IUST International Journal of Engineering Science,
Vol. 19, No.5-1, 2009, Page 61-69

A SOFTWARE FOR PREDICTION OF PERIODIC RESPONSE OF NON-LINEAR MULTI DEGREE OF FREEDOM ROTORS BASED ON HARMONIC BALANCES

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Abstract: *It is the purpose of this paper to introduce a computer software that is developed for the analysis of general multi degree of freedom rotor bearing systems with non-linear support elements. A numerical-analytical method for the prediction of steady state periodic response of large order nonlinear rotor dynamic systems is addressed which is based on the harmonic balance technique. By utilizing harmonic balance with appropriate condensation, it is possible to considerably reduce the number of simultaneous nonlinear equations inherent to this approach. Using this method, the set of nonlinear differential equations governing the motion of the rotor systems is transformed to a set of nonlinear algebraic equations. A condensation technique is also used to reduce the nonlinear algebraic equations to those only related to the physical coordinates associated with nonlinear components. The stability (linear) of the equilibrium solutions may be conveniently evaluated using Floquet theory, particularly if the damper force components are evaluated in fixed, rather than rotating, reference frames. The versatility of this technique is illustrated on systems of increasing complexity with and without damper centralizing springs.*

Keywords: *Rotor dynamics, fluid film bearings, inherent non-linearity, harmonic balance method, system reduction*

1. Introduction

The study of the motion of rotating machinery, i.e. rotor-dynamics, has long been an important field of engineering research. Rotors are found in a wide range of applications ranging from those found in large scale machinery used in the power generation industry to tiny rotors used in medical equipment. Rotating machinery generally consists of flexible shafts on support systems rolling element bearings, fluid film bearings, seals, etc.

The application of squeeze film dampers are commonly found in aircraft gas turbine engines, whereby these dampers provide additional external damping to the rotor bearing system for the purpose of reducing the synchronous response of the rotor especially while traversing critical speeds. There are two basic configurations of these dampers, which are the dampers with retainer springs and those without retainer springs. They differ in the way the rotor finds its position in the damper clearance space. In the damper without retainer spring, the journal that usually lies at the bottom of the clearance space when the rotor is at rest, is lifted when sufficient imbalance is generated during running conditions of the rotor. In the damper with retainer spring, the journal is fitted with a spring, which often takes the form of a thin ribbed cylinder known as a squirrel cage. The retainer spring is fixed, at one end, to the dampers journal, whilst the other end is fixed to the damper's housing. A centralizing mechanism is occasionally used in conjunction with the retainer spring for the purpose of centring the journal in the damper clearance space. The stability and imbalance response of a flexible rotor mounted in centrally preloaded squeeze film dampers has been theoretically and experimentally investigated [1,2], whereby bistable operation of the rotor was found at certain values of design and operating parameters. Nikolajsen and Holmes [3] observed non-synchronous whirl orbits in the experimental response of a flexible rotor supported by journal bearings in series with squeeze film dampers with retainer springs. The effect of fluid inertia for cavitated dampers operating at moderately large squeeze film Reynolds number has been theoretically observed by San Andres and Vance [4] to possibly reduce or totally eliminate bistable operation and jump phenomena in the response of a flexible rotor mounted in centrally preloaded

Paper first received May. 10 ,2007 and in revised form July, 05. 2009.
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