20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Modelling of crack initiation and propagation in HPDC aluminium alloys: Experimental insights and modelling strategies

David Morin[1], Odd Sture Hopperstad[2], Bastien Bussiere[3], Dinesh Ram[4], Vegard Aune[5], Lars Edvard Blystad Dæhli[6]

[1] NTNU, Norwegian University of Science and Technology, Norway. david.morin@ntnu.no
[2] NTNU, Norwegian University of Science and Technology, Norway. odd.hopperstad@ntnu.no
[3] NTNU, Norwegian University of Science and Technology, Norway. bastien.bussiere@ntnu.no
[4] NTNU, Norwegian University of Science and Technology, Norway. dinesh.ram@ntnu.no
[5] NTNU, Norwegian University of Science and Technology, Norway. vegard.aune@ntnu.no
[6] NTNU, Norwegian University of Science and Technology, Norway. lars.e.dahli@ntnu.no

Paper ID: 198
Symposium S15: Size-dependent materials modelling

Abstract

In the context of lightweight vehicle design—an essential enabler for the electrification of transportation—high-pressure die-cast (HPDC) aluminium components are becoming increasingly attractive to the automotive industry. These components enable the replacement of multiple assembled parts by large, integrated structures, thereby simplifying body-in-white assembly and offering significant cost and weight savings. Despite these advantages, HPDC aluminium components exhibit pronounced stochastic fracture behaviour due to the presence of casting defects. These defects, which include gas porosity, shrinkage porosity, and oxide films, vary widely in size, morphology, and origin. Moreover, their spatial distribution within a component is strongly governed by the casting process, further complicating reliable structural design. In such materials, crack initiation and propagation result from a subtle interplay across multiple length scales, governed by the nature, size, and distribution of casting defects. Capturing these mechanisms within predictive numerical simulations therefore remains a significant challenge. In this presentation, we first report experimental observations of crack initiation and propagation in an

HPDC aluminium alloy, highlighting the key challenges associated with failure in these materials. Building on these results, we then propose, develop, and validate a multiscale modelling framework tailored to HPDC aluminium alloys. The proposed approach incorporates multiple length scales to reproduce experimental observations and to capture the distinct mechanisms governing crack initiation and propagation in HPDC components.

Keywords:

Ductile failure Stochastic failure Regularization Gradient-based non-locality Aluminium