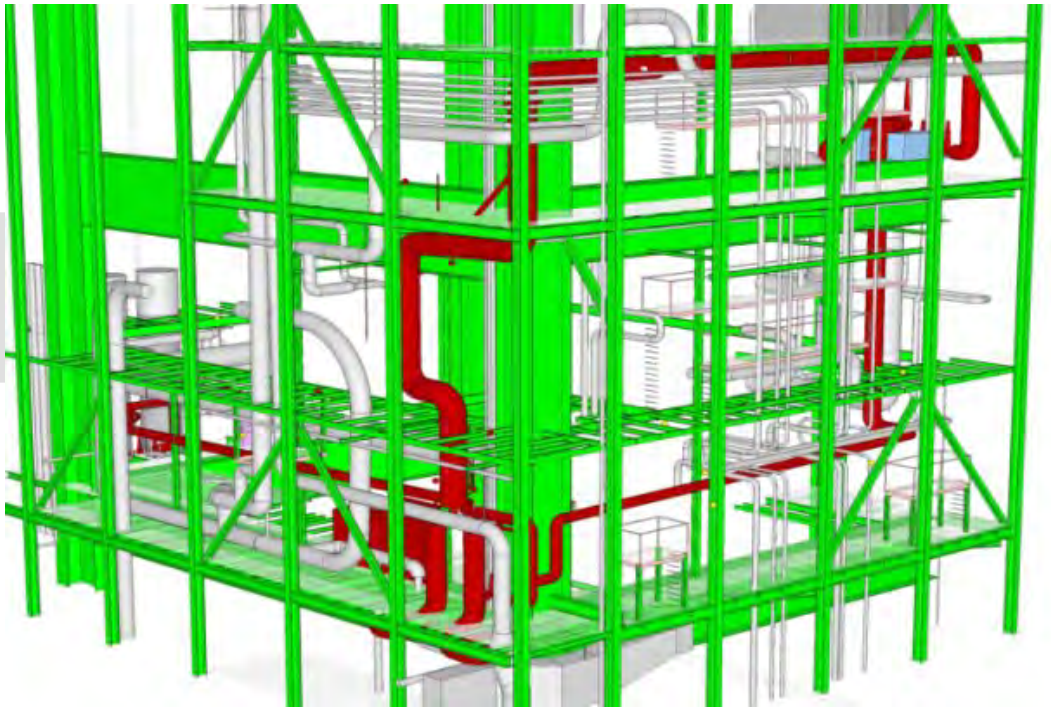
HWTII (Hochtemperatur-Werkstoff-Teststrecke)

- **Demonstration of the feasibility of a 700 °C power plant**

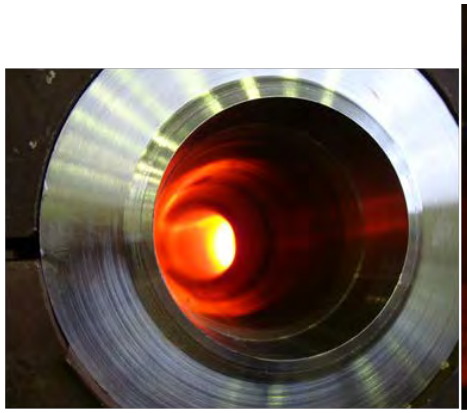


- Component behaviour under superposition of primary and secondary stresses (Alloy 617, Alloy 263, thick-walled components)
- Creep + thermal cycles; Temperature cycles between 400 °C and 725 °C
- Functionality of pipes, HP-Bypass valve, control and shut off valves, header

Results: 9.900 h (ϑ > 700 °C) operation and 2638 thermal cycles!
(Operation: 2012-2014)

HWTII, Results and experience

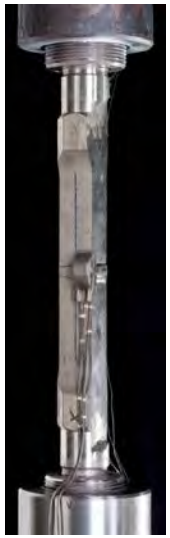
- **Qualification of manufacturing – bending process**



Results:
Avoiding of creation of surface defects during bending

- Evaluation of criticality
- Surface turning
- Additional NDT

- **Qualification of manufacturing – welding procedure**



Results:

