Structure Elements with Crack-Type Defects Durability Estimation

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Abstract. The objective of this study consists in elaborating computational procedures to analyze durability of structural elements with crack-type defects under remote alternating loads. The novelty of the proposed method consists both in applying new benchmark tests for crack propagation analysis, and analyzing structure durability for structure elements with different defects. The problem of the stress intensity factor estimation for mode I loading is reduced to solution of a hypersingular integral equation. Analytical solutions of this equation with different right parts are obtained for penny-shape cracks. It is the basis for verifying boundary-type numerical methods. The problem of determining the number of cycles to failure for structural elements subjected to cyclic loading (tension-compression) with a given frequency and amplitude is solved. The Paris dependence for fatigue crack growth has been used to determine the critical number of cycles before failure. Numerical results characterizing the durability of structural elements with crack-like initial defects have been accomplished.

Keywords: Stress Intensity Factor, Hypersingular Integral Equations, Crack Propagation.

1 Introduction

Due exhausted normative resource of hydro-turbine, petrochemical, power equipment at many industrial enterprises, the question arises of the possibility to extend the service life of both individual components, and complex parts of machinery. This is explained necessity to replace morally and physically obsolete equipment to ensure the operational reliability of the units in further operations whit fulfilling guarantees for power and efficiency. Since the specified equipment operates for a long time, its elements and assemblies are usually weakened by various kinds of microdefects. It should be noted, that crack propagation is a major mechanism affecting functionality and performance of structural elements. It is known that small cracks are usually not identified by visual inspection during repair works. But under alternating loads, such small cracks are gradually developing, and this can lead to partial or complete destruction of the structural

Conclusion and future research

The method has been developed for calculating the critical number of loading cycles for structural elements under the sign-variable cyclic load. It is assumed that in the zones of the highest stress concentration there may be defects such as cracks. The number of loading cycles, which leads to the growth of cracks to unacceptable sizes, is determined according to the Paris criterion. The calculation of SIF is accomplished using the hypersingular integral equation technique. The analytical solution is obtained for the circular crack in the unbound domain that will be used as benchmark test for validation of numerical methods, especially boundary-type ones. The penny-shape cracks are considered, and evaluation of the residual life is provided. The most dangerous crack size is estimated.

Further, scientific methods, criteria and software will be developed for estimating the resistance to fracture of rocket structures and turbine impellers under alternative loadings. The durability of structure elements made of composite and nanocomposite materials will be considered. The domain-type and boundary-type numerical methods will be involved into investigation.

Acknowledgments

The authors are very grateful to our foreign collaborators, professors Alexander Cheng and Stavros Syngellakis, Wessex Institute of Technology, for their constant support and cooperation.

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