Review on Intermediate Shaft of Automobile Gear Box

Mr. Ashish S. Apate[1]

[1]*Assistant Professor, Department of Engineering Sciences, AISSMS IOIT, Pune, Maharashtra, India.*

Abstract - *Intermediate shaft is the most important part of a gear box of automobile. Different gears are mounted on the intermediate shaft to transmit power from input shaft to output shaft with different speed ratios. With reference to the researcher every material system containing individual mass and stiffness distribution is susceptible to vibrate. Free vibration analysis is requisite to determine the natural frequencies of material system. These are responsible for resonance phenomenon. When the load frequency is matched with one of the natural frequencies the resonance occurs.*

Key Words: Intermediate shaft, Gear box, FEA, composite material, Vibrations.

1. INTRODUCTION

Bending vibrations and critical speeds of rotating shafts is perhaps the most common problem that is discussed by a vibration engineer, as it is a vexing day-to-day problem in the design and maintenance of the machinery. A few rotor weigh as much as 100 tons as in the case of big steam turbines and obviously they deserve utmost attention in this regard. The rotors have always some amount of surplus unbalance however well they are balanced, and will get into resonance when they rotate at speeds equal to bending natural frequency. These speeds are called as critical speeds. As far as possible they should be avoided. Even while taking the rotor through a critical speed to an operational speed, special precaution should be taken. In fault detection of bearing, detection of misalignment and condition monitoring of bearing or gearing system is necessary because the system has to rotate at different speeds. If specific r.p.m. matches with critical speed which is nearer to first bending natural frequency of shaft will generate excessive vibrations due to resonance.

1.1 S. M. Ghoneam et al., "Dynamic Analysis of A Rotating Composite Shaft" [1]

In this paper, dynamic analysis of a rotating composite shaft is done. Composite materials have interesting properties such as high strength to weight ratio, compared to metals, which make them very attractive for rotating systems. Attempts are being made to alter metal shafts by composite ones in many applications: drive shafts for helicopters, centrifugal separators, and cylindrical tubes for the automotive and marine industries. The paper is concerned with the dynamic analysis of a rotating composite shaft. The numerical finite element technique is use to compute the eigen pairs of laminated composite shafts. A finite element model has been developed to formulate the stiffness matrices using lamination theory. These matrices take into account the effects of axial, flexural and shear deformation on the eigen-nature of rotating composite shaft. The Campbell diagram is use to compute the critical speed of rotating composite shaft and instability regions to achieve accuracy and for controlling the dynamic behavior of the system in resonance state. The affect of laminate parameters: stacking sequences, fiber orientation, boundary conditions and fiber volume fractions effect on natural frequencies and instability thresholds of the shaft are studied.

From experimental modal analysis, it can be noticed that the amplitude of specimens [0/90/0/90/0] are higher than those of the other specimens and [0/0/0/0/0/0] has lower ones. And the maximum amplitude at 25% fibre volume fraction compared with the 65% fibre volume fraction by almost 0.9%. The comparison between the numerical and experimental results proves that the suggested finite element models of the composite shaft provide an useful accurate tool for the dynamic analysis of rotating composite shaft.

1.2 Hsaing-Chieh Yu et al., "Ro bust modal vibration suppression of a flexible rotor" [2]

In this paper, an active robust model vibration control of a rotor system supported by magnetic bearings is studied. Finite element method is applied to formulate the rotor method. The Timoshenko Beam theory, effects of shearing deformation is considered in their work. This study associate the independent modal space control (IMSC) approach. This approach is effective for vibration suppression when the system is subjected to impulsive or step loading, speed variation and sudden loss of disc mass.

1.3 G.N.D.S. Sudhakar et al., "Identification of unbalance in a rotor bearing system" [3]

In this paper, model based methods for fault detection by using equivalent loads minimization method is discussed. They have identified fault in a rotor bearing system by minimizing difference between correspondent loads estimated in the system due to the fault and theoretical fault model loads. Two different approaches: Equivalent loads minimization and vibration minimization techniques are applied for identification of unbalanced fault in a rotor system, fault identified by measuring transverse vibrations at only one location.

The study of rotating machinery appears in the context of machines and structures due to the significant number of aspects typical to their operation that impact their dynamic behavior and maintenance. Therefore, rotor bearing systems face numerous problems that affect a wide variety of machines, e.g., compressors, pumps, motors, centrifuge machines, large and small turbines. This type of machine finds various applications in the industry, such as, automotive, aerospace and power generation. In most applications an unpredictable stoppage can lead to considerable financial losses and risks.

Consequently, there is an evident need for the complete modeling of rotating systems, including the components of the interface between fixed and moveable parts, such as the hydrodynamic bearings. Bench-scale experimental analyses provide more complete models of the main parts of the rotor, with strong emphasis on the modelling of the bearings of rotary machines, since they constitute the rotor foundation structure connecting elements. The machinery parameters are needed to study the dynamic behavior of the system, namely the Campbell diagram, stability analysis, critical speeds, excitation responses, control and health monitoring. The determination of unknown parameters in rotating machinery is an ambitious task. To run over this difficulty, the use of optimization techniques to solve the inverse problem represents an important alternative approach.