- Avoiding of specific welding defects
- Effectiveness
- Process security

HWTII, Results and experience

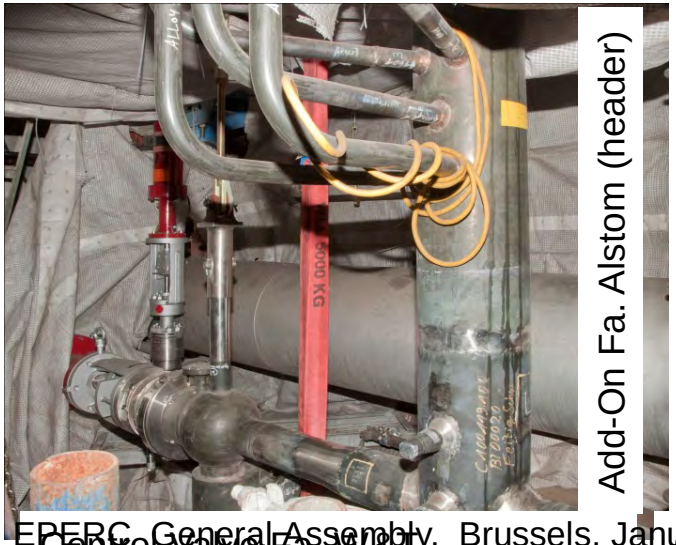
- **Key Components (instrumentation and online monitoring, > 70 Temperature recording points, 16 Strain gauges)**

Stop valve, Fa. KSB

Pipe with support construction

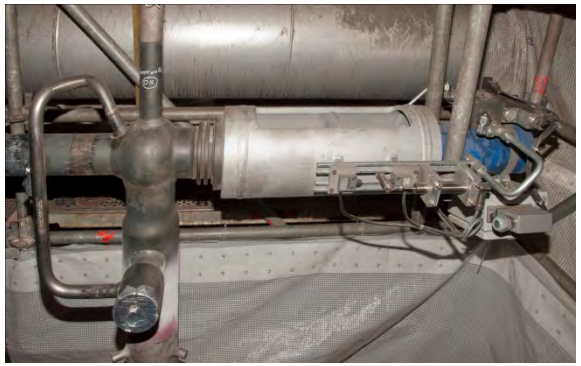
„Biegebremse“: Secondary stresses in pipe bend

Support construction



Add-On Fa. Alstom (header)

