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Improved gearbox simulations for diagnostic and prognostics purposes using finite element model reduction techniques

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Abstract

Lumped parameter models (LPMs) are widely utilised to predict the dynamic behaviour of mechanical systems such as gearboxes. LPM gives reasonable representation of the dynamics of the system if masses can be lumped at certain locations, such as gears, shafts, bearings, etc. LPM have the advantage of simulating the structure using a limited number of degrees-offreedom (DOF), which facilitates studying the behaviour of gears and bearings in the presence of nonlinearities and geometrical faults. However, it is difficult to account for the casing flexibility in the LPM models which is an important consideration in the lightweight structures such as in aircraft applications and this results in poor spectral matching over a wide frequency range. In the case of continuous systems, where masses are distributed equally over the structure (gearbox casing), other methods, such as finite element analysis, are often used to study the behaviour of the structure. The use of finite element model (FEM) results in a large number of DOF, which in turn complicates simulating the whole system's response to the presence of nonlinearities and to gears and bearing faults. This in turn limits the validity of the simulated results and restricts their later usage in the diagnostics and prognostics of the gears and bearings. This paper describes the use of dynamic reduction technique to reduce the FEM of a gearbox casing into manageable and well representative DOF of the casing. The reduced model of the casing is embedded with the LPM of the internals (shafts, gears and bearings), which was previously developed with the aid of Simulink and has the capability of capturing stiffness nonlinearities arising from gears and bearings and has also the capability of simulating geometrical faults (spalls) for both gears and bearings. This paper mainly deals with the simulation of localised and extended inner race bearing faults. The results show the improvements obtained through combining the reduced model of the casing with the LPM model and a much better correspondence with measured signals.

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