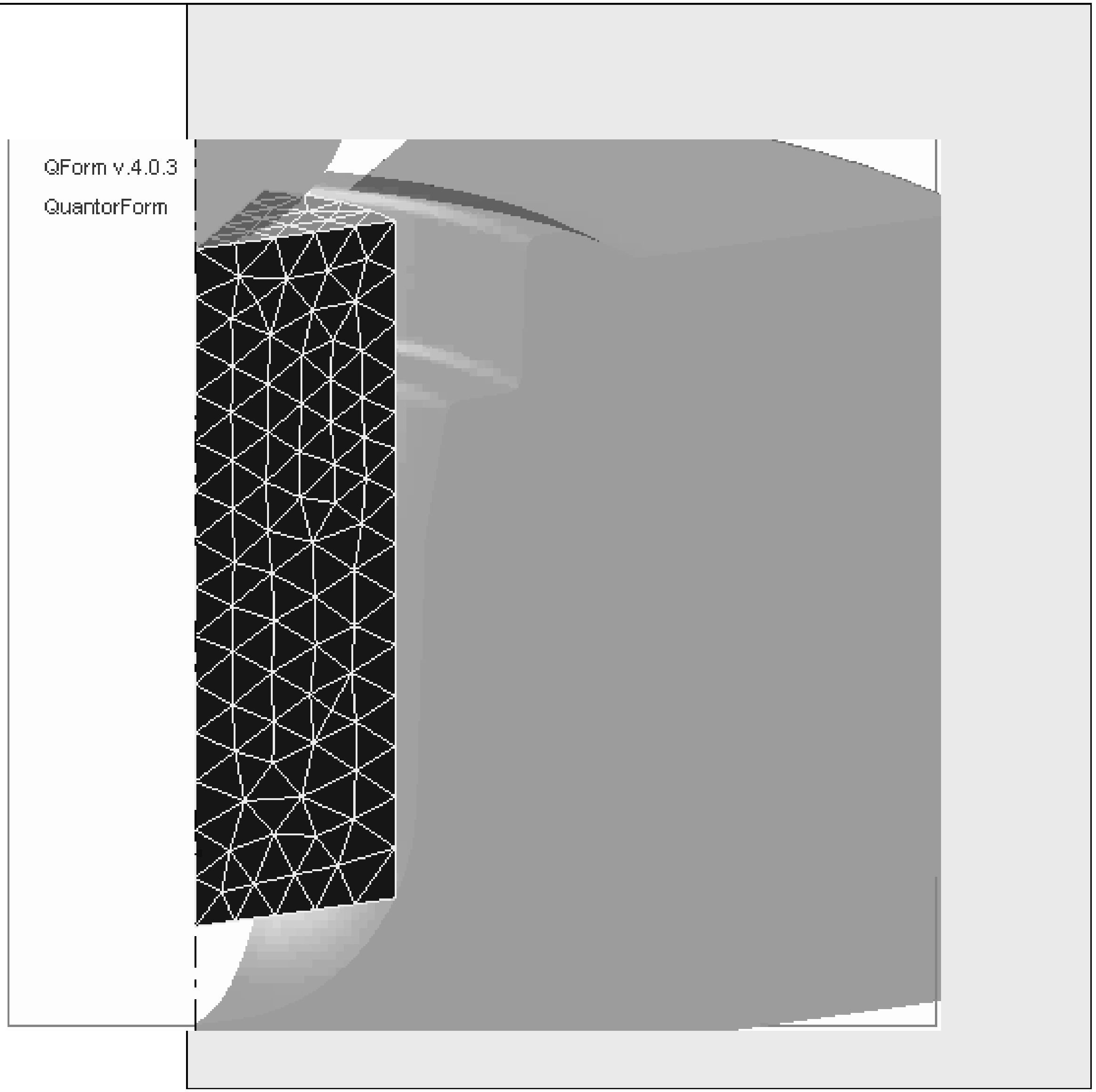
Identification of the laps in simulation in QForm3D

The lap





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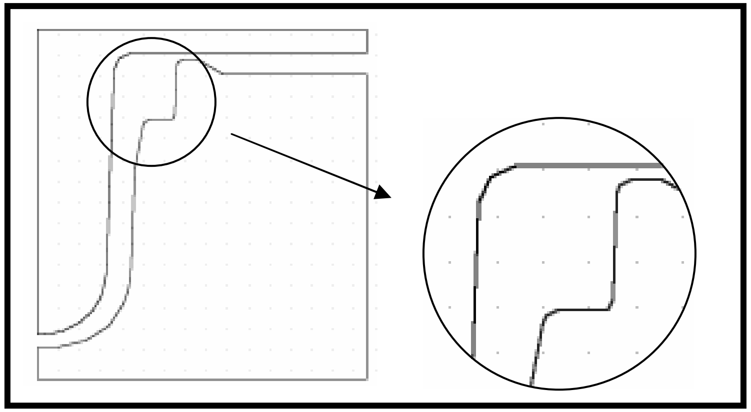
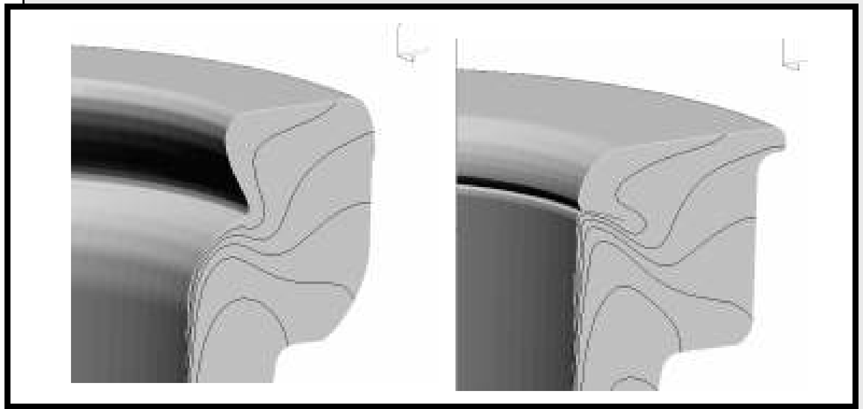
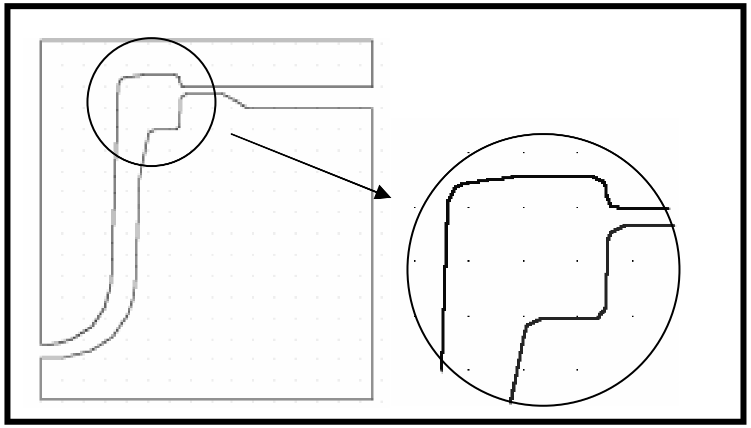
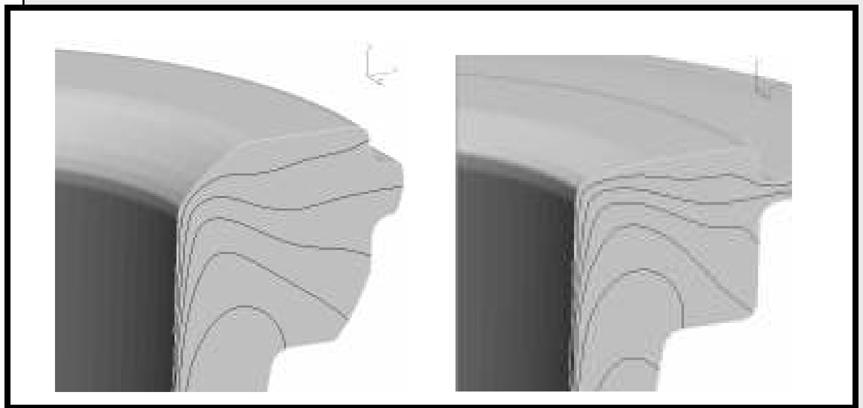
Finding the solution by means of simulation

