Vibration Analysis of Non-homogenous Orthotropic Visco-elastic Rectangular Plate of Parabolically Varying Thickness with Thermal Effect

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The present work analyses the vibration behaviour of non-homogeneous orthotropic visco-elastic rectangular plate of parabolically varying thickness on the basis of classical plate theory when the all edges are clamped and are subjected to linearly thermal variation. For non-homogeneity of the plate material it is assumed that the density of the plate material varies parabolically along the x-direction. For visco-elastic materials, basic elastic and viscous elements are combined. The Kelvin model for visco-elasticity is considered here, which is a combination of elastic and viscous elements connected in parallel. Using the separation of variable method, the governing differential equation has been solved. The time period and deflection corresponding to the first two modes of vibrations of clamped plates have been calculated for different values of thermal gradients, non-homogeneity constants, taper constants, and aspect ratio, with the help of Rayleigh-Ritz techniques, and are shown by graphs.

1. INTRODUCTION

The thermal effect of non-homogenous viscoelastic plates on vibration is of great interest in the field of engineering, with applications such as improved designing of gas turbines, jet engines, space craft, and nuclear power projects, where metals and their alloys exhibit visco-elastic behaviour. Therefore, for these reasons, such structures are exposed to high-intensity heat fluxes, and thus the material properties undergo significant changes. In particular, the thermal effect of elasticity of the material on the modules cannot be taken as negligible.

Space technology is developing very rapidly in the present era, and the importance of studying the vibration of plates of certain aspect ratios with some simple restraints on the boundaries has increased. The motors of rockets and aircraft in cold regions are developed with the use of soft filaments in aerospace structure supported with elastic or visco-elastic media. When finalising a design, a construction engineer should understand the first few modes of vibration, as they are significant.

Plates of variable thickness have been extensively used in civil, electronic, mechanical, aerospace, and marine engineering applications. The practical importance of such plates has made vibration analysis essential, especially since the vibratory response needs to be accurately determined in the design process in order to avoid resonance excited by internal or external forces.

The plate type's structural components in aircraft and rockets have to operate under elevated temperatures that cause non-homogeneity in the plate material, i.e. elastic constants of the materials become functions of space variables. An up-to-date survey of the research in this area shows that authors have come across various models to account for non-homogeneity of plate materials, and many researchers have proposed dealing with vibration. However, none of them consider non-homogeneity with a thermal effect on orthotropic visco-elastic plates of parabolically varying thickness.

The term vibration describes repetitive motion that can be measured and observed in a structure. Unwanted vibration can cause fatigue or degrade the performance of the structure. Therefore, it is desirable to eliminate or reduce the effects of vibration. In other cases, the goal may be to understand the effect of vibration on the structure, to control or modify the vibration, or to isolate it from the structure and minimise the structural responses.

Vibration can be sub-categorised, such as free versus forced vibration, sinusoidal versus, and linear versus rotation-induced vibration. Free vibration is the natural response of a structure to some impact or displacement. The response is completely determined by the properties of the structure, and its vibration can be understood by examining the structures mechanical properties. For example, when we pluck the string of a guitar, it vibrates at the tuned frequency and generates the desired sound. The frequency of the tone is a function of the tension in string and is not related to the plucking technique.

A great deal of research informs the study presented here. Laura, et al. discussed transverse vibrations of rectangular plates with thickness varying in two directions and with edges elastically restrained against rotation.[1] Leissas monograph[2] contains an excellent discussion of the subject of vibrating plates with elastic edge support. Gupta and Singhal discussed the effect of non-homogeneity on the thermally-induced vibration of an orthotropic visco-elastic rectangular plate of linearly varying thickness.[3] Lal has studied the transverse vibra-