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Isogeometric analysis of functionally graded plates using a new quasi-3D shear deformation theory based on physical neutral surface

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Abstract

In this paper a new simple and efficient quasi three-dimensional (quasi-3D) shear deformation theory is presented for the static and free vibration analysis of functionally graded and sandwich plates by using the isogeometric analysis (IGA) method and physical neutral surface position. The theory uses five independent unknowns and satisfies the free transverse shear stress conditions on the top and bottom surfaces of plate without a need for shear correction factor. The IGA utilizes Non-Uniform Rational B-Spline (NURBS) functions, which fulfills C^1 continuity requirement. Numerical results compared with 3D, quasi-3D and 2D solutions show the efficiency of the present model.

Keywords: A. Plates; B. Vibration; C. Computational modeling; Functionally graded materials

1. Introduction

FGMs are a new class of composites which have a continuous variation of material properties from one side to another. Because of this property, the stress concentration that is found in laminated composites is eliminated. These materials are a new generation of advanced composite materials which are proposed for thermal barrier purposes in high temperature environments. The concept of FGM was introduced in 1984 by Japanese material scientists. FGM is usually made from a mixture of ceramic and metal due to its low thermal conductivity and great toughness. So FGMs have high temperature resistance and prevent fracture. FGMs are widely used in many structural applications such as mechanics, aerospace and other industries.

Many theories have been developed to analyze plate structures. The classical plate theory (CPT) relies on the Kirchoff-Love assumptions which provides acceptable results for thin plates. The first order shear deformation theory (FSDT) accounts for transverse shear deformation effects. To satisfy the free transverse shear stress conditions on the top and bottom surfaces of plate, a shear correction factor is required. The shear correction factor is difficult to determine, because it depends on the geometric parameters, boundary and loading conditions. To avoid the use of shear correction factor, many higher order shear deformation theories (HOSDT) have been developed such as third order shear deformation theory (TSDT) [1], polynomial shear deformation theory (PSDT) [2,3], sinusoidal shear deformation theory (SSDT) [4,5], trigonometric shear deformation theory (TrSDT) [6-8], inverse trigonometric shear deformation theory (ITrSDT) [7,9-11], hyperbolic shear deformation theory (HSDT) [12-18], inverse

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