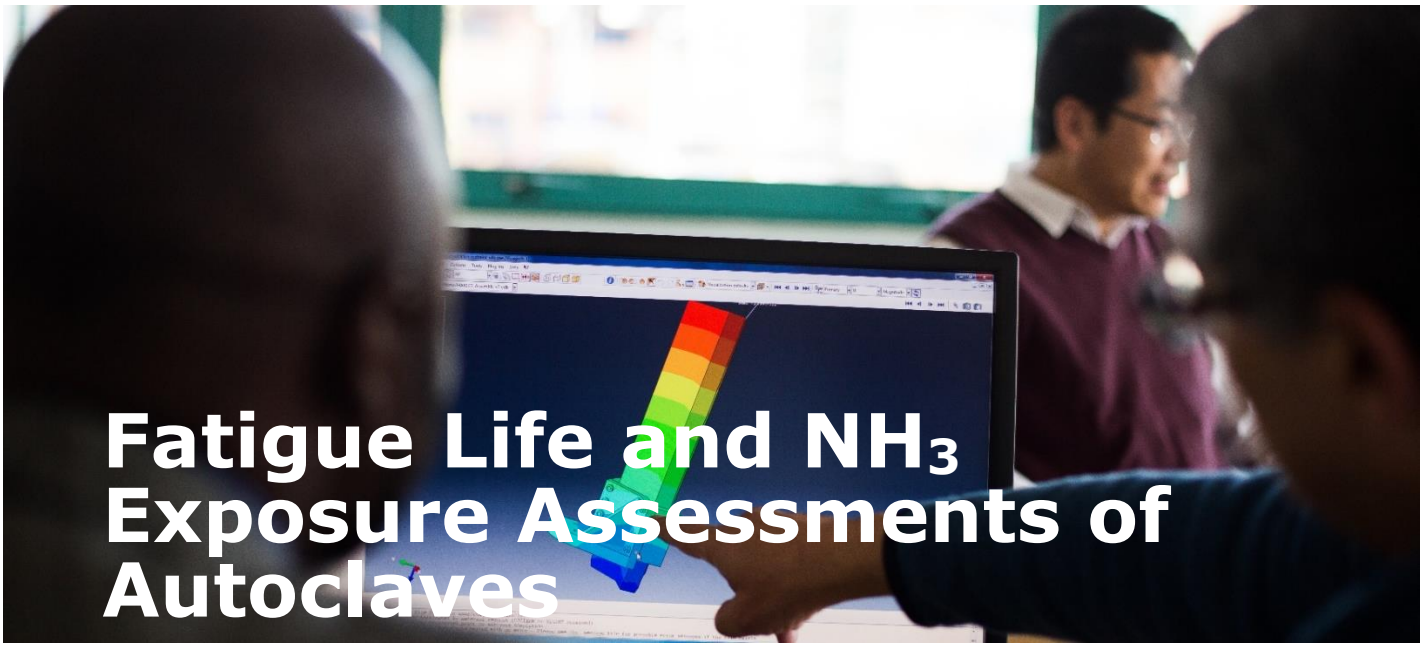

Fatigue Life and NH_3 Exposure Assessments of Autoclaves

Case study

Three of our client's autoclave vessels were approaching their end of design fatigue life. These vessels had been exposed to liquid ammonia (NH_3). The client requested EASL to assess the likelihood of NH_3 stress corrosion cracking (SCC) and remnant life of these vessels based on operational data.

Our approach

To provide the most cost-effective solution to our client's requirements, we followed a staged approach for the integrity assessment. The assessment was divided in to the following four tasks (with task 4 dependent on findings from previous tasks):

Task 1: A desktop based review of the current guidance and industrial understanding of SCC of steels exposed to ammonia and the susceptibility of vessel to SCC.

Task 2: Revisit of the design stress calculation via more refined finite element analysis methods. The actual plant operating conditions are considered.

Task 3: Revisit of the fatigue life calculations using ASME VIII Division 2 assessment methods.

Task 4: Carry out a fracture mechanics based limiting defect size and crack growth assessment using API 579-1 / ASME FFS-1 methods. The necessity to carry out this assessment was dependent on the findings from Tasks 1 and 3.

A 3D solid-brick finite element model (FEM) representing the vessel was generated using ABAQUS CAE.

The most recent inspection reports were reviewed to assess general corrosion of the vessel and the review findings were used to determine remaining thickness values for locations where no measured thicknesses were available. Sequentially-coupled thermal stress analyses were carried out to assess the effects of thermal gradient local to the socket pipes due to transition between insulated and non-insulated regions.

