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HEAT CONDUCTION AND THERMAL STRESS ANALYSIS OF LAMINATED COMPOSITES

M.T.K olhe
Department of Mathematics, Arts Comm and Science College
Arvi Dist Wardha (M.S) India
M.N.Gaikwad
Department of Mathematics, H.R. Arts and Science College
Ashti Dist Wardha (M.S) India

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Abstract

The current paper considers the straight static warm pressure investigation of composite designs through a shell limited component with variable through-thethickness kinematic. The temperature profile along the thickness course is determined by tackling the Fourier heat conduction condition. The refined models considered are both Equivalent Single Layer (ESL) and Layer Wise (LW) and are gathered in the Unified Formulation via Carrera (CUF). These license the dispersion of relocations, stresses along the thickness of the diverse shell to be precisely portrayed. The shell component has nine hubs, and the Mixed Interpolation of Tensorial Components (MITC) strategy is utilized to differentiate the film and shear locking peculiarity. The overseeing conditions are gotten from the Principle of Virtual Displacement (PVD). Cross-utilize plate, tube shaped and round shells with basically upheld edges and exposed to bi-sinusoidal warm burden are examined. Different thickness proportions and ebb and flow proportions are thought of.

Keywords:*Heat conduction, laminated, Geometrical*

Introduction

In the average aeronautical designs composite materials have tracked down a rising measure of uses. Progressed composite materials consolidate various properties, including high explicit strength and solidness, and almost no coefficient of warm development in the fiber direction. These important properties bring about a developing utilization of composite materials in

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structures exposed to extreme warm climate, like high temperatures, high slopes and cycling changes of temperature. Thusly the warm distortions and stresses which are instigated by non-uniform temperature in composite constructions become significant boundaries in foundational layout. Utilization of higher-request speculations will make it conceivable to decide these boundaries exactly in composite constructions. In each evolved computational model, the pressure examination ought to be gone before by an exact warm investigation, which gives the temperature input information expected for the warm outside load.

A palatable warm pressure examination is just conceivable assuming that best in class and refined computational models are created to accurately rough the solidness framework, and assuming a right warm burden is perceived. Once in a while the assessment of a right warm burden could be required regarding any further assessment for the computational models. Review including the thermo-versatile conduct utilizing traditional or first-request speculations are portrayed. As of late, a few higher-request two-layered models have been produced for such issues, which consider just an accepted temperature profile through the thickness. Among these, specifically compelling is the higher-request model. A similar temperature profile is involved by to acquire a shut structure answer for the thermo mechanical examination of laminated and sandwich shells. Accept a straight or steady temperature profile through the thickness. Examine the non-direct thermoplastic way of behaving of shells through the Finite Element Method, yet the appointed temperature profile is straight. In the structure of the inconsistent dissemination of temperature through the thickness, are imperative, in the initial an old style shell hypothesis for composite shells is given, the second comments the significance of the crisscross type of relocations in the warm investigation of composite shells. On account of shells, further examinations were made for both shut structure and Finite Element strategy, and for a powerless definition for the instance of state conditions including the limit conditions. Over the most recent couple of years numerous commitments have been proposed, which depend on Carrera Unified Formulation, to research the warm impacts in composite designs. In [12] a review because of the through-the-thickness temperature profile on the thermo-mechanical reaction of multifaceted anisotropic good and bad plates has been tended to. The somewhat coupled pressure issue was considered by settling the Fourier's conductivity condition. The significance of blended

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speculations for a right expectation of cross over shear/ordinary burdens because of warm loadings has been commented in. A completely coupled thermo-mechanical examination applied to plate structure is utilized in. Different kind of burdens as issues connected with uniform, three-sided, bi-three-sided (tentlike), and restricted in-plane conveyance of temperature were considered in The Ritz technique, in view of the decision of mathematical preliminary capacities, was utilized in Extension to Functionally Graded Materials (FGMs) has been done in A warm soundness examination of practically reviewed material, isotropic and sandwich plates is contemplated in the Ritz strategy is utilized and uniform, straight, and non-direct temperature profile is considered for various cases. An augmentation of the thermo versatile plan to shells has been done in and the Fourier heat conduction condition was utilized for shell in [The thermo-mechanical investigation of practically reviewed shell is considered in Analytical shut structure arrangements are accessible in not very many cases. The arrangement of the vast majority of the commonsense issues requests uses of approximated computational techniques.

