On the role of Fe-content on the damage behavior of an Al-Si-Cu alloy

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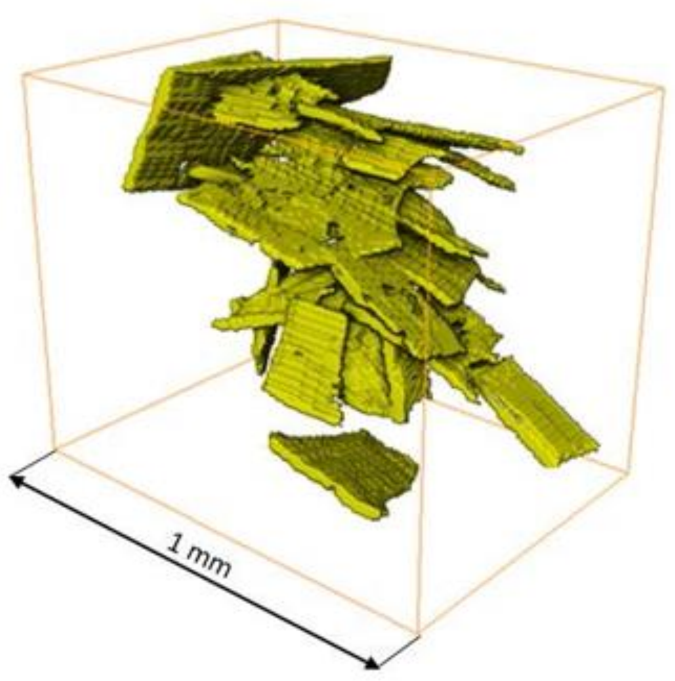
Introduction

The use of the recycled Al-Si-Cu alloys for the production of structural parts has received a considerable amount of interest in recent years since secondary alloys can significantly reduce production costs as well as the CO_2 emissions associated with the production of primary aluminum. However, the recycling process of the aluminum alloy leads to the accumulation of iron, which causes the formation of brittle Fe-rich intermetallic inclusions. The aim of this work is to study the influence of the Fe-content of the damage behavior of an Al-Si-Cu alloy by X-ray tomography. Fatigue tests were conducted and the fracture surfaces were analyzed by scanning electron microscopy as well as X-ray tomography in order to analyze the crack initiation and propagation processes.



Material and experiments

Fatigue specimens were cast by gravity die casting at a melt temperature of 760°C in a steel mold pre-heated at 350°C. A high resolution lab X-ray tomograph [ZEISS Xradia Versa 520] was used for the three-dimensional measurements of the casting defects and fracture surfaces. Fatigue tests were performed and the fracture surfaces were subsequently analyzed by scanning electron microscopy and micro-computed-tomography with the aim of classifying the different fracture damage scenarios and characterizing the fatigue behavior.

Results

The fracture surfaces show different characteristic damage mechanisms at different ranges in the probability distribution of the lifetime from the alloy with 2.28% Fe content (see Fig. 1).

