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A combined critical distance and highly-stressed-volume model to evaluate the statistical size effect of the stress concentrator on low cycle fatigue of TA19 plate

Rongqiao Wang[1,2,3], Da Li[1], Dianyin Hu[1,2,3,*], Fanchao Meng[4], Hui Liu[1], Qihang Ma[1]

(*1. School of Energy and Power Engineering, Beihang University, Beijing 100191, China;*
2. Collaborative Innovation Center of Advanced Aero-Engine, Beijing 100191, China;
3. Beijing Key Laboratory of Aero-Engine Structure and Strength, Beijing 100191, China
4. Mining and Materials Engineering, McGill University, Montreal, QC H3A 0C5, Canada)

Abstract

Titanium alloy has been widely used for compressor discs in aero-engines due to its high specific strength. As a common geometry feature in compressor discs, bolt hole with stress concentration can cause compressor discs to fail under low cycle fatigue (LCF). In this study, the statistical size effect of such stress concentrators was investigated by LCF experimentations and theoretical predictions for titanium alloy plate specimens with a central circular hole (CHP). Four different scales of test sections without the influence of geometrical size were specially designed and experimental tests were conducted under LCF loading at 180°C. The strain-controlled LCF tests of smooth specimen were also carried out at the same temperature. It is found that the predicted LCF lifetime from the theory of critical distance (TCD) correlates well with experimental results for the 100%-scale CHP specimens. However, it fails to accurately predict the dependence of LCF lifetime on the statistical size effect for CHP specimens at the other scales i.e., 40%-scale, 60%-scale, and 80%-scale. Furthermore, a novel methodology combining the TCD and highly-stressed-volume models is proposed to evaluate the statistical size effect, which exhibits much improved accuracy than the TCD method alone. The new model not only inherits the versatility of the TCD method but providing an essential assessment of the statistical size effect.

Keywords: statistical size effect, critical distance, low cycle fatigue, life prediction, stress concentration, highly-stressed-volume

* Corresponding author at: School of Energy and Power Engineering, Beihang University, Beijing 100191, P.R. China. E–mail address: hdy@buaa.edu.cn (D.Y. Hu).