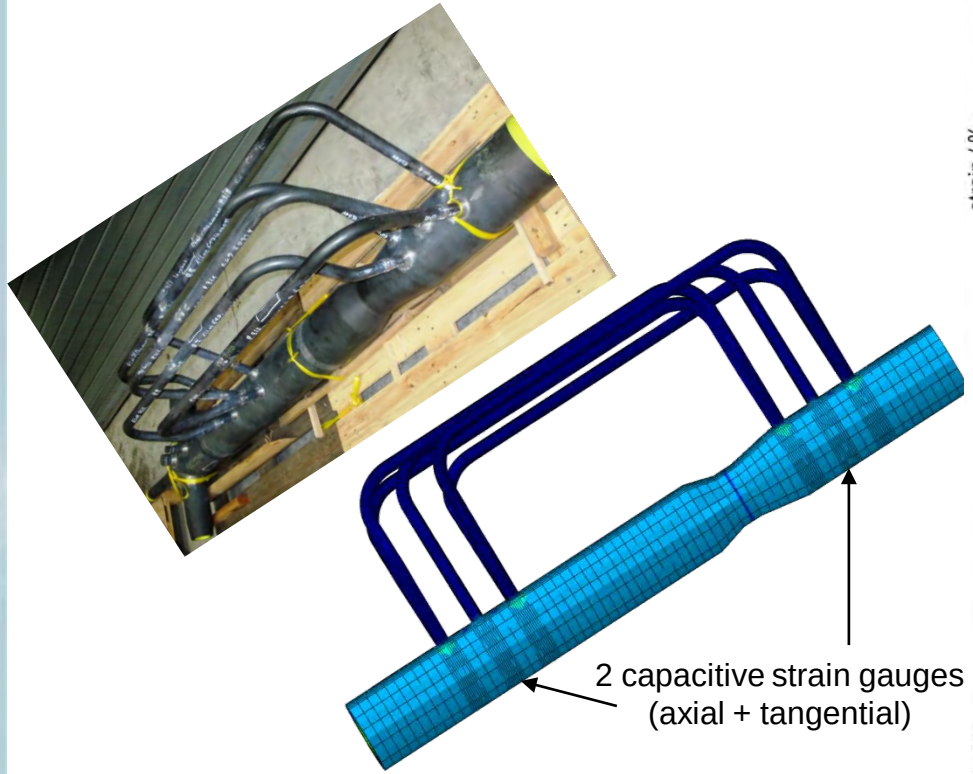
Control Valve Fa. W&T



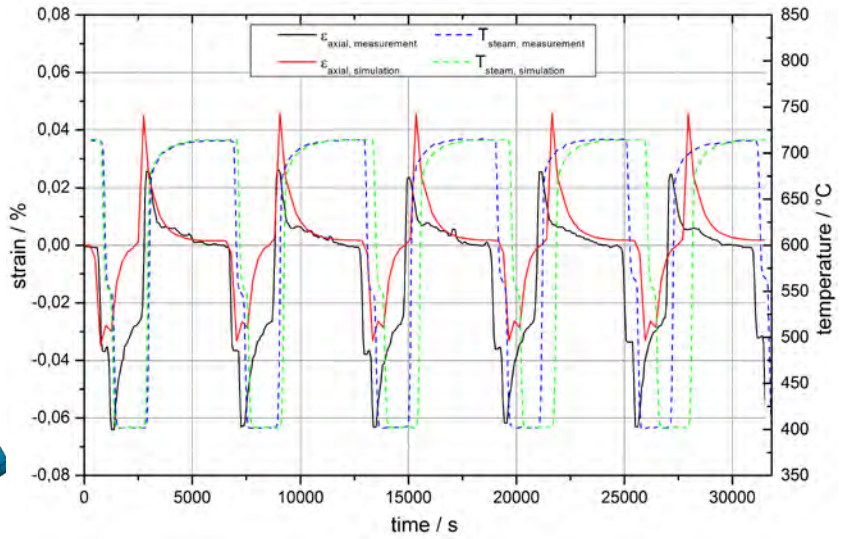
Control Valve Fa. Bopp & Reuther

Numerical modelling, validation

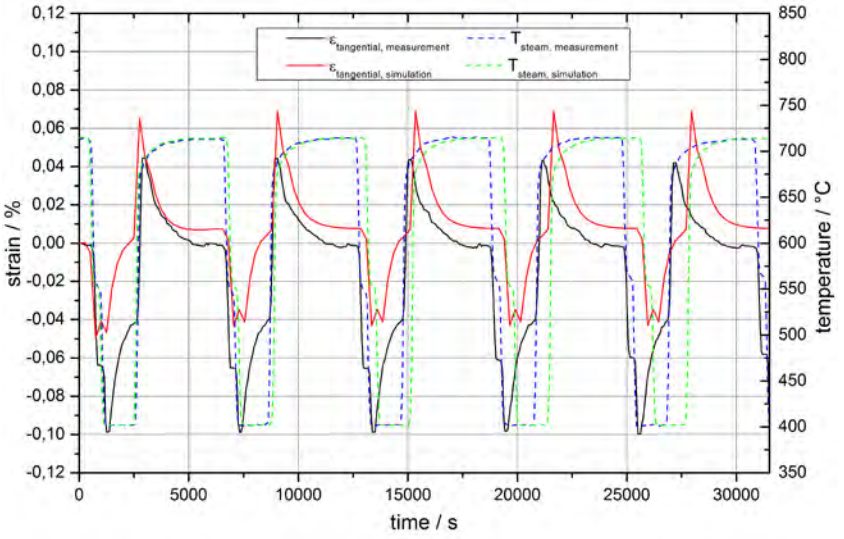
- **Strain measurement, experiment = simulation**



