Failure modelling in aluminium HPDC components: Using a probabilistic approach

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Abstract

The main challenge in the design of aluminium High Pressure Die Casting (HPDC) components is that the mechanical properties depend on the internal defects. The process chain and the shape of the component cause the defects [1]. Typical defects are porosity due to turbulence and solidification shrinkage, gas porosity, oxide films and cold flow areas. The distribution of these is not homogeneous but systematic (spatial) and stochastic (local) [2]. As a consequence the mechanical behaviour, especially the fracture behaviour, is of a stochastic character [3].

Usually a material homogeneity is assumed in Finite Element (FE) simulations. For materials like HPDC alloys a deterministic and homogeneous model leads to extremely conservative results. An alternative is to use a probabilistic approach in FE modelling. A probabilistic approach leads to statements about the risk of failure.

In the present work, two phenomenological weakest link models are presented and discussed. The models base on the work by Dørum et al. [4] and Unosson et al. [5]. Here, the phenomenological failure criterion by Cockcroft-Latham is used. It is assumed that the failure parameter follows a weakest link distribution. Based on an extensive material characterization of a HPDC alloy the essential distribution functions are calibrated.

The probabilistic approaches combined with a v. Mises plasticity model are implemented as user-defined material models in the FE solver LS-Dyna. Aspects of the analysis of FE simulations with a probabilistic approach are also discussed. FE simulations of tensile tests are compared with the experimental database. The results show that the presented models capture the probability of failure with good accuracy. In addition, results of component tests are used for the validation of the probabilistic approach.

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