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A Note on Thermal Stress Analysis

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Introduction

The search for an accurate and successful model describing the behavior of thermoelastic materials is a critical component of material science. The propagation of thermomechanical waves in solid materials has been researched in numerous mathematical models that have been made available by researchers. Talking about thermomechanical transition mathematical models employing elastic materials demands a vast area, not just one investigation. The dynamical temperature and the conductive temperature were used as the foundation for the thermos elasticity model. The value of the heat supply is proportional to the difference between these two temperatures. Many researchers who used spherical media for their applications and issues thought that a body with a spherical cavity is removed from the situation at the sphere's center. Materials with different functional grades are often used in elevated temperature applications. When using graded materials, thermal stresses, residual stresses, and stress concentration factors may be reduced while utilizing the features of both materials.

Description

Incompatible graded finite elements are created and validated to provide accurate and effective finite element analysis for heat transmission and transient thermal stress studies in two-dimensional functionally graded materials. The gradation of material qualities inside an element is addressed by user-defined subroutines in ABAQUS. Numerous numerical methods, including finite element analysis, have been developed to solve these differential equations. The behavior of the entire structure can be predicted in any engineering problem by figuring out the value of some fundamental unknowns, also referred to as field variables. These unknown field variables are limitless, but finite element reduces them to finite numbers by breaking up the solution region into smaller chunks called elements and representing the field variables as approximating or interpolating functions inside each element. As a result, the choice of element interpolation function determines the accuracy of the entire system. This has led to the development of several finite elements with various forms and interpolation functions [1,2].

A multi-component composite called graded materials has a macroscopic compositional gradient from one component to the next. However, because this composite retains a sizeable amount of the composite elements in pure form, it can fully utilize the capabilities of each component. For instance, the refractoriness of a ceramic and the toughness of a metal can be combined without compromising the refractoriness of the ceramic or the toughness of the metal. Due to this feature, extensive research has been done on these materials demonstrating its application as a structural component in a variety of fields, including aerospace, biomedical engineering, electrical engineering, transportation, and many more, particularly in elevated temperature environments. Structures are subjected to abrupt temperature changes in a variety of high-temperature environments, which cause thermally induced strains or motions. To avoid any catastrophic faults, it is imperative to limit these pressures, and research shows that graded materials with an optimal composition are helpful in doing so. It demonstrated that the analysis of thermal stress and heat transmission in FGM is analytically challenging and that only a few numbers of closed-form solutions are feasible. Due to this feature, extensive research has been done on these materials demonstrating its application as a structural component in a variety of fields, including aerospace, biomedical engineering, electrical engineering, transportation, and many more, particularly in feverish temperature environments. Structures are subjected to abrupt temperature changes in a variety of high-temperature environments, which cause thermally induced strains or motions. To avoid any catastrophic faults, it is imperative to limit these pressures, and research shows that graded materials with an optimal composition are helpful in doing so. It demonstrated that the analysis of thermal stress and heat transmission in FGM is analytically challenging and that only a few numbers of closed-form solutions are feasible.

To solve such heat difficulties and mechanical problems more precisely, numerical solution might be applied. As a result, a mathematical model of a rotationally symmetric thermoelastic, homogeneous, and isotropic solid sphere has been created. The hyperbolic two-temperature generalized thermoelectricity theory has been used to write the governing equations. The sphere's boundary is thermally shocked and not volumetrically deformed. Using Hospital's rule, the examined functions' central singularities have been eliminated. Different mechanical damage values, two-temperature parameters, and rotation parameter values have been used in the graphic representation of the numerical data [3-5].

Conclusion

All the functions under study are significantly impacted by the two-temperature parameter. While damage and rotation have very minor effects on conductive and dynamical temperature rise, they have a significant impact on deformation, displacement, stress, and stress-strain energy. In the Lord-Shulman model and the hyperbolic one-temperature theory, the thermal and mechanical waves propagate on the thermoelastic body at limited speeds.

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