MICROSTRUCTURE SENSITIVITY OF FRETTING CRACK NUCLEATION FOR FERRITIC-PEARLITIC STEEL

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ABSTRACT

Ferritic-pearlitic steels are widely used in structural applications involving highly-loaded contacts, including railway tracks and flexible marine risers. Fretting wear and fatigue are specific failure modes relevant to such nominally-static contacts, where micro-scale relative slip and contact width are typically at the same length-scale as key microstructural features in these materials. Previous work has shown the statistical significance of average grain size in fretting crack initiation for a CoCr alloy [1]. The material investigated here contains two distinct phases. The distribution of these phases and other microstructural attributes (e.g. crystallographic texture) in the contact zone is likely to play an important role in crack nucleation. A crystal plasticity (CP) computational framework is developed to assess the microstructure sensitivity of a ferrite-pearlite steel in fretting.

The microstructure of the material is characterized using optical microscope and SEM techniques to facilitate the generation of realistic micromechanical finite element geometries with respect to grain size, grain shape, and phase volume fractions via a weighted Voronoi tessellation approach. A physically-based material model [2], with length-scale effects, based on strain gradient theory, is implemented to simulate the micromechanical behavior of the material. Mechanical cyclic test data is employed to calibrate a representative volume element model to identify CP parameters for the material. The calibrated model successfully predicts the experimentally measured cyclic stress-strain behavior across a number of strain ranges.

A 3D fretting contact model, which incorporates the calibrated CP material model and microstructure geometry in the contact zone, is developed to investigate microstructure sensitivity in fretting fatigue. The evolution of friction and wear is characterized via a recently-developed piezoelectric fretting wear test rig. A study is performed to assess the significance of phase distribution and texture in crack initiation. A scale-consistent fatigue indicator parameter strain energy dissipation *W* is implemented to predict number of cycles to crack initiation. Specific recommendations are made in relation to the optimization of the microstructure of ferritic-pearlitic steels for fretting crack initiation.

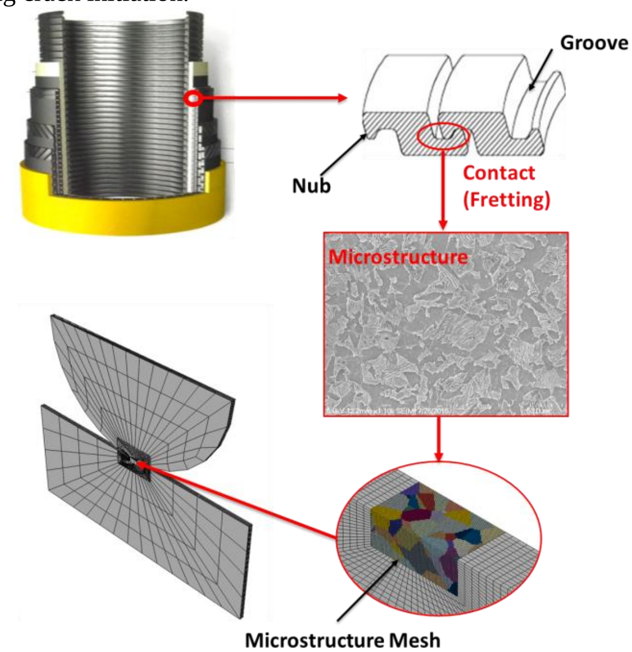

Fig.1 Schematic of micromechanical fretting modelling of marine risers.

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