Our solution

A susceptibility review of the autoclave vessel operation was carried out to determine the likelihood of SCC occurring. It was judged that NH_3 SCC is not credible during the operation of the autoclave vessel.

The images show the temperatures and FE predicted stresses in the vessel. The FE predicted stresses were used in the fatigue life assessment to determine the remnant cyclic life of the vessel under the current operating conditions.

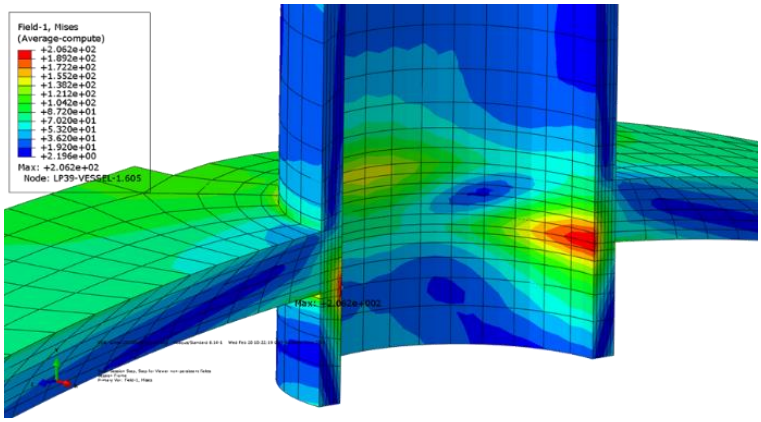

Figure 1 FE predicted von Mises stresses (MPa)

The reassessment of the rupture disc nozzle junction (FE predicted bounding location) in accordance with ASME VIII Div 2, Part 5 calculated the permissible number of cycles to be 313,099. Based on the actual number of cycles since commissioning of the vessel, the calculated fatigue damage was 0.37. Assuming the autoclave vessel continues to function under the operating conditions considered in this assessment, it was judged that the vessel has 49 years remnant fatigue life.

Value delivered

From our findings, and utilising advanced analysis methods, it was demonstrated to the client that the vessel was fit for the continued operation up to 49 years, thereby making a case for a return to service, avoiding the unnecessary high costs of replacing the component.

If EASL can help you getting back vessels to service, please get in touch with us.

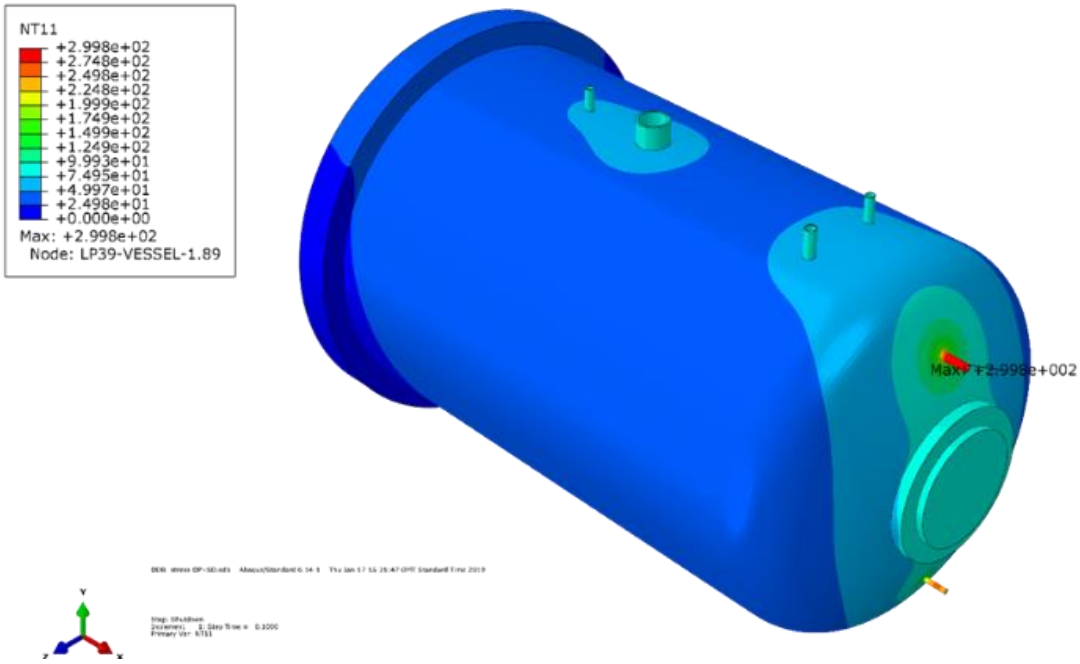

Figure 2 FE predicted temperatures (°C)

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