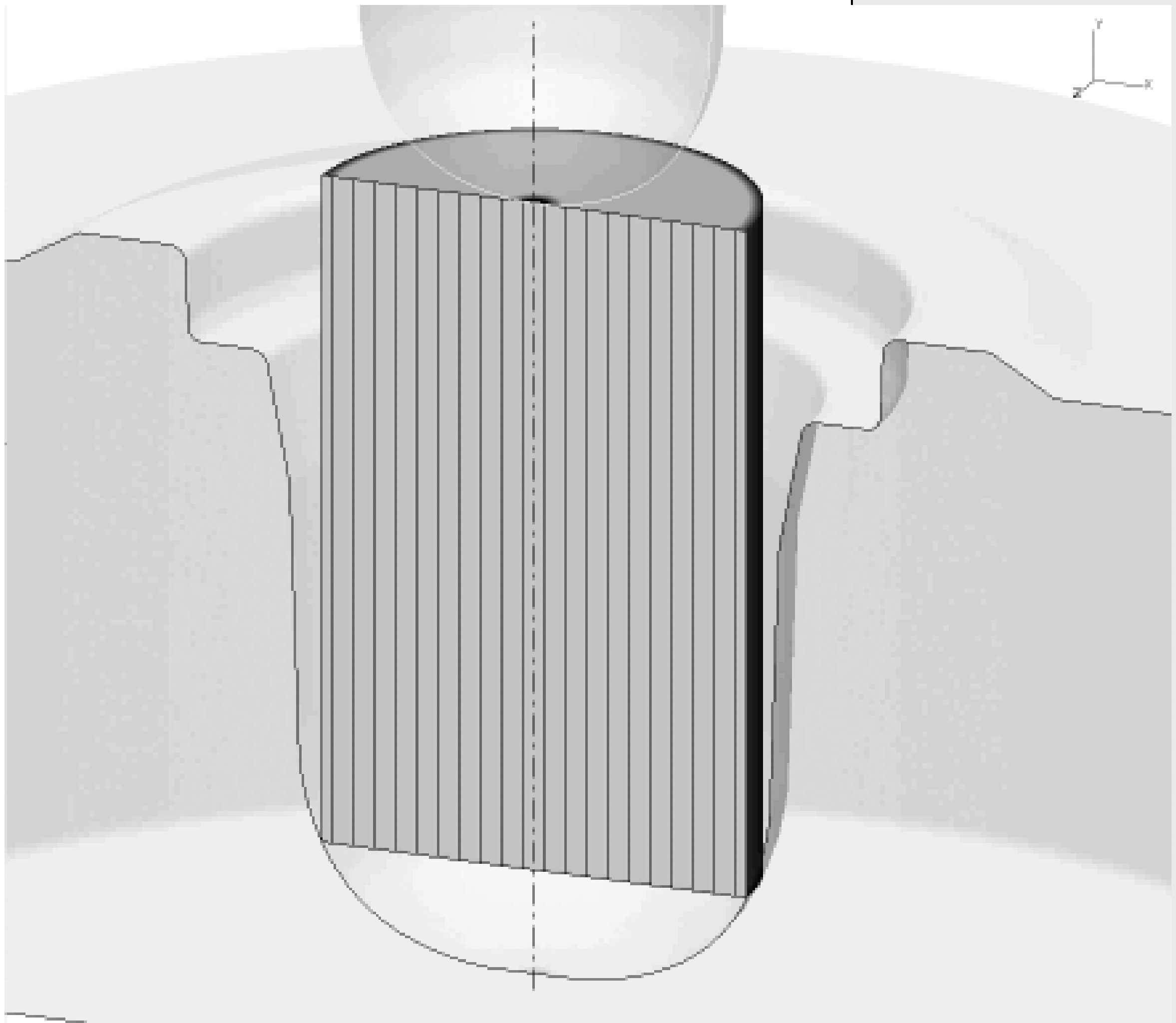






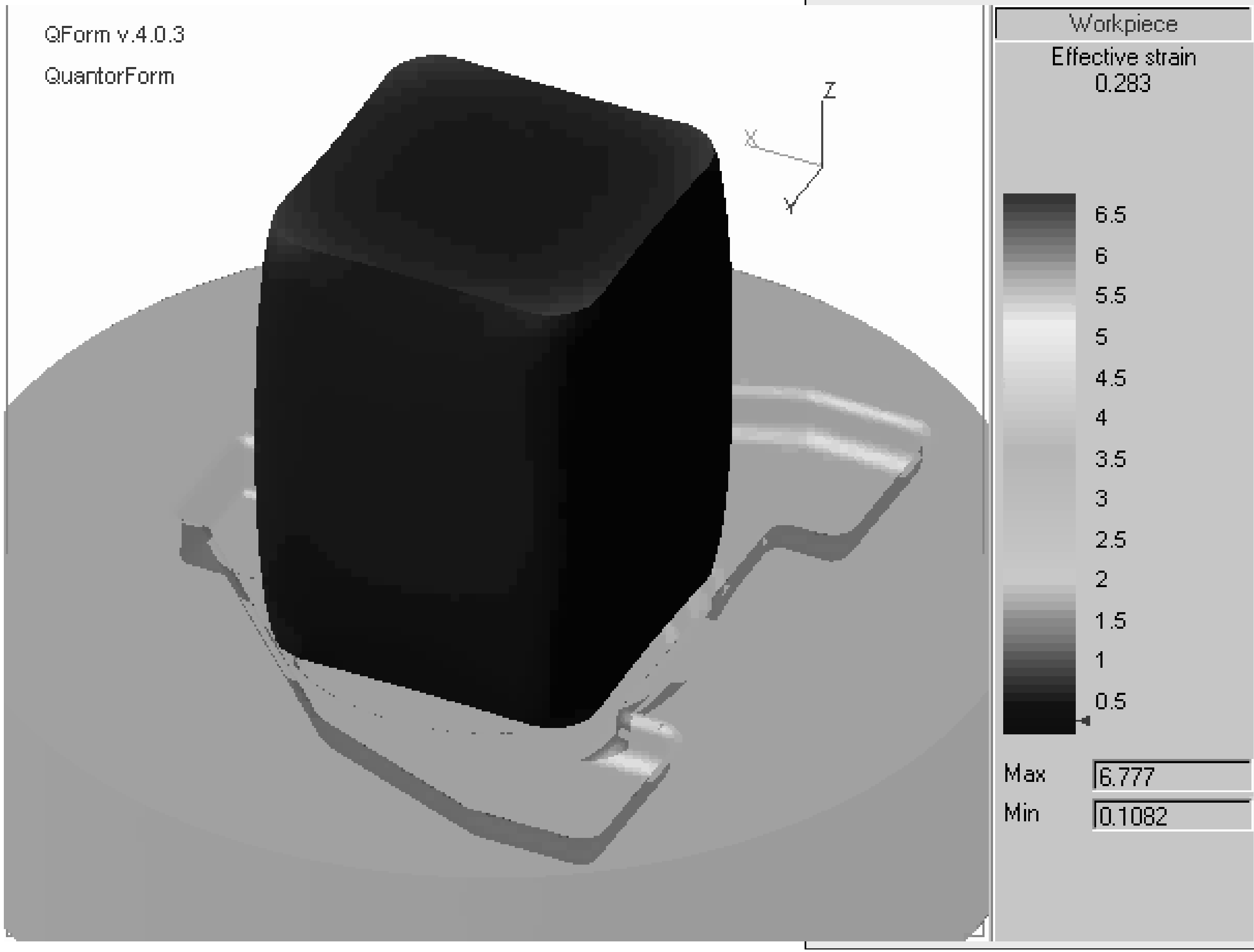


Finding the solution by means of simulation



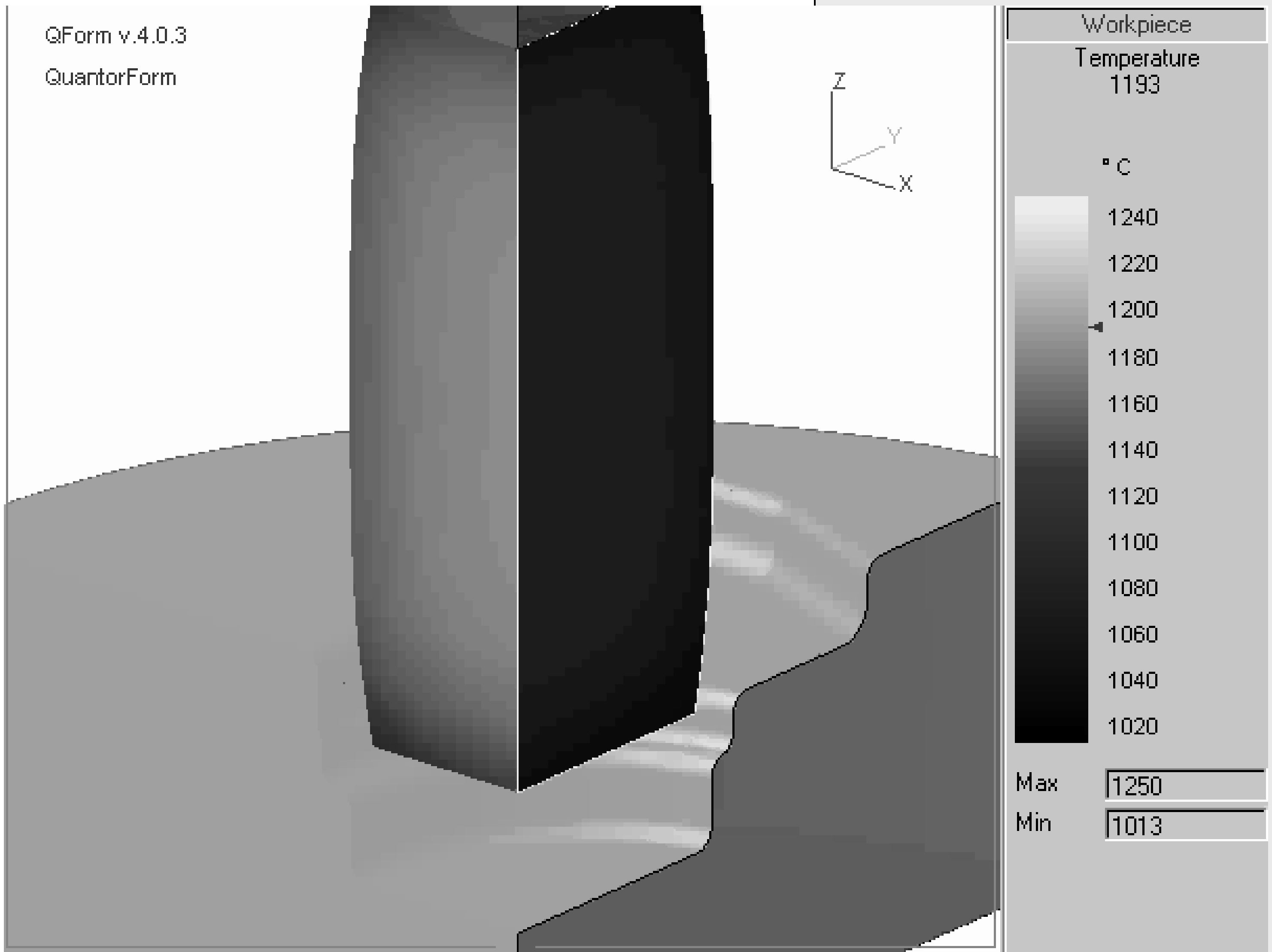
No lap after the die modification

Identification of the laps in simulation



Detecting the laps in 3D simulation

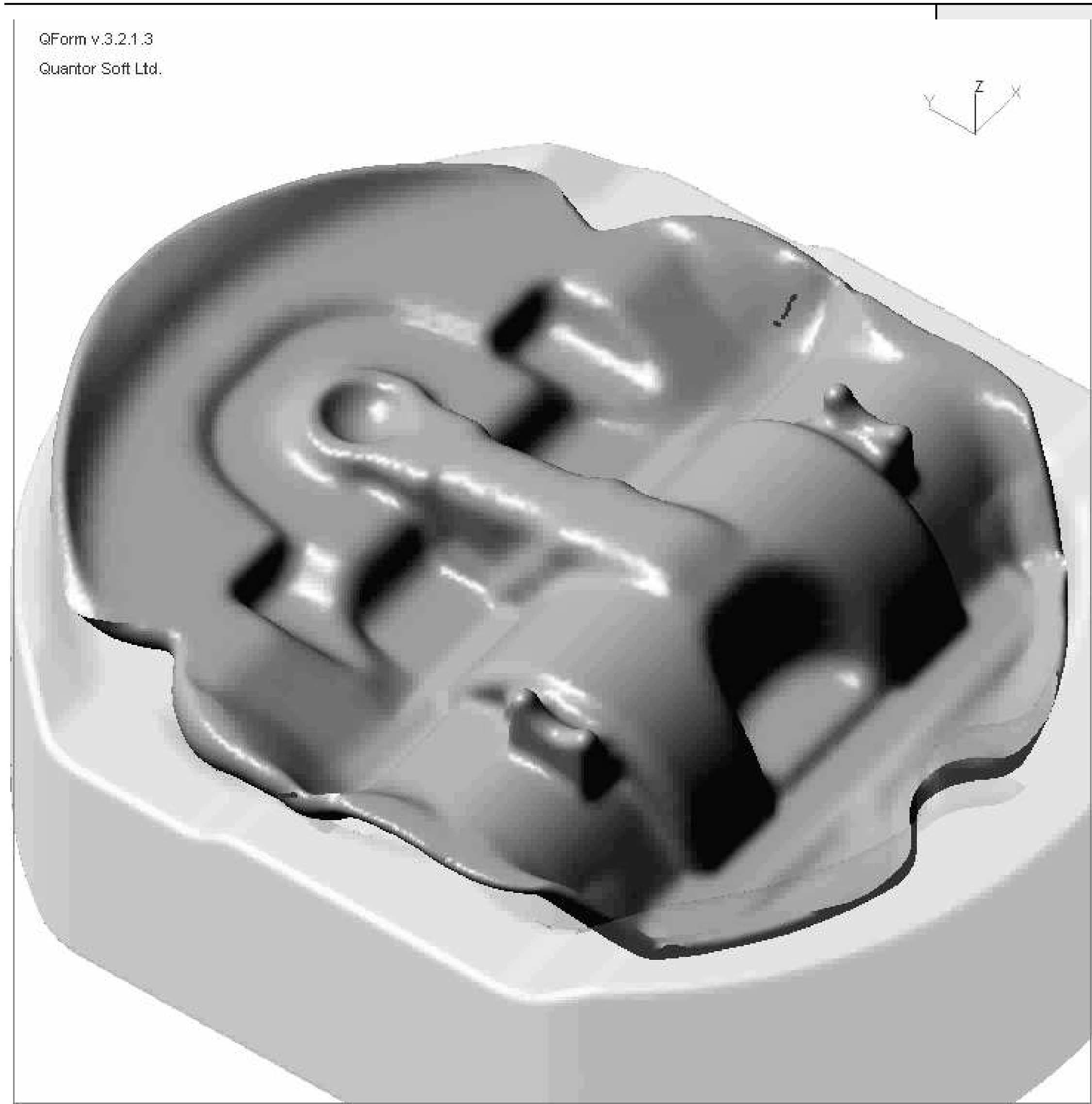
Identification of the laps in simulation



Detecting the laps in 3D simulation

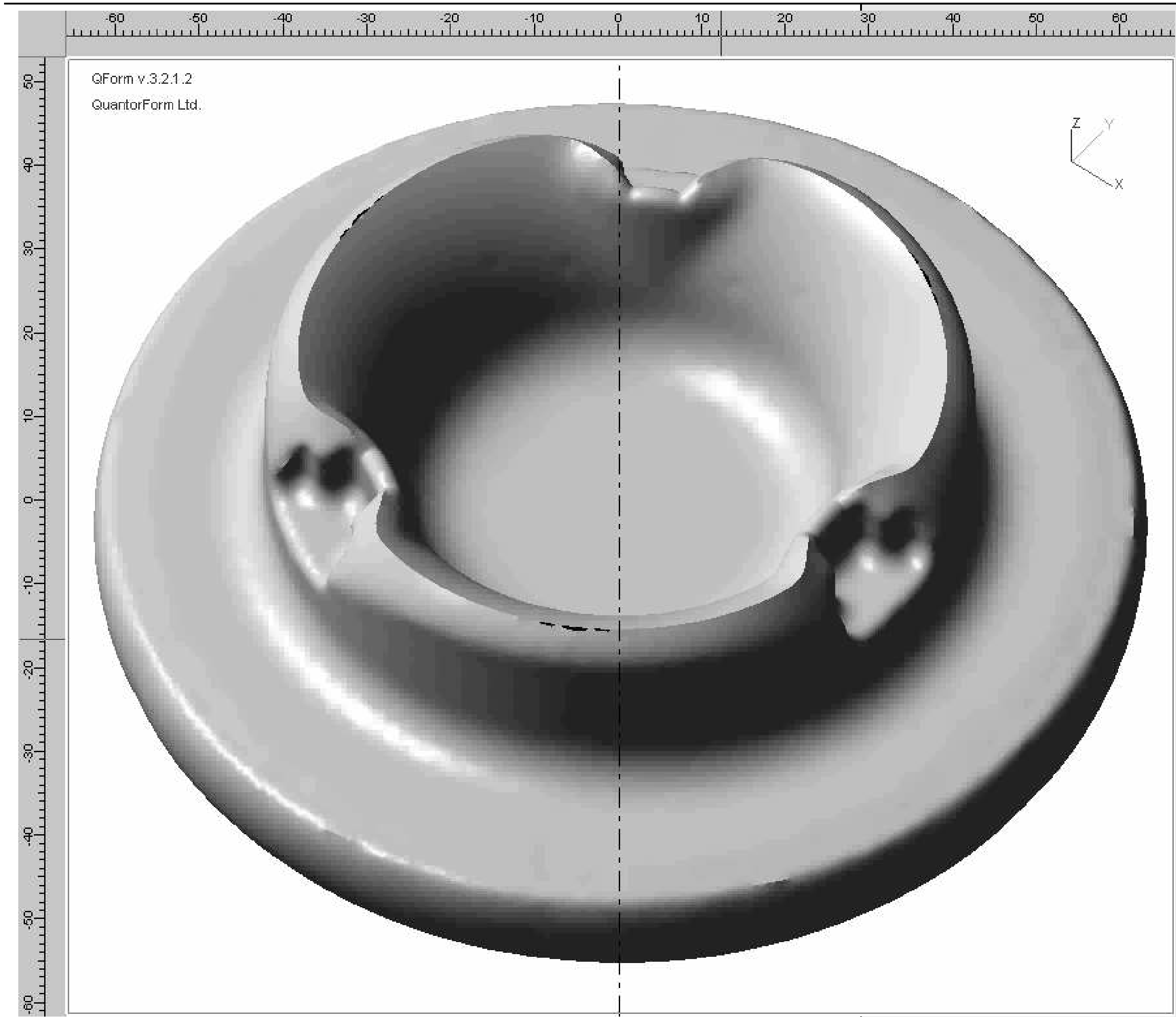
(crosscut view)

Identification of the laps in simulation



Precise shape prediction and location of possible defects

Identification of the laps in simulation



The simulation shows exact location of the defects

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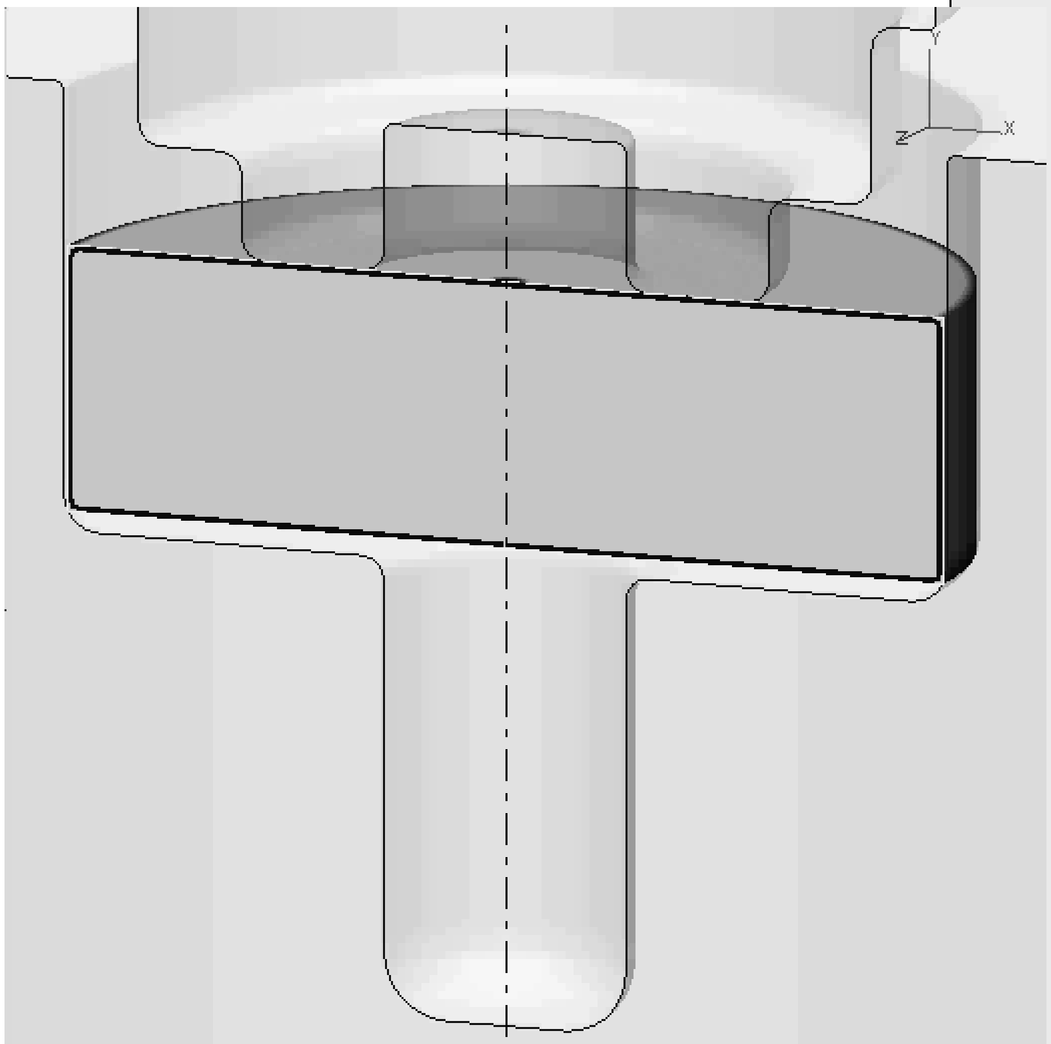
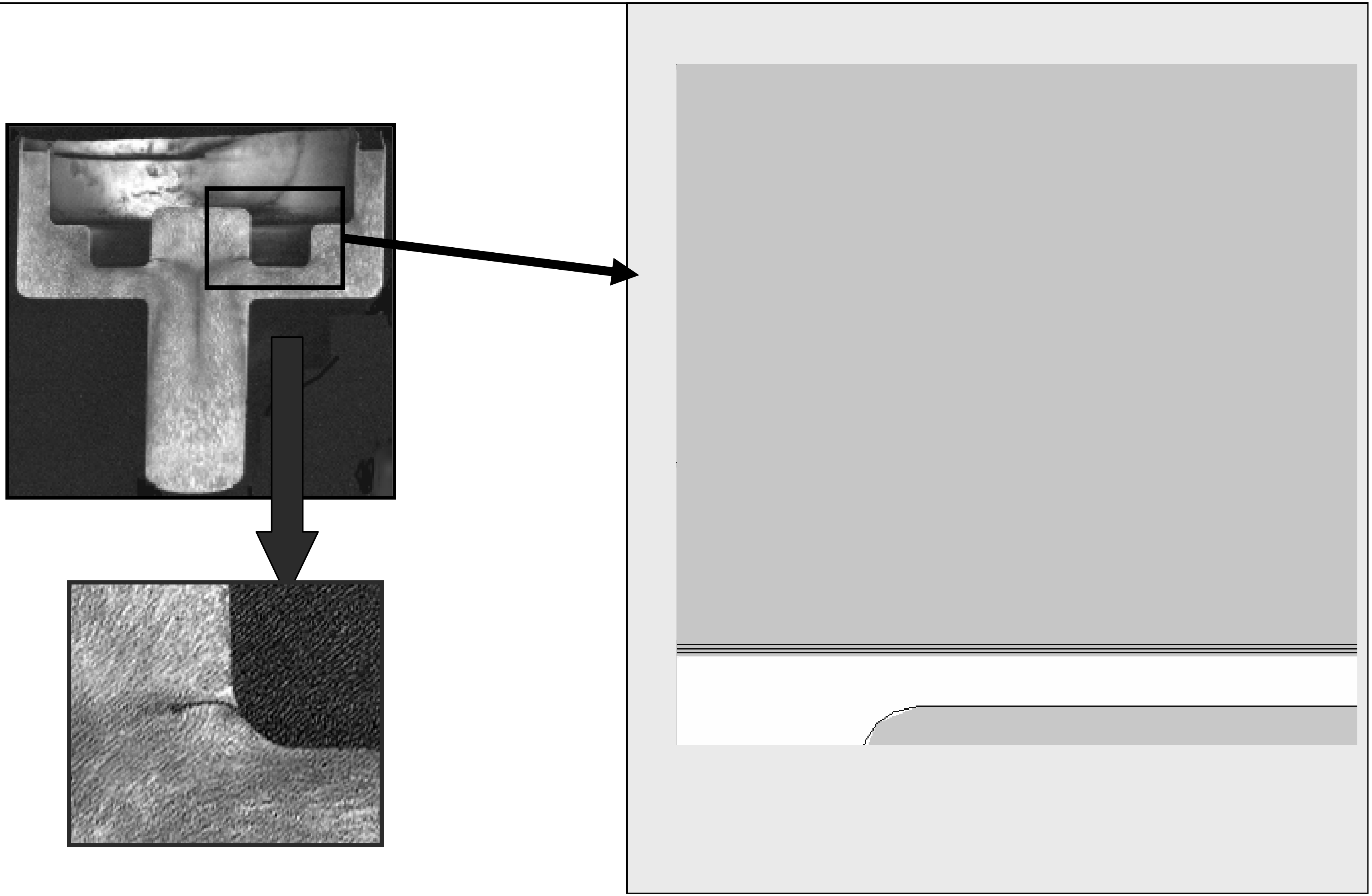
Prediction of the flow-through defect by means of simulation in QForm2D



The flow-through defect is detected by means of special "under-surface" flow lines