In this paper, the creators want to exhibit as the supposition of deduced straight temperature profile in the thickness bearing could be off-base for specific shell and plate designs, and as the utilization of the Fourier heat conduction condition could result required to acquire a right warm burden. Along these lines, we might want to exhibit as an off-base warm burden nullifies the static reaction of plate and shell structures in any event, when cutting-edge computational models are utilized. An improved doubly-bended shell limited component for the examination of composite designs under warm loads is here introduced, it is a characteristic augmentation of the plate limited component introduced in. The shell limited component depends on the Carrera's Unified Formulation (CUF), which was produced for multifaceted designs.

Both Equivalent Single Layer (ESL) and Layer Wise (LW) speculations contained in the CUF have been executed in the shell limited component. The Mixed Interpolation of Tensorial Components (MITC) technique [26-29] is utilized to differentiate the layer and shear locking. The administering conditions for the straight static investigation of composite constructions are gotten from the Principle of Virtual Displacement (PVD), to apply the limited component strategy. The temperature profile is determined addressing the Fourier heat conduction condition and contrasted and the direct profile through the thickness for every two-layered model. Cross-

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utilize plate, tube shaped and circular shells with just upheld edges and exposed to bi-sinusoidal warm loads are dissected. The outcomes got with the various models contained in the CUF, are contrasted and the specific arrangement given in the writing and the scientific Navier's answer type. At last, plates and shells with various cover and limit conditions are additionally investigated involving high-request speculations to give FEM benchmark arrangements.

OBJECTIVE

1. Study on Geometrical and constitutive relations for shel.
2. Study on Heat conduction and Thermal Stress.

Geometrical and constitutive relations for shel

Shells are bi-layered structures in which one aspect (in everyday the thickness in z course) is irrelevant as for the other two in-plane aspects. Math and the reference framework are demonstrated in Fig. 1. By considering complex designs, the square of a minuscule direct fragment in the layer, the related microscopic region and volume are given by:

$$
\begin{aligned}
ds_k^2 &= H_\alpha^{k^2}\, d\alpha_k^2 + H_\beta^{k^2}\, d\beta_k^2 + H_z^{k^2}\, dz_k^2 \,, \\
d\Omega_k &= H_\alpha^k H_\beta^k \, d\alpha_k \, d\beta_k \,, \qquad (1) \\
dV &= H_\alpha^k \, H_\beta^k \, H_z^k \, d\alpha_k \, d\beta_k \, dz_k \,,
\end{aligned}
$$

Where the metric coefficients are:

$$
H_\alpha^k = A^k(1 + z_k/R_\alpha^k), \quad H_\beta^k = B^k(1 + z_k/R_\beta^k), \quad H_z^k = 1 \,. \qquad (2)
$$

k signifies the k-layer of the complex shell; R k α and R k β are the primary radii of the mid surface of layer k. A k and B k are the coefficients of the main principal type of Ωk (Γk is the Ωk limit). In this paper, the consideration has been limited to shells with consistent radii of ebb and flow (round and hollow, circular, toroidal calculations) for which A k = B k = 1. Subtleties for shells are accounted for in. Geometrical relations license the in-plane ϵ k p and out plane ϵ k n strains to be communicated as far as the relocation u. The accompanying relations hold:

$$
\begin{aligned}
\boldsymbol{\epsilon}_p^k &= [\epsilon_{\alpha\alpha}^k, \epsilon_{\beta\beta}^k, \epsilon_{\alpha\beta}^k]^T = (\boldsymbol{D}_p^k + \boldsymbol{A}_p^k)\, \boldsymbol{u}^k \,, \\
\boldsymbol{\epsilon}_n^k &= [\epsilon_{\alpha z}^k, \epsilon_{\beta z}^k, \epsilon_{zz}^k]^T = (\boldsymbol{D}_{n\Omega}^k + \boldsymbol{D}_{nz}^k - \boldsymbol{A}_n^k)\, \boldsymbol{u}^k \,. \qquad (3)
\end{aligned}
$$

