ME Seminar

Rolling Contact Fatigue - From a particle to a catastrophic failure of a helicopter gearbox: the steps to simulate the whole process

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ABSTRACT

Surface fatigue is today the main cause of rolling bearing failure in aerospace applications. This type of fatigue can develop simply as a result of surface roughness, but is exacerbated by the presence of surface defects such as indentations. The management of lubricant pollution, which causes surface indentation or denting, is very costly and cannot be perfect, since pollution is both present in new oils, continuously generated by lubricated systems, and introduced during system operations. As a result, oils systematically carry particles of various origins which are brought into contacts by lubrication systems. As they pass between the surfaces, the particles are crushed and indent the surfaces, creating defects which will be the preferred sites for fatigue initiation and cracking during subsequent operating cycles. This may lead to catastrophic failure.

As denting of surfaces cannot be prevented, a good understanding of indentation and fatigue mechanisms on dents as well as how cracks propagate is necessary to guarantee bearing reliability and reduce maintenance costs. Firstly, a "Coupled Euler-Lagrange" (CEL) finite element model is developed to reproduce the actual indentation process of bearing surfaces and study its effects. Secondly, surface fatigue is studied under repeated over-rolling using fatigue criteria from the literature in the context of dry contact with a Semi-Analytical Method (SAM). The effect of the lubricant is then added by setting up a multigrid solver to solve the transient elastohydrodynamic lubrication (EHL) problem. Lastly a novel efficient numerical approach for the simulation of three-dimensional propagation of non-planar frictional crack under Rolling Contact Fatigue (RCF) is proposed. The developed model relies on a global-local strategy involving the semi-analytical method, dedicated to the resolution of 3D contact problems, and the eXtended-Finite Element Method (X-FEM), dedicated to the solving of 3D crack problems.

ABOUT THE SPEAKER

Daniel Nélias is Professor of Mechanical Engineering at INSA Lyon. His research deals with contact mechanics (effect of plasticity and inhomogeneities on running-in, rolling contact fatigue or fretting wear, viscoelastic layered materials), the characterization of materials at high temperature or after high rate thermal loading, the modelling of processes (shot and laser peening, cavitation and water peening, electromagnetic pulse peening, grinding, cutting, welding, coating deposit, cold spray and additive manufacturing) and integrity of structures under extreme conditions. He is the co-author of more than 140 papers published in peer-reviewed journals and the mentor of 26 MSc and 64 Ph.D. students. He is also an active member of the ASME and STLE societies in the US, past vice-chair and treasurer of the Executive Committee of the ASME Tribology Division, past-chair of the ASME Contact Mechanics Technical Committee, and former member of the IJTC Conference Planning Committee that was active until 2013 (International Joint Conference between ASME and STLE). He has been the chairman of the 2011 STLE Annual Meeting held in Atlanta (conference with more than 1,300 attendees), chairman of the Tribology Frontiers Conference 2015 held in Denver, Co., USA, (October 25-27, 2015, 200 attendees about), and served as one of the STLE directors (2013-2019).

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