Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure
Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid
Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1

PAPER REF: 7137

THE MECHANICAL AND THERMAL BEHAVIOR OF EXPONENTIALLY GRADED SANDWICH PLATES IN BENDING TEST

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ABSTRACT

A four-variable refined plate theory is developed to analyze the bending behavior of functionally graded material (FGM) sandwich plates subjected to thermomechanical loads. The sandwich plate faces are FGM, of which the Young's modulus, Poisson's ratio, and thermal expansion coefficient are assumed to vary according to an exponential law distribution in the thickness direction. Two types of FGM sandwich plates, i.e. one with FGM face sheets and homogenous core and the other composed of homogenous face sheets and FGM core are considered. The number of unknown functions involved in the present theory is only four. The governing equations are deduced based on the principle of virtual work and then these equations are solved via Navier approach. Close-form solutions for simply supported FGM sandwich plates are obtained. Comparative studies are conducted to demonstrate the validity and efficiency of the present theory. The effects of significant parameters such as the gradient index, side-to-thickness ratio, layer thickness ratio and loading type on the thermomechanical bending behaviors are discussed in detail.

Keywords: functionally graded material, thermomechanical loads, sandwich structures.

INTRODUCTION

Sandwich structure with homogeneous face sheets and homogeneous core [1] have been widely used in areas of aircraft, aerospace, naval/marine, construction, transportation, and wind energy systems. With the development of advanced materials, functionally graded material (FGM) is now being explored in sandwich plates design. Two new types of sandwich structures with FGM face sheets and homogeneous core or with homogeneous face sheets and FGM core have been proposed and investigated [2]. The continuously and smoothly varying material properties of FGM help to eliminate mechanically and thermally induced stresses due to the material property mismatch at the interfaces which is a major problem in conventional sandwich structures [3]. Therefore, the mechanical, thermal and thermomechanical behaviors of functionally graded (FG) sandwich structures have received great attention.

RESULTS AND CONCLUSIONS

The deflections and stresses of two types of FGM sandwich plates under thermomechanical loads are presented and compared with the existing solutions to verify the accuracy of the present method. Typical mechanical properties for metal and ceramics used in the numerical examples are listed in Table 1. The dimensionless relations for the deflection and stresses of thermomechanical bending problem are the same used in Ref. [4].

In this paper the thermomechanical bending response of two types of FGM sandwich plates, Figure 1, is investigated by using a refined four-variable plate theory. Parameter studies are carried out to analyze the influences of power index *p*, inhomogeneity parameter *k*, geometrical parameters (*a/b*, *a/h* ratios) and thermal load on the dimensionless deflections and normal stresses of the FGM sandwich plates, Figures 2 and 3.

Table 1 - Material properties used in the FGM sandwich plates

Properties	Metal:Ti-6Al-4V	Ceramic:ZrO_2
$E_i\,(GPa)$	66.2	117.0
μ_i	1/3	1/3
$\alpha\left(10^{-6}/\mathrm{K}\right)$	10.3	7.11

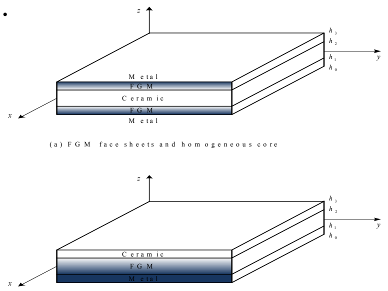

Fig. 1 - Two different types of FG sandwich plates

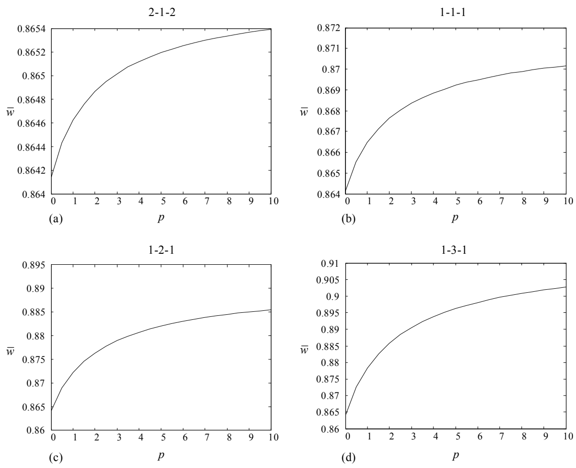

Fig. 2 - Effect of the inhomogeneity parameter *p* on the dimensionless center deflection $\tilde{\omega}$ of type-A sandwich plates: (a) (2-1-2), (b) (1-1-1), (c) (1-2-1), (d) (1-3-1)

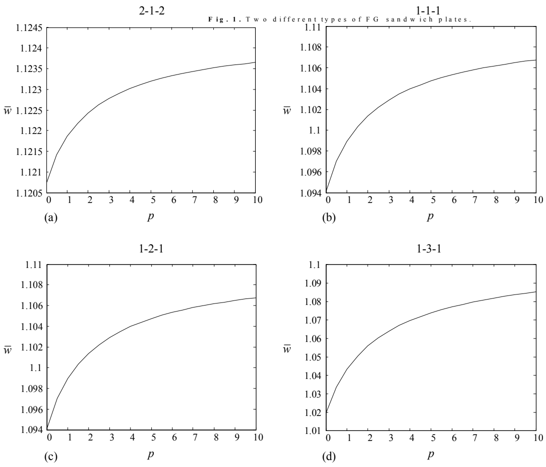

Fig. 3 - Effect of the inhomogeneity parameter *p* on the dimensionless center deflection $\tilde{\omega}$ of type-B sandwich plates: (a) (2-1-2), (b) (1-1-1), (c) (1-2-1), (d) (1-3-1)

ACKNOWLEDGMENTS

The authors gratefully acknowledge the funding by grant MOST 106-2221-E-158-003.

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