The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

INTEGRATED DEEP DRAWING AND HIGH-CYCLE FATIGUE SIMULATION USING A CONTINUOUS-TIME APPROACH

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Key Words: *High-Cycle Fatigue, Metal Sheet Forming, Finite Element Analysis, Floating Structures.*

Floating structures may suffer from high-cycle fatigue (HCF) failure as a result of complex stress histories caused by repeated wave loads of variable amplitude. Traditionally, fatigue life estimation is performed in three steps; simplifying the complex load history using a cycle-counting method [1], calculating the fatigue damage associated with each cycle using a fatigue limit function [2], and adding up the damage per cycle using a cumulative damage rule [3]. Opposed to this frequency-based approach where fatigue damage is accumulated in discrete cycles, continuous models that describe damage accumulation as an integral in the time domain [4] is gaining attention for the purpose of complete machinery simulations (CMS). In the Ottosen-Stenström-Ristinmaa (OSR) model [4], a back-stress modified endurance surface in six-dimensional stress space separates safe configurations, where fatigue damage cannot develop, from unsafe configurations, where fatigue damage can develop under certain conditions. The model, clearly inspired by plasticity theory, enables fatigue damage to be formulated in a unified manner, inherently accommodating multiaxial, non-proportional and complex stress histories.

In the past few decades, phenomenological plasticity models [5] describing the behaviour of rolled metal sheets during forming has been a topic of extensive research. Software based on the finite element method (FEM), such as LS-DYNA, allows conducting advanced simulations of deep-drawing processes, using state-of-the-art material models to predict spring-back [6] and residual stress distributions in the formed components [7]. Yet, as the major application is in the tooling industry, the main attention has been directed towards avoiding material failure in production, rather than assessing the functionality and capacity of final components [8]. Acting as a superimposed mean stress during variable loading, the presence of residual stress may strongly influence the fatigue life of a component. Nevertheless, few efforts have been dedicated to the coupling of forming simulations and HCF analysis, investigating residual fatigue life of deep drawn components.

In this work, the deep drawing and fatigue life of a floating aluminium structure made from a 1.5 mm thick rolled AA5083-H111 sheet is investigated through LS-DYNA simulations. The deformation during drawing, and the subsequent elastic spring-back upon release will be simulated, using a non-quadratic anisotropic yield function with mixed isotropic and kinematic hardening. The possibilities of the OSR model to predict the fatigue life of the structure when subjected to a complex load history that mimics the effects of inshore wave loads will be investigated.

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