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Dynamic response of a simplified nonlinear fluid model for viscoelastic materials under random parameters

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ABSTRACT

In this paper, a simplified spring-dashpot model is proposed to represent the complicated nonlinear response of some viscoelastic materials. Recently, the viscoelastic modeling has been adopted by many researchers to characterize some parts of the human body in bioengineering and to simulate many material properties in mechanical engineering, electronic engineering and construction engineering. Sometimes it is impossible to estimate the constant parameters in the model deterministically, therefore, the damping coefficient of the dashpot and the spring constants of the linear and nonlinear springs are considered as stochastic to characterize the random properties of the viscoelastic materials. The mean value of the displacement of the nonlinear model, subjected to constant rate displacement, can be solved analytically. Based on the closed-form solution, the proposed method produces the statistical dynamic response of the simplified nonlinear fluid model, which is fairly useful in estimating the reliability of the nonlinear system.

1. Introduction

Generally speaking, a linear spring-dashpot model is magnificent to describe many materials for its simplicity and closed-form solution. However, the linear model cannot generate the nonlinear elastic responses which are exhibited in many viscoelastic materials [1,2]. Recently, the viscoelastic modeling has been adopted by many researchers to characterize some parts of the human body in bioengineering. Among others, the following researchers have already contributed to the development of this field [3–8]. In addition, viscoelastic modeling has been utilized by many researchers to simulate material properties especially in mechanical engineering, aerospace engineering, material engineering, electronic engineering, mechanics and construction engineering. Recently the following researchers have made contributions to the development of this field [9–13].

In this investigation, a simplified spring-dashpot model is proposed to represent the complicated nonlinear response of some viscoelastic materials. First of all, we adopt the standard Maxwell fluid model to obtain the softening behavior of the material, then we add a nonlinear spring in parallel to the linear spring as shown in Fig. 1. Sometimes it is impossible to estimate the constant parameters in the model deterministically, therefore, the damping coefficient of the dashpot and the spring constants of the linear and nonlinear springs are considered as stochastic to characterize the random properties of the viscoelastic materials. The purpose of this study is to obtain the statistical responses of simplified nonlinear fluid model analytically or partially analytically if possible.

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