Study of the effect of non-linear end supports on the unbalance response of the elastic shaft

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Abstract. Nonlinearities in modelling the dynamic behaviour of systems are often neglected for simplicity, however, accurate prediction of response and the issue of stability, especially in the cases of low tolerance on response, justifies the nonlinear dynamic model of a system. This study focuses on the analytical prediction of the unbalanced response of a Jeffcott rotor with rolling element bearings at ends supported on viscoelastic supports, and the role of support damping on the nonlinear dynamic behaviour, particularly the undesirable jump phenomenon of the rotor. Deformation-dependent stiffness of rolling element bearings makes the system of equations nonlinear. A detailed study with non-dimensional parameters is attempted to find optimum damping for minimizing the response.

Introduction

Considering the bearings at the ends of the rotor-shaft to have linear stiffness characteristic generally mean that the stiffness of the bearings does not depend on the deformation of the journal. However, it has been shown that the ball and roller bearings possess non-linear stiffness characteristic i.e. the stiffness of these bearings vary with the deformation of the rolling element [1]. The effect of these non-linear bearing stiffness characteristics on the unbalance response of the rotor in a rotor shaft system supported on viscoelastic supports has been studied.

Results and discussion

Figure 1 (left) shows the system schematically. As the excitation is sinusoidal in nature due to the unbalance in the rotor, the stiffness of the viscoelastic support is complex in nature. The deformation dependent stiffness of both ball and roller bearings has been found out in [1]. It is seen that the stiffness of the ball bearing is proportional to the square root of the deflection of the rolling element, whereas for a roller bearing the stiffness is proportional to the deflection of the rolling elements raised to the exponent 1/9.
The method of solution is identical to that given in [2] where the authors have calculated the unbalance response of a rotor shaft system on nonlinear bearings and have not considered any support mass.

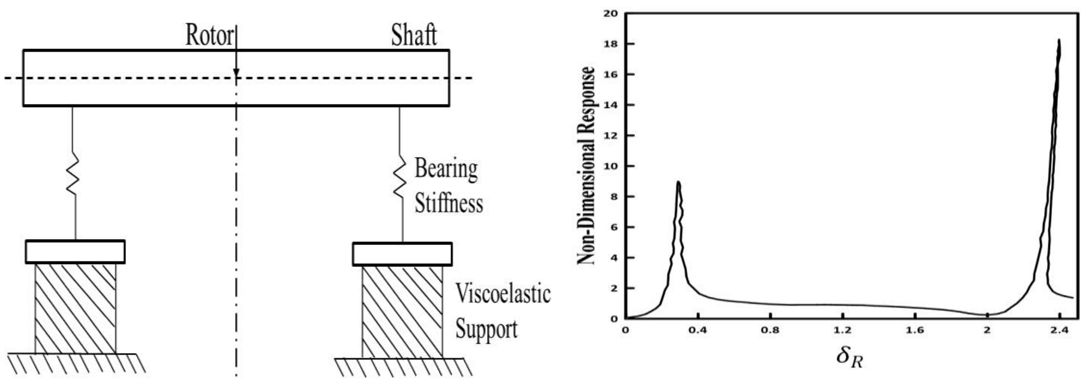

Figure 1: System configuration (left) and unbalance nonlinear response (right)

A detailed parametric analysis of the unbalance response amplitude of the rotor shown in Figure 1 (right) has been done to find out the effect of each parameter on the response. One parameter has been chosen each time and its value has been varied keeping the value of the other parameters unchanged. A jump phenomenon is observed visible mainly in the second peak of the unbalance response plot which is a typical characteristic of the system having non-linear element.

References

[1] Harris T. A., Mindel M. H. (1973) Rolling element bearing dynamics. *Wear* **23(3)**:311-337.
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