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The explicit form of the introduced arrays is:

$$\boldsymbol{D}_p^k = \begin{bmatrix} \frac{\partial_\alpha}{H_\alpha^k} & 0 & 0 \\ 0 & \frac{\partial_\beta}{H_\beta^k} & 0 \\ \frac{\partial_\beta}{H_\beta^k} & \frac{\partial_\alpha}{H_\alpha^k} & 0 \end{bmatrix}, \quad \boldsymbol{D}_{n\Omega}^k = \begin{bmatrix} 0 & 0 & \frac{\partial_\alpha}{H_\alpha^k} \\ 0 & 0 & \frac{\partial_\beta}{H_\beta^k} \\ 0 & 0 & 0 \end{bmatrix},$$

$$\boldsymbol{D}_{nz}^k = \begin{bmatrix} \partial_z & 0 & 0 \\ 0 & \partial_z & 0 \\ 0 & 0 & \partial_z \end{bmatrix}, \qquad (4)$$

$$\boldsymbol{A}_p^k = \begin{bmatrix} 0 & 0 & \frac{1}{H_\alpha^k R_\alpha^k} \\ 0 & 0 & \frac{1}{H_\beta^k R_\beta^k} \\ 0 & 0 & 0 \end{bmatrix}, \quad \boldsymbol{A}_n^k = \begin{bmatrix} \frac{1}{H_\alpha^k R_\alpha^k} & 0 & 0 \\ 0 & \frac{1}{H_\beta^k R_\beta^k} & 0 \\ 0 & 0 & 0 \end{bmatrix}. \qquad (5)$$

The meaning of the 3D constitutive conditions allows the anxieties to be communicated through the strains. The summed up Hooke's regulation is thought of, by utilizing a straight constitutive model for minuscule distortions. In a composite material, these conditions are acquired in material directions (1, 2, 3) for each orthotropic layer k and afterward pivoted in the overall curvilinear reference framework (α, β, z). Along these lines, the pressure strain relations after the pivot are:

$$\boldsymbol{\sigma}_p^k = [\sigma_{\alpha\alpha}^k, \sigma_{\beta\beta}^k, \sigma_{\alpha\beta}^k]^T = \boldsymbol{\sigma}_{pd}^k - \boldsymbol{\sigma}_{pT}^k = \boldsymbol{C}_{pp}^k\, \boldsymbol{\epsilon}_p^k + \boldsymbol{C}_{pn}^k\, \boldsymbol{\epsilon}_n^k - \boldsymbol{\lambda}_p^k\, \theta^k$$
$$\boldsymbol{\sigma}_n^k = [\sigma_{\alpha z}^k, \sigma_{\beta z}^k, \sigma_{zz}^k]^T = \boldsymbol{\sigma}_{nd}^k - \boldsymbol{\sigma}_{nT}^k = \boldsymbol{C}_{np}^k\, \boldsymbol{\epsilon}_p^k + \boldsymbol{C}_{nn}^k\, \boldsymbol{\epsilon}_n^k - \boldsymbol{\lambda}_n^k\, \theta^k \qquad (6)$$

