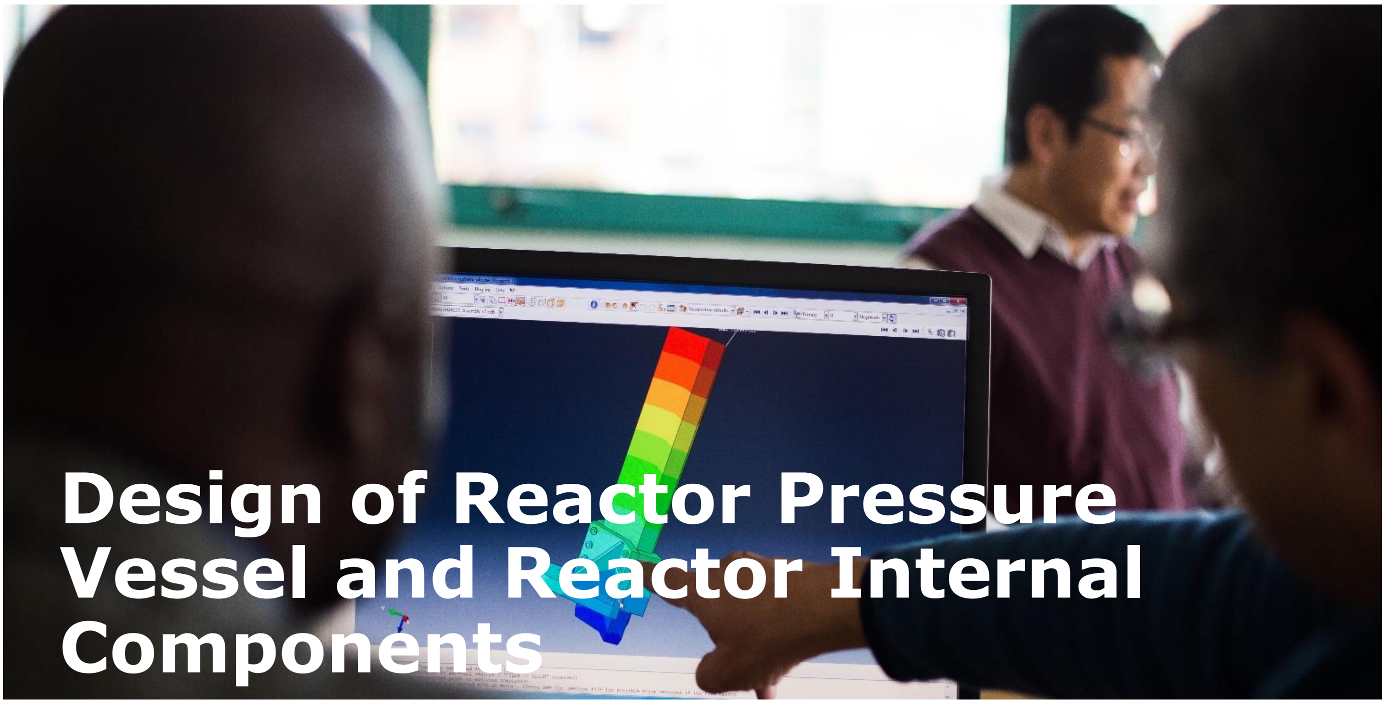

# Design of Reactor Pressure Vessel and Reactor Internal Components

## Case study

**Our client is developing a concept design for its nuclear reactor with specific requirements related to road transport limits of its key components. Therefore the size of a number of components in the reactor pressure vessel (RPV) body and reactor vessel internals (RVIs) was required to be confirmed using stress analyses to ensure that the overall assembly remains within road transport limits. The design and construction code for the RPV and RVIs was ASME III.**

## The solution

The main aims of the work were as follows:

- to confirm preliminary sizing of components for the RPV body, RPV nozzles and reactor vessel internals;
- to consider up to three external profiles for the RPV nozzles and thereby identify any conflicting requirements for ease of manufacture and structural integrity; and
- to confirm the adequacy of shielding in limiting the effects of irradiation shift on fracture toughness and hence the effects on defect tolerance.

For the RPV body and RVIs, work was confined to design-by-rule assessments in accordance with ASME III, and supporting hand calculations considering design pressure, bolt-up loads, design temperatures and simple assessments of thermal stresses in plain cylinders, spheres and flat plates.