- Axial strain



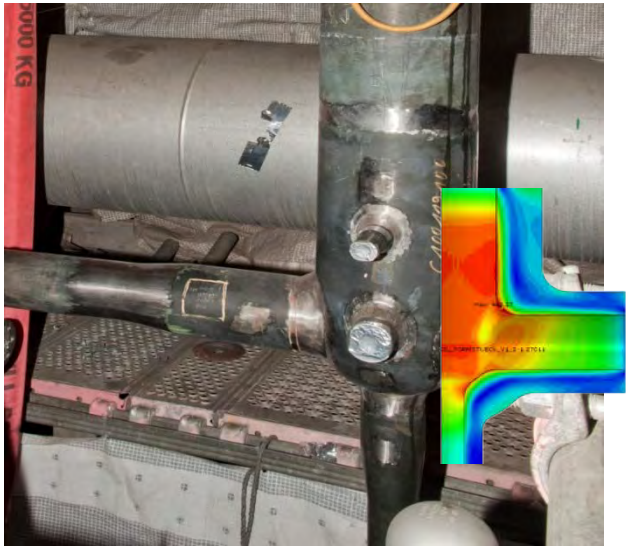
- Hoop strain

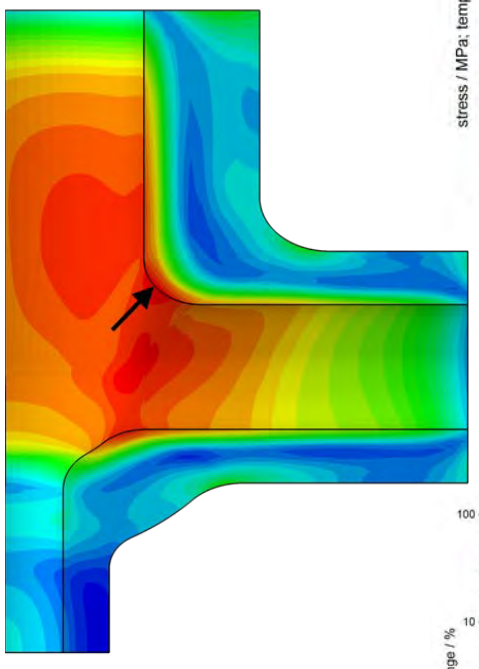


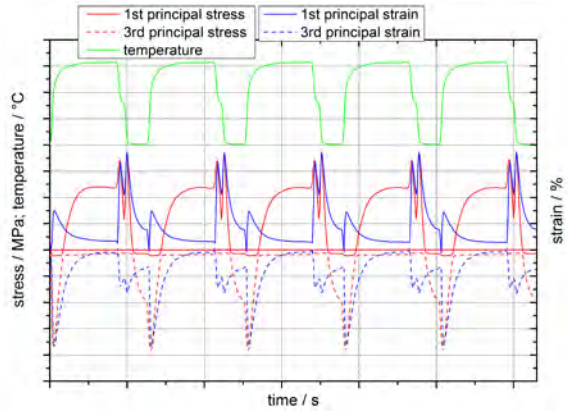
- Relatively good approximation of strain
- Further improvement expected with ongoing calculations using a constitutive equation with kinematic hardening

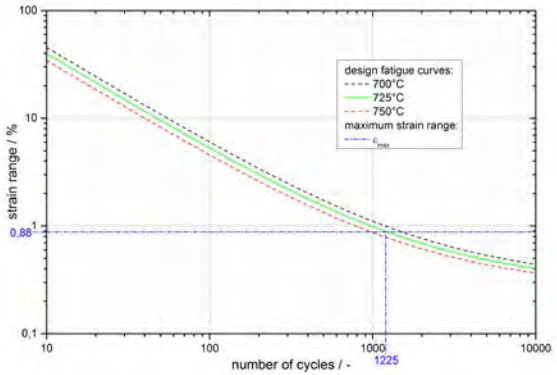
Numerical modelling for assessment

- **Evaluation at the maximum loaded areas**
- **Distribution of mises stress in cross-pi**