Prediction of the flow-through defect by means of simulation in QForm2D



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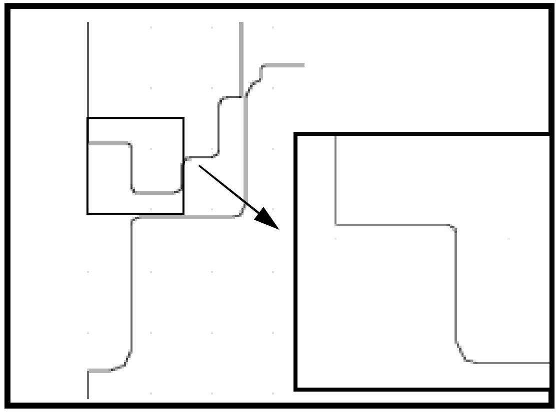
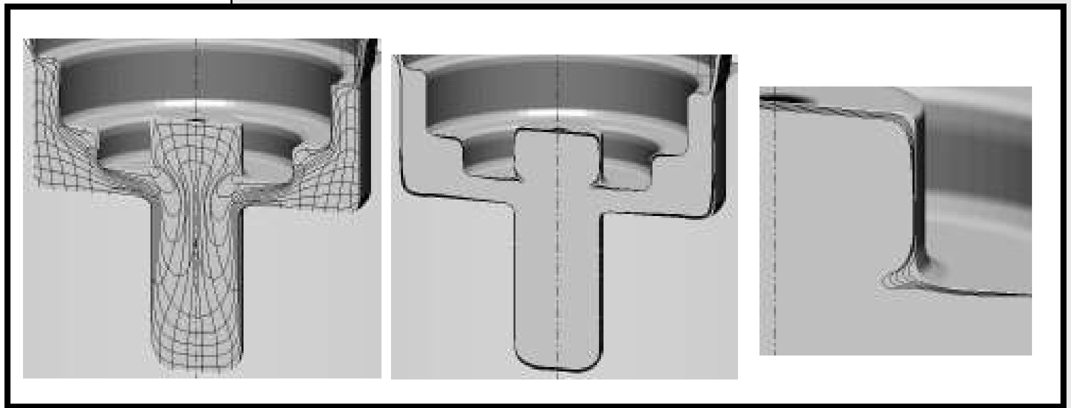
Prediction of the flow-through defect by means of simulation in QForm2D

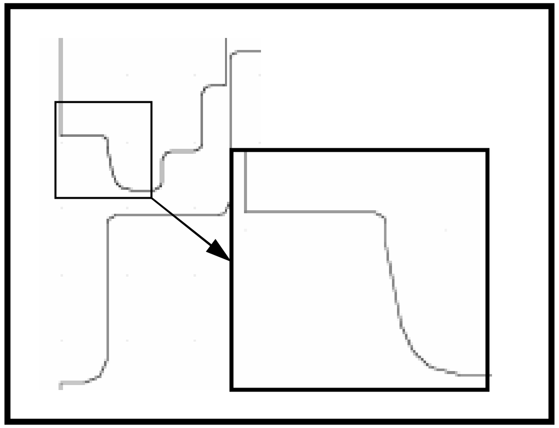
Initial die design



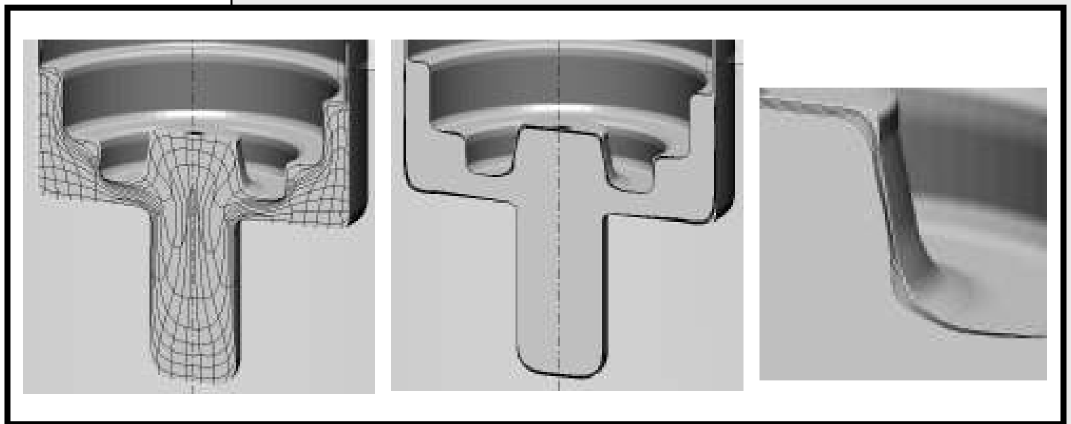
Flow-through defect



Modified die design



The forged part without flow-through defect



Prediction of the flow-through defect by means of simulation in 3D

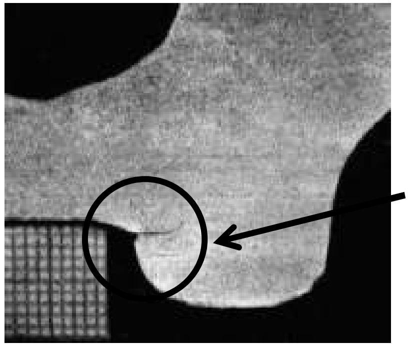
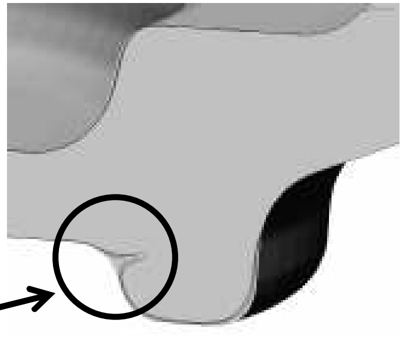
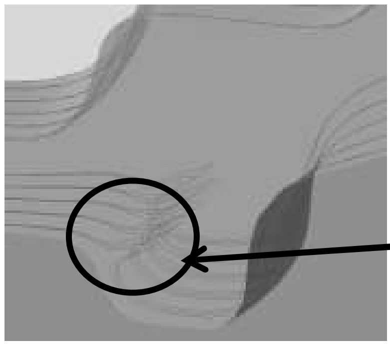


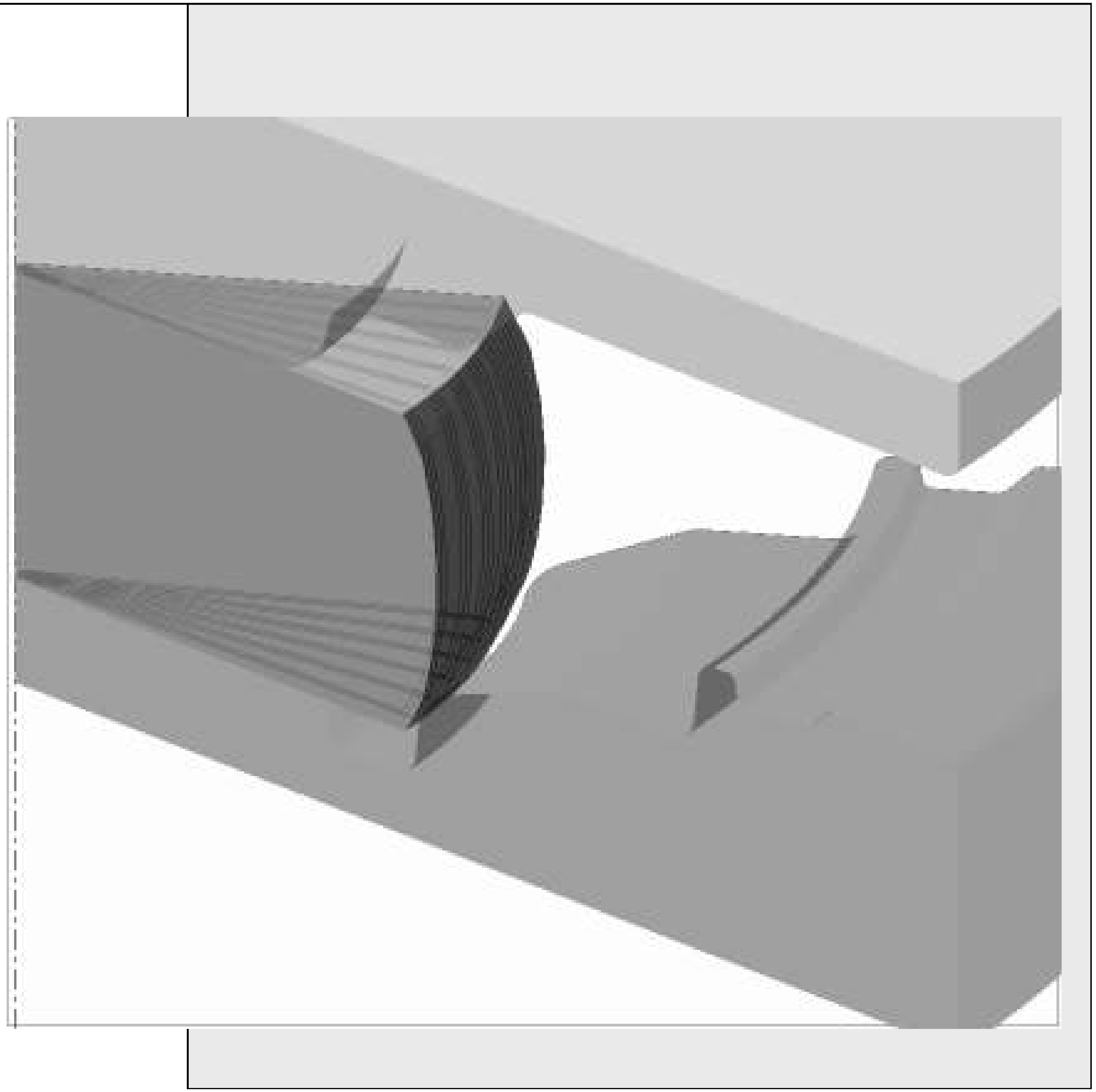
Photo with defect



QForm2D



QForm3D



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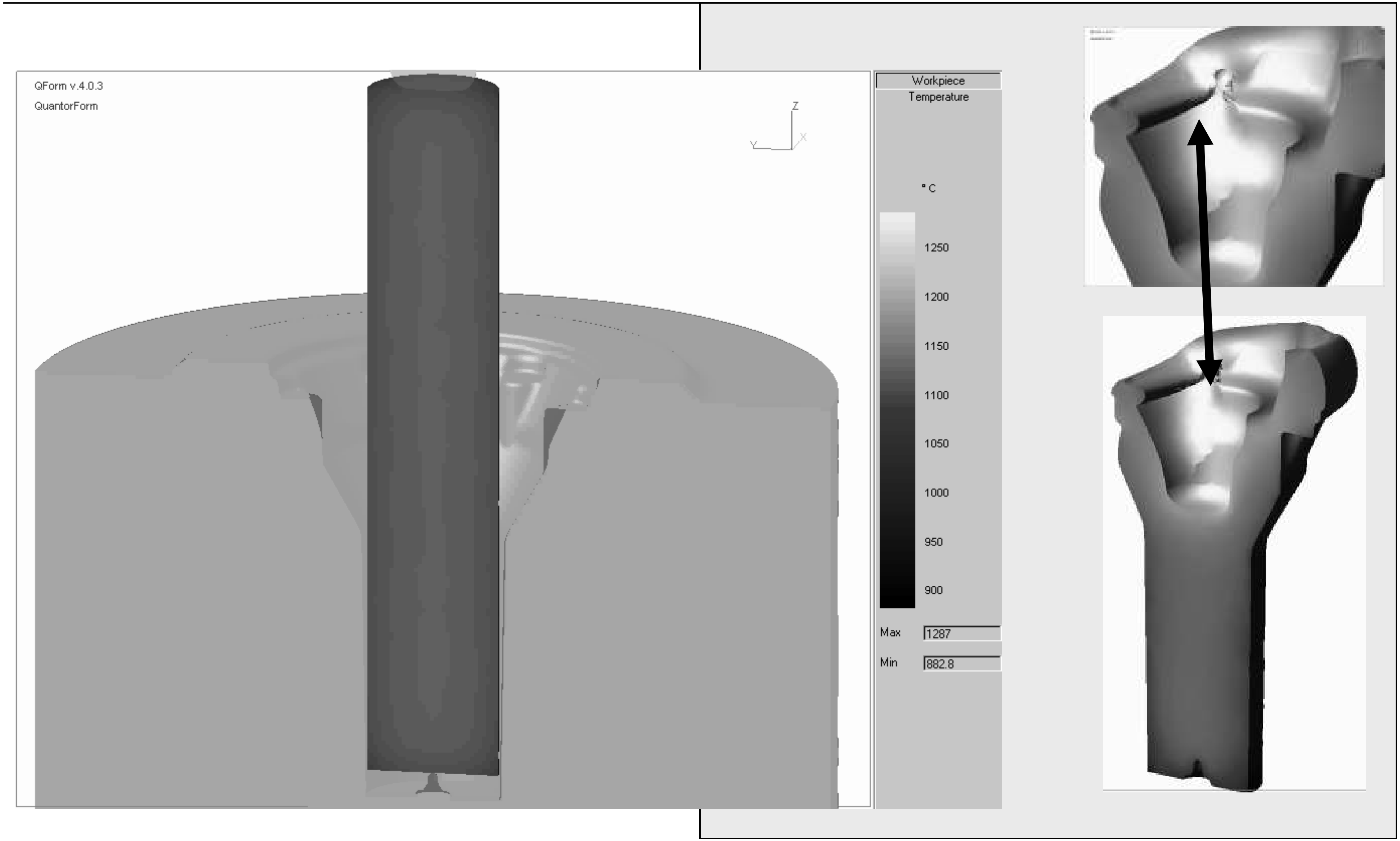
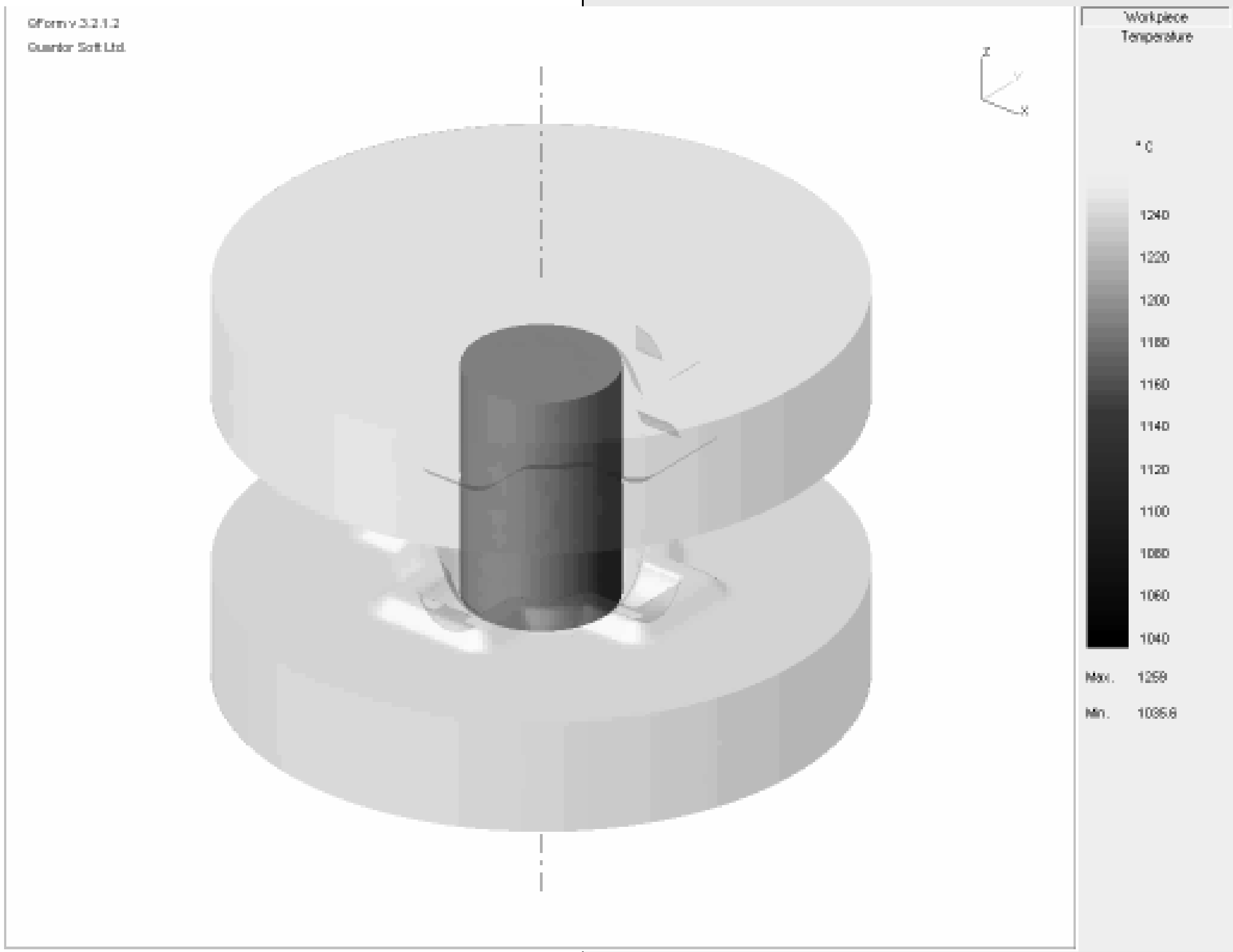
Instability in forging



