Fatigue Lives of Power Plant Structures Due to Load Sequence Effects Originating from Fluctuating Production of Renewable Energy

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The change in operation of conventional power plants due to the increasing use of renewable energies causes additional stresses to the components by a high number of smaller load cycles. This fact results in a demand for validated new approaches to estimate fatigue life especially for welded joints which are the weak parts within the piping. The components are operated in the LCF regime where short fatigue crack growth determines the life. Therefore a non-linear fracture mechanics based approach was chosen. For the development and validation of the model, an experimental campaign was performed including fatigue tests of smooth specimens with various microstructures of X6CrNiNb18-10 (AISI 347) as well as specimens containing mechanical and microstructural notches. Experiments are performed with all types of specimens with an increasing complexity from constant to variable amplitude loading, the latter also applied as pseudo-random sequence derived from measurements in power plants. The developed non-linear fracture mechanics based model uses the effective cyclic J-Integral normalized to the crack length to replace crack growth calculation by a linear damage accumulation. To consider the loading history an algorithm for the calculation of crack opening and crack closure is used. The advantages of this approach are shown by a comparison of the results with results of the experiments as well as of conventional damage calculations. The differences in the approaches will be highlighted and used for further considerations of how to improve the life prediction for variable amplitudes.