Where

$$\boldsymbol{C}_{pp}^k = \begin{bmatrix} C_{11}^k & C_{12}^k & C_{16}^k \\ C_{12}^k & C_{22}^k & C_{26}^k \\ C_{16}^k & C_{26}^k & C_{66}^k \end{bmatrix} \quad \boldsymbol{C}_{pn}^k = \begin{bmatrix} 0 & 0 & C_{13}^k \\ 0 & 0 & C_{23}^k \\ 0 & 0 & C_{36}^k \end{bmatrix}$$

$$\boldsymbol{C}_{np}^k = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ C_{13}^k & C_{23}^k & C_{36}^k \end{bmatrix} \quad \boldsymbol{C}_{nn}^k = \begin{bmatrix} C_{55}^k & C_{45}^k & 0 \\ C_{45}^k & C_{44}^k & 0 \\ 0 & 0 & C_{33}^k \end{bmatrix} \qquad (7)$$

$$\boldsymbol{\lambda}_p^k = \boldsymbol{C}_{pp}^k\, \boldsymbol{\alpha}_p^k + \boldsymbol{C}_{pn}^k\, \boldsymbol{\alpha}_n^k$$
$$\boldsymbol{\lambda}_n^k = \boldsymbol{C}_{np}^k\, \boldsymbol{\alpha}_p^k + \boldsymbol{C}_{nn}^k\, \boldsymbol{\alpha}_n^k \qquad (8)$$

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$$\boldsymbol{\alpha}_p^k = \begin{bmatrix} \boldsymbol{\alpha}_1^k \\ \boldsymbol{\alpha}_2^k \\ 0 \end{bmatrix} \qquad \boldsymbol{\alpha}_n^k = \begin{bmatrix} 0 \\ 0 \\ \boldsymbol{\alpha}_3^k \end{bmatrix} \qquad (9)$$

$$\boldsymbol{\lambda}_p^k = \begin{bmatrix} \boldsymbol{\lambda}_1^k \\ \boldsymbol{\lambda}_2^k \\ \boldsymbol{\lambda}_6^k \end{bmatrix} \qquad \boldsymbol{\lambda}_n^k = \begin{bmatrix} 0 \\ 0 \\ \boldsymbol{\lambda}_3^k \end{bmatrix} \qquad (10)$$

The subscripts d and T mean mechanical and thermal contributions. The material coefficients Cij depend on the Young's moduli E1, E2, E3, the shear moduli G12, G13, G23 and Poisson moduli ν12, ν13, ν23, ν21, ν31, ν32 that characterize the layer material. αij are the thermal expansion coefficients, λij are the coefficients of thermo-mechanical coupling and θ k is the difference with a reference temperature.

Carrera Unified Formulation for Shell

The variety of the dislodging factors along the thickness heading is deduced hypothesized. A few dislodging put together hypotheses can be planned with respect to the premise of the accompanying conventional kinematic field. The fundamental component of the Unified Formulation via Carrera (CUF) is the bound together way where the removal factors are dealt with.

$$\boldsymbol{u}^k(\alpha, \beta, z) = F_s(z)\boldsymbol{u}_s^k(\alpha, \beta);$$
$$\delta\boldsymbol{u}^k(\alpha, \beta, z) = F_\tau(z)\delta\boldsymbol{u}_\tau^k(\alpha, \beta) \qquad \tau, s = 0, 1, \ldots, N \quad (11)$$

Where (α, β, z) is a curvilinear reference framework, wherein α and β are symmetrical and the curve radii Rα and Rβ are steady in each mark of the space Ω (see Fig. 1). The uprooting vector u = {u, v, w} has its parts communicated in this framework. δu demonstrates the virtual removal related with the virtual work and k recognizes the layer. Fτ and Fs are the alleged thickness capacities relying just upon z. we are the obscure factors relying upon the directions α and β. τ and s are aggregate lists and N is the request for extension in the thickness bearing accepted for the relocations.

Classical Theories

The simplest plate/shell theory is based on the Kirchhoff/Love's hypothesis, and it is usually referred to as Classical Lamination Theory (CLT)[33],[34]. Both transverse

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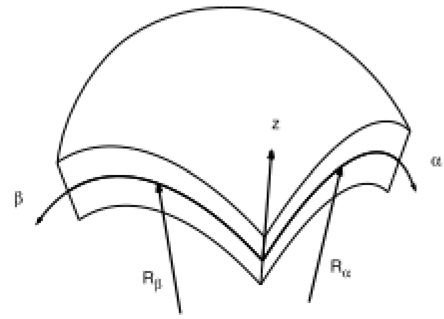

Figure 1: Reference system of the double curvature shell.

