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Hygrothermomechanical Behavior of Thick Composite Plates Using High Order Theory

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Abstract

The structures made of composite materials represent a very great part of research in aeronautical and aerospace engineering considering their specific characteristics in term of lightness and rigidity. During service these structures are subjected to changely environmental conditions that sometimes are extremely in term of temperature and humidity which cause residual stresses. The determination of this stress is highly significant for the reliability of the design stages and dimensioning.

This study investigates the behaviour of thick composite laminates using the high order method through stresses calculation. The composite plate is subjected to mechanical solicitation and working in a hygrothermal environment. Temperature and humidity are taken into account in the calculation of stresses. Different simulations are carried out for different profile of temperature and concentration distribution (linear, constant, parabolic, etc.) to observe the response of structures.

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Nomenclature

u,v,w	displacement of a point in x,y,z direction respectively.
u_0,v_0,w_0	displacement of a point on the mid plane in x,y,z direction respectively.
$ø_x,ø_y$	rotations of transverse normal about x ,y axis respectively.
$\varepsilon_{xx},\varepsilon_{yy},\varepsilon_{xy}$	strains components in xx,yy,xy plane respectively.
γ_{xz},γ_{yz}	transverse shear strain in xz,yz plane respectively.
$N_{ij},M_{ij},P_{ij},Q_{ij},R_{ij}$	stress resultants in i,j plane.
A,B,D,E,F,H	stifnesses matrices.

1. Introduction

During their operations services the aeronautical structures are subjected to variable conditions in terms of temperature and humidity. These environmental parameters cause significant solicitations. Particular attention is given to the behavior of the thick plates. Many research and investigations are made in these themes. Reddy developed a high order theory Reddy[1], this model has been adopted by several research [2-5].There after Reddy [6] has proposed a finite element formulation for the behavior's prediction of thick plates under thermal loading. A.M.Zenkour[7] treated the static thermo-elastic response of symmetric and anti-symmetric cross-ply laminated plates. O.Sayman [8] studied the stresses behavior for a composite,with a metal matrix under linear thermal loading, and later O.Sayman [9-10] Studied the stresses behavior for a composite with a metal matrix under parabolic thermal loading. Reddy [11] has treated the problem of thick plate under sinusoidal mechanical loading with linear thermal loading.Pipes & al[12] studied stresses state by taking into consideration the temperature and absorbed moisture in laminated composite plate. Sai Ram & al[13] proposed a finite element method to present the temperature and moisture effects, on the bending with a transverse shear deformation. Basi & al[14] considered the hygrothermal effects in a developed theory to calculate the stresses state in a thick composite plate. Patel & al[15] developed the problem of static and dynamic behavior of a thick laminated plate, subjected to hygrothermal loading using a higher order theory. Lo SH & al[16] studied the behavior of a laminated plate in hygrothermal environment using a global local higher order theory.

The present paper deals with higher order shear deformation theory (HSDT) and consider a rectangular composite plate with length a, width b and thickness h, made of T300/5208 (see Fig. 1). The plate is subjected to a sinusoidal transverse mechanical load q(x, y) and temperature/moisture field $\Delta T(x, y, z)/\Delta C(x, y, z)$. The plate is referred to a coordinate system (x, y, z) with the coordinates x and y along the in-plane directions and z along the thickness direction. The plate is composed of orthotropic cross ply layers. The purpose of this paper is to examine the influence of temperature and concentration field to simulate the behavior of the composite plate.

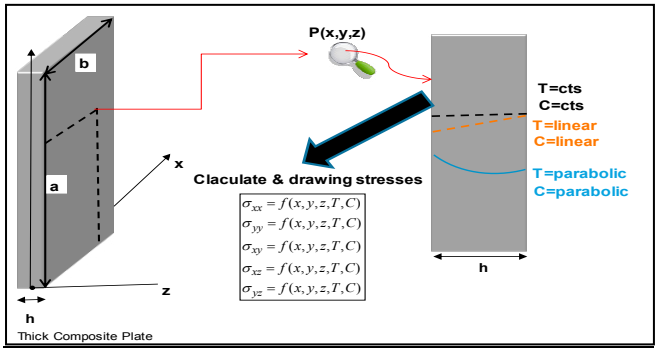

Fig.1.Problem Definition