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TBCC进气道变几何泄流腔研究

Study of variable geometry bleed cavity of TBCC inlet

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作者	单位
张华军	南京航空航天大学 能源与动力学院, 南京 210016 ; 中国人民解放军驻四二〇厂军事代表室, 成都 610503
郭荣伟	南京航空航天大学 能源与动力学院, 南京 210016
谢旅荣	南京航空航天大学 能源与动力学院, 南京 210016

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中文摘要:

提出了一种用于内并联型涡轮基组合循环(TBCC)进气道全马赫数范围的可变几何泄流腔方案,给出了可变几何泄流腔的设计方法;研究了泄流腔及其几何特征参数对进气道流场特征和气动性能的影响,获得了几何特征参数对进气道气动性能的影响规律.最后,采用三维流场数值模拟手段,对泄流腔可变形面参数随飞行马赫数 Ma_0 的调节规律和进气道在全马赫数范围内的气动特性进行了研究,结果表明:泄流腔开启之后,随着 Ma_0 的增加,泄流腔进口宽度和喉道高度不断减小,且均呈前急后缓的减小趋势;在 $Ma_0 \leq 2.0$ 和 $Ma_0 \geq 2.5$ 时,泄流腔进口前角均随 Ma_0 的增加而减小;当 $Ma_0 \leq 2.5$ 时,进气道的总压恢复系数均在0.8以上,当 $2.5 < Ma_0 \leq 4.5$ 时,进气道的总压恢复系数均在0.3以上,符合进气道总体方案的要求;冲压模式下,冲压通道的出口马赫数均小于0.4,出口静压均大于0.5个标准大气压(50.6625kPa),均能满足冲压燃烧室的燃烧需求.结合高速风洞试验研究结果,印证了可变几何泄流腔方案的可行性.

英文摘要:

Scheme of variable geometry bleed cavity which was used in over/under type of turbine-based combined cycle(TBCC) inlet in full Mach number range and its design method were presented. The characteristic of inlet flow field and the inlet aerodynamic performance affected by bleed cavity and the configuration of cavity geometry parameters were investigated, based on which the law of inlet aerodynamic performance affected by cavity geometry parameters was obtained. Three-dimensional numerical simulation of over/under type TBCC inlet with bleed cavity was performed. The paper presents the influence of free stream Mach number on variable geometry design parameters, and aerodynamic characteristics of the inlet in full Mach range. Once the bleed cavity is opened, the width of the cavity entrance and the height of the throat keep decreasing. The decreasing rate is very high at the beginning, but becomes relatively low later. When the free stream Mach number is lower than 2.0, or higher than 2.5, the leading angle at the entrance of the bleed cavity is decreasing as the increase of Mach number. When the free stream Mach number is less than 2.5, the total pressure recovery of the inlet is beyond 0.8. When the free stream Mach number is from 2.5 to 4.5, the total pressure recovery of the inlet is beyond 0.3. The aerodynamic characteristics of the inlet meet the demands of the scheme. At ramjet mode, the exit Mach number of the ramjet diffuser is all below 0.4 and the exit pressure of the ramjet diffuser is all beyond 0.5 standard atmosphere pressure(50.6625kPa). The ramjet diffuser can fulfill the combustion condition of the ramjet combustion chamber. The feasibility of the variable geometry bleed cavity scheme was confirmed by the numerical and wind tunnel test results.

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