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Fracture of High Pressure Die Cast aluminum: effect of stress state

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Abstract

The demand for High Pressure Die Castings (HPDC) has increased significantly in the past years, particularly in the automotive sector. To improve cost efficiency, this business sector has a strong drive to reduce part count and assembly effort by transitioning to large, single-piece cast components. To ensure sustainable design of those components, finite element simulations play a key role to assess their mechanical behaviour, thereby reducing the need for costly experiments. However, the aluminum silicon alloys combined with the HPDC process tend to create a wide range of defects (e.g., gas pores, shrinkage pores, and oxide bifilms) which have significant influence on the fracture properties of the material and thus need to be identified and considered with respect to ductility. The casting defects are randomly distributed throughout the components, and their shapes and sizes can vary due to process variations during high-pressure die casting. Combined with the highly heterogeneous microstructure comprising primary α-Al and eutectic regions, these defects lead to stochastic fracture properties of the material that makes it difficult to predict when fracture will occur. Therefore, developing fracture models that account for the random nature of ductility in those materials is now a necessity to assess the reliability of HPDC components. To study the influence of stress state on fracture, defined by the stress triaxiality and Lode parameter, various samples made from an AlSi10Mg cast profile were tested under different loading states while keeping the same plastically activated

volume. CT-scans were performed to obtain a projection image of the defects in the samples and correlate their influence on the ductility of the material. Due to the inherent scatter in the fracture properties, a large number of tests were performed to ensure reliable statistics of the fracture strain. Further, the experiments were used to validate a post-processor approach applicable to finite element simulations of cast components at the macro scale.

Keywords:

Aluminium High Pressure Die Casting Stress State Stochastic failure