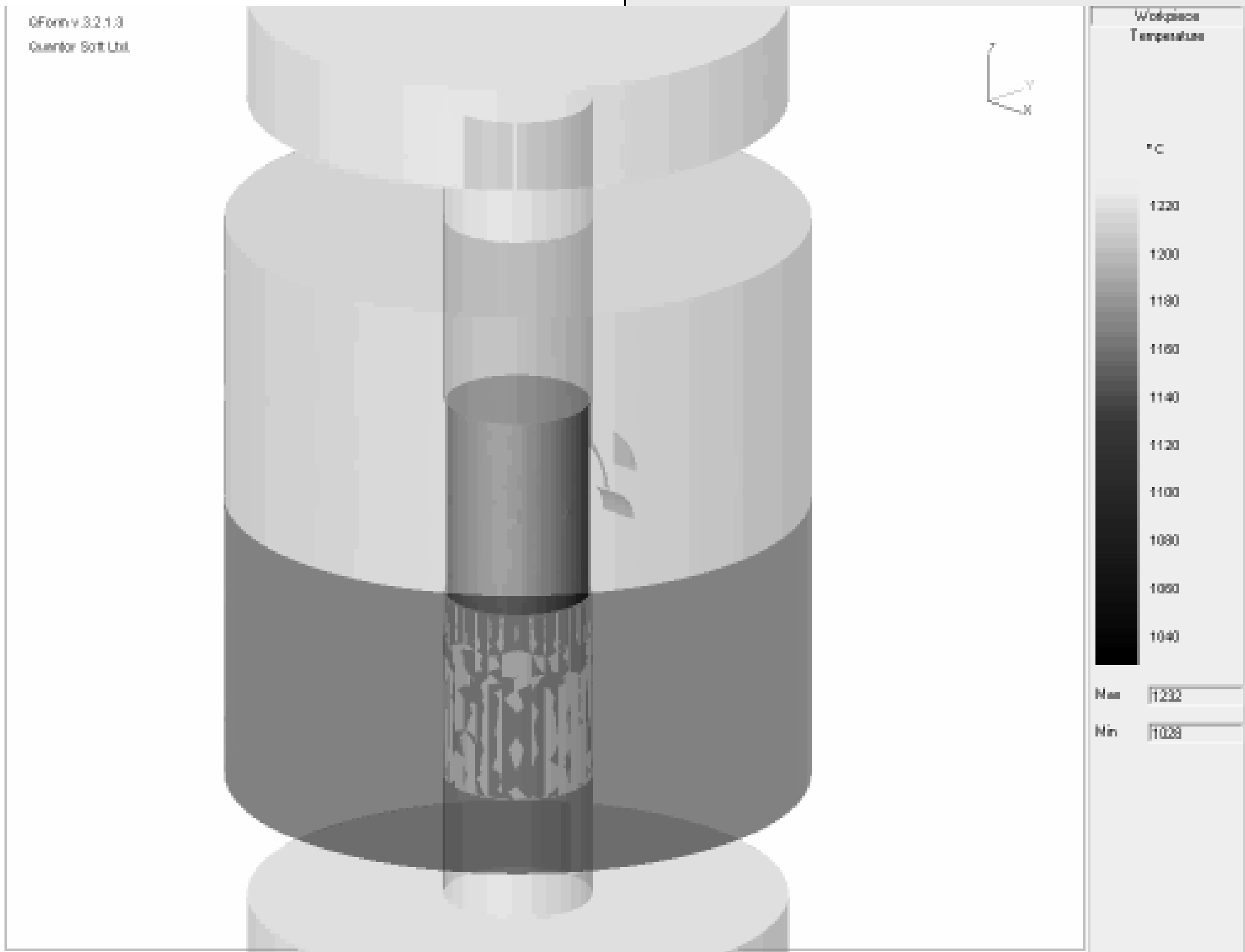
Multiple tools sets

Next >>

Conventional forging with flash



Flashless forging



25-35% material saving

Solving technological problems using QFORM3D

1. Filling the dies at lower load
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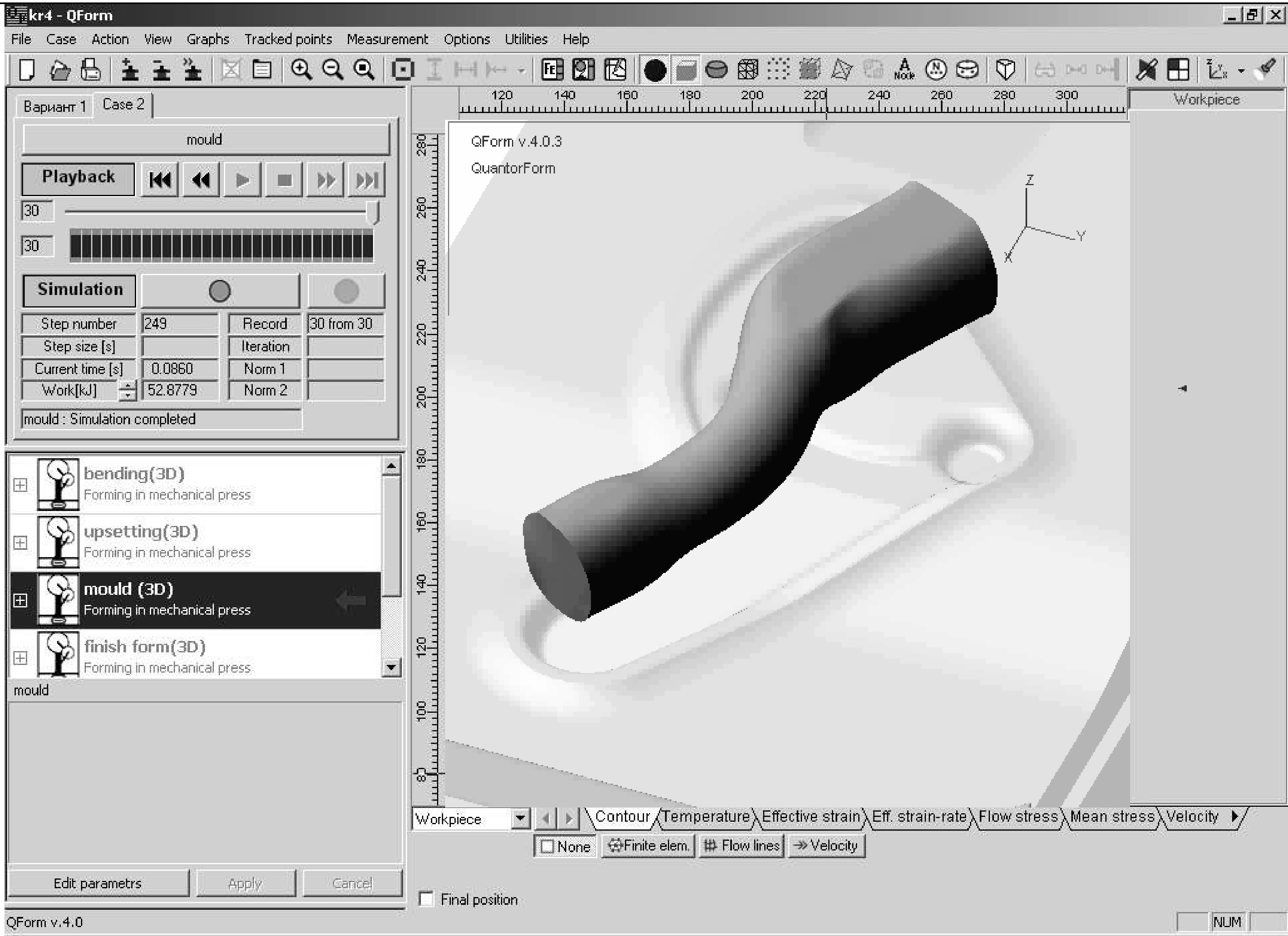
Third blow – closed die – defect is detected



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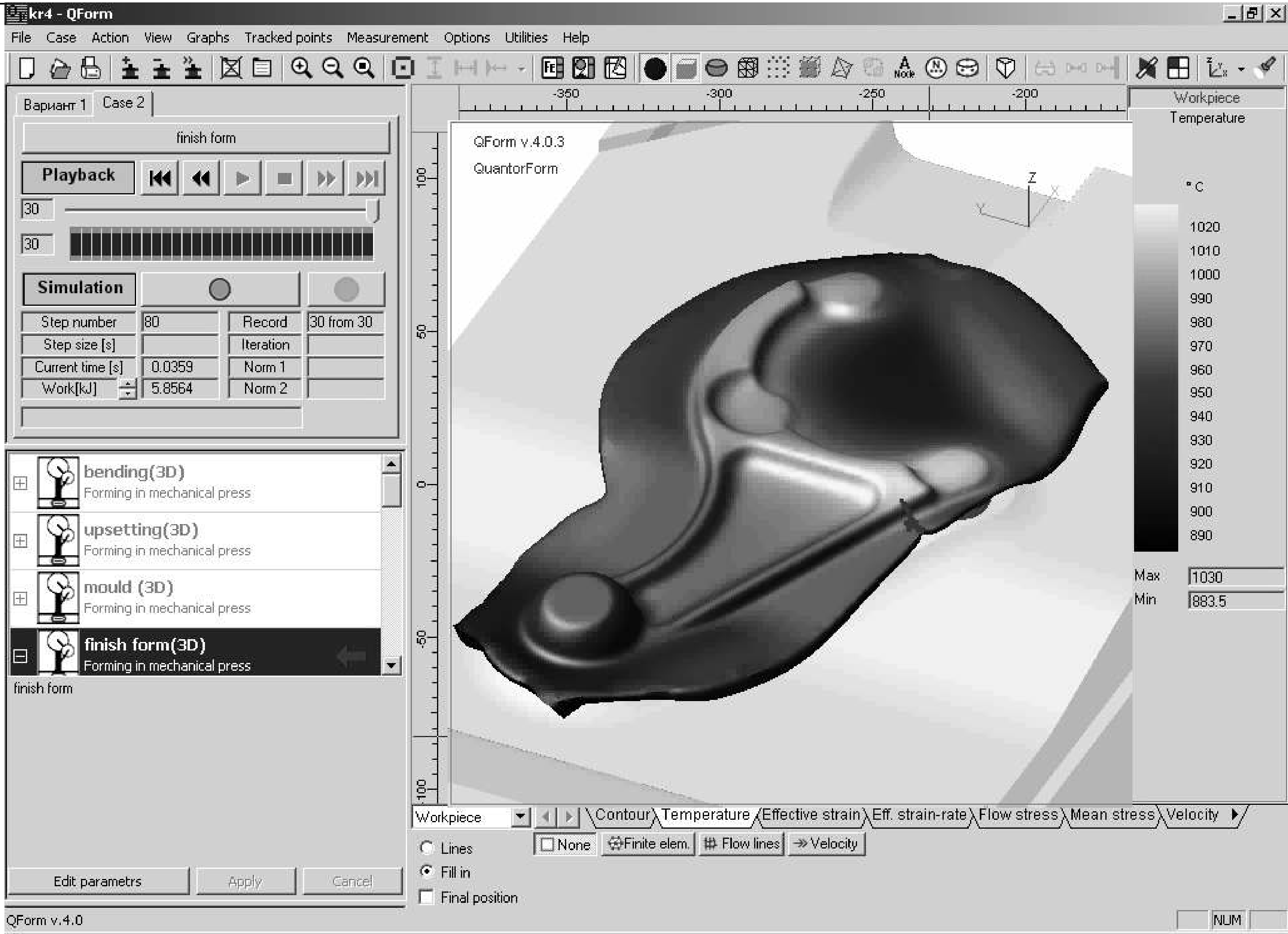
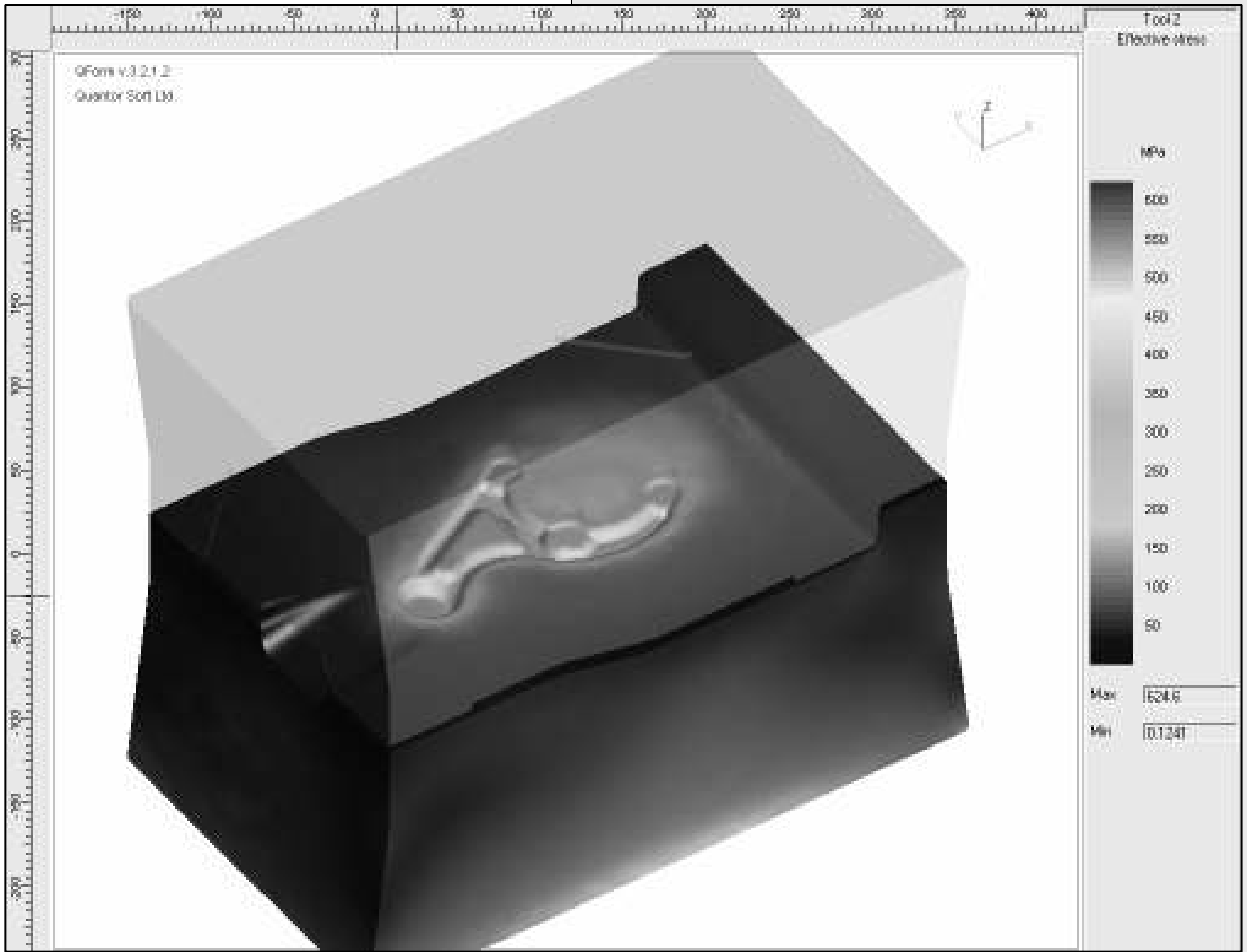
4th blow – closed die – defect is still in the critical area



