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Dynamic instability of axially moving viscoelastic plate

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Abstract: This paper is devoted to the investigation of the transverse vibration and dynamic stability of the axially moving viscoelastic plate with two opposite edges simply supported and other two opposite edges with simply supported or free. By considering the Kelvin–Voigt model of viscoelasticity, the equation of motion of the plate is derived. The normalized power series method is employed to obtain the complex eigen equations for the axially moving viscoelastic plate. The variation relationship between the first three complex frequencies of the system and the dimensionless axially moving speed with different aspect ratio and dimensionless delay time are analyzed. The results show that the dimensionless delay time, axially moving speed as well as the aspect ratio have remarkable effects on dynamic behaviors and stability of the axially moving viscoelastic plate.

Keywords: normalized power series method; divergence speed; flutter speed.

1. Introduction

Examples of axially moving systems, such as high-speed magnetic tapes, power transmission chains and belts, paper sheets under processing, band saws etc, are widely used in various engineering in industry. Transverse vibration of such systems is generally undesirable although characteristic of operation at high transport speeds. Above a certain critical moving speed, such axially moving systems may experience dynamical instabilities as flutter instability or divergence instability and even to cause structural failures. So, the accurate prediction of their instability behavior plays a crucial role in their reliable and lightweight structural design.

The important problem in considering axially moving system is how to model the system's material. In particular, the damping effect of viscoelastic material can be used to reduce the vibration of structures. In the case of viscoelastic materials, the state of strain in an element at a particular time not only depends on the state of stress at this time, but also on the history of stresses. Similarly, the state of stress of an element depends on the history of strains. It makes the dynamic analysis much more complicated. On the other hand, axially moving system is simplified as one-dimensional string and beam or two-dimensional plate dictated the difficulty of the establishment of the governing equation for the system. Based on the two points mentioned above, the state-of-art on the viscoelastic axially moving system is divided into two categories: axially moving viscoelastic

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