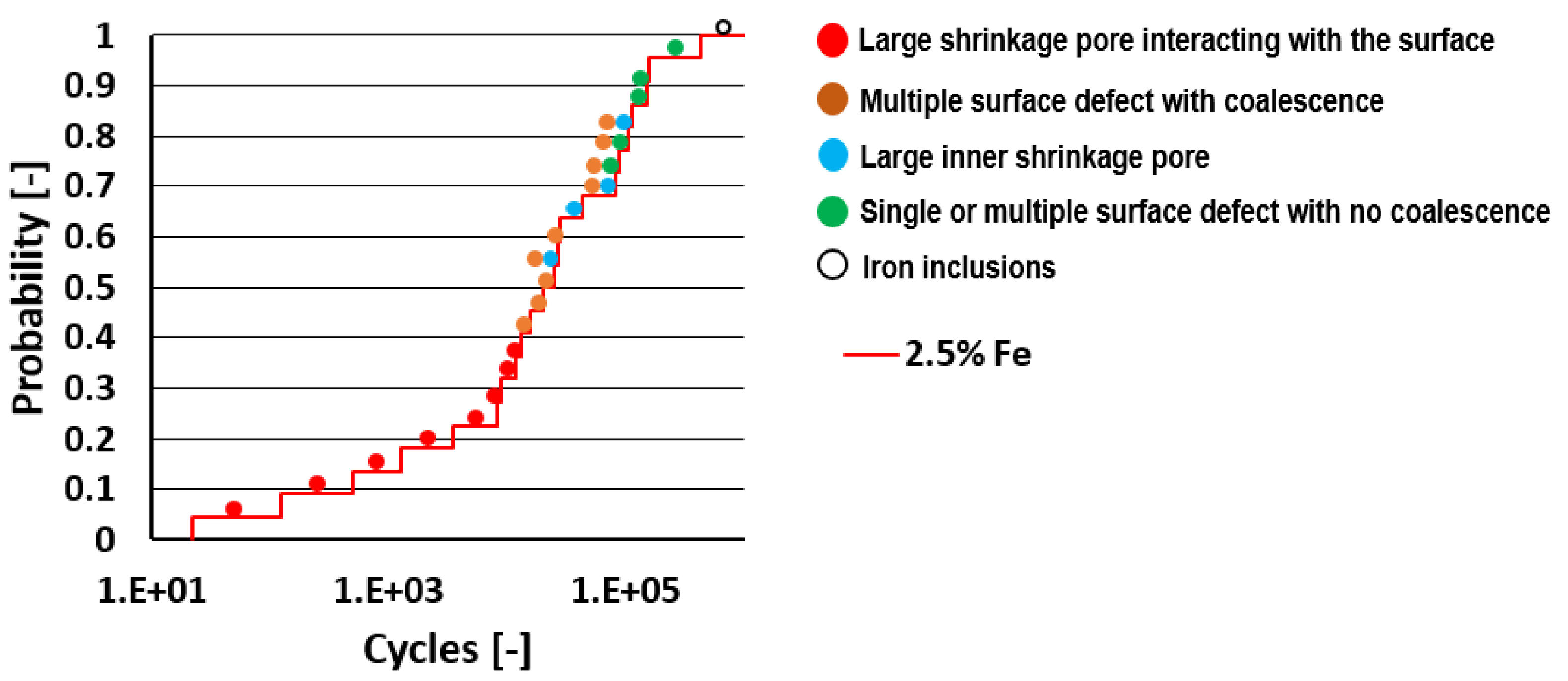


Fig. 1 Classification of the damage mechanisms in the statistical distribution of the fatigue cycles from 2.28% Fe content specimens.

Fig. 2 shows high volume fraction and size of shrinkage pores that interacted with the surface crack that caused the failure. It can be observed that the shrinkage pores are surrounded by large ß-Al_5FeSi particles between the dendritic arms in zone near the fracture surface.

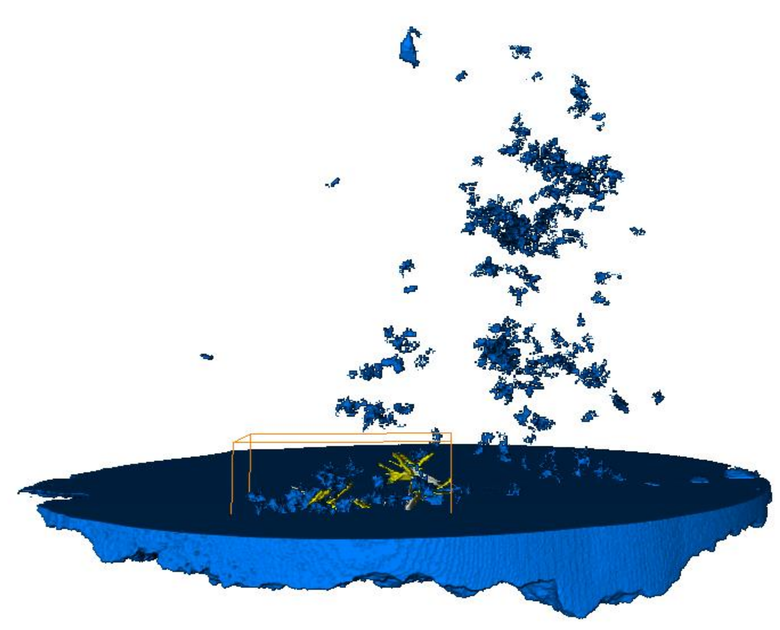


Fig. 2 3D reconstruction of the ß-Al_5FeSi inclusions located between the dendritic arms of the shrinkage pores located under the fracture surface.

Conclusions

The lowest range of the fatigue life probability distribution is characterized by fatigue specimens failing after very few cycles. In the fracture surfaces of these specimens large shrinkage pores can be observed together with large Fe-rich inclusions joining the dendritic arms of the pores. In this scenario, rapid crack initiation occurs at the surface and crack grows at a high rate as a result of the rupture of the ß-Al_5FeSi inclusions in the surrounding of the large shrinkage pore. The highest range in the probability distribution is characterized by specimens in which cracks do not initiate from Fe-rich inclusions at the surface

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