屠秋野,陈劼,蒋平,严红明,蔡元虎.压气机过渡段造型及三维数值模拟[J].航空动力学报,2015,30(6):1414~1422

压气机过渡段造型及三维数值模拟

Geometric modeling and 3-D numerical simulation for gooseneck of compressor

投稿时间：2013-12-25

DOI： 10.13224/j.cnki.jasp.2015.06.017

中文关键词: 过渡段 造型 S形曲线 总压损失 三维数值模拟

英文关键词: gooseneck geometric modeling S-shaped polynomial curve total pressure loss 3-D numerical simulation

基金项目:

作者	单位
屠秋野	西北工业大学 动力与能源学院, 西安 710072;先进航空发动机协同创新中心, 北京 100191
陈劼	西北工业大学 动力与能源学院, 西安 710072;先进航空发动机协同创新中心, 北京 100191
蒋平	中国航空工业集团公司 商用航空发动机有限责任公司, 上海 200241
严红明	中国航空工业集团公司 商用航空发动机有限责任公司, 上海 200241
蔡元虎	西北工业大学 动力与能源学院, 西安 710072;先进航空发动机协同创新中心, 北京 100191

中文摘要:

提出一种基于S形曲线压气机过渡段造型方法.该方法将过渡段造型归结为S形内壁曲线拐点相对位置,面积分布率极值及其极值点相对位置3个几何控制因素.并采用此方法构造了一系列压气机过渡段,并针对这些过渡段进行三维数值模拟.结果表明:面积分布率极值是影响过渡段性能最重要的因素;可以通过调整面积分布率极值来控制过渡段最大面积处相对马赫数,减小外壁气流附面层厚度及支板形成的低压尾迹区;同时,配合变化较陡的内壁造型和合理的面积分布率曲线极值点相对位置,可以改善外壁形状,抑制附面层变厚.对于所研究的过渡段,内壁拐点相对位置为0.18,面积分布率极值点相对位置为0.20,相对马赫数为0.65时,总压损失最小.

英文摘要:

The employed S-shaped polynomial curves as the basis of the gooseneck of compressor geometric modeling. The method used the relative location of S-shaped inflection point of inner wall curve, the peak point and its value of the area distribution rate to control the gooseneck geometrics modeling. A series models were constructed from the baseline gooseneck modeling to analyze with 3-D numerical simulation. The results indicate that the peak value of area distribution rate has the most important effects on the total pressure loss of gooseneck. An relative Mach number can be obtained by changing the peak value of area distribution in order to reduce the flow separation near the outer wall and after the struts.Meanwhile inner walls with large curvature near the entrance of gooseneck modeling, and area distributions rate with an appropriate position of peak point can improve the streamline of outer wall. For example, the total pressure loss of gooseneck reached its minimum at relative location of inflection point of inner wall of 0.18, and relative location of peak point of area distribution rate of 0.20 at relative Mach number of 0.65.

参考文献(共17条):

[1] Ortiz D C,Miller R J,Hodson H P,et al.Effect of length on compressor inter-stage duct performance[R].ASME Paper GT2007-27378,2007.

[2] Willin F,Eriksson L E.Response surface-based trandition duct shape optimization[R].ASME Paper GT2006-90978,2006.

[3] Ghisu T,Molinari M,Parks G T,et al.Axial compressor intermediate duct design and optimization[R].AIAA-2007-1868,2007.

[4] 阙晓斌,侯安平,周盛.基于壁面压力梯度控制的压气机S形过渡段设计[J].航空学报,2010,31(3):459-465. QUE Xiaobin,HOU Anping,ZHOU Sheng.S-shaped compressor transition duct design based on wall pressure gradient control[J].Acta Aeronautica et Astronautica Sinica,2010,31(3):459-465.(in Chinese)

[5] 阙晓斌,侯安平,周盛.轴流压缩系统带支板过渡段的轴对称等效方法[J].航空学报,2010,31(9):1715-1722. QUE Xiaobin,HOU Anping,ZHOU Sheng.Axisymmetric equivalent of S-shaped transition duct with struts in axial compression systems[J].Acta Aeronautica et Astronautica Sinica,2010,31(9):1715-1722.(in Chinese)

[6] 张国臣,徐志晖,张秉龙,等.双涵道S形弯管气动性能的数值研究[J].沈阳航空航天大学学报,2011,28(2):30-34. ZHANG Guochen,XU Zhihui,ZHANG Binglong,et al.Numerical investigation of the aerodynamic performance of a twin-branch S-shaped duct[J].Journal of Shenyang Aerospace University,2011,28(2):30-34.(in Chinese)

[7] 高丽敏,冯旭栋,陈璇,等.关于压气机过渡段设计方法的探讨[J].航空学报,2013,34(5):1057-1063. GAO Limin,FENG Xudong,CHEN Xuan,et al.Exploration about compressor intermediate duct design[J].Acta Aeronautica et Astronautica Sinica,2013,34(5):1057-1063.(in Chinese)

[8] Gillis J C,Johnston J P.Turbulent boundary-layer flow and structure on a convex wall and its redevelopment on a flat wall[J].Journal of Fluid Mechanics,1983,135(10):123-153.

