

# VIBRATION ANALYSIS OF FGM CYLINDRICAL SHELL: A STATE-OF-THE-ART-REVIEW

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## ABSTRACT

*This paper is a review of the various approaches considered to study the static and dynamic behavior of Functionally Graded Material (FGM) cylindrical shell. The approximate and close form approach are well thought-out. The review is carried out vibration characteristics of FGM cylindrical shell predicted using various theories offered by many researchers without considering the detailed mathematical inference of various approaches. The variation of material parameters through the shell thickness and boundary conditions on the behavior of FGM cylindrical shell are discussed. The aim of this paper is to serve the benefits of researchers and engineers already intricate in the analysis and design of FGM structures.*

**Keyword:** *Functionally graded material, Vibration, FEM, Thermal effect.*

## I. INTRODUCTION

Structure component is used many different material compositions to optimize details of structure of loading condition. Local stress concentration is reduced by quick transition to material constants. Due to high stiffness to weight ratio of composite materials and structure are used in field of advanced engineering.

Japan scientist was obtained functionally graded material since 1980. Functionally graded materials are recovering mechanical and thermal parameters of structure components under high temperature conditions. Phase distribution variation is reproduced in their volume fraction. The variation on phase volume fractions is completely through the thickness of the structure.

The FGMs structure components are difficult to analysis compare to homogeneous structure components due to spatial variation in material constants [1]. Many applications of cylindrical shells are established in engineering application and industry field. They are generally used as load bearing structures of aircraft, building and ships. However, last seventeen years most of research work were published.

## II. VIBRATION ANALYSIS

Various approaches have been considered for the vibration analysis of FGM cylindrical shell is further classified into two approaches: approximate approaches and Close form approaches.

### 2.1 Approximate approaches

To achieved the approximate method few techniques have been used by various researchers.

#### 2.1.1 Finite Element Method (FEM)

Various researchers studied the dynamic analysis of FGMs cylindrical shell using FEM.

Using finite element formulation Reddy J.N. and Chin C.D. [2] examined dynamic response of FGMs cylindrical shell. Governing equations were derived using first-order shear deformation theory. Material constants were varied according to power law distribution.

Loy C.T. et al. [3] examined dimensionless frequency of FGMs cylindrical shell using Rayleigh-Ritz method. The investigation were based on Love's shell theory. Material constants are presumed to be dependent on temperature and varied according to power law distribution through thickness direction.

Pradhan S.C. et al. [4] studied vibration characteristics of FGMs cylindrical shell using Rayleigh-Ritz method. The investigation were based on Love's shell theory. Material constants are temperature dependent and varied according to power law distribution in radial direction.

Bhangale K. Rajesh and Ganesan N. [5] studied vibration analysis of simply supported FGMs cylindrical shell under magneto-electro-elastic effect using finite element method. Material constants were varied in shell thickness followed by power-law distribution.

Navazi H.M. et al. [6] examined natural frequencies of simply supported FGMs cylindrical shell under thermal effect using Galerkin's method. Governing equations were derived using Love's shell theory. Material constants dependent on temperature and varied according to power law distribution in radial direction.

Zhao et al. [7] presented static and dynamic analysis of FGMs cylindrical shell using finite element method. The investigation were based on sander's shear deformation theory. Material constants were varied according to power law distribution in thickness direction.

Using finite element method Santos H. [8] studied vibration analysis of FGMs cylindrical shell. The investigation were based on 3D-elastic theory. Material constants were varied according to power law distribution in the thickness direction.

NaeemMN et al. [9] examined dimensionless frequency of FGMs cylindrical shell using Ritz method. Sanders and Budiansky's thin shell theory was used in this studied. Material constants were varied in shell thickness followed by power law distribution.

Asgari M and Akhlaghi M [10] investigated frequency analysis of simply-supported 2DFGMs cylindrical shell using finite element method. Governing equations were based on 3D elastic theory. Material constants were varied according to power law in radially and axially direction.

Arshad Hussain Shahid et al. [11] examined non-dimension frequency of bi-layered FGMs cylindrical shell using Rayleigh-Ritz method. Governing equations were based on Love's thin shell theory. Material constants were varied from shell thickness according to power-law distribution.

Pandey Shashank et al. [12] examined natural frequencies of FGMs sandwich shell under thermal and non-thermal effect using finite element method. Material constants are dependent on temperature and varied according to Mori-Tanaka and Voigt's rule of mixture in radial direction. The temperature distribution are non-linear in thickness direction. This analysis is done by using thin shell theory.

#### 2.1.2 Differential Quadrature Method (DQM)

Yang J. et al. [13] examined static and dynamic analysis of FGMs cylindrical panel under thermal environment using DQM. Reddy's higher order deformation theory was used to obtained the governing equation. Material

constants are presumed to be dependent on temperature and varied according to power law distribution through thickness direction.

Zhi-yuan Cao and Hua-ning Wang [14] investigated frequency parameters of FGMs cylindrical shell with holes using numerical method. Governing equations were based on Hamilton's principle. Material constants were varied according to power law distribution in thickness direction.

The natural frequencies of three layers FGMs cylindrical shell was reported by Batra R.C. [15] using Flugge's shell theory. Material constants were varied according to power law distribution in thickness direction.

Malekzadeh P. et al. [16] proposed natural frequencies of rotating FGMs cylindrical shells under thermal effect using DQM. Material constants are temperature dependent and varied according to power law in thickness direction. The analysis based on first order shear deformation theory. Governing equation were derived using Hamilton's principle.

Neves A.M.A. et al. [17] investigated vibration response of FGMs cylindrical shell using higher-order deformation theory. Governing equations were based on principle of virtual work. Material constants were varied according to power law distribution in thickness direction.

Ebrahimi M.J. et al. [18] examined non-dimensionless frequency of 2DFGMs cylindrical shell using differential quadrature and integral quadrature method. Governing equations were based on Love's shell theory. Material constants were varied according to power law in radially and axially direction.

Dimensionless frequency of 2D axisymmetric FGMs cylindrical shell was presented by Najafizadeh M.M. et al. [19] using DQM. Governing equation were derived by Euler's equation and Hamilton's principle. Material constants were varied according to power law in axially and radially direction.

Foroutan M. et al. [20] examined frequency analysis of FGMs cylindrical shell using mesh less method. Material constants were varied according to power law distribution in radial direction.

### 2.1.3 Perturbation Method and Taylor Series Method

Ng T.Y. et al. [21] proposed vibration analysis of FGMs cylindrical shell under harmonic axial loading using Bolotin's method. Governing equations were based on Donnell's shell theory. Material constants were varied according to power law distribution.

## 2.2 Closed form approaches

### 2.2.1 Method of Separation of Variables

JinGuoyong et al. [22] examined natural frequencies of FGMs cylindrical shell using Haar wavelet method. The investigation were based on first-order deformation theory. Material constants were varied according to power law in thickness direction.

### 2.2.2 Finite Fourier Transformation

Kadoli Ravikiran et al. [23] proposed natural frequencies of clamped-clamped FGMs cylindrical shell under thermal effect using Fourier series expansion method. The investigation was followed by First order deformation theory. Material constants were assume to power law variation through shell.

Ansari R. and Darvizeh M. [24] examined dynamic performance of FGMs cylindrical shell using Stoke's Fourier transformation under different boundary conditions. The theoretical formulation was obtained using first order deformation shell theory. Material constants are temperature dependent and assumed to vary through shell thickness according to power law, exponential law and sigmoid law.

### III. CONCLUSION

This review is reported on modern advances in approximate approaches and Close form approaches for the vibration analysis of FGM cylindrical shell. Most of the approaches considered for the analysis of FGM cylindrical shell are the additions of the related approaches used for isotropic cylindrical shell. The important role of material parameters to obtained response of FGM cylindrical shell.

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