Increasing the die life

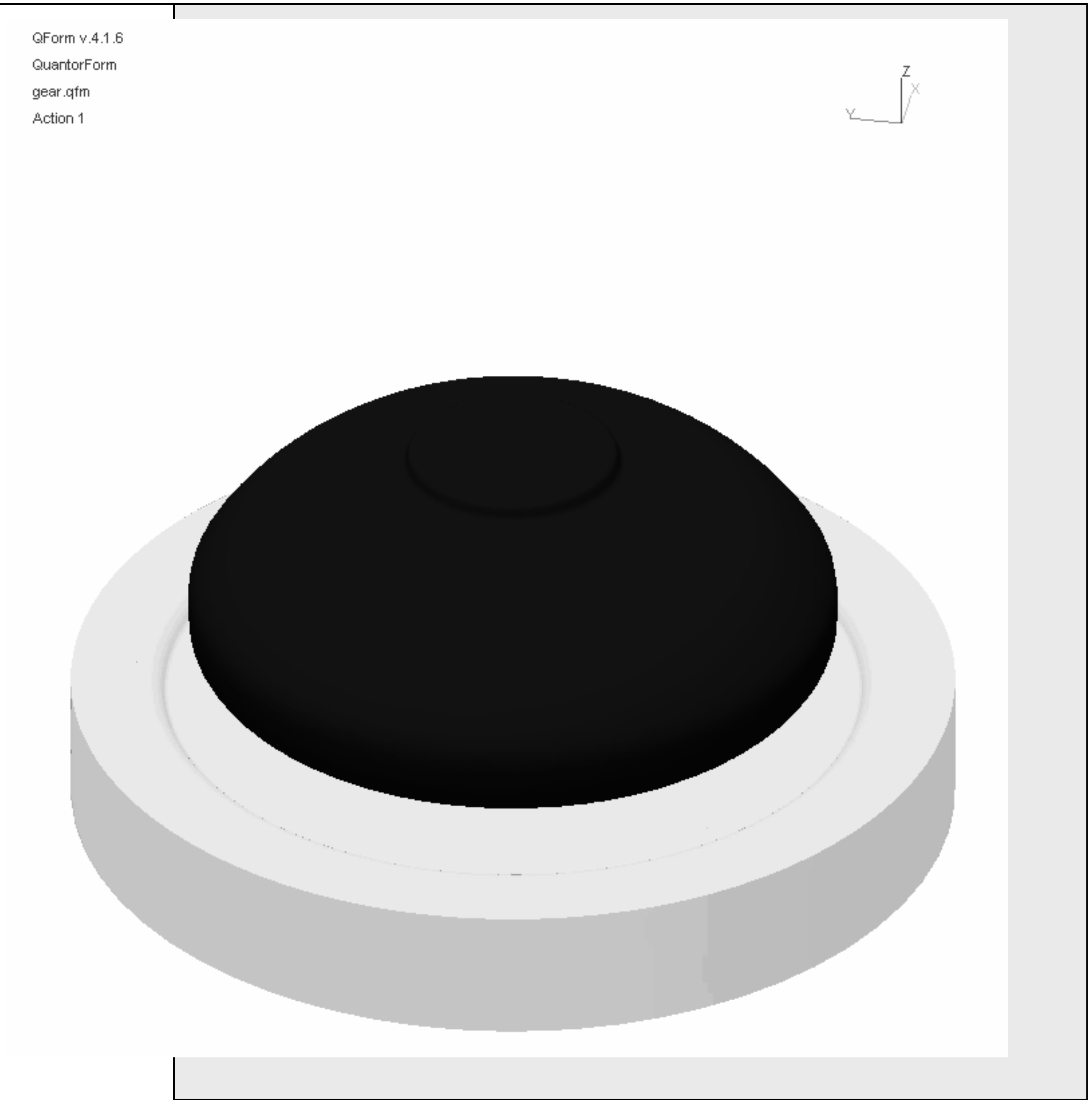
Die stress in solid die block



Next >>

Gear forging simulation

- **Simulated in Half Section on QForm**

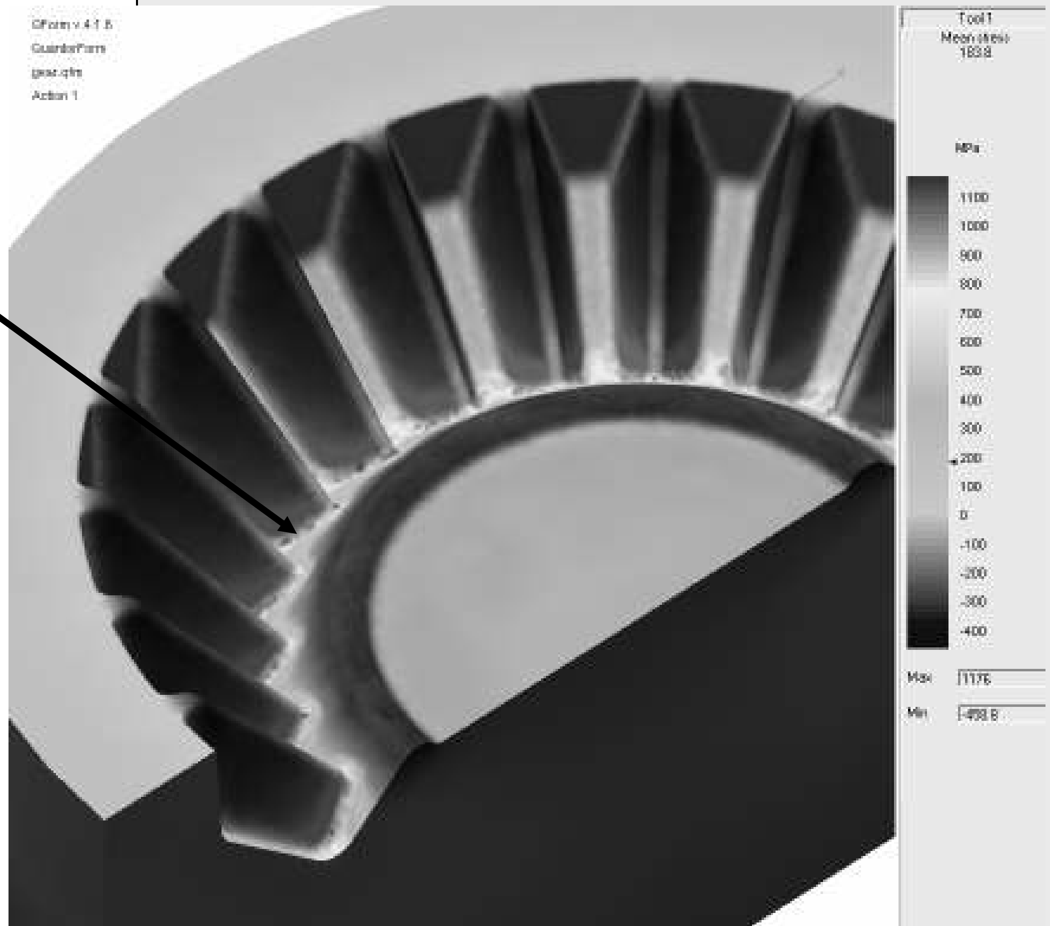


Die crack

- 23 Toothed Gear with Finish-Forged Teeth for Combined Harvester PTO Application
- Dies Cracking After Around 400 Parts
- Improvement Needed for Production Quantities

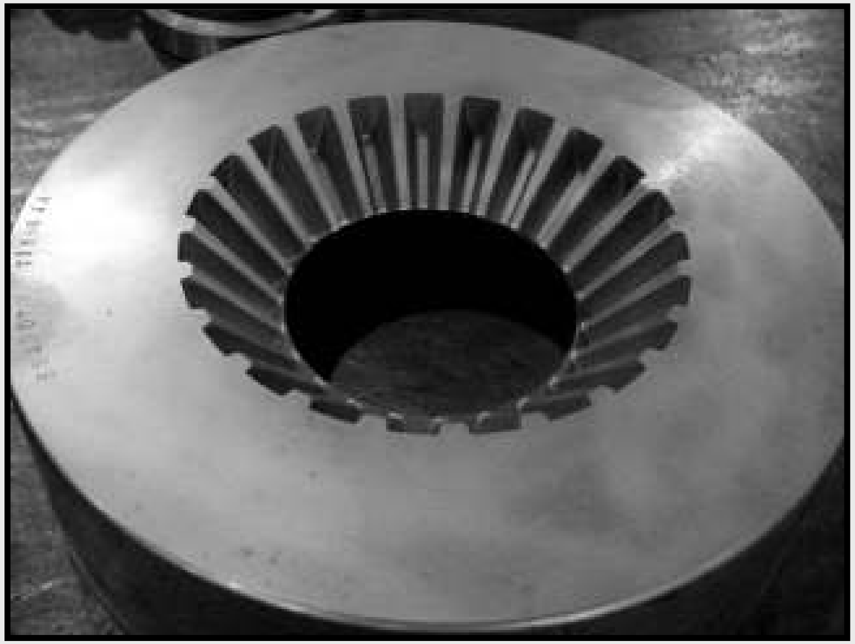
Die stress in solid die block

- **Maximum Stress Shown Where Dies Were Cracking**



Split die instead of solid die block

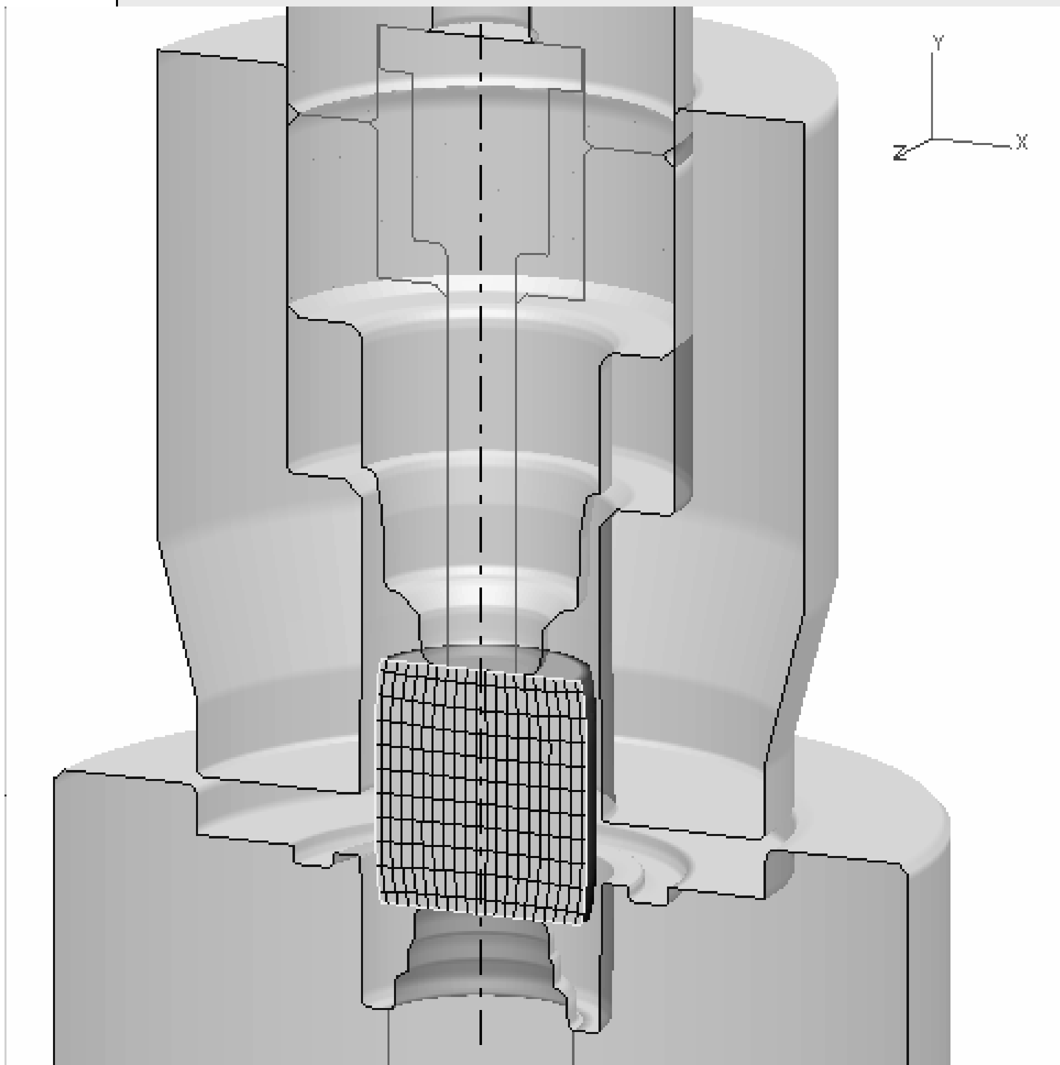
- “Inserted” Die Now Machined
- To Trial on Next Production Batch



- Potential Improvement in Die Life: At Least 150%
- Potential Cost Saving: ~£2000 (approx 4 dies)

