11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Prediction of fatigue crack growth of the contact wire in the railway catenary using XFEM simulation

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Key Words: *crack growth, fatigue, residual stresses, contact wire, railway catenary, XFEM.*

The role of the railway catenary system is to transmit the electrical energy from the energy supply point to trains. To ensure a good energy capture during the passage of a train, the pantograph applies a vertical force on the contact wire. This upward force causes a periodic bending stress which can lead to a fatigue fracture.

To predict the propagation of this fatigue crack, different approaches could be considered. In this paper, we used the eXtended Finite Element Method (XFEM) [1], implemented in the software CASTEM developed by Commissariat à l'Energie Atomique (CEA), to simulate the fatigue crack growth of the contact wire.

The material characteristics and parameters of the Paris law were identified thanks to experimental tests performed in a laboratory of Société Nationale des Chemins de Fer Français (SNCF). Specimens were cut directly from the contact wire. Different mean-stress levels were considered. The stress intensity factors were calculated by Finite Elements Method using the domain integral.

In order to optimize the calculation time, some special strategies for the mesh in 3D and the boundary treatment were developed. A numerical convergence study was performed.

Different geometries of the initial crack were studied. The numerical results showed a good agreement with observation in term of the evolution of the crack shape and its growth rate. The residual stresses of the contact wire were measured by X-ray diffraction [2]. These residual stresses were integrated in our simulations. A lower crack growth rate was obtained.

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