Indian Journal of Science and Technology, *Vol 6(11), 5459–5468, November 2013*

Stability Analysis of Nonlinear Time Varying System of Beam-moving Mass Considering Friction Interaction

M. Ghomeshi Bozorg* and M. Keshmiri

Department of Mechanical Engineering, Isfahan University of Technology, Isfahan, Iran;
m.ghomeshibozorg@me.iut.ac.ir, mehdik@cc.iut.ac.ir

Abstract

In this paper, a new analysis is performed on dynamic behavior of beam-moving mass system, considering all the linear and nonlinear inertia terms of the moving mass as well as the friction between the beam and the mass. The partial deferential governing equation is transferred to a discretized form, using Galerkin method. Then the Homotopy perturbation method is used to solve the nonlinear time varying discretized equation of motion. In addition to the approximate analytic solution of the equation, the border line of stable and unstable regions and the resonance curves in the mass-velocity parametric plane are determined semi-analytically. The numerical simulation is used to verify these new finding from the analysis.

Keywords: Beam-moving Mass, Homotopy Perturbation Method, Nonlinear Time Varying System.

1. Introduction

Analyzing the dynamic interaction of a beam under the passage of a moving mass received the first attention from the apparition of railways in the nineteenth century and has been studied from different aspects by researchers. In recent years, due to economical reasons, there has been a growing trend towards the construction of more slender structures, inducing more pronounced vibrations. This fact emphasizes the importance of studying the formation of such phenomena and how to control them. Therefore, determining the verge of instability or conditions for appearance of resonance in structures supporting massive traffic is essential; as such instances may result in irreversible dangerous situations.

The research on this subject, neglected inertia terms of the vehicle and considered it as a moving load [1–8]. In many of these cases, vehicle transition recurrence equal to the beam natural frequencies are presented as trigger to resonance. In some other investigations researchers considered only the linear inertia term of the moving mass [9–11]. Only a restricted number of them included all components of moving mass acceleration in their analysis [12–14].

Homotopy methods are among those which have been recently employed to analyze vibrating systems. The extensive works based on homotopy method can be categorized in two groups. The first belongs to the class of convergence techniques for enhancing solutions accuracy which is irrelevant here. The second part focuses on the potential of homotopy methods to solve diverse differential equations. Some of those works which lean on this method for solving dynamic systems are enumerated in references [15–24].

Although there has been a general trend to employ homotopy method in studying and analyzing system's dynamics, nonetheless to the best of knowledge, dynamic stability investigation of a nonlinear time varying system via this approach has not been done yet.

In this paper, for the first time the dynamic behavior of the beam-moving mass system considering all components of the moving mass acceleration as well as the friction between the beam and moving mass, as a nonlinear time variant system, is investigated via homotopy

*Corresponding author:
M. Ghomeshi Bozorg (m.ghomeshibozorg@me.iut.ac.ir)