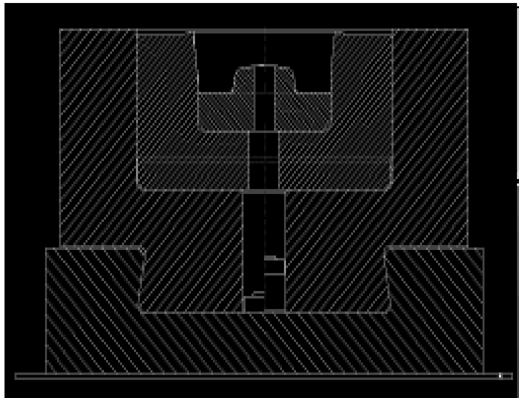
Complex die assemblies

Pre-stressed dies with inserts and pegs



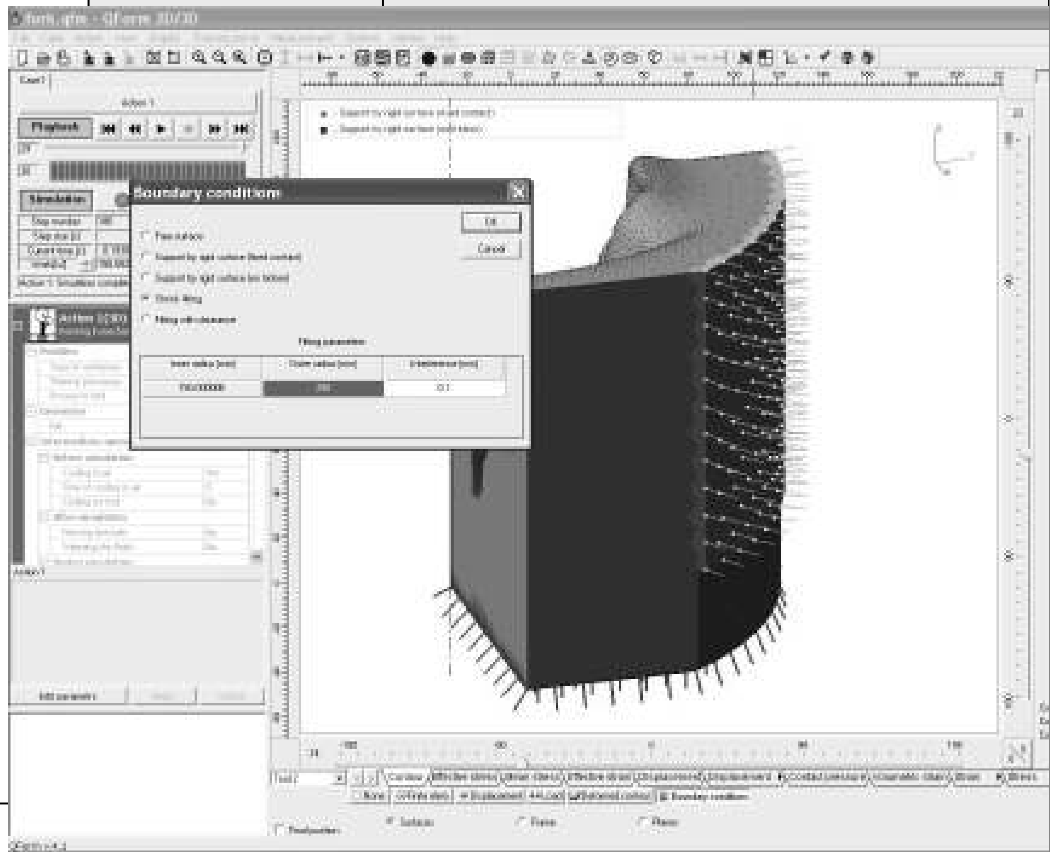
Next >>

Effective stress distribution in assembled die

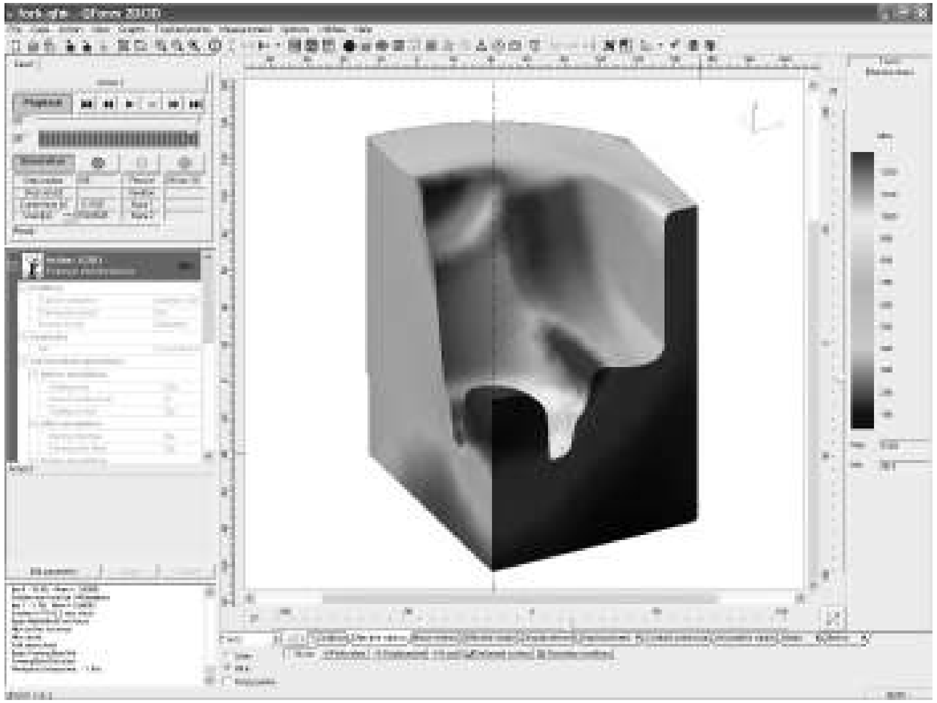


Next >>

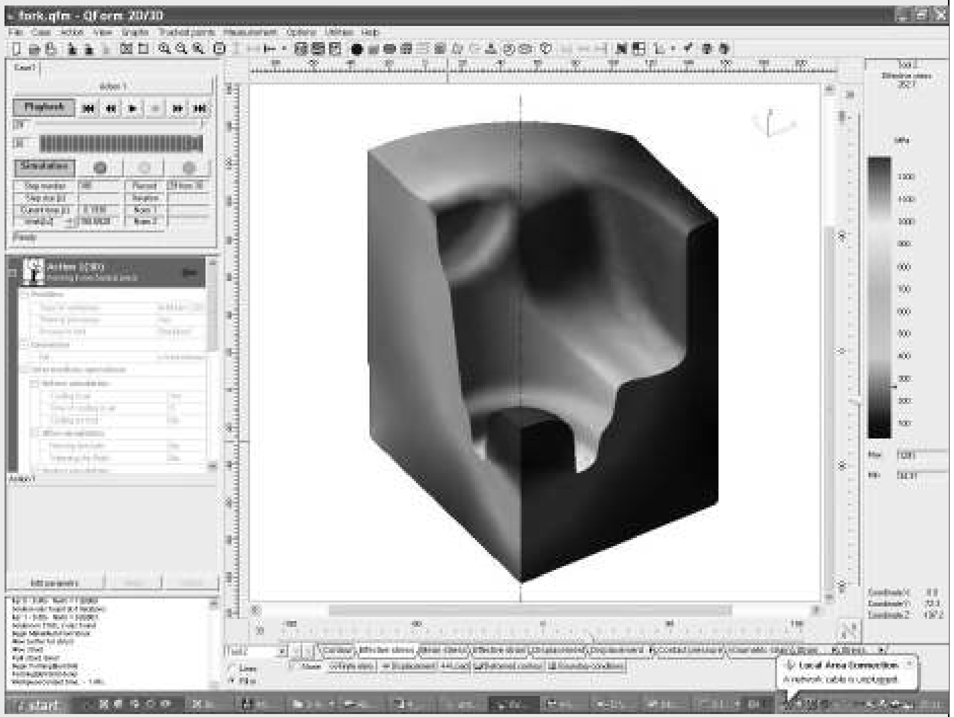
Shrink ring for the dies in 3D



The effect of shrink fitting for the dies

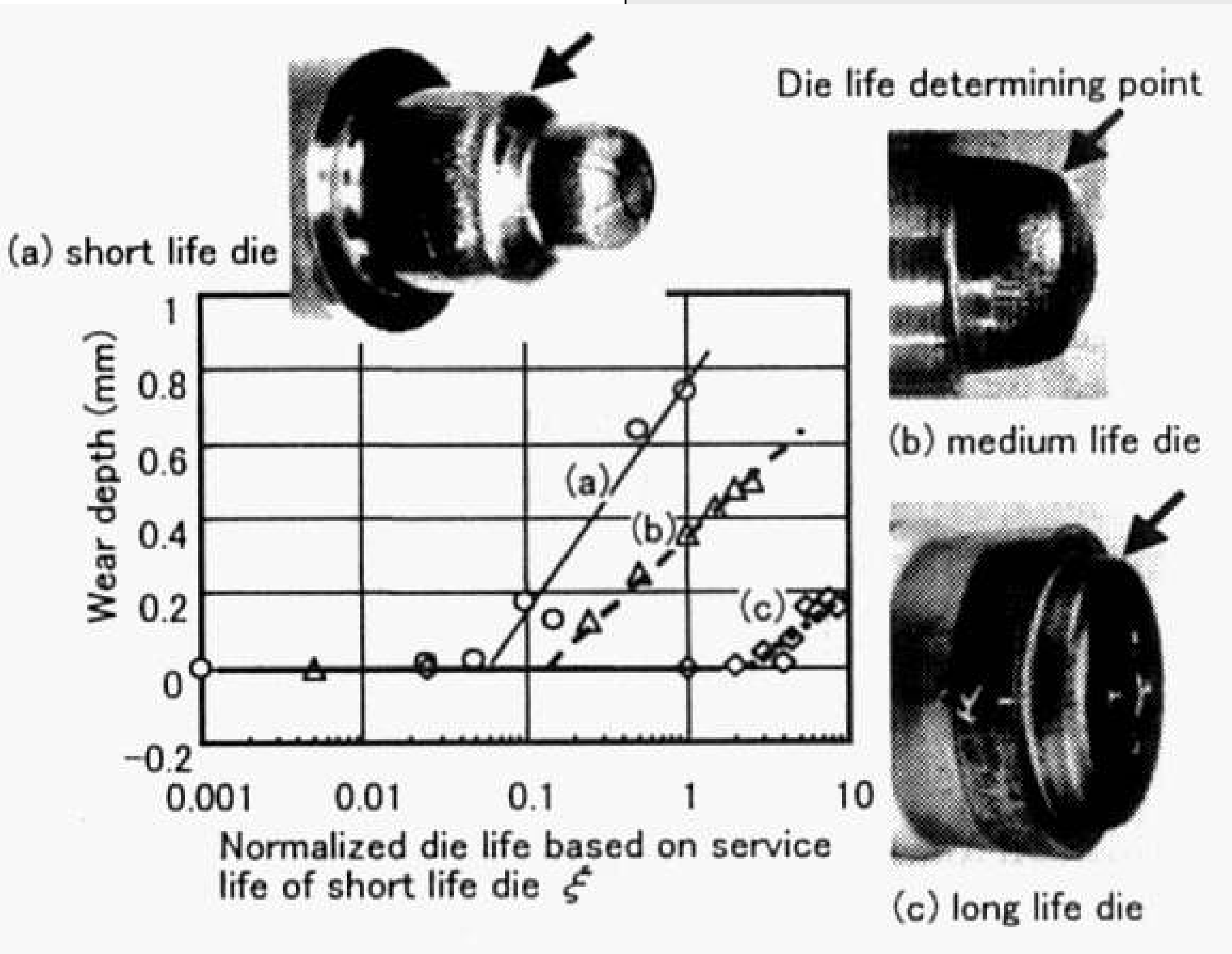


Effective stress distribution with free lateral surface



Effective stress distribution with shrink fitting

Die wear prediction



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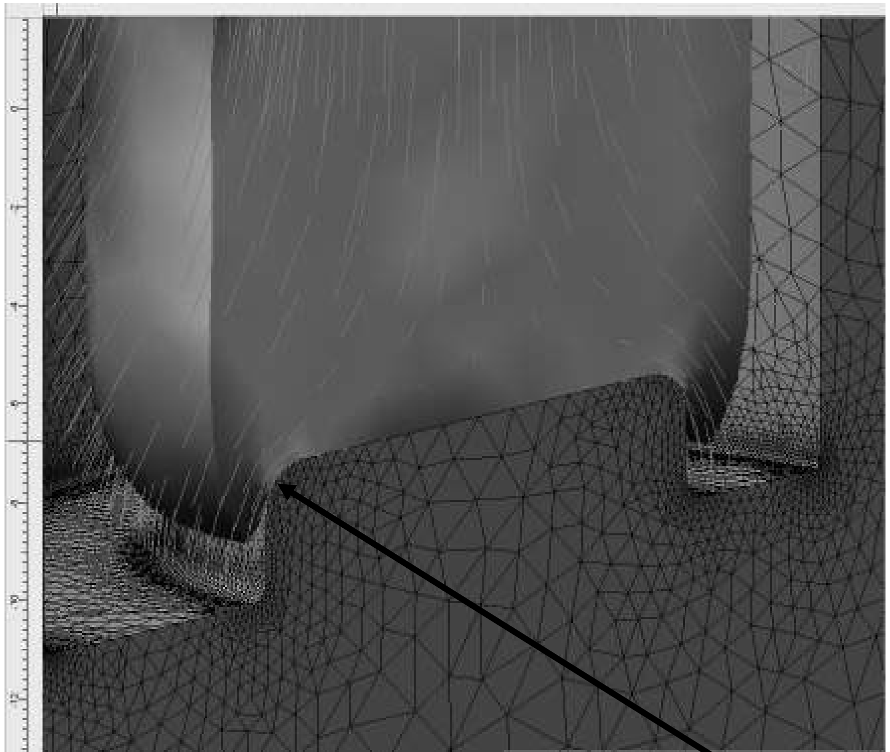
Die wear prediction



Die wear depends on:

- Contact traction
- Relative sliding velocity on a die surface
- Yield stress of the die material
- Time of the contact

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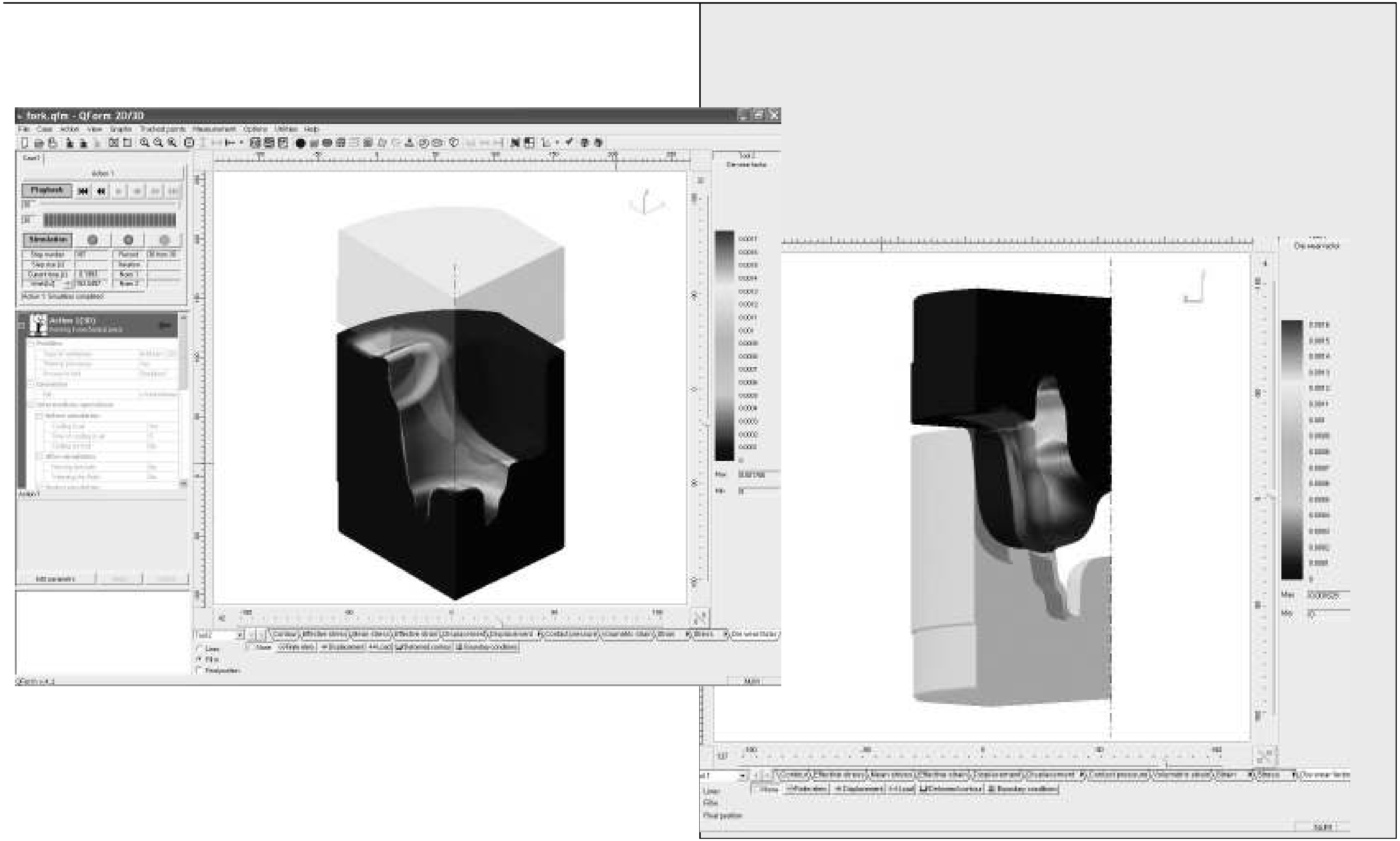
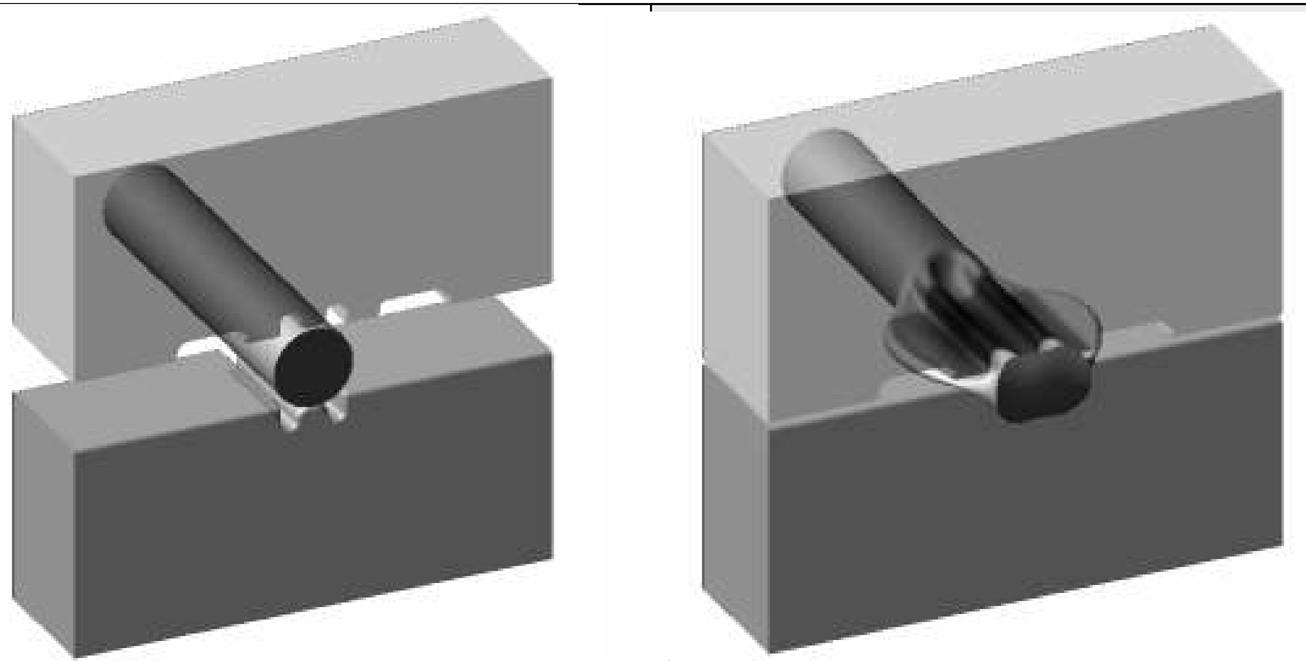
Die wear prediction: relative die wear factor distribution



1

Comparing the results of the predicted die wear distribution with the experiment

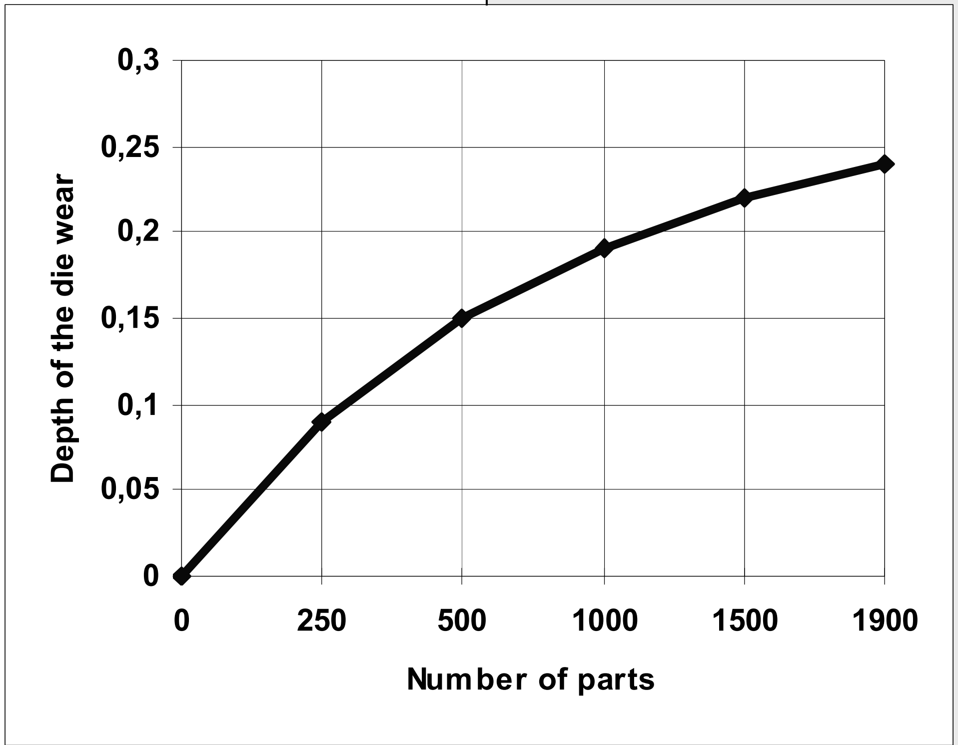


a. b.

The conditions of the experiment: round bar 13mm, steel AISI 1030, temperature 1100-1150 degrees C

The experimental results of the die wear evaluation are obtained by Dr. Jan Cermak, Czech Technical University in Prague

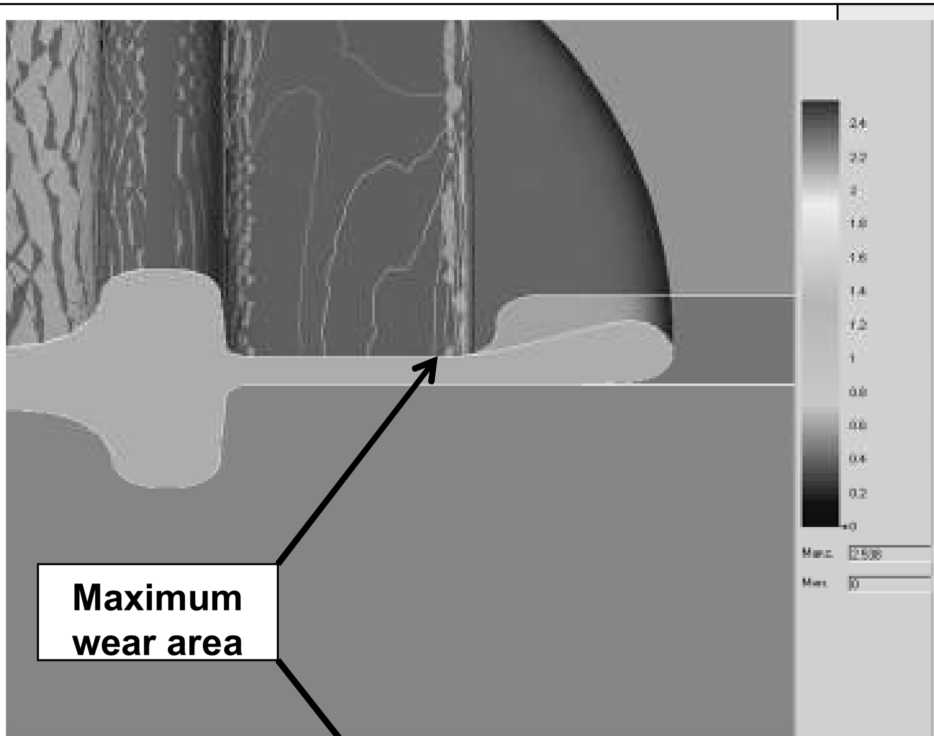
The experimental evaluation of the abrasive wear



The maximum depth of the die wear (mm) versus the number of the forged parts (the upper die)

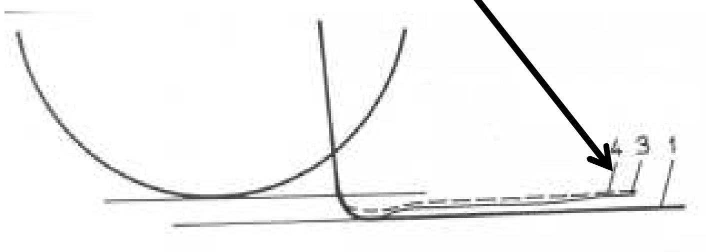
1

Abrasive wear distribution *10^{-1} mm of the upper die



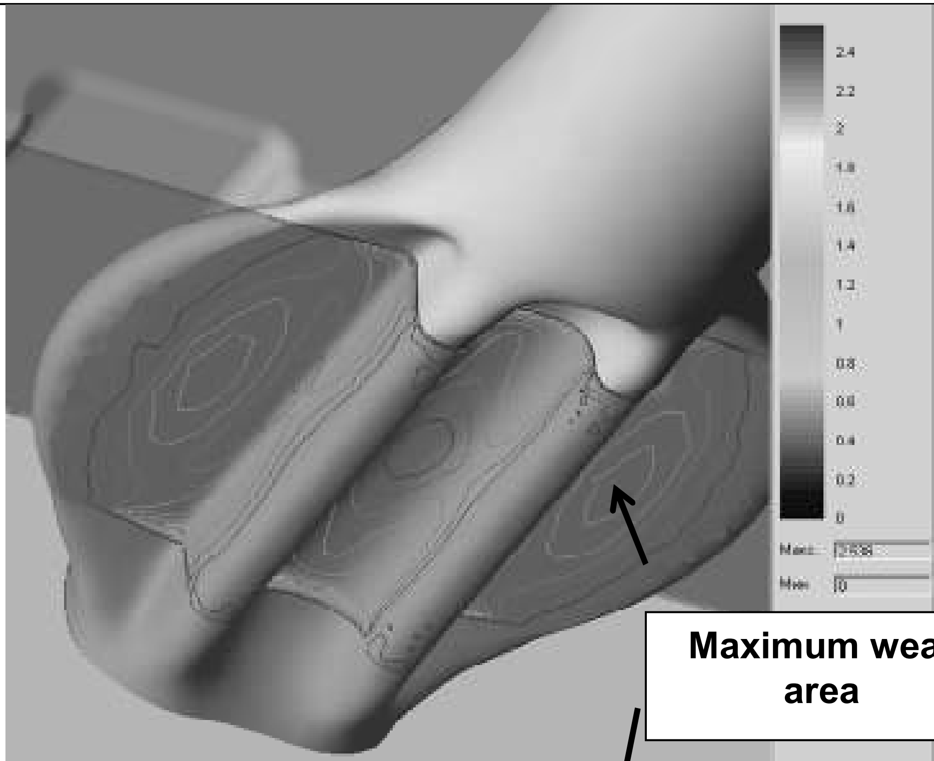
Maximum wear area

Simulation results



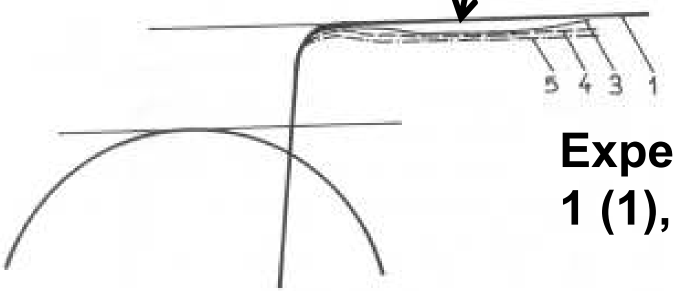
Experimental measurement after:
1 (1), 500 (2), 1000 (3), 1500 (4) and 1900 (5) parts.

