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

航空学报 » 2014, Vol. 35 » Issue (1) :132-140 DOI: 10.7527/S1000-6893.2013.0333

周向平均方法在某风扇/增压级分析中的应用

万科, 朱芳, 金东海, 桂幸民

北京航空航天大学 能源与动力工程学院 航空发动机数值仿真中心, 北京 100191

Application of Circumferentially Averaged Method in Fan/Booster

WAN Ke, ZHU Fang, JIN Donghai, GUI Xingmin

Aeroengine Numerical Simulation Research Center, School of Energy and Power Engineering, Beihang University, Beijing 100191, China

摘要

通过对三维（3D）Navier-Stokes方程进行周向平均，得到了通流模型的控制方程，对其采用时间推进有限体积方法进行数值求解。为实现风扇/增压级在设计初期的快速性能评估，考察了周向平均方法在风扇/增压级分析中的准确性。分别利用NUMECA三维数值模拟软件和周向平均通流模型（CAM）对某高通流风扇/增压级进行了性能分析，从对比结果来看，周向平均通流模型在近设计点给出了与三维数值模拟十分接近的特性参数，最大误差不超过2.0%。在风扇转子中，由于周向平均通流模型能捕获通道激波，其物理本质与三维平均结果有所区别，因此径向参数分布与三维有所差异。而在亚声速流动下的增压级及外涵道各叶片排出口参数的径向分布与三维数值模拟结果都能很好地吻合。

关键词： 通流模型 周向平均 风扇/增压级 性能 数值模拟

Abstract:

The governing equations of a throughflow model are derived by circumferentially averaging the three-dimensional (3D) Navier-Stokes equations, which are solved using a time marching finite volume approach. In order to rapidlly obtain the performance predictions and flow fields of fan/booster in the preliminary design stage, the rebiability of circumferentially averaged method (CAM) is investigated. A high throughflow fan/booster is evaluated by 3D numerical simulation NUMECA and a circumferentially averaged throughflow model. The results reveal that the performance predicted by NUMECA at the near design point is very close to the 3D results, with a maximum error under 2.0%. As the passage shock can be captured by circuferentially averaged method in the fan, which is physically at variance with the 3D averaged results, the total pressure ratio and adiabatic efficiency radial distributions are somewhat different from the 3D computation results. In the subsonic flow, the radial distributions of blade rows in the booster and bypass fit well with the 3D simulation results.

Keywords: throughflow model circumferentially averaged fan/booster performance numerical simulation

Received 2013-04-09; published 2013-07-15

Fund:

国家自然科学基金（50736007，51006005，51236001）

Corresponding Authors: 桂幸民，Tel.：010-82339387 E-mail：guixm@buaa.edu.cn Email: guixm@buaa.edu.cn

About author: 万科 男，博士研究生。主要研究方向：叶轮机周向平均方法。Tel：010-82316082 E-mail：wanke328@126.com；朱芳 女，博士研究生。主要研究方向：风扇/增压级气动设计。Tel：010-82316082 E-mail：zhufang@sjp.buaa.edu.cn；金东海 男，博士，副教授。主要研究方向：风扇/压气机气动优化设计、数值模拟。Tel：010-82339391-109 E-mail：jdh@buaa.edu.cn；桂幸民 男，教授，博士生导师。主要研究方向：高负荷跨声压气机流动机理，气动设计技术与数值模拟，实验测试技术。Tel：010-82339387 E-mail：guixm@buaa.edu.cn

引用本文:

万科, 朱芳, 金东海, 桂幸民. 周向平均方法在某风扇/增压级分析中的应用[J]. 航空学报, 2014, 35(1): 132-140.DOI: 10.7527/S1000-6893.2013.0333

WAN Ke, ZHU Fang, JIN Donghai, GUI Xingmin. Application of Circumferentially Averaged Method in Fan/Booster[J]. Acta Aeronautica et Astronautica Sinica, 2014, 35(1): 132-140.DOI: 10.7527/S1000-6893.2013.0333