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固体力学与飞行器设计

考虑模糊失效准则的结构疲劳寿命可靠性

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Reliability Analysis of Structure Fatigue Life Under Fuzzy Failure Criteria

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摘要 针对常规设计中对功能函数失效状态规定与常识不符这种情况，提出了考虑模糊失效准则的结构疲劳寿命可靠性,将结构寿命视为随机变量，而设计寿命视为模糊变量，研究了设计寿命服从线性L-R分布时的结构疲劳寿命可靠度，给出了随机载荷下结构疲劳寿命概率密度函数的确定方法，并提出了随机变量与模糊变量相组合时的一种新的可靠度数值计算方法，该方法先利用Gauss-Legendre积分将模糊可靠度求解的二次积分转换成一次积分，列出与Legendre多项式零点相对应的阀值，然后在给定的阀值下，将设计寿命转化成普通的截集区间，在截集区间内假定结构疲劳寿命概率密度函数服从均匀分布，利用Monte Carlo模拟得到对应于该阀值的结构疲劳寿命可靠度值。数值结果表明，常规设计下结构的疲劳寿命可靠度偏于危险。

关键词： 模糊失效准则 疲劳 可靠性 Gauss-Legendre积分 Monte Carlo模拟

Abstract： In view of the fact that the failure state of the performance function in the traditional design is often inconsistent with common sense, a reliability model of fatigue life which takes into consideration the fuzzy failure criteria is presented. The fatigue life and the fatigue design life are treated respectively as a random variable and a fuzzy random variable, and reliability is analyzed when the fatigue design life obeys linear L-R distribution. The probability density function of fatigue life under random load is deduced. A new numerical algorithm for fuzzy reliability analysis with random variables and fuzzy variables is developed. The double integration to calculate fuzzy reliability is first reduced to univariate integration by use of Gauss-Legendre integration. Thresholds corresponding to Gauss-Legendre abscissas are listed, and the fatigue design life is truncated to the subset under the given threshold. Then the probability density function of fatigue life is supposed to be of uniform distribution in the truncated subset. The reliability of structure fatigue life corresponding to the threshold can be obtained using Monte Carlo simulation. Numerical results show that the fuzzy reliability analysis of fatigue life tends to provide more safety than traditional analysis does.

Keywords： fuzzy failure criterion fatigue reliability Gauss-Legendre integration Monte Carlo simulation

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