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民机客舱下部吸能结构分析与试验相关性研究

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Correlation Study of Crash Analysis and Test of Civil Airplane Sub-cabin Energy Absorption Structure

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摘要

以民机典型机身段客舱下部结构为研究对象,建立了结构坠撞有限元模型,利用LS-Dyna软件进行了结构能量吸收特性分析。基于吸能结构思想,以降低传递到客舱地板的加速度载荷为设计目标,提出了一种民用飞机客舱地板下部结构吸能设计方法。设计制造了全尺寸的吸能结构试件,并进行了垂直坠撞试验。为评估坠撞分析与试验的相关性,提出了一种基于能量的能量吸收特性评估方法。首先对预试验分析结果与试验结果进行了相关性分析,根据相关性分析结果对分析模型进行了修正。修正后坠撞分析结果与试验结果的相关性表明,乘员质心处的平均加速度响应峰值误差为16.44%,最大平均反弹速度误差为10.53%,修正后模型的总体刚度与实际结构一致,分析获得的结构总体变形模式与试验结果基本一致。但能量吸收时间和加速度峰值出现的时间与试验结果相比误差较大,表明结构连接失效等结构建模细节对计算结果有显著的影响。

关键词： 民用飞机 吸能设计 吸能结构 坠撞试验 适坠性

Abstract:

A finite element crash model of a typical civil airplane sub-cabin structure is developed and then a structural energy absorption analysis is conducted with the LS-Dyna code. An energy absorption design method is introduced based on energy absorption structure concept to minimize the cabin floor acceleration response. Then a full-scale test article is designed and manufactured, and a drop test is conducted to verify the design features and the modeling method. A correlation evaluation method based on energy is introduced, and the finite element model is updated after the correlation analysis between the pre-test analysis results and the test results. The updated analysis results show good agreement with the test results. The error of the average peak acceleration response at the centroid of the simulated occupant is 16.44%, and the error of the average maximum rebound velocity of the model is 10.53%. The global deformation modes of the test and simulation also fit well. But the error of the energy absorption duration and time when the peak acceleration appears are fairly large, which indicates that certain structural modeling features, such as the structural joint dynamic failure mode, have significant impact on the computational results.

Keywords: civil airplane energy absorption design energy absorption structure drop test crashworthiness

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