On the Rotor to Stator Contact Dynamics with Impacts and Friction - Theoretical and Experimental Study - DTU Orbit (12/08/2019)

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The contact between a rotor and its stator can in some cases be considered as a serious malfunction that may lead to catastrophic failure. This major threat arises normally from full annular dry friction backward whirl and whip motion where the rotor runs and rubs at a high frequency on the inner surface of the stator, and thereby traversing the full extent of the clearance. Normal and friction forces are exerted on the rotor at each impact and rubs. These particular forces can sustain the rotor in a persistent backward dry whirl or whip motion. In that case, the friction force plays a significant role during dry contact since it changes the precession of the rotor motion. This thesis gives a comprehensive experimental and theoretical study on the rotor to stator contact dynamics, under the influence of dry friction. Different backward full annular dry motions are generated and analyzed theoretically and experimentally. In the theoretical part of the work, the strong nonlinear effects included in the modelling stem from dry friction and impacts. The contact deformations and forces are assumed to happen in a continuous manner during impacts. On the basis of this assumption, the piecewise smooth and discontinuous nonlinear equations of motion are formulated. This allows the use of a smoothening method in order to facilitate the numerical integration procedure and prevents numerical instabilities. This method has proven to be successful and efficient. The performance of two different types of backup bearings, i.e. an annular guide and a new unconventional pinned backup bearing, is also thoroughly studied. The motion of the rotor is studied by use of trajectory plots, time series and spectral analyses. The pinned backup bearing prevents the rotor from entering a full annular contact state, which leads to significant reduction of contact forces and eliminates dry whirl and whip motions. Research publication on the study of experimental measurements of contact forces and behavior during rotor to stator contact are rare. In this regards, the full instrumented test rig designed specially to investigate rotor-stator contact problems, allows comprehensive experimental studies on the contact force behavior. The theoretical results appear to be in good agreement with the experiments. Nevertheless, among one of the future aspects, it is necessary to use comprehensive uncertainty analysis in the investigation of the friction coefficient behavior.

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