Brittle fracture and fatigue of unsteadily rotated structures

Gilad Yakir*[1], Eduardo Gutierrez-Prieto[1], Veronique Lazarus[2], and Pedro Reis†[1]

[1]Ecole Polytechnique Fédérale de Lausanne – Switzerland

[2]Institut des Sciences de la mécanique et Applications industrielles – Centre National de la Recherche Scientifique - CNRS, Electricité de France - EDF, ENSTA Paris, Institut Polytechnique de Paris – 828 bd des maréchaux 91762 Palaiseau cedex France, France

Abstract

Nearly every machine built since the Industrial Revolution involves rotating components such as wheels, gears, fans, and turbines, which are so ubiquitous that they often go unnoticed. Regardless of their size and purpose, the dynamics of rotating systems can be described by a set of differential equations with respect to an observer or a frame of reference (FoR). A FoR can either be inertial (*i.e.* non-accelerating), implying that any object within it has a zero applied net force will move at a constant velocity, or non-inertial (i.e. accelerating). A non-inertial FoR produces what are known as fictitious (or pseudo) forces. More specifically, a rotating non-inertial FoR generates three fictitious forces: (*i*) *Coriolis*, (*ii*) *centrifugal*, and (*iii*) *Euler* forces. We examine the brittle fracture of a rotating structure subjected to these coupled fictitious forces. In this talk, we consider the following problem: What governs the brittle fracture of rotating pre-notched cantilevered beams? We introduce a pre-crack to a beam-like acrylic sample. The coupled centrifugal and Euler forces invoke the tensile opening mode (mode I) and, by choosing the beam configuration, either the in-plane shear mode (mode II) or the tearing mode (mode III). We conduct systematic experimental and finite element simulations to study the interaction of the coupled modes. We show that linear elastic fracture mechanics (LEFM) can predict the onset of crack propagation under certain loading conditions. Using the same apparatus, we also investigate the fatigue of a soft tissue-like hydrogel.

*Speaker

†Corresponding author: pedro.reis@epfl.ch