Reliability Assessment of Vacuum Induction Melting Vessel Subject to Chloride SCC

Client Confidential

The Problem

Our client required a vacuum induction melting (VIM) furnace vessel to be designed and manufactured in general accordance with the pressure vessel design code PD5500, with suitable manufactured integrity. In addition to this, the design of the furnace vessel and all items on the vacuum boundary were required to be designed in such a way that it would not be feasible for water ingress. Chloride stress corrosion cracking (CLSCC) was identified as a potential damage mechanism.

Our Approach

A series of 3D linear elastic finite element analyses were performed to demonstrate fitness-for-purpose against the design by analysis criteria of PD 5500. The fatigue life of the vessel under anticipated normal operating conditions was determined. The FE predicted stresses were used as input to a fracture mechanics assessment of the critical defect size and anticipated fatigue crack growth rate and upper bound crack growth rates for CLSCC. The results from these analyses were used to determine the level of reliability for the proposed design of the vessel.

Outcome

An optimum inspection period of 3 years was suggested. Using the methodology of API581, the vessel failure frequency for SCC related failures was determined to be below the stated acceptance criterion. It was recommended that the use of duplex and super duplex stainless steels, UNS S32900, S31803, S32205 and S32760 would provide enhanced resistance to chloride stress corrosion cracking.