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DEFECT-SENSITIVE FATIGUE PERFORMANCE OF METAL ADDITIVELY MANUFACTURED COMPONENTS: FROM LCF TO VHCF

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ABSTRACT

The reliable use of metal additively manufactured (AM) components in safety- and performance-critical applications requires fatigue assessment methods that reflect industrial design requirements and manufacturing characteristics. This invited session addresses fatigue performance across the entire fatigue-life spectrum, from low-cycle fatigue (LCF) to very-high-cycle fatigue (VHCF), focusing on the role of manufacturing defects and their spatial distributions.

Industrial perspectives will establish requirements for component qualification, durability, and manufacturing quality. Contributions will examine the influence of powder-based metal AM, process monitoring, frequency and defect detection on the reliability of fatigue-critical components. Central themes include how defect type, size, morphology, location, and population affect fatigue behaviour across life regimes, and how these effects depend on the material system and its susceptibility to defect formation. This includes distinguishing defect-controlled crack initiation from crack propagation and assessing how the significance of defects changes from LCF to VHCF using fracture mechanics-based modelling approaches.

The session will also address fatigue-informed structural design and computational life prediction. Topics include integrating fatigue criteria into topology optimization, such as surrogate-based approaches for LCF design and stress optimization for high-cycle fatigue. Both stress-based and strain-based descriptions will be considered, alongside fracture-mechanics approaches for predicting component lifetime.

By bringing together industry, research institutes, and universities, the session aims to identify the modelling, experimental, and manufacturing advances needed to assess and improve the fatigue strength of AM components consistently across the full range of service lives.