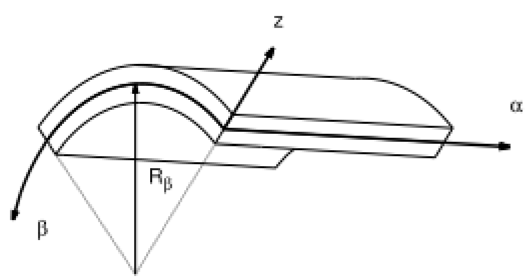

Figure 2: Reference system of the cylindrical shell.

Removal is expected consistent in the thickness heading. Also, nearby impacts because of concentrated loads can't be addressed on the off chance that a straight uprooting field is thought of. To eliminate the irregularity totally, higher-request development of the obscure as for the z coordinate is required. For additional subtleties, the perusers can allude to the article.

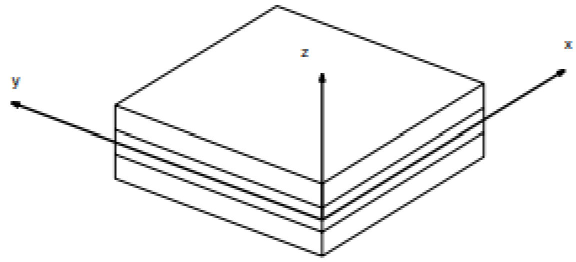

Figure 3: Reference system of the plate.

Shear strains and transverse normal strains are discarded, in usual applications being negligible with respect to the in-plane ones,

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$$\begin{cases} u(\alpha,\beta,z) = u_0(\alpha,\beta) - z\dfrac{\partial w_0}{\partial \alpha} \\ v(\alpha,\beta,z) = v_0(\alpha,\beta) - z\dfrac{\partial w_0}{\partial \beta} \\ w(\alpha,\beta,z) = w_0(\alpha,\beta) \end{cases} \qquad (12)$$

The inclusion of transverse shear strains, in the theory mentioned here, leads to Reissner-Mindlin Theory, also known as First-order Shear Deformation Theory (FSDT) [35],

$$\begin{cases} u(\alpha,\beta,z) = u_0(\alpha,\beta) + z\,u_1(\alpha,\beta) \\ v(\alpha,\beta,z) = v_0(\alpha,\beta) + z\,v_1(\alpha,\beta) \\ w(\alpha,\beta,z) = w_0(\alpha,\beta) \end{cases} \qquad (13)$$

Be that as it may, these speculations, because of their irregularity in disposing of the cross over typical pressure in the material constitutive conditions, are presently not substantial when 3D nearby impacts show up. Among these, extending impacts are dismissed in CLT and FSDT models in light of the fact that the cross over.

Equivalent Single Layer Theories

Many endeavors have been made to work on old style plate/shell models. The CUF has the capacity to extend every dislodging variable in the removal field at any ideal request freely from the others and concerning the precision and the computational expense has been presented. Such a stratagem grants us to treat every factor freely from the others. This turns out to be incredibly helpful when multifield issues are explored, for example, thermoelastic and piezoelectric applications. On account of Equivalent Single Layer (ESL) models, a Taylor extension is utilized as thickness capacities:

$$\boldsymbol{u} = F_0\boldsymbol{u}_0 + F_1\boldsymbol{u}_1 + \ldots + F_N\boldsymbol{u}_N = F_s\boldsymbol{u}_s, \qquad s = 0, 1, \ldots, N. \qquad (14)$$

$$F_0 = z^0 = 1, \quad F_1 = z^1 = z, \quad \ldots, \quad F_N = z^N. \qquad (15)$$

Following this approach the displacement field can be written as:

$$\begin{cases} u(\alpha,\beta,z) = u_0(\alpha,\beta) + z\,u_1(\alpha,\beta) + \ldots + z^N\,u_N(\alpha,\beta) \\ v(\alpha,\beta,z) = v_0(\alpha,\beta) + z\,v_1(\alpha,\beta) + \ldots + z^N\,v_N(\alpha,\beta) \\ w(\alpha,\beta,z) = w_0(\alpha,\beta) + z\,w_1(\alpha,\beta) + \ldots + z^N\,w_N(\alpha,\beta) \end{cases} \qquad (16)$$

