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

航空学报 » 2013, Vol. 34 » Issue (2) :263-272 DOI: 10.7527/S1000-6893.2013.0030

基于机翼气动设计准则的超临界机翼气动优化研究

杨昆淼, 张卫民, 王斌

中国航天空气动力技术研究院 空气动力应用技术研究发展中心, 北京 100074

Research of Supercritical Wing Optimization Based on Aerodynamic Design Principle of Wing

YANG Kunmiao, ZHANG Weimin, WANG Bin

Aerodynamics Research and Development Center, China Academy of Aerospace Aerodynamics, Beijing 100074, China

摘要

机翼的气动特性决定了一架飞机的经济性、安全性、舒适性以及环保性,而机翼的气动设计问题十分复杂,需要满足合理的机翼气动设计准则,才具有工程实用价值。基于计算机辅助工程(CAE)的机翼优化设计方法需要较少的人力成本,但无法保证气动设计准则得到满足,其结果仍需大量的后续修改工作。因此,当前实际工程应用中,机翼的设计仍然在很大程度上依赖于设计人员的经验,需要大量的人力。为了提高机翼优化设计结果的工程实用价值,进而减少后续人工设计工作量,提高机翼气动设计的效率。首先对机翼表面压力分布进行分析;然后根据机翼气动设计准则,在传统升阻特性目标函数的基础上,构造新的目标函数;最后将这个新的目标函数代入优化过程。研究结果表明:升阻特性难以全面地描述机翼的气动特性,以其为目标函数无法保证设计结果满足气动设计准则,不具工程实用价值;而根据机翼气动设计准则构造的目标函数能够在优化过程中保证设计准则得到满足,有效提高设计结果的工程实用价值;同时,与传统直接以升阻特性为优化目标的优化过程相比,该方法引入的额外计算量可以忽略不计。

关键词: 机翼 气动设计准则 压力分布 优化 计算机辅助工程

Abstract:

The aerodynamic characteristics of an wing play a critical role in the economics, safety, comfort and environmental protection of an aeroplane. However, the aerodynamic design processes are highly complicated, which should follow principles of wing aerodynamic design to obtain practical engineering value. Computer-aided engineering (CAE) based wing optimization requires less manpower, yet it may not guarantee that the design principles are observed and its results still call for a great deal of subsequent processing. Thus, in recent engineering applications, the aerodynamic design process adopted still relies highly on the experiences of the designers, which means a large amount of manpower. The purpose of this research is to improve the practical engineering value of the wing optimization results, so as to reduce the amount of subsequent processing and improve the efficiency of the wing design process. It first analyzes the wing surface pressure distribution. And then, according to the wing aerodynamic design principles, a new objective function is constructed based on the traditional objective functions determined from lift and drag characteristics. Finally, the new objective function is substituted into the optimization process. The results of this optimization are in keeping with the principles of aerodynamic design of the wing, and possess practical engineering value. Compared with traditional optimization processes, whose objectives are determined by lift and drag characteristics only, the method introduces hardly any additional time cost. The research results show that the lift and drag characteristics cannot comprehensively describe the aerodynamic characteristicss of the wing. Therefore, the objective functions based on them cannot guarantee the design principles to be followed, which makes them of little value in practical engineering application. On the contrary, the objective function which is constructed according to the wing aerodynamic design principles can guarantee the design principles to be followed in the optimization process, and efficiently improve the practical engineering value of the design results.

Keywords: wing aerodynamic design principle pressure distribution optimization computer-aided engineering

Received 2012-02-03; published 2012-04-06