Numerical study of inclusion parameters and their influence on fatigue lifetime

Karl Gillner, Manuel Henrich, Sebastian Münstermann

PII: S0142-1123(18)30042-2
DOI: https://doi.org/10.1016/j.ijfatigue.2018.01.036
Reference: JIJF 4565

To appear in: *International Journal of Fatigue*

Received Date: 28 October 2017
Revised Date: 29 January 2018
Accepted Date: 31 January 2018

Please cite this article as: Gillner, K., Henrich, M., Münstermann, S., Numerical study of inclusion parameters and their influence on fatigue lifetime, *International Journal of Fatigue* (2018), doi: https://doi.org/10.1016/j.ijfatigue.2018.01.036

Numerical study of inclusion parameters and their influence on fatigue lifetime

Karl Gillner[1], Manuel Henrich[1], Sebastian Münstermann[1]

[1] *Steel Institute of RWTH Aachen University, Intzestraße 1, 52072 Aachen, Germany*

Abstract

The understanding of the influence of inclusion parameters like size, shape and surface roughness on the material's fatigue behavior can provide important guidelines for future material design. In this study, a numerical model is used to calculate the influence of inclusions on fatigue properties. The model consists of the statistical evaluation of numerous representative volume element (RVE) calculations in combination with a crystal plasticity (CP) constitutive model. The RVEs contain inclusions which differ in size, shape, surface roughness and elastic mismatch to the matrix. These parameters have been identified to determine the fatigue lifetime for the case that inclusions are the origin of failure. For each inclusion type, up to 100 RVEs are generated. The RVEs have statistically equivalent distributed microstructural properties but differ in detail, though. The results show that the inclusion size has the biggest influence on the lifetime. The influence of shape and roughness of the inclusion surface is negligible small. The study of the elastic mismatch is matching literature findings. All in all, this study shows that the numerical model can be used to calculate the influence of inclusions on fatigue lifetime. The use of the model can help to reduce the experimental effort for specifying the minimum cleanness requirement of a steel to guarantee the structural integrity under cyclic loading.

Keywords: Fatigue indicator parameter, representative volume element, microstructure

1. Introduction

The requirements of steel products in terms of mechanical properties have vastly increased over the last decades. Downstream products manufacturers demand for material features which scratch physical and economical limits. A common example is illustrated by the cleanness of steel with regard to lifetime under cyclic service conditions. Murakami and Endo (1) showed that not only lowering the inclusion content but also the maximum size has a positive effect on the lifetime of metallic components. Other investigations claim similar relationships (2; 3) and have expanded their research with regard to the morphology of the inclusion (4). These results support the customer demands for very clean materials which increase the production efforts for the manufacturers. However, Duckworth and Ineson. (5) showed that a threshold of inclusion size exists underneath a lowering of size does not have any lifetime increasing effect. This makes

Email address: Karl.Gillner@iehk.rwth-aachen.de Manuel.Henrich@iehk.rwth-aachen.de Sebastian.Muenstermann@iehk.rwth-aachen.de (Karl Gillner[1], Manuel Henrich[1], Sebastian Münstermann[1])