Functionally Graded Conical Shell: A Perspective View

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Abstract- Fiber-reinforced composite materials are composed by embedding the fiber materials in the matrix material. Mainly fiber composites have two types first is random or short fiber reinforced composite and other is continuous or long fiber reinforced composites. In random fiber-reinforced composites, the fiber materials are in short discontinuous forms and are arranged in random order throughout the matrix material. The main important factor in the analysis of the laminated shell structures is its individual layer properties, which may be made of orthotropic, isotropic or anisotropic materials. The primary function of a laminated shell is to transfer the loads from the edges of one layer to another.

Keywords: Fiber, orthotropic, isotropic, anisotropic materials.

I. INTRODUCTION

Historical examples of composites are available in the various literatures. Significant examples include the use of reinforcing mud walls in houses with bamboo shoots, glued laminated wood by Egyptians (1500 B.C.), and laminated metals in forging swords (A.D. 1800). In the 20th century, high structural strength and glass fiber reinforced composites were developed in the early 1930s and the technology of modern composite materials has progressed significantly since then. Aircraft and boats were built out of these glass fiber composites which are commonly known as fiber-glass. The application of composite materials has extensively increased since the 1970s because of the development of new fibers like boron, carbon, and aramids and some other new composite structures with the matrices made from metals, polymer and ceramics. In recent years the applications of the composite materials have increased extensively in different fields of engineering because of its great strength and light weight. Composite structures belong to the category of such engineering materials in which two or more materials mixed with each other at a macroscopic level with some significant changes in physical and chemical properties and forms a new material with better material properties than those of the individual components used alone. They are continuously used in various engineering fields because of its better properties than other conventional materials like higher strength, higher stiffness, low weight, design flexibility, wear resistance, corrosion resistance, good thermal properties and better fatigue life. Because of these properties there are a wide range of application of composite materials like in aircraft/military industry, construction industry, automobile/transportation sector, marine applications, chemical industry, electrical and electronics applications, nuclear industry etc.

II. LITERATURE SURVEY

Lei et al. [2022] investigated the buckling behavior of functionally graded carbon nanotube-reinforced composite (FG-CNTRC) plates under the effects of different mechanical loadings by using element-free kp-Ritz method. The buckling analysis is carried out for functionally graded single-walled carbon nanotubes (SWCNTs) reinforced plates by using first-order shear deformation plate theory and mesh free method. The effective material properties for single-walled carbon nanotubes reinforced plate materials is based on a micromechanical model, either the extended rule of mixture or the Eshelby Mori Tanaka method.

Chakraborty et al. [2021] modeled a new beam element to analyze the thermoelastic behavior of FGMs based beam structures. The element considered first order shear deformation theory and the thermal and elastic properties are varying in the thickness direction. Wave propagation, static and free vibration problems are considered to examine the variation in thermoelastic behavior of functionally graded material (FGM) beam with pure ceramic beams or pure metal.

Azadi [2021] presents finite element method (FEM) based forced and free vibration analysis of functionally graded material based beams by considering the temperature dependent material properties. In this work, material properties were graded in the thickness direction of beams by considering simple power law distribution of constituent's volume fractions. Finally the dynamic analysis has been done for the damped and undamped systems.

Yas and Heshmati [2020] presented the vibrational study of functionally graded nanocomposite beams under the effect of moving loads which is reinforced by randomly oriented straight single walled carbon nanotubes (SWCNTs) by considering the Timoshenko and Euler-Bernoulli beam theories.

Dastjerdi et al. [2019] investigated dynamic analysis of functionally graded materials based nanocomposite cylindrical structures reinforced by single walled carbon nanotubes subjected to an impact load by a mesh free method. Stress wave propagation study and free vibration analysis of single-walled carbon nanotube reinforced composite (SWCTNRC) cylinders are studied in this work.

Wali et al [2015] investigated free vibration analysis of functionally graded material (FGM) based shell structures by using 3d shell model based on a discrete double directors shell elements. The material properties of the shell structures are assumed to vary in the direction of shell thickness according to the power law distributions of the constituents and the fundamental frequencies are derived from the virtual work principle.

Bhangale et al. [2014] presented the effect of vibration behavior and thermal buckling of FGM based truncated conical shells in the environment of large temperature condition. The analysis for the free vibration and the thermal buckling has been done by considering the temperature dependent material properties.

Haddadpour et al. [2013] presented the analysis of free vibration for simply supported functionally graded cylindrical shell structures under the effect of temperature. The equations of motions are based on von Karman Donnell and shell theory of Love's equations.

III. APPLICATIONS OF FUNCTIONALLY GRADED MATERIALS (FGMS)

A wide variety of applications exist for functionally graded material structures.

1. Aerospace
• Aerospace skins
• Engine components
• Vibration control
• Adaptive structures
• Fuselages of airplane

2. Engineering
• Cutting tools
• Shafts
• Engine components
• Turbine blades

3. Optics
• Optical fiber
• Lens

4. Electronics
• Semiconductor
• Substrate
• Sensor
• Actuator
• Integrated chips

5. Chemical plants
• Heat exchanger
• Heat pipe
• Reaction vessel
• Substrate

6. Energy conversion
• Thermoelectric generator

• Thermo-ionic converter
• Solar cells, fuel cells

7. Biomaterials
• Implants
• Artificial skin
• Drug transport system
• Prosthetics
• Artificial tissues

8. Commodities
• Building material
• Sports goods
• Car body
• Casing of different materials

IV. CONCLUSIONS

In this study, the free vibration responses of functionally graded conical shell panel are performed. The Voigt's micro-mechanical material model via power-law distribution is utilized for evaluating the effective material properties in thickness direction of shell panel.The solutions are obtained using commercially available finite element tool ANSYS APDL using Block Lanczos eigenvalue extraction method. In order to show the stability and consistency, the convergence study has been carried out by varying mesh densities.

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