Characterization of Damage Behavior in a Nickel-base Superalloy Based on Crystal Orientation Analysis

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Abstract

In the case of failure incidents involving important components, it is necessary to clarify the fracture mechanism by failure analysis. In the case of conventional steel materials, according to the individual fracture mode the fracture surfaces have unique fracture morphology corresponding to tensile, impact, creep and fatigue conditions. We can identify the mechanism of a fracture by observing its fracture surface, and this is known as the fractography. However regarding nickel-base superalloys, any differences in fracture morphology are unfortunately barely distinguishable, which makes it difficult to conduct fractography.

In this paper, in order to characterize the damage behavior of superalloys, the crystal orientation analysis within grains by using the crystal orientation analysis has been carried out. As a result, it was found that the cross section of fracture samples have unique distinguishable morphology corresponding to the individual fracture mode. Furthermore, the striations corresponding to the fatigue crack growth rate was found in the crack cross-sectional sample. It was considered that the striation observed on the cross section reveals the fatigue crack growth rate, as with striations found in the fatigue fracture surface such as conventional steel materials.

On the case study of the actual (service and damaged) gas turbine blade, the crystal orientation analysis as the fractography revealed the mechanism of cracking and the fatigue crack growth rate. Thus, it is concluded that the crystal orientation analysis of damage materials allows the qualitative estimation of the fracture mode and the quantitative life assessment of the fatigue crack growth.