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Study of Modal Characteristics of a geared rotor system

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Abstract

Modal analysis is used to determine the inherent dynamic characteristics of a system in forms of natural frequencies, damping factors and mode shapes. These parameters are important in the design of a system for dynamic loading conditions. Conventionally, modal analysis is performed with specific commercial tools. On the other hand, modern FEA softwares have good potential to perform modal analysis studies. This work attempts modal analysis using solid elements in ANSYS Workbench of a geared rotor system supported on ball bearings at the ends. This has been carried out to study the natural frequencies in different modes, to predict the direction of whirl of various modes as well as to study Campbell diagram. . In the end, effect of variation in bearing stiffness has been found out on natural frequencies in various modes of the geared rotor system.

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*Keywords:*Modal analysis;gear rotor system; mode shapes; Campbell diagram;

1. Introduction

Gearbox is a complex structure and is the combination of rotary parts and stationary parts. Due to spin induced forces, vibrations generate in the geared rotor system and gear meshing considerably affects these vibrations. There are many studies in transverse and torsional vibration analysis of gear systems ([1] – [4]). However studies combining axial, transverse and torsional vibration and those also using solid models are not found much in literature. It is important to include all these considerations in the analysis to get a complete idea about the dynamic characteristics of gear rotor systems.

Modal analysis is a technique used to determine, improve and optimize dynamic characteristics of engineering structures [5]. It can be used for determining the inherent dynamic characteristics of a system in forms of natural

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frequencies, damping factors and mode shapes. To better understand any structural vibration problem, the resonances of a structure need to be identified and quantified. A common way of doing this is to define the structure's modal parameters [6]. Many studies about modal analysis of gear rotor systems have been reported in literature, e.g. Kahraman et al. [7] developed a FE model of a geared rotor system on flexible bearing considering rotary inertia of shaft, axial loading on shaft, flexibility and damping of bearing, stiffness and damping of gear mesh and concluded that bearing compliances can greatly affect the dynamics of geared system. Modal dynamic behaviour of gear pair system can be affected by manufacturing errors in gear tooth which is studied by DriotandPerret-Liaudet [8].

Above studies show that dynamic characteristics of gear rotor system can be identified with the help of much relied Finite element (FE) analysis. FE analysis can be performed by following numerical simulation approach or by developing a model in any commercially available FE analysis software. The aim of this work is to build a gear rotor model in FEA software and to assess its dynamic capabilities by performing modal analysis. This work helps out in understating the results of natural frequencies, modal damping and mode shapes, reported for the gear rotor system.

2. Numerical Example

The geared rotor-shaft system as shown in Fig. 1 has been considered for the purpose of simulation. The gear pair is mounted on a 30 mm diameter uniform steel shaft of length 254 mm. Gears are located at the centre of shaft as shown in the Fig. 1. The location, geometry and other properties of the gear system are given in Table 1 and it is assumed to be made from steel with a Young's modulus of 210 GPa, Poisson's ratio of 0.3 and a density of 7850 kgm^{-3}.

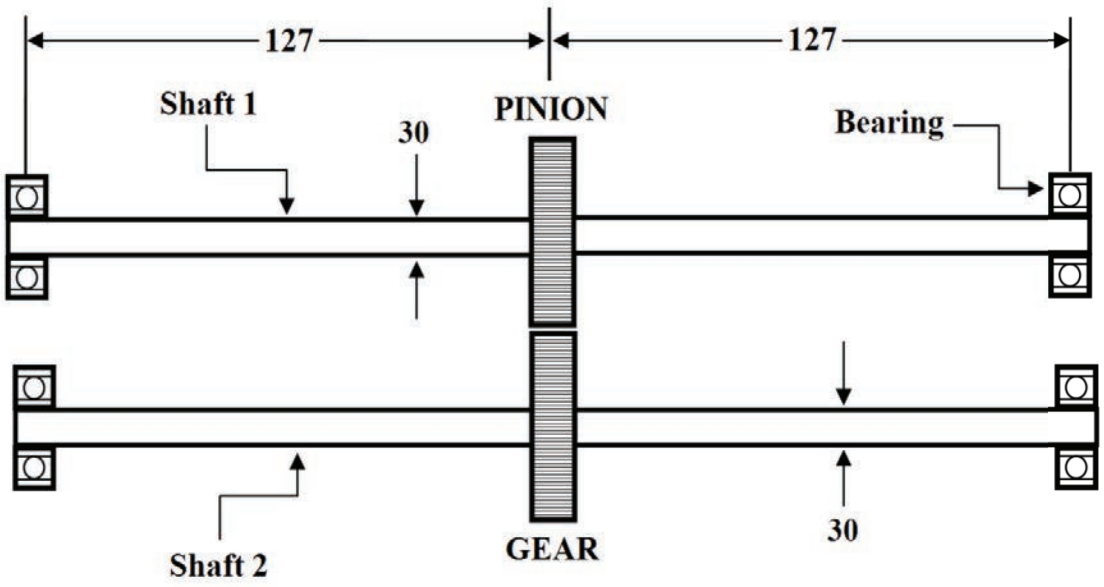

Fig. 1. A schematic diagram of geared rotor system (All dimensions are in mm.)