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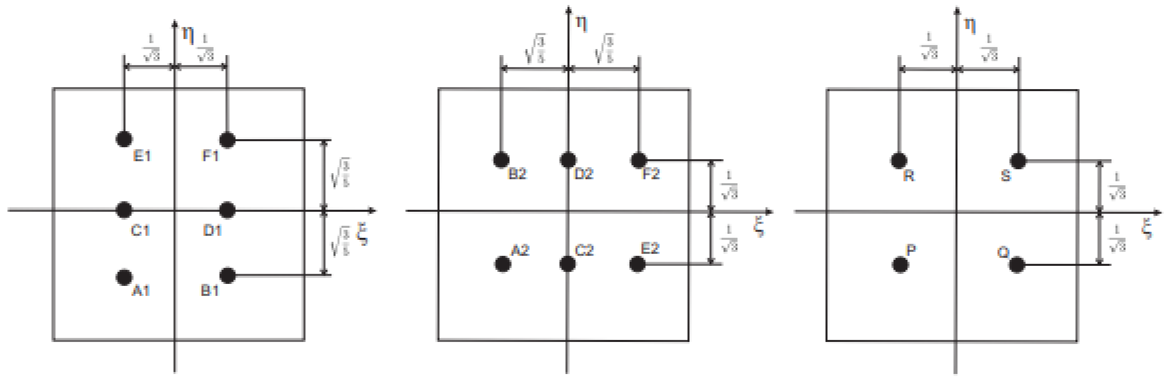

Components $\varepsilon_{\alpha\alpha}$ and $\varepsilon_{\alpha z}$ Components $\varepsilon_{\beta\beta}$ and $\varepsilon_{\beta z}$ Components $\varepsilon_{\alpha\beta}$

Figure 4: Tying points for the MITC9 shell finite element.

In general:

$$\begin{cases} u(\alpha,\beta,z) = F_0(\alpha,\beta) + F_1\, u_1(\alpha,\beta) + \ldots + F_N\, u_N(\alpha,\beta) \\ v(\alpha,\beta,z) = F_0(\alpha,\beta) + F_1\, v_1(\alpha,\beta) + \ldots + F_N\, v_N(\alpha,\beta) \\ w(\alpha,\beta,z) = F_0(\alpha,\beta) + F_1\, w_1(\alpha,\beta) + \ldots + F_N\, w_N(\alpha,\beta) \end{cases} \quad (17)$$

Traditional models, for example, those in view of the Firstorder Shear Deformation Theory (FSDT), can be gotten from an ESL hypothesis with N = 1, by forcing a consistent cross over relocation through the thickness by means of punishment procedures (that is, the level of opportunity given by the direct piece of the cross over dislodging is punished by appointing boundless worth to the comparing term in the corner to corner of the solidness network). Likewise a model in light of the speculations of Classical Lamination Theory (CLT) can be communicated through the CUF by applying a punishment method to the constitutive conditions (the punishment is here applied to the shear modulus in the grid of the material coefficients). This licenses to force invalid cross over shear strains in the shell.

Conclusions

This paper has managed the static examination of composite shells through a limited component in light of the Unified Formulation via Carrera. An appraisal of the component has been performed by breaking down basically upheld cross-utilize plates, tube shaped and circular shells under sinusoidal warm burden with both determined warm profiles (addressing the Fourier heat conduction condition) and accepted direct temperature profile. The outcomes have been

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introduced as far as both cross-over relocations and cross over shear stresses, for different thickness proportions and curve proportions. The exhibitions of the shell component have been tried, and the various hypotheses (old style and refined) contained in the CUF have been looked at. The shell component is without locking, for all the LW and ESL models considered. The outcomes combine to the reference arrangement by expanding both the lattice and the request for extension of the relocations in the thickness course.

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