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Influence of High-temperature Air on Three-dimensional Nozzle Structure Design

Bu Junhui*, Liu Huaiyin, Wang ying & Sun Yongtang

China Academy of Aerospace Aerodynamics, 100074, Beijing, China

Abstract

In this paper, the exit diameter of nozzle is Φ 1.4 m, and the Mach number is 4.0; the nozzle is used in high-speed free jet wind tunnel for engine test with high temperature and pressure air and the mixture of heater combustion as working medium; The mixture is high temperature gas, mainly contains CO2 ,N2 and H2O. In the process of nozzle structural design, consider the interaction of radiation heat transfer and convection heat transfer fully; heat transfer problems aimed at the nozzle in complex gas, solid, liquid multiphase flow, form the calculation model of the radiation- convection - steady state – convection. Calculated by engineering and Ansys methods, The results show that, the convection heat transfer has an important effect on the air- surface by the high-temperature air in the entrance and the thorat of nozzle; Convection heat has a great influence on the air-surface temperature distribution of nozzle. It must be applied to the solution of temperature field in the nozzle structure design.

A great deal of experiments show that, the temperature of the nozzle entrance and exit on the air-surface is close to the calculation results. The experimental results show that the nozzle works very well. In this paper, the calculation is described in details. The teat transfer calculation and some typical experimental results of three-dimensional nozzle and the photographs of the nozzle are also presented.

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Keywords: Convection heat transfer;Three-dimensional nozzle; Structure;Flow field.

1. Introduction

Since the arms race tend aerospace, Due to the increased difficulty of optimization of aircraft shape, some

* Corresponding author. Tel.: +86- 18811069098; .
E-mail address: bjhht11@163.com

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countries are committed to the development of high performance engine. The development process of the engine needs a lot of simulation test on the ground, the test technology is complex and costly, so each country attaches importance to the construction and testing technology of test facility. Due to the high temperature, high pressure and the poor working condition in the engine testing platform , design of the structural components become the difficulty of engine testing platform. In this paper, the exit diameter of nozzle is Φ 1.6 m, and the Mach number is 4.0, and the design temperature of this nozzle is 875 k, and the design pressure 2.2 MPa. The nozzle is used in high-speed free jet wind tunnel for engine test with high temperature and pressure air as working medium. It is different from the conventional nozzle design of wind tunnel, it uses high temperature and pressure air and the mixture of combustion