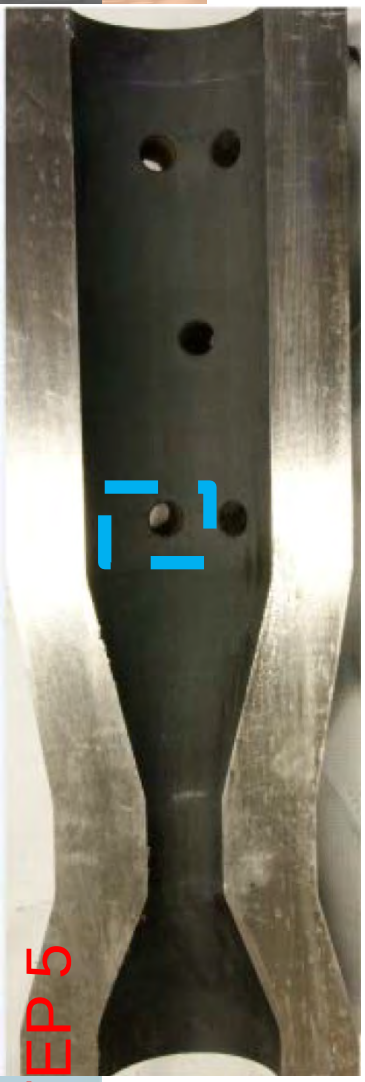




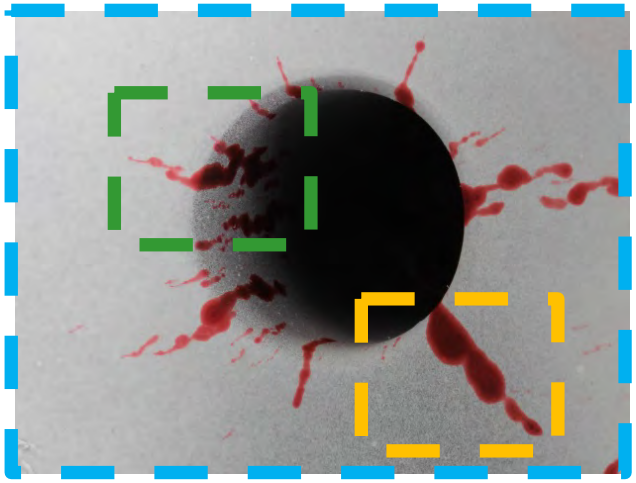


- Temporal courses of temperature and max/min principle strains respectively stresses

Alloy 617 mod. - Inner hole r = 3 mm

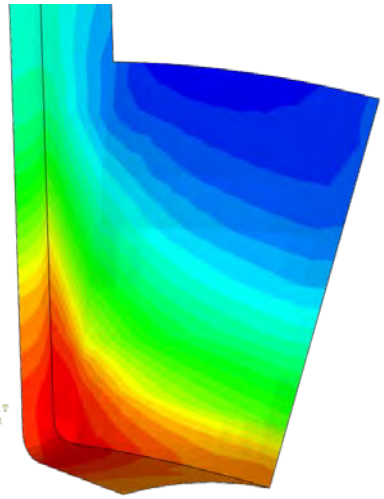


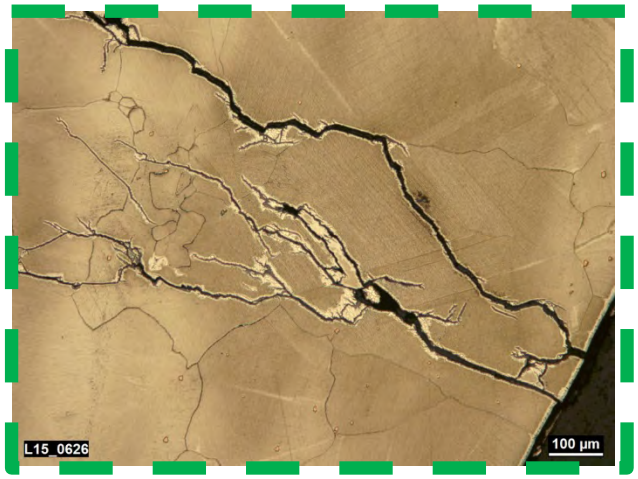
- Dye penetrant inspection



- Opened crack

- Tangential stress distribution





- Transgranular cracks beginning on the surface
- Isolated intergranular cracks

STEP 5

To be considered

- A-USC requires alternative materials
- Nickel alloys especially in thickwalled components / structure show different properties and deformation and damage behavior (ductility, ageing …)
- Manufacturing routes are different → implications on quality assurance
- NDT techniques need specific development,
- different detectability limits etc
- Fracture mechanics properties are not available in the same manner as for ferritic-martensitic steels

- Currently available data have to be analyzed with regard to
  - Completeness
  - Transferability into regulations to ensure safety of PE

Summary

- Research work on pressure equipment design, operation, monitoring and calculation is going on
- In the last decade there was focus on high efficient later on on flexible operated plants.
- A reasonable data base mechanical properties, creep, fatigue and creep-fatigue as well as fracture mechanics data could be determined
- Constitutive equations for the simulation of static creep and thermal cyclic established and the parameters approximated
- Test loops with tubes and thick-walled boiler components operated successfully
  - Experience on the material behaviour in the plant
  - Functionality of components
- Numerical simulations carried out with the aim to predict stresses and strain and life time of components

Thank you for your attention!