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复合材料厚板双轴非线性刚度特性分析

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Nonlinear Stiffness Analysis of Thick Composite Laminate Under Biaxial Load

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摘要 基于非线性本构关系与厚板理论,研究了一种采用增量步迭代法对复合材料厚层合板渐进失效过程进行双轴刚度特性分析的方法。以三维Hashin失效准则为单层板失效判据,当层合板中有一层或多层被检测到失效时,对失效层进行刚度折减,并在增量过程中不断更新刚度矩阵。采用有限元软件MSC.Patran自带的编程语言PCL,编写了计算程序。应用该程序分别对不同材料和不同铺层的层合板算例进行非线性刚度计算,给出了不同的铺层和材料组合下层合板在不同载荷比下的应力-应变曲线,展示了层合板渐进失效过程中应力-应变的变化关系,为复合材料厚板失效分析过程中的刚度变化提供理论与计算依据。

关键词： 非线性本构模型 厚板理论 刚度折减 渐进失效 双轴加载

Abstract： An incremental solution method based on thick laminate theory coupled with a nonlinear constitutive model is applied to the stiffness analysis of thick composite laminates under biaxial load during progressive failure calculation. The 3D Hashin criterion is employed to predict the failure of the individual plies in the laminates. Degradation is performed when failure is predicted and the stiffness of the laminates is updated step by step during the incremental solution. A program written in PCL (Patran Command Language, the secondary development language of commercial FEM software MSC.Patran) is employed to analyze the nonlinear stress-strain variation for different laminates with various materials. The process of progressive stiffness analysis in this paper provides the foundation for stiffness variation analysis during the failure process of thick composite laminates.

Keywords： nonlinear constitutive model thick laminate theory stiffness degradation progressive failure biaxial load

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