SUMMARY OF Ph.D. DISSERTATION

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Title

Nonlinear Vibration Phenomena
in an Elastically Mounted System for a Diesel Engine
(Influence of Internal Resonance on the Primary Bouncing Resonance)

Abstract

Diesel engines are used widely because of their robustness and longevity. Also, in recent years, many improvements to diesel engine design and performance have been made. One particular remaining problem with diesel engines is the noise and vibration they generate. Great efforts have been made, and remain ongoing, to elucidate the mechanisms affecting the occurrence of these vibrations and the resulting environmental noise pollution. Recently, by solving several technical problems, the vibration isolation system used for electric power generation engines was applied to the primary diesel engines used in marine applications.

Chapter 1 reviews the classical design approaches to vibration isolation systems based on linear vibration theory. It describes the features of the material used for vibration isolation and also the uncoupled elastically-mounted system used in this research.

Chapter 2 shows the analytical model which includes geometric nonlinearity and assumes that the six degrees of freedom system is reduced to three degrees of freedom. Finally the governing equation, which encompasses nonlinear vibrations, is obtained using Lagrange's equation.

Chapter 3 shows the experimental setup consistent with the analytical model. This was used to confirm the occurrence of the super harmonic vibration component due to the geometric nonlinearity in the system. Moreover the method of normal form method was applied to reduce the coupled super harmonic nonlinear terms in the three degree of freedom governing equation. As a result, the equation governing the super harmonic component of vibration was derived by reducing the order of the basic equation.

Chapter 4 describes the nonlinear normal modes (NNMs) of the vibration isolation system. There are similar modes and non-similar modes in NNMs. The non-similar modes were obtained using the method of Vakakis (the classic method). Furthermore, the steady state response was obtained for internal resonance with the frequency ratio 2:1:1.

In Chapter 5, in order to investigate the influence of internal resonance on the three degrees of freedom system, the passage through resonance was investigated both theoretically and experimentally. This is certain to occur whenever the engine is started or stopped. It was considered that, for practical systems, the rotor speed of a diesel engine may be unable to pass through resonance when the driving torque is smaller than the load torque. In the experiments, the rotor was driven by a D.C. motor to accurately control the revolution speed near resonance. However, sometimes the speed of electric motors does not change in proportion to input voltage. In order to investigate this phenomena; the equations describing it were specified and added to the equations governing the dynamics of the system. Adjustments to the driving torque of the D.C. motor were performed by controlling the electrical input voltage. Also, the internal resonance characteristic of 2:1:1 was applied to the 3 dof system. Under the internal resonance condition, the load torque decreased and passage through resonance became easier to confirm than for non-resonant conditions. This is because energy flows into the rotational oscillation of the rigid body and this energy is unrelated to the driving torque.

Finally, the theoretical and experimental results obtained in this thesis are summarized in Chapter 6.