For the RPV nozzles three finite element analyses (FEA) were undertaken analyzing the nozzles for design pressure and temperature loadings. Thermal stresses due to temperature loading were determined using an axisymmetric FEA model of a short section of the cylinder. Transient heat transfer and thermal stress analyses were conducted using FEA for a suitably representative, severe thermal fault transient agreed with the client.

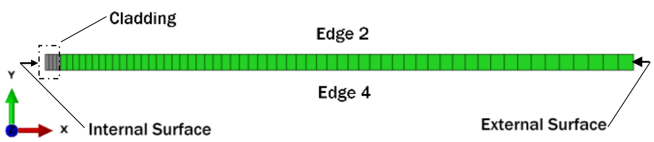


*Figure 1 Axisymmetric FE model*

A defect tolerance assessment of the RPV when subject to a transient event specified by the client was also carried out using the R6 procedure. It considered a bounding estimate of the irradiation ductile-brittle temperature transition shift on fracture toughness.

# The outcome

Design checks using design-by-rule methods confirmed that the RPV shell and RVIs were fit-for-purpose. The nozzle thickness and design was optimized using the FE predicted results. It was found that thickness in the nozzle region could be reduced by 20% and still maintain a design margin against failure.

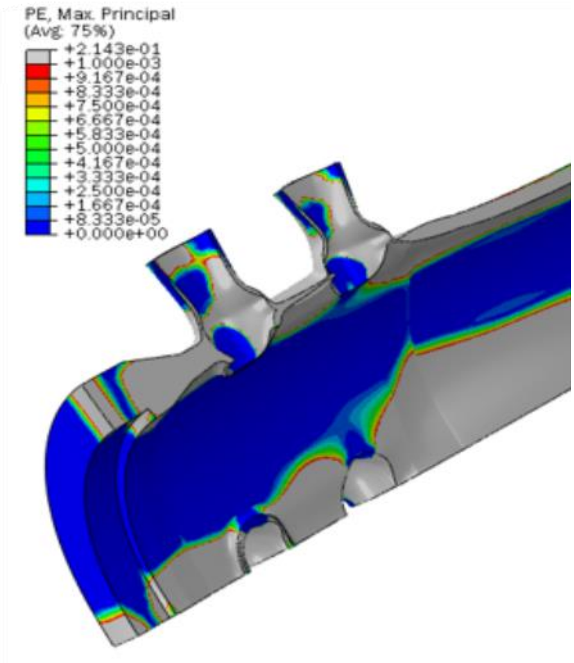


*Figure 2 FE predicted plastic strain in the RPV body*

For the fracture mechanics assessment, transient thermal stresses were obtained from the FE analysis of the transient event. In addition to thermal stresses, stresses due to internal pressure and residual stresses were also included in the assessment.

The fracture mechanics based assessment predicted a limiting defect depth greater than the detection capability limits of non-destructive testing (NDT) inspection methods. This limiting defect size is used to qualify the NDT method to be used to inspect the RPV.

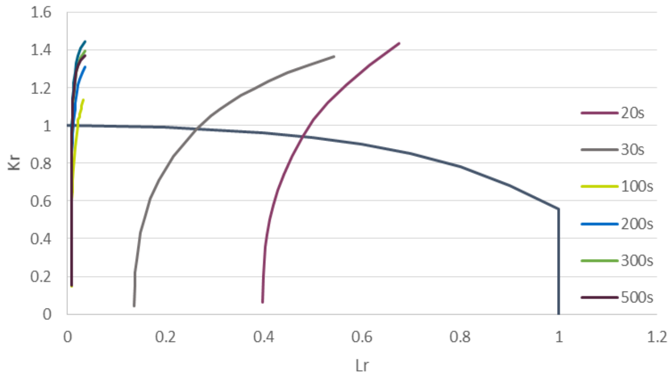


*Figure 3 Limiting defect assessments for various thermal transient time points*

# Value delivered

**This study was used to optimise the design of reactor pressure vessel, and reactor vessel internals. The results from the study helped the client reduce weight of the reactor pressure vessel nozzle and optimize the size to meet the road transport limits. The study also provided the limiting defect size to be used to qualify the NDT equipment for end-of-manufacturing inspection of the reactor pressure vessel.**

**If you would like to discuss how EASL can help your business, please get in touch.**


engineering analysis services ltd.

2 Edward Court, George Richards Way, Altrincham, WA14 5GL

0161 923 0070 www.easl-stress.co.uk

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