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超声速飞机低声爆布局混合优化方法研究

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Hybrid Optimization Approach Research for Low Sonic Boom Supersonic Aircraft Configuration

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摘要

声爆精确预测及低声爆设计方法已成为新一代军民用超声速飞机研制过程中必须解决的关键难题之一。将改进后的SGD(Seebass-George-Darden)反设计方法、声爆预测算法与遗传算法相结合,形成低声爆布局混合优化方法,利用遗传算法对SGD参数进行优化,得到具有较低声爆超压值和较大有效容积的等效截面积分布,进而得到低声爆布局方案。构建了低声爆混合优化设计环境,可以对方案的声爆水平、感觉噪声级、机体有效容积以及等效截面积分布等进行计算分析,在总体设计阶段具有较高的工程实用价值。优化后的方案采用连翼布局,钝形机头设计,优化后方案的声爆超压值降低了14.51%,机体有效容积增加了15.08%。由于尾部激波强度的不同,地面声爆感觉噪声级随滚转角的变化呈现先变小、后变大、再变小的趋势,对于尾部声爆波形还需进一步优化研究,以降低感觉噪声级。

关键词： 超声速飞机 计算气动声学 气动布局 多目标 反设计 激波 声爆

Abstract:

High fidelity sonic boom prediction and low sonic boom design methods are key technologies of next generation supersonic aircraft. By coupling a modified SGD (Seebass-George-Darden) method, a high fidelity sonic boom prediction method and a Pareto genetic algorithm, a hybrid optimizing approach is developed. The parameters of the SGD method are optimized and an equivalent area distribution with a lower sonic boom overpressure and large available volume can be obtained. By using the optimized equivalent area distribution, a low boom layout can be designed. A low sonic boom configuration mixed optimizing environment is developed, which integrates sonic boom analysis, perceived loudness analysis, available volume calculation and equivalent area distribution generation. The low sonic boom configuration mixed optimizing environment can be used in the conceptual design phase. The optimized layout is a joint wing configuration with a blunt nose. The sonic boom overpressure decreases by 14.51% and the available volume increases nearly 15.08%. Due to the different strengths of the after shock wave, the relationship between the PLdB and roll angle is complex. The after shock of the sonic boom should be optimized in future work for mitigating PLdB.

Keywords: supersonic aircraft computation aeroacoustics aerodynamic configuration multi-objective inverse design shock wave sonic boom

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