ABSTRACT

In the field of rotating machines (steam turbines, turbochargers, pumps, etc.), the Morton effect designates the creation of a synchronous excitation source due to the thermal bow of the rotor in the hydrodynamic bearings. This vibratory source is often called thermal imbalance. Under its effect, the amplitude and the phase of the synchronous vibrations of the rotor evolve gradually over time. In most cases, the Morton effect remains stable and the effects of thermal imbalance on the vibrations are not detrimental to the operation of the machine. However, if the conditions are favorable, the dynamic behavior of the rotor becomes unstable and the instability of the synchronous vibration, in other words the unstable Morton effect, could occur.

To better understand and analyze the triggering conditions of this instability, it is necessary to simulate the Morton effect accurately. This simulation requires the coupling of several physical models. These are the model of hydrodynamic lubrication, the thermomechanical model of the rotor and the model of rotor dynamics. This multi-physics coupling is not simple because of the different time scales of the thermomechanical phenomenon and the rotor dynamics. The strategy of heat flux averaged over a rotation period makes it possible to overcome this difficulty and to reduce the calculation time. The modeling of the Morton effect is validated by a comparison between the numerical results and the experimental results obtained at the Pprime Institute.

A method based on the influence coefficients is then used to analyze the stability of the Morton effect. The applications of this method on concrete cases make it possible to highlight the physical phenomena responsible for the unstable Morton effect.

Keywords: synchronous vibration instability, Morton effect, thermal unbalance, hydrodynamic bearings, thermo-hydrodynamics, rotor thermal deformation