Abrasive wear distribution *10^{-1} mm of the lower die



Maximum wear area

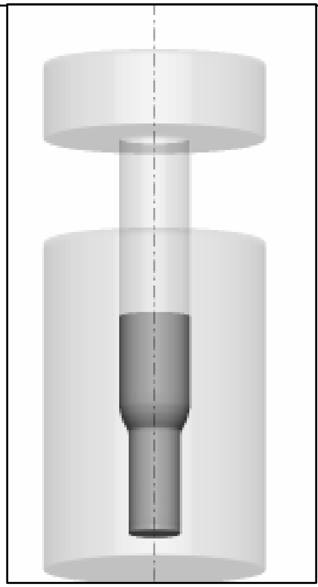
Simulation results



Experimental measurement after:
1 (1), 500 (2), 1000 (3), 1500 (4) and 1900 (5) parts.

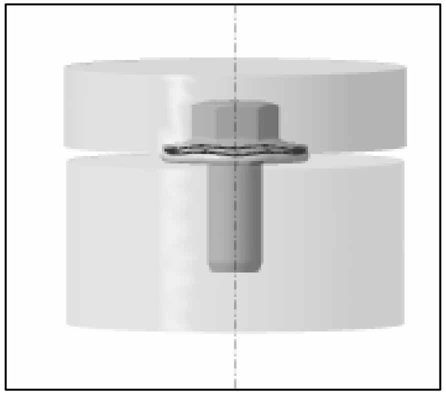
Initial technology of cold forging of the bolt

1st action

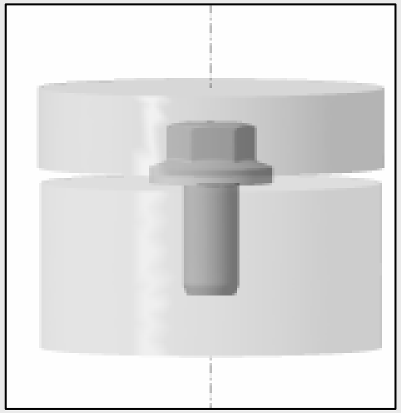


2nd action

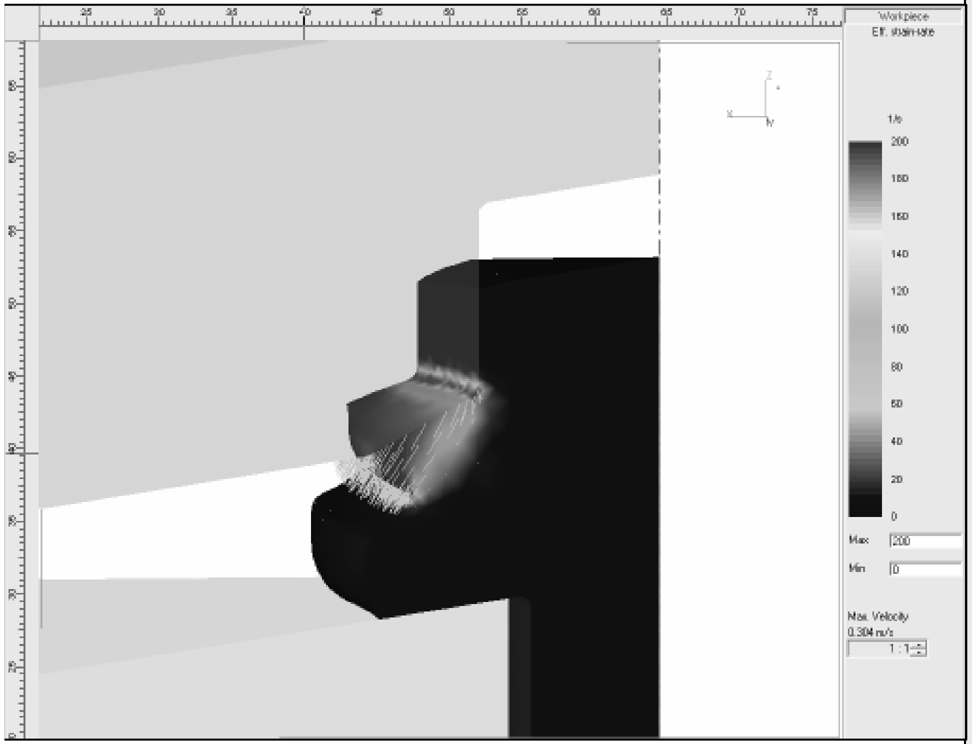
3rd action



Trimming



Initial technology of cold forging of the bolt



Intensive sliding of forged material under the upper die at the 3rd action of the initial technology

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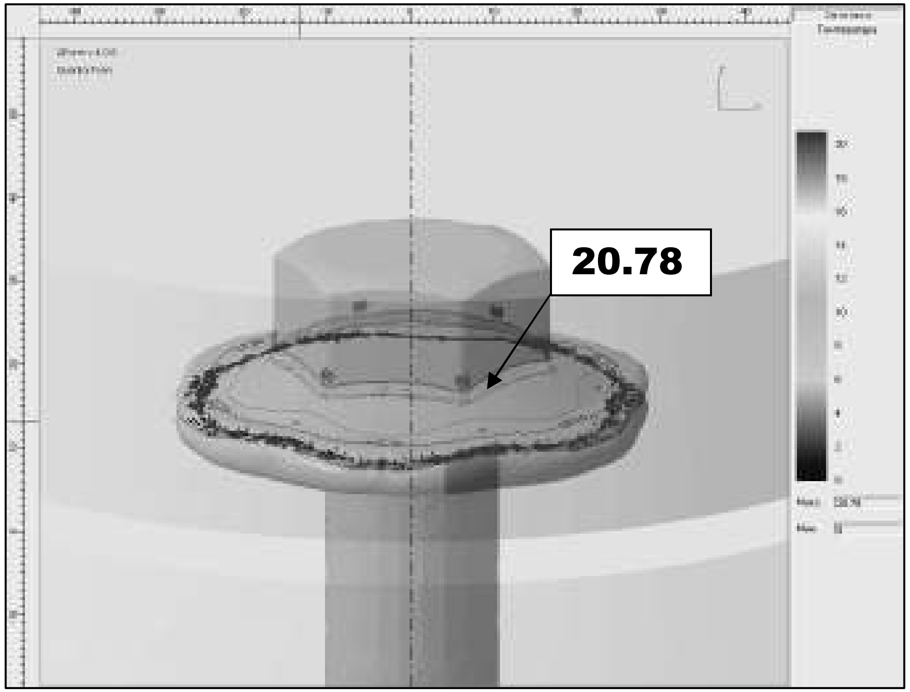
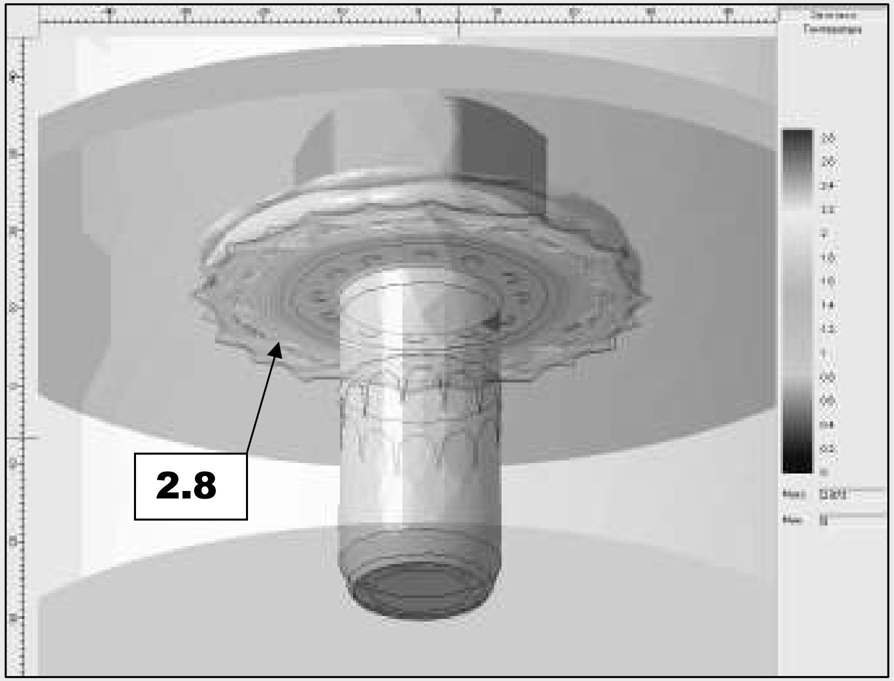
3

Relative die wear maximum values

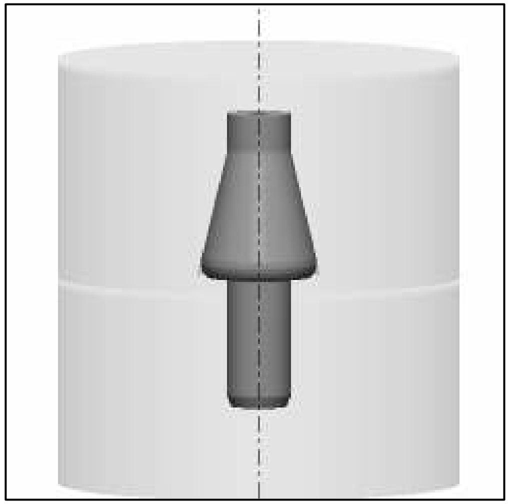




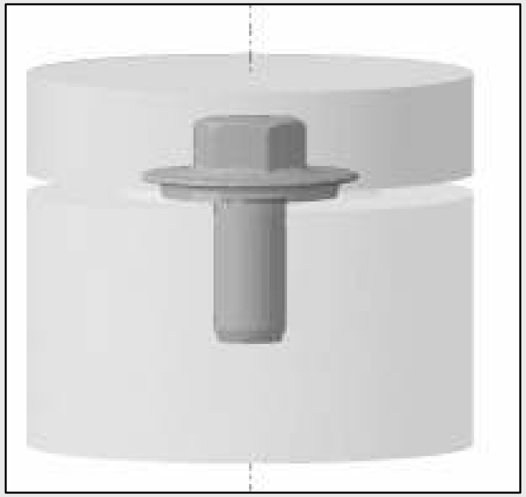
maximum die wear w_r=20.78 exactly on the edge of the upper die;

4

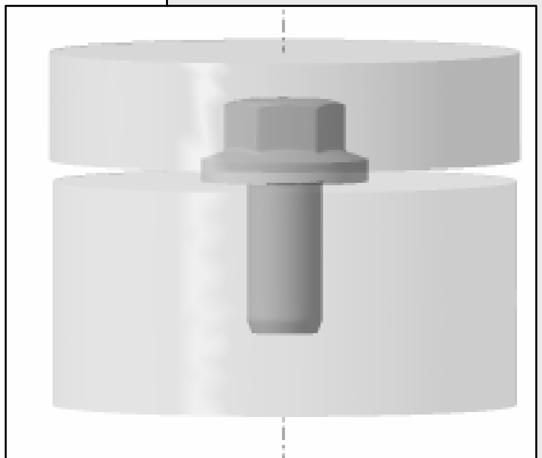
Modified technology of cold forging of the bolt



1st action

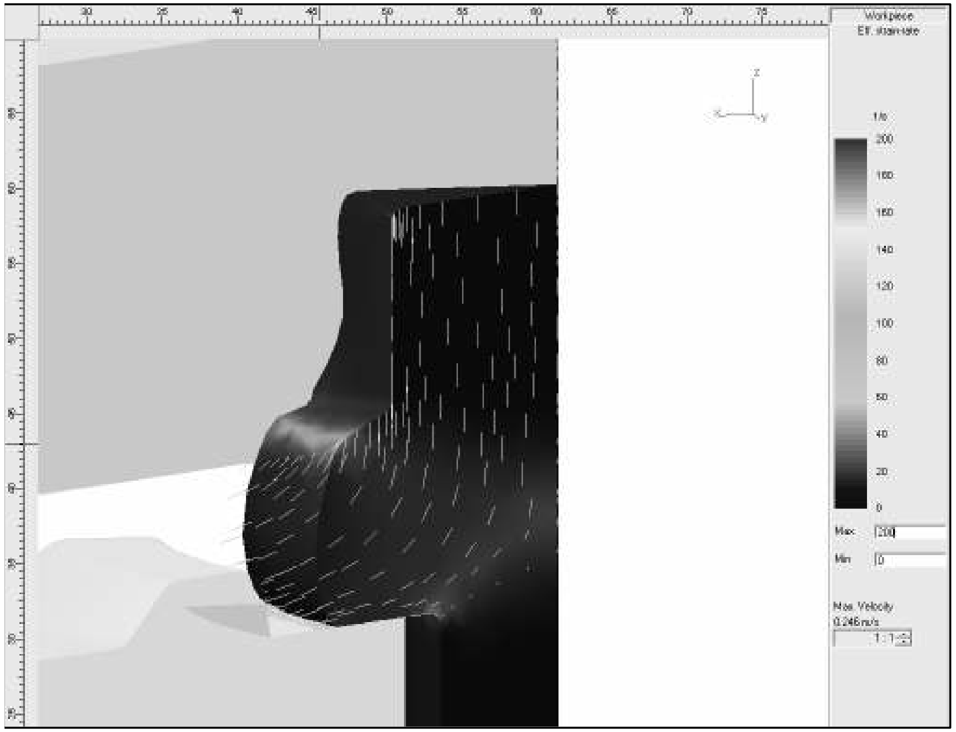


2nd action



Trimming

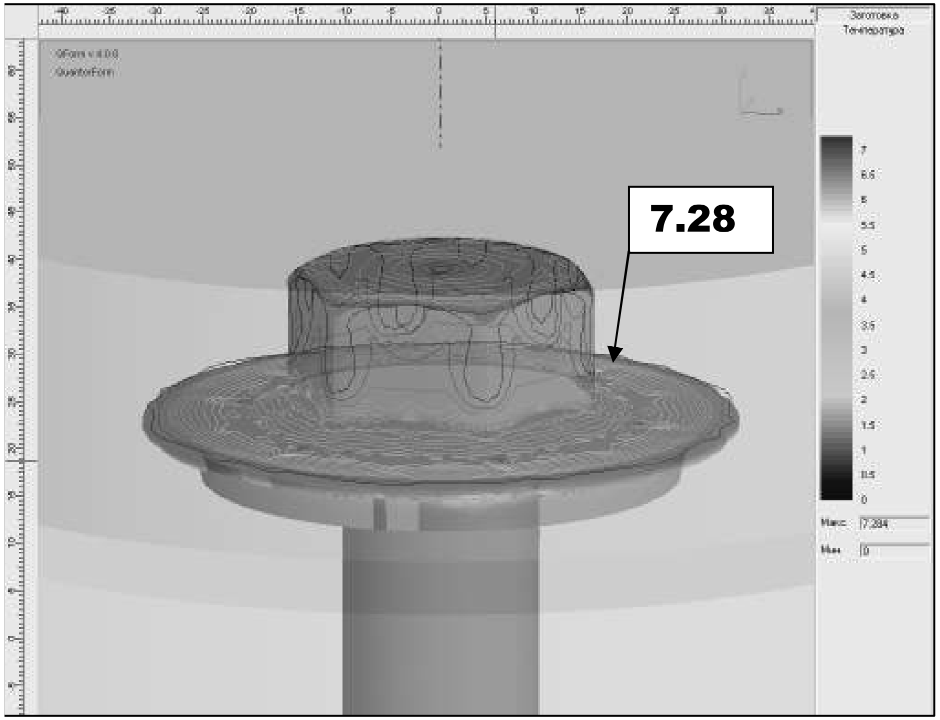
Velocity vectors and the effective strain

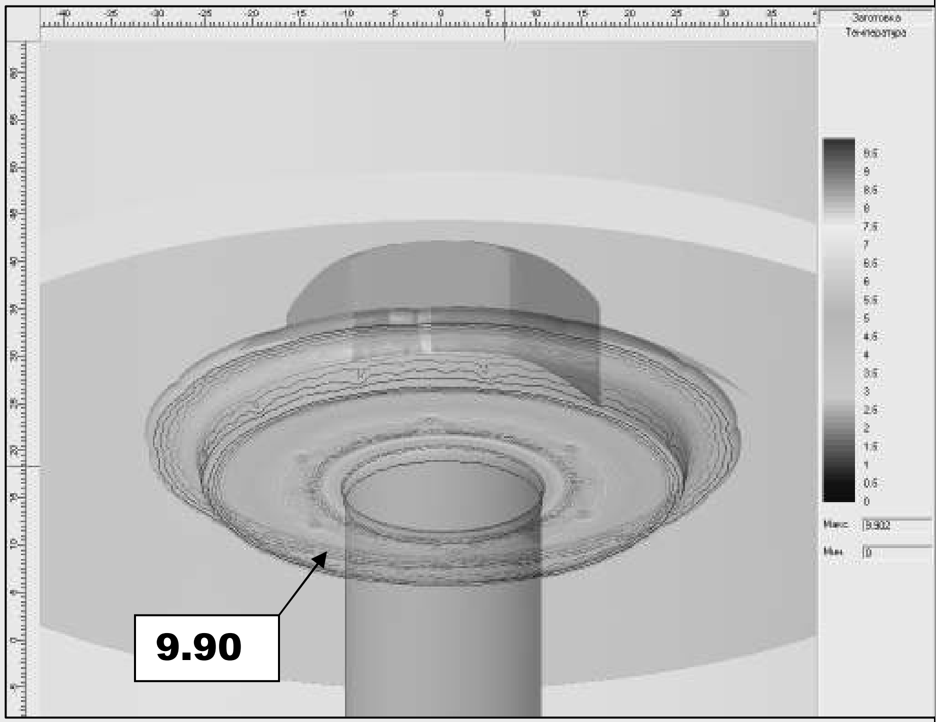


Filling of the die cavity for modified technology (b) with equal sliding of the material along upper and lower dies.