[9] Barlow R S,Johnston J P.Structure of a turbulent boundary layer concave surface[J].Journal of Fluid Mechanics,1988,191(7):137-176

[10] Lee C C,Louis S,Boedicker M C.Subsonic diffuser design and performance for advanced fighter aircraft[R].AIAA 85-3073,1985.

[11] 屠秋野,胡伟瀚,陈劼.S形进气道中心线方程构造及其影响的研究[J].航空工程进展,2013,4(3):98-102. TU Qiuye,HU Weihan,CHEN Jie.S-shaped intake central line equation construction and study of its implications[J].Advances in Aeronautical Science and Engineering,2013,4(3):98-102.(in Chinese)

[12] Ladson C,Brooks C.Development of a computer program to obtain ordinates for NACA 4-digit,4-digit modified,5-digit,and 16-series airfoils[R].NASA TM X-3284,1975.

[13] Eriksson L E.Development and validation of highly modular flow solver versions in G2DFLOW and G3DFLOW series for compressible viscous reacting flow[R].Goteborg,Sweden:Volvo Aero Corporation,1995.

[14] Wilcox D C.Turbulence modeling for CFD[M].La Ca ada, CA:DCW Industries Incorporated,1998.

[15] 周莉,韦威,蔡元虎.离心压气机级串列叶栅扩压器内流场的数值研究[J].航空动力学报,2012,27(11):2562-2568. ZHOU Li,WEI Wei,CAI Yuanhu.Numerical investigation on flowfield of centrifugal compressor with tandem cascade diffuser[J].Journal of Aerospace Power,2012,27(11):2562-2568.(in Chinese)

[16] 崔健,程朝青,杨春,等.多级轴流压气机子午流道堵塞面积律[J].航空动力学报,2010,27(11):2520-2527. CUI Jian,CHENG Zhaoqing,YANG Chun,et al.Blockage area rule for multi-stage axial compressor meridional channel[J].Journal of Aerospace Power,2010,27(11):2520-2527.(in Chinese)

[17] Abdellatif O E.Experimental study of turbulent flow characteristics inside a rectangular S-shaped diffusing duct[R].AIAA-2006-1501,2006.

[3] 刘晓波,彭文启,刘静玲,华祖林,王雨春.基于POM模式的感潮河段三维水动力模拟[J].水力发电学报,2009,28(1).
[4] 谢彦文.某压气机内部三维流场数值模拟研究[J].上海汽轮机,2014(3):209-211.
[5] 田涛,孟宪举.卫生洁具三维数值模拟[J].河北理工大学学报（自然科学版）,2008,30(1):89-91,95.
[6] 田涛,孟宪举.卫生洁具三维数值模拟[J].河北理工学院学报,2008(1).
[7] 刘建平,陈茂兵.水力旋流器的三维模拟[J].绿色科技,2013(12):274-276.
[8] 赵海,吴换营,蔡付林,徐进超.分段低压自流输水系统中无压连接段水力特性三维数值模拟[J].水电能源科学,2010,28(9).
[9] ZHAO Ying-wu,王如根,WAN Chun-shan.压气机三维流场数值仿真及湍流模型研究[J].微计算机信息,2008,24(25).
[10]张涛,李文平,林刚.金属管材冷旋压成形过程的三维有限元数值模拟[J].锻压技术,2003,28(2):31-32.
[11]李玲,陆亚钧.叶片安装角槽式轮毂处理的三维数值模拟[J].航空动力学报,1998,13(1):99-102,112.
[12]秦绪国,刘沛清,屈秋林,徐婕.三维多段机翼地面效应数值模拟[J].航空学报,2011,32(2):257-264.
[13]顾阳,蹇兴东,耿国盛,纪明民.高速切削加工的三维数值模拟[J].工具技术,2010,44(6):38-41.
[14]彭强.压力恢复系统超声速扩散段三维流场数值模拟[J].强激光与粒子束,2002,14(3):349-352.
[15]姚建达 范维澄.三维离散传播辐射模型的理论及数值分析[J].燃烧科学与技术,1995,1(3):264-267.
[16]侯恩科,吴立新,李建民,吴育华,董荣泉,邓智毅,刘宏军.三维地学模拟与数值模拟的耦合方法研究[J].煤炭学报,2002,27(4):388-392.
[17]马福喜 王金瑞.三维水流数值模拟[J].水利学报,1996(8):39-44.
[18]李勇明,赵金洲,郭建春.考虑缝高压降的裂缝三维延伸数值模拟[J].钻采工艺,2001,24(1):34-37.
[19]朱军政.强潮海湾温排水三维数值模拟[J].水力发电学报,2007,26(4):56-60,55.
[20]段杰辉,高德申,王晓松,张贝贝.一个模拟密度分层流特征的改进三维数值模型[J].中国水利水电科学研究院学报,2009,7(3):206-210.