Public Abstract
First Name:YU-CHENG
Middle Name:
Last Name:SU
Adviser's First Name:YUYI
Adviser's Last Name:LIN
Co-Adviser's First Name:
Co-Adviser's Last Name:
Graduation Term:FS 2009
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Title:Modeling, Verification, and Optimal Design of Nonlinear Valve Spring

The objective of this study is the optimal design of helical spring based on dynamic criteria. The most important dynamic performance criterion of a helical spring is the resonance behavior, including dynamic stress, coil closing, and surge. In order to perform computer aided optimization, the construction of an accurate dynamic model is necessary. The more variables are considered as design variables, the more flexible and better designs are possible. More design variables are also making the description of dynamics more complex. In this study, predictive dynamic models for variable pitch angle, variable wire diameter, and variable spring radius are derived by fundamental mathematics and mechanics principles. These models are nonlinear partial differential equations, in general more complex than the well known and commonly used wave equation.

Numerical solution of these dynamic models is also called dynamic simulation. In this study, finite difference method combined with moving boundary solutions are applied to obtain the dynamic response. Dynamic responses as a time domain, discrete data from various models are compared with data from physical dynamic experiments to verify the accuracy of the models, and to improve the parameters in the dynamic models. Fast Fourier Transform (FFT) is utilized as a tool to evaluate severity of resonance in different models and in optimization process.

To verify that the use of finite difference in the simulation process is providing stable and reliable results, the numerical solutions are compared with solutions obtained using ABAQUS-MATLAB programs. Results in terms of system eigenvalue calculation obtained by different programs, either commercial or Finite Difference Method (FDM), showed very good agreements.

Numerical optimization results obtained in this study also showed that it is worthwhile to introduce more design variables to increase the flexibility in an optimal design process for obtaining better results.