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EIGENFREQUENCIES AND STABILITY OF ELASTIC AND VISCOELASTIC ACCELERATING PANELS WITH FLUID–STRUCTURE INTERACTION

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Models of axially moving materials, and especially of their out-of-plane vibrations, are commonly considered in the context of industrial production processes, such as paper making. Typical models include axially moving strings, beams, panels (plates with cylindrical deformation), membranes and plates. Research into the field began in 1897 [1]. Other important classical studies include e.g. [2, 3], and the field has remained active to this day; e.g. [4, 5]. Classically an elastic material model has been used, but in the recent years the focus of research has shifted to viscoelastic materials. Both linear and nonlinear models have been investigated in the literature.

Problems of out-of-plane behaviour of axially moving materials share some of their mathematical formulation with those of axially compressed stationary materials, leading to questions of stability. The problem parameter of interest is, typically, the axial velocity of the material, which is assumed constant.

However, it is known that in paper machines the axial tension of the paper web in open draws is generated by a velocity difference between adjacent rollers. Thus, an axial strain component is generated, and the material accelerates axially. Axially accelerating moving materials have been investigated since the 1970s, see e.g. [6]. Recent focus has been on accelerating viscoelastic materials; e.g. [7, 8].

In the case of lightweight materials, such as paper, one further consideration arises from the inertial contribution of the surrounding air. It is not sufficient to consider the vibrations of the moving material in vacuum, but the fluid–structure interaction must be accounted for. The surrounding air is known to change both the frequencies of natural vibration and the critical velocity [9].

In the present study, we investigate an axially accelerating panel subjected to an axial potential flow. The acceleration is considered to be purely space-dependent in the Eulerian reference frame, i.e. there is no time dependence. The flow component is handled via a Green's function solution [10], leading to a one-dimensional integrodifferential model. Both linear elastic and Kelvin–Voigt viscoelastic material models will be considered.

The eigenfrequency spectrum will be parametrically investigated as a function of the axial velocity, and the critical velocity will be determined. Numerical results with comparisons between the different cases will be presented.

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