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基于粒子滤波算法的疲劳裂纹扩展预测方法

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A Fatigue Crack Growth Prediction Method Based on Particle Filter

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摘要 参考文献 相关文章

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摘要

针对飞机故障预测和健康管理系统中提出的损伤扩展预测与结构剩余寿命管理的要求，提出了一种粒子滤波与结构健康监测方法相结合的结构疲劳裂纹扩展预测方法。首先采用ABAQUS_Python二次开发软件，实现了对裂尖奇异单元网格的自动划分，进而得出不同裂纹长度、角度下裂纹尖端处的应力强度因子幅，提出采用二参数的Paris规则建立粒子滤波的状态方程，即损伤及寿命的扩展演化模型；采用基于压电元件和主动Lamb波的结构健康监测方法，实时观测更新裂纹信息并同粒子滤波算法相结合，建立了粒子滤波的观测方程。疲劳载荷作用下的裂纹扩展实验结果表明，20 000次循环载荷后预测裂纹扩展长度误差在2%以内。本文方法可以有效预测结构裂纹的扩展，消除Paris规则预测裂纹扩展的误差累积及工程应用中多种不确定性的影响。

关键词： 疲劳裂纹扩展 粒子滤波算法 结构健康监测 故障预测与健康管理 有限元分析

Abstract:

Prognostics and health management systems in aircraft pose requirements for damage propagation prediction and structure residual life management. In this paper a method is proposed for predicting fatigue crack propagation based on the particle filter and structural health monitoring. First the crack-tip singular element mesh is generated by using ABAQUS_Python secondary development software and then the crack tip stress intensity factor range of different crack lengths and angles is calculated, while the two parameters Paris rules are used as the state equation of the particle filter, which is the damage propagation and life evolution model. By using the method of structural health monitoring based on piezoelectric elements and active Lamb waves, the state of the crack can be updated online, and combined with the particle filter, an observation equation is established. The experimental results show that the error of crack length after 20 000 load cycles is less than 2%. The method proposed in this paper can effectively predict crack propagation, and eliminate the error accumulated by Paris rule prediction and reduce various uncertainties in engineering application.

Keywords: fatigue crack propagation particle filter algorithm structural health monitoring fault prognostics and health management finite element analysis

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