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Effect of Idealization Models on Deflection of Functionally Graded Material (FGM) Plate

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Functionally graded materials (FGM) are a class of composites, in which the properties of the material gradually change over one or more Cartesian directions, the combination of which results in an assembly with higher performance than components taken separately. This class of composite materials has gained considerable attention in the engineering community, especially in high-temperature applications such as nuclear reactors, aerospace, and power generation industries. The aim of the current work is to study the influence of homogenization (idealization) models and thermal loads on static deflection behavior of sandwich functionally graded plate. Several micromechanical models have been employed to obtain the effective material properties of the two-phase FGM plate. The FGM plate is subjected to linear and no linear thermal loads. The integral theory used contains only four variable functions as against five in the case of other HSDTs. The governing equation are derived and resolved via virtual work principle and Navier's model. The accuracy of the proposed analytical model is confirmed by comparing the results with those given by others model existing in the literature.

Keywords: Homogenization, Sandwich plate, Functionally graded plate, Deflection, Navier solution.

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1. INTRODUCTION

Materials are continuously developed from iron, pure metals to composite materials which are in use today. Pure metals have very limited use, since actual application may require contrary property requirement which cannot provide by using single metal. As compared to pure metals, alloys can be stronger and more versatile. Bronze which is alloy of copper and tin was the first alloy that was developed in 4000 BC (Bronze age). Since then, different mixtures of metals and non-metals were tried to combine strengths of multiple materials as per functional requirement[1]. Functionally graded materials (FGM) are a class of composites in which the properties of the material gradually change over one or more cartesian directions [2]. FGMs have a wide range of applications in various sectors due to their flexibility in making a particular composite material according to the requirement. FGMs are used in aerospace structures, military applications, medical applications, photoelectronic devices, automotive parts, and sporting equipment. FGMs are advantageous over conventional structural materials and layered composites due to their continuous change in characteristic properties, thermal stability, good damping properties, and high toughness. Additionally, they are used as coating materials which reduce heat loss from engine exhaust system components and can be used in high and low temperature zones. FGMs are also used in forming tools and cutting tools, making them a useful material for many applications.

There has been a considerable research report on thermal stresses, fracture, thermo mechanical response, buckling, free vibration, etc., of FGM structural elements during the last two decades [3]. Due to the importance and wide technical applications of FGMs structures, they have been addressed by many researchers [4].

The aim of the using the micromechanical models is to accurately predict the effective multiphysics properties. and to quantify the effect of microstructure on the multiphysics behavior of materials by the application of continuum mechanics to a small-scale. Several micromechanical models of FGMs have been reviewed in [5-9]. To assess the effect of the micromechanical models on the structural responses of FG plates.

In this paper at first time the influence of the thermal load with linearity and nonlinearity variations is presented. Then, the effect of the micromechanical models (Voigt, Reuss, LRVE and Tamura) are employed to determine the effects on the Center deflection $\bar{w}$ of the sandwich functionally graded plate.

2. PROBLEM DEFINITION AND GOVERNING EQUATIONS

2.1 Materials Properties

The geometry of the domain problem is assumed to a rectangular plate with thickness "h", length "a", and width "b". The plate has three layers (two faces sheet and a core) (Fig. 1).

The FG-face sheets are made by two materials Titanium (as metal) and Zirconia (as ceramic). The Table 1 resumed the values of The Young modulus, thermal expansion coefficients α and poison ratioν of Ceramic and metal phases.

The volume fraction of the FG-faces sheet are assumed varies as following functions.

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