In the present contribution, the mono and multi-objective algorithms based on Simulated Annealing were used in the design and identification of rotor bearing systems. For illustration purposes, two simple test were studied by using the proposed methodology. The aim for the first application was to increase the difference between two critical speeds of the rotor-bearing system through the formulation of a multi objective problem, where the radii of bar elements were taken as design variables. To solve this multi-objective problem the Multi-objective Optimization Simulated Annealing (MOSA) algorithm was proposed.

This strategy is based on the Simulated Annealing algorithm associated with the non-dominated sorting and crowding distance operators. The second application consists in the identification of unknown parameters of flexible rotor bearing systems. The objective function was defined as the difference between the unbalance experimental responses of the rotor and the simulated unbalance responses so that the parameters of damping and stiffness are obtained by an inverse problem approach. The experimental data used were generated by using the solution of the direct problem and adding artificial noise. In all applications, the finite element method was used to obtain the mathematical model of the system. It is important to emphasize that the results obtained in both test-cases are considered satisfactory as compared with those obtained by other evolutionary strategies.

In addition, it is possible to conclude that the proposed method represents an interesting alternative for design and identification of mechanical systems. Further research work will be focused on the influence of the optimization parameter values on the solution of the optimization problem. Also, strategies to dynamically update the SA parameters will be calculated. Finally, the authors will study the performance of the Simulated Quenching algorithm aiming at proposing a hybrid approach involving the Simulated Annealing and Simulated Quenching algorithms.

1.4 E.Chatelet et al., "A Three Dimensional Modeling of the Dynamic Behavior of Composite Rotors" [4]

In this paper, composite materials are used for many rotor applications and different adapted modeling techniques have been discussed. When the shaft is thick and long bending deformations need to be considered. On the other hand, when the structure becomes thin-walled, deformations of the sections should be considered. These deformations have a significant effect on flapwise bending modes and are fully associated with ring-type modes. Analytical or numerical approaches based on beam theories are useful but can be limited by their assumptions. The approach proposed here is based on a finite element full modeling. First the dynamic behavior of the rotating structure is written in terms of mode shapes. Second the structure is supposed to be cyclically symmetric.

This paper presents numerical techniques for the calculation of natural frequencies and mode shapes of composite rotors. This technique, based on a three dimensional finite element discretization of the assembly, can deal with bending or torsional shaft modes, as well as with ring type thin walled tubes or disc shaft couplings. The computational effort needed is kept acceptable by using efficient reductions. First a, modal reduction, based on mode shapes at rest, is used to calculate the behavior of the rotating structure and the whole disc-shaft assembly is supposed to be cyclically symmetric. The application to a composite rotor, often considered as a reference test case in the literature, and to a short cylinder illustrates and validates the proposed method. Finally results obtained on simple disc shaft assembly show the effects of possible couplings between shaft and disc deformations. The difference between the critical speeds predicted by the flexible disc and rigid disc models is about 8.4%. The highly coupled nature of the first shaft bending mode and the disc mode with one nodal diameter is clearly highlighted.

1.5 R. Sino et al., "Dynamic Analysis of a Rotating Composite Shaft" [5]

In This paper, the dynamic instability of an internally damped rotating composite shaft is done. A homogenized Finite element beam model, which takes into account internal damping, is introduced and then used to assess natural frequencies and instability thresholds. The influence of laminate parameters: stacking sequences, fiber orientation, transversal shear exact on natural frequencies and instability thresholds of the shaft are studied. The results are compared to those obtained by using equivalent modulus beam theory (EMBT), modified EMBT and Layerwise beam theory (LBT), which are used in the literature. This parametric study shows that shaft instability thresholds can be very sensitive to laminate parameters. This work deals with the stability analysis of an internally damped rotating composite shaft. A Simplified Homogenized Beam Theory (SHBT) is developed and compared to the classical Equivalent Beam Modulus Theory (EMBT), the Modified Equivalent Beam Modulus Theory (modified EMBT) and the Layerwise Beam Theory (LBT). The method developed avoids the main drawbacks associated with EMBT formulation.

The paper shows that the frequencies and the instability thresholds with respect to the ply angle for a specific value of L/Ro=20.83, in order to demonstrate the influence of angle orientation. Frequencies increases as the fiber angle decreases. The system is stiffer when fibers are directed mostly along the shaft axis. Thus internal damping decreases as the frequencies increase leading to an increase in the instability threshold. The critical speeds obtained by the method developed are in good agreement with those obtained by LBT and modified EMBT as well as the experimental one. The study highlights that EMBT simplifications may lead to significant discrepancies in terms of frequencies. These discrepancies appear to be greater for instability thresholds.

The analysis shows that although transversal shear has a minor influence on the first frequencies, its effect is much more significant for the following ones, thereby directly influencing instability thresholds However, this method requires some improvements to take account of the coupling effects induced by nonsymmetrical stacking.

2. CONCLUSIONS

In this review, effect of change in diameter of the intermediate shaft on natural frequency is studied. Also effect of change in length of the intermediate shaft on natural frequency is studied. The effect of change in materials of the intermediate shaft on natural frequency is studied. From the analysis it is possible to avoid the critical speeds and hence to avoid resonance.

This can be done by changing the materials like composite, changing shaft shape (circular cross section to rectangular cross section etc.). We can use hollow shaft instead of solid circular shaft without altering the basic shaft design for theory of failures.

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BIOGRAPHIES

Mr. Ashish S. Apate
Asst. Prof. AISSMS IOIT, Pune.