Experimental and numerical study on the effect of interference on shrink-fitted assemblies under fretting-fatigue solicitations

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Abstract

Shrink-fitting is a common process used to assemble mating components such as axles, wheels, or sleeves, with significant applications in the railway and maritime industries. These assemblies are exposed to complex multiaxial fatigue loadings, including rotary bending, compression, and torsion. Moreover, differential deformations between the two parts can induce local fretting damage, which may lead to wear or crack initiation.

This study aims to explore the impact of interference values on fretting-fatigue behavior and consequently on the lifetime of such assemblies. Currently, no consensus has been reached in scientific literature regarding this issue. Modifying the interference value directly affects contact pressure, which in turn influences local stresses and sliding amplitudes, which are the driving factors of fretting. However, the impact on lifetime appears to depend strongly on the range of induced contact pressure, which remains notably low in the studied application due to the conforming contact configuration. Both experimental and numerical studies will be conducted to address this issue comprehensively.

The experimental investigations will focus on a simplified rotary bending loading case using two specially designed test benches. The test specimens consist of steel shafts with shrink-fitted bronze sleeves, representing a scaled model of a maritime drive shaft. Tests will be performed over a wide range of interference values to obtain fretting-fatigue S-N curves. Damage characterization will primarily address fretting wear debris and cracks. The third body layer, believed to control crack initiation, will be precisely quantified using a new disassembly-free protocol to enhance measurement precision.

In parallel, finite element analysis (FEA) modeling will be conducted to deepen the understanding of the phenomenon and to develop a life prediction model. The simulation will consider interference fitting and bending, as well as friction at the interface, to extract local contact variables such as slip and surface shear. Wear will also be integrated into to ensure accurate modeling of the fretting fatigue process. Multiple tribological and multiaxial fatigue criteria will be applied in post-processing to quantify fretting-fatigue damage.

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