6

Modified technology of cold forging of the bolt

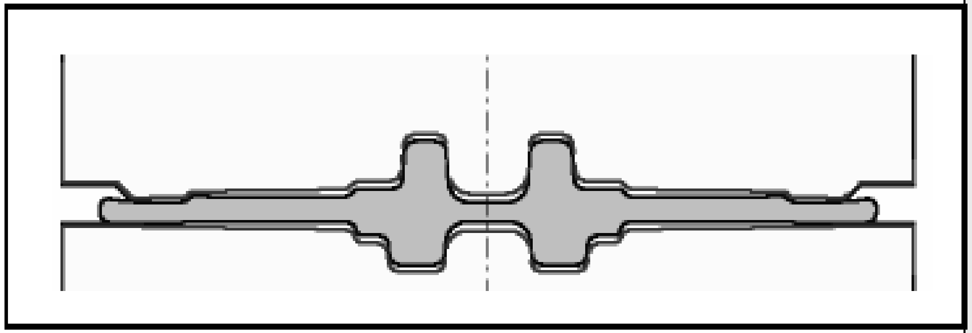




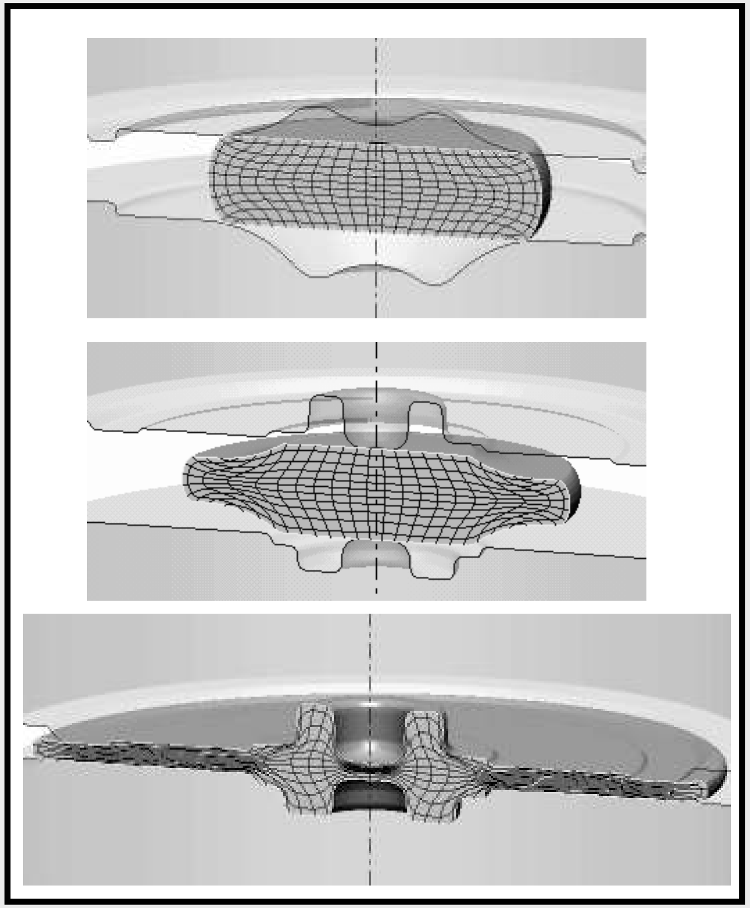
Maximum relative die wear w_r =9.90 on the lower die

Elastic deflection of the dies and its compensation

Deflection of the die (magnified)

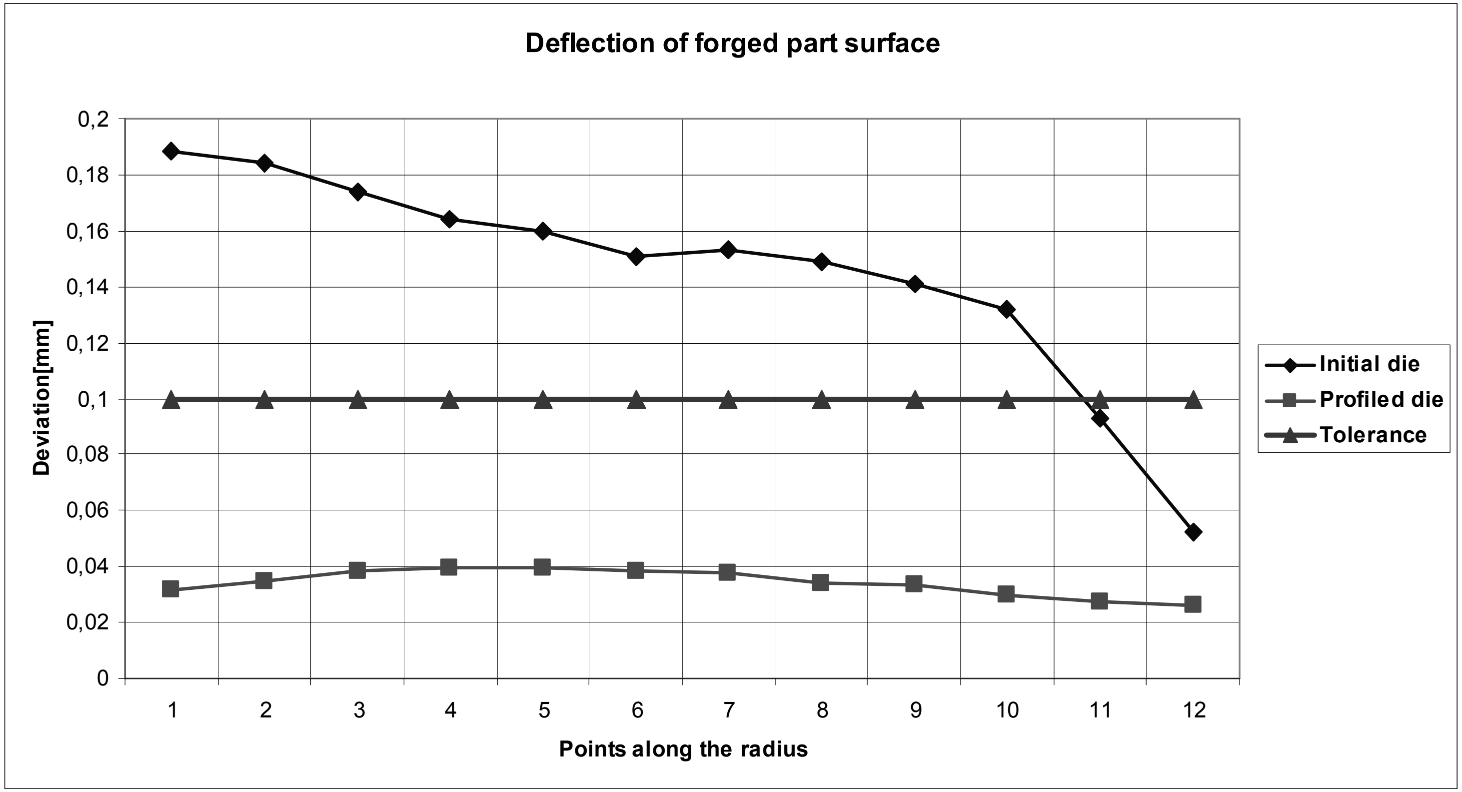


the stages of forging



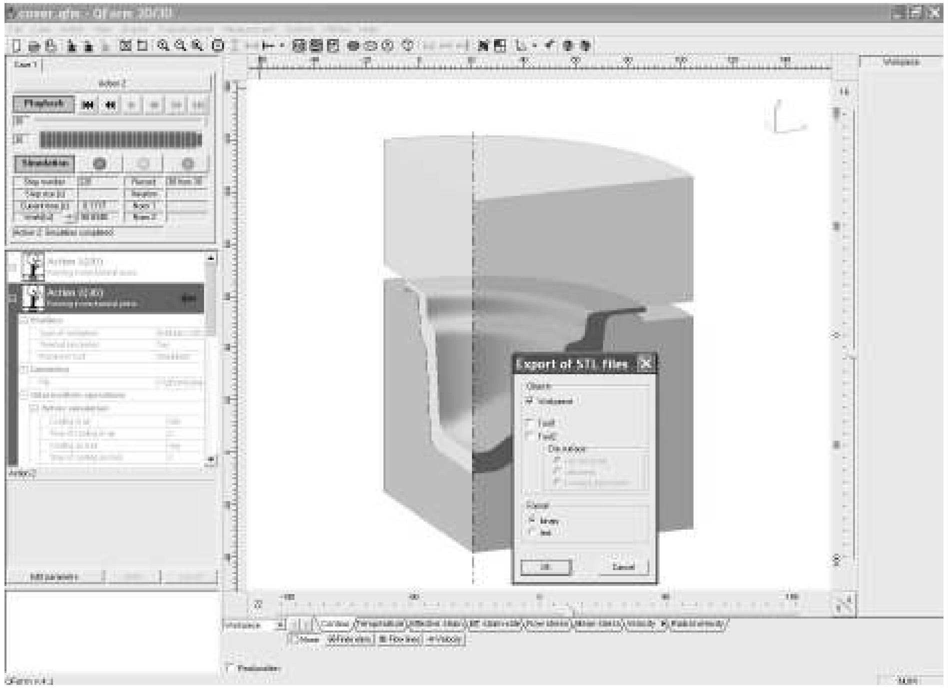
Elastic deflection of the dies and its compensation

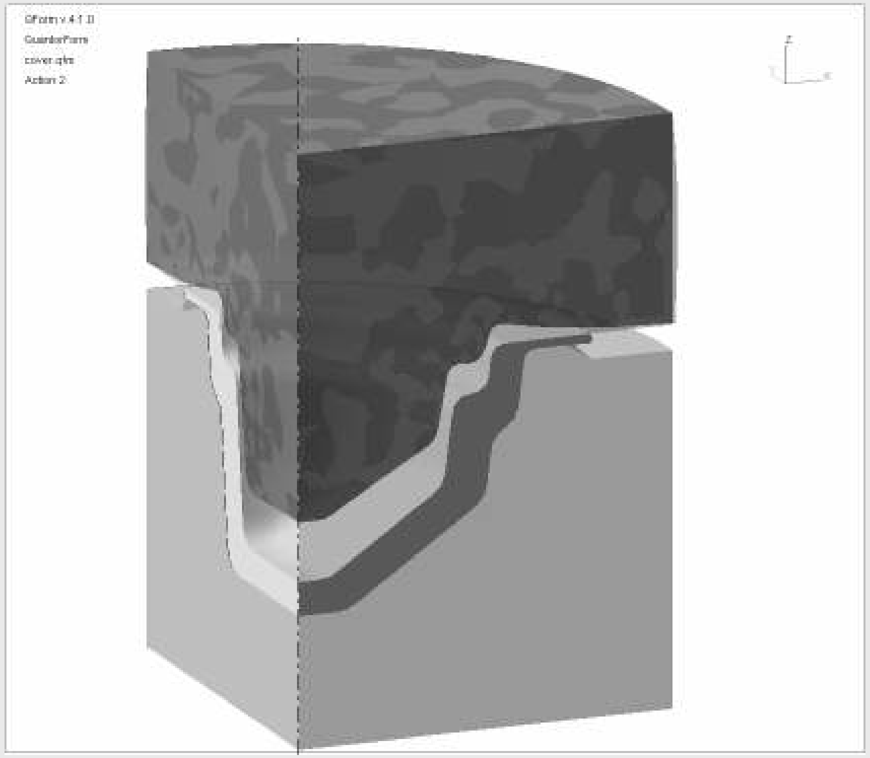
Graphs of upper die surface deflection along the radius of the forged part for initial and profiled die shape



Elastic deflection of the dies and its compensation

Export of deformed and profiled shapes of the tools





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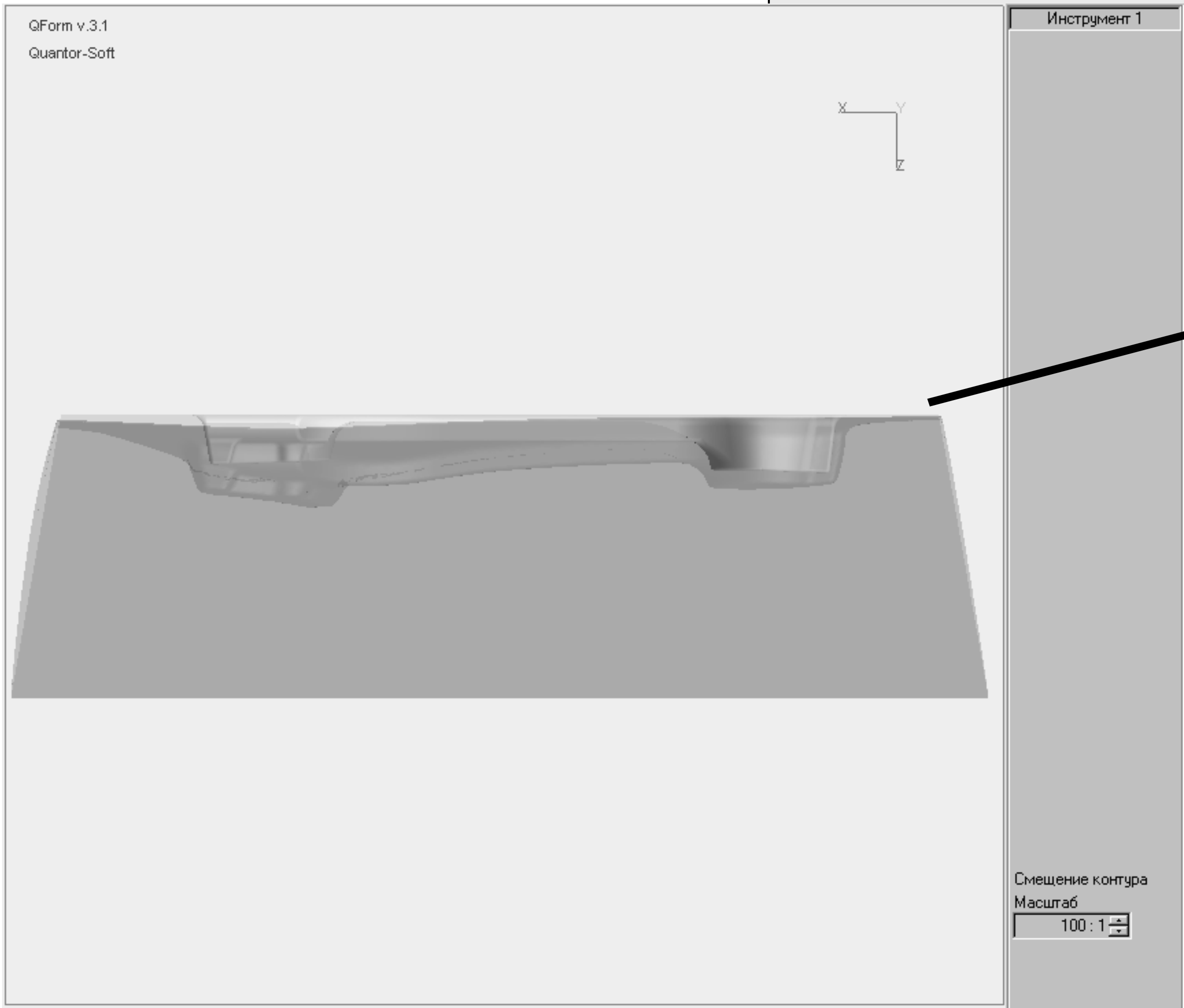
Compensation of the elastic deformation of the dies

The blocker die surface deflection (magnification factor 100)



Export of profiled die shape to CAD for precise forging

QForm is very economically efficient

- It is the perfect tool for die designer and forging engineer that they use in their everyday practice

- It saves material, tools, energy

- The development is fast and effective, no forging trials required for new jobs

- Then using QForm the forging skill is significantly improving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