航空学报
ACTA AERONAUTICA ET ASTRONAUTICA SINICA
ISSN 1000-6893
CN 11-1929/V

航空学报 » 2013, Vol. 34 » Issue (8) :1832-1845 DOI: 10.7527/S1000-6893.2013.0319

双向梯度复合材料裂纹尖端应力强度因子研究

陈康, 许希武, 郭树祥

南京航空航天大学 机械结构力学及控制国家重点实验室, 江苏 南京 210016

Stress Intensity Factors at Crack Tips in Two-directional Graded Composites

CHEN Kang, XU Xiwu, GUO Shuxiang

State Key Laboratory of Mechanics and Control of Mechanical Structures, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China

摘要 | 参考文献 | 相关文章

Download: PDF (8642KB) HTML 0KB Export: BibTeX or EndNote (RIS) Supporting Info

摘要

为了进一步改善梯度复合材料力学分析及设计水平,推导了一种适用于双向梯度复合材料断裂特性分析的梯度扩展单元法(XFEM)。采用细观力学方法描述材料沿梯度方向变化的力学属性,通过线性插值位移场给出了4节点梯度扩展单元随空间位置变化的刚度矩阵,建立了结构的连续梯度有限元模型,并采用交互能量积分计算得到了裂纹尖端的应力强度因子(SIF)。通过与已有文献结果对比验证了梯度扩展单元的优越性,并讨论了双向梯度结构中相关参数对SIF的影响规律,得到结论:梯度扩展单元能够提高梯度材料中裂纹尖端SIF的计算精度,其计算结果随着网格密度的增加迅速收敛于精确解;双向梯度结构的组份分布形式和属性梯度能够明显影响裂纹尖端的SIF;对于多裂纹双向梯度结构,裂纹间的相互作用增大了裂纹尖端的SIF,弹性模量大的一侧SIF较大。

关键词： 双向梯度复合材料 有限单元法 应力强度因子 梯度扩展单元法 交互能量积分

Abstract:

To further improve the level of mechanical analysis and design of graded composites, a graded extended finite element method (XFEM) is proposed for fracture characteristic analysis in two-directional graded composites whose varying properties along gradient directions are predicted by a micromechanics method. The spatially varying stiffness matrices of 4-node graded extended finite elements are calculated by linear interpolation of displacement fields and a continuous gradient finite element model is established. The stress intensity factors (SIFs) of crack-tip are finally calculated by the interaction energy integral method. The superiority of graded XFEM is verified through comparison with relevant literature. Furthermore, the influence of material parameters on SIFs in two-directional graded structures is discussed in detail. The calculation accuracy of SIFs can be obviously improved by graded XFEM and the results converge to accurate solutions quickly as mesh density increases. The SIFs in two-directional graded structures can be markedly affected by constituent distribution and property gradients. In two-directional graded structures with multiple interior cracks, the SIFs are enlarged by the interaction between cracks and are larger at positions with higher elastic modulus.

Keywords: two-directional graded composite finite element method stress intensity factor graded extended finite element method interaction energy integral

Received 2012-09-17; published 2012-12-24

Fund:

国家自然科学基金(11272146)

Corresponding Authors: 许希武 Email: xwxu@nuaa.edu.cn

About author: 陈康 男,博士研究生。主要研究方向:工程问题的力学建模与数值仿真。Tel:025-84891780 E-mail:chenkang@nuaa.edu.cn;许希武 男,博士,教授,博士生导师。主要研究方向:复合材料结构力学,飞行器结构完整性评定技术和计算力

Service

把本文推荐给朋友

加入我的书架

加入引用管理器

Email Alert

RSS

作者相关文章

陈康

许希武

郭树祥

学。Tel:025-84896588 E-mail:xwxu@nuaa.edu.cn

引用本文:

陈康, 许希武, 郭树祥. 双向梯度复合材料裂纹尖端应力强度因子研究[J]. 航空学报, 2013, 34(8): 1832-1845.DOI: 10.7527/S1000-6893.2013.0319

CHEN Kang, XU Xiwu, GUO Shuxiang. Stress Intensity Factors at Crack Tips in Two-directional Graded Composites[J]. Acta Aeronautica et Astronautica Sinica, 2013, 34(8): 1832-1845.DOI: 10.7527/S1000-6893.2013.0319