

# Fatigue Life Assessment of Pressure Vessel Subjected to Cyclic Pressure

## Case Study Highlights

### Client Profile:

Pressure Vessel Manufacturer, USA

### Objective:

To assess the fatigue life of a pressure vessel for cyclic pressure service in accordance with ASME BPVC (Boiler & Pressure Vessel Code) Section VIII, Div. 2 Part 5 Ed. 2013

### Solution:

The pressure vessel design was assessed for fatigue life estimation using finite element analysis as per the standards mentioned in the ASME BPVC Section VIII, Div. 2 Part 5. The design was analyzed for different pressure loading conditions to determine stress and deformation values. The computed results were also validated against theoretical calculations. Based on the results, improvement in the design was suggested as the vessel was found to fail earlier than the expected number of loading cycles.

### Challenges:

- Identifying design parameters and material properties for finite element analysis
- Developing finite element model for the pressure vessel
- Calculating fatigue as per ASME Section VIII, Div. 2 Part 5
- Validating the FEA results against theoretical calculations
- Evaluating the design for safety against the expected number of loading cycles

### Benefits

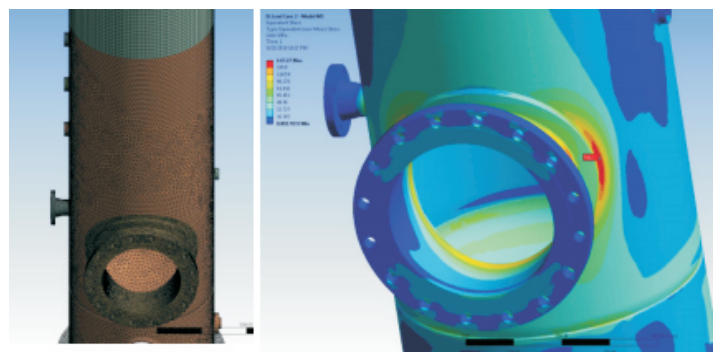
- Determined the safety of the vessel design prior to manufacturing, thereby reducing the manufacturing time significantly
- Prevented the probability of fatal accidents through fatigue analysis
- Changes in the design for strength improvement made easier by providing information on vessel regions requiring geometrical changes

Pressure vessels are designed to store gases and liquids at pressure different from the ambient conditions. The large pressure difference necessitates careful designing of the vessels to avoid fatal accidents, which is why their design, manufacturing and operation are often regulated by engineering authorities. The ASME Boiler and Pressure Vessel Code (BPVC) is one such set of mandatory guidelines to design pressure vessels in accordance with the standards, to ensure prolonged useful life as well as safety.

Within the ASME BPVC Section VIII, the Division 2 includes an alternative set of rules for material, design, fabrication, inspection and testing of pressure vessels having internal or external pressure exceeding 15psi. The Division 2 also has provisions to utilize finite element analysis, to determine stresses in the equipment and traditional theoretical calculation approach to estimate fatigue life of the vessel (mentioned in Part 5 "Design by Analysis Requirements").

## The Solution

Hi-Tech provided FEA solution to a leading pressure vessel manufacturer from USA, to determine the stress and deformation values and estimate the fatigue life as per the ASME code Section VIII, Division 2. The FEA model of the pressure vessel was developed and different loading conditions were applied. The stress and deformation due to pressure loading were measured and were also validated with theoretical calculations as per ASME code. Fatigue analysis was done to calculate allowable useful life cycle of the vessel against the designed cycles. The values for fatigue strength and penalty factors were taken as per the ASME guidelines. Results of the fatigue analysis indicated a fatigue damage factor exceeding unity, thereby suggesting premature failure of the vessel. The probability of the vessel to fail early was ascertained by applying pressure loading for the desired number of cycles. The premature fatigue failure confirmed that the design is not safe, and chances of fatal accidents may occur after a specific number of pressure loading cycles



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