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INVESTIGATION OF FATIGUE PROPERTIES OF SOME STEAM TURBINE BLADE MATERIALS

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ABSTRACT

An extensive fracture mechanics and fatigue tests have been performed for several turbine blade materials supporting the project concerning with the corrosion fatigue prediction for steam turbine blades. Based on these tests, the Kitagawa-Takahashi diagram was created and used for correlating pit to crack data, e.g. to define the critical pit size, when the pit may initialize the crack forming and propagation. The fatigue crack threshold and fatigue limit at several cycle asymmetry parameters R are necessary input parameters for the diagram design. This work deals with obtaining both parameters using mechanical tests.

Keywords: fatigue crack threshold, fatigue limit, turbine blade.

INTRODUCTION

The assessment of influence of corrosion pit dimensions to the fatigue life uses the material fatigue life behaviors such as the fatigue limit σ_{ac} and the parameters of the fatigue crack growth such as fatigue crack threshold K_{ath}. These both material parameters are used for design of the limit curve for corrosion fatigue occurrence - the Kitagawa-Takahashi diagram. Here, the constant fatigue limit enclose the blade strength for small pit dimensions, whereas for larger pits this limit value falls linearly with pit size using the fatigue crack threshold and cycle asymmetry as the parameters. Under this curve, neither fatigue damage nor crack initialisation occurs.

Four types of steam turbine blade materials were selected for presented investigations: AK1.9 (X12Cr13), AK1TD, T552 (1.4939) and T671. Tests were realised in air at room temperature and at 100°C for following cycle asymmetry parameters: R = -1, 0, 0.5 and 0.8. The high cycle fatigue tests were performed on resonance electro-dynamical testing machine Zwick/Roell Amsler 10HFP 5100 using circular samples ø 3 mm. The fatigue growth tests were realized on resonance hydraulic testing machine Schenck 100 kN using standard compact CT samples with one side notch. A combined method for tracking the crack tip was used. Two cameras were installed from both sample sides and the position of the crack tip was determined at short test interrupting after 50000 cycles. In addition to this, the potential drop technique was used for automatic monitoring of crack development. You can see the cameras from both sample sides as well as the electrodes added to the test specimen in Figure 1.

RESULTS AND CONCLUSIONS

The results of fatigue crack growth rate investigations were the relations between the crack growth rate da/dN and the cyclic stress intensity K_a (see example in Figure 2) and resulting relations between evaluated threshold and coefficient of cycle asymmetry R An example for material T671 is given in Figure 3.

The result of fatigue investigations were the relations between the evaluated fatigue limit and coefficient of cycle asymmetry R. An example of such relation obtained for material T671 is given in Figure 4.

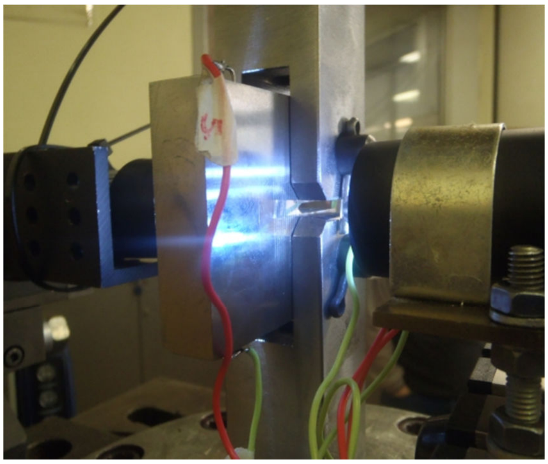

Fig. 1 - Set-up for crack growth measurement

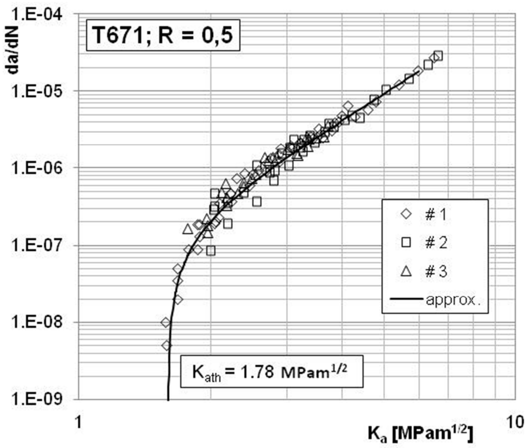

Fig. 2 - Example of fatigue crack growth curve

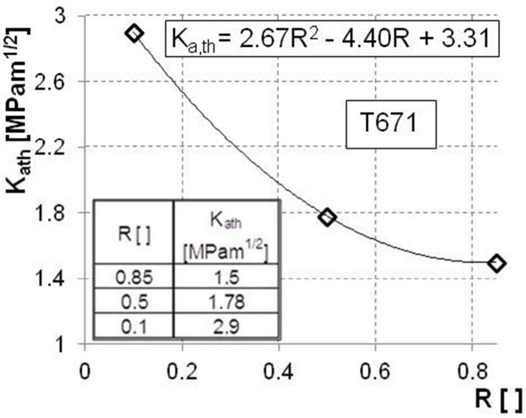

Fig. 3 - Relation of threshold limit and coefficient of cycle asymmetry R

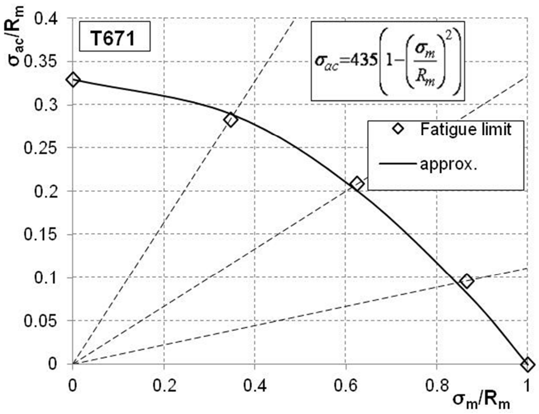

Fig. 4 - Relation of fatigue limit and coefficient of cycle asymmetry R

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