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Analysis of Self-Balanced Thermal Stresses in Long Flat Rectangular Isotropic Plates

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ABSTRACT

The presence of nonlinear temperature distributions, very common in structures such as spaceships, supersonic aircrafts, industrial furnaces, among others, induces the emergence of self-balanced thermal stresses. However, a unified procedure that allows a rapid and efficient determination of thermal stresses in structures under adverse temperature variations is rarely found in technical literature. This article aims to present the formulation for the determination of self-balanced thermal stresses and thermal strains in long flat rectangular plates that are isotropic and free of external loads at their ends, as well as the comparison of the results of this formulation, with results obtained through the application of the finite element method. The plate in question is extremely thin, thus, it is considered that the plate is working in plane stress state. The expressions for the stress and strain fields are obtained through a very well-known equation in the literature given by [1] and obtained alternatively by [2]. In this analysis, it will be considered basic simplifying assumptions arising from the condition of distribution of self-balanced thermal stress, where the resulting efforts are zero in the plate cross section and, in addition, it will be considered an approximate temperature field, in polynomial format, which will represent the non-linear temperature distribution acting along the width of the plate. Thus, the stress and strain fields shall be determined using the polynomial coefficients related to the approximate polynomial field that represents the temperature distribution. The comparison of the approximate analytical results, obtained for the thermal stress and thermal strains, with the corresponding results from the numerical analysis by the finite element method, showed a high level of accuracy for points away from the free ends. Therefore, based on the methodology proposed in this work, the stress and strain fields, arising from a non-linear thermal variation, can be calculated quickly and accurately using the coefficients of the polynomial that represents the approximate temperature field acting in the plate.

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