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AN APPROXIMATE ANALYTICAL APPROACH FOR NONLINEAR THERMODYNAMIC PROBLEM OF FGM SHALLOW SPHERICAL SHELLS WITH TIME DEPENDENT PARAMETERS

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ABSTRACT

This article deals with an approximate analytic solution of nonlinear vibrations spherical shallow shells made of functionally graded materials (FGM) under the temperature loading. The thickness is depends on the time. The material properties are changed in the thickness direction according to the power law distribution. The governing nonlinear differential equation with variable in time coefficients describes the effect of temperature on the dynamic behaviour of the shell, is solved on the basis of hybrid asymptotic approximation using perturbation methods and phase integrals (WKB method). The comparison of the results for numerical integration of the initial equation with the proposed approximate analytical solution is given.

Keywords: asymptotic approximation, nonlinear dynamic problem FGM shallow shells, time dependent parameters.

INTRODUCTION

Thin walled structures made of functionally graded materials (FGM) with metal inner surface and ceramic in outer surface are widely used, for example, in modern air-space systems, shipbuilding, electronics and other fields of science and technology. The attention to them is increasing because of flexibility in design to have desired strength and durability.

FGMs belong to the class of composite materials in which the material properties are changing in the thickness direction or discontinuous as a stepwise gradation of the material constituents (Dao Huy Bich; 2012). Composite shell structures which are used for modern flying apparatus undergo large deflection and/or static and nonlinear dynamic external mechanical and temperature loading (M. Darabi, 2008). That is why it is important to take into account the geometrically nonlinear effects to ensure more accurate structural analysis and design. In recent years, important studies about vibration and stability of FGM plates and shells under static, dynamic loading and in high temperature environment have been carried out, with using mostly numerical approaches and just few ones deal with asymptotic approaches because of the difficulties in numerical calculations.

The present work deals with an approximate analytical solution of nonlinear dynamic problem of FGM imperfect shallow shells based upon the von Karman theory for moderately large normal deflections with time dependent parameters. The governing nonlinear nonhomogeneous singular differential equation with variable in time coefficients describes the effect of temperature on the dynamic behavior of the shell, is solved using combination of perturbation and phase integrals method.

We have obtained an approximate analytical solution for the governing equation. The comparison of results from numerical integration of the initial equation with approximate analytical solution is given.

RESULTS AND CONCLUSIONS

The comparison of solutions showed, for some parameters of structure, analytical solutions are in a good enough correlations with direct numerical simulation of initial nonlinear differential equation with variable in time coefficients.

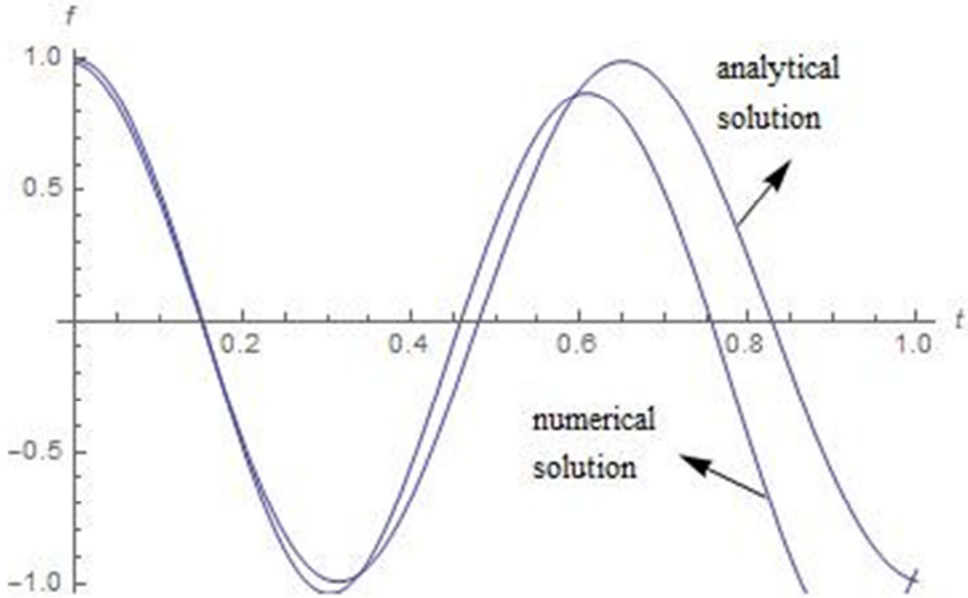

Fig. 1 - Comparison of numerical and analytical solution

Further investigations will be devoted to analyze the nonlinear dynamic behavior of complex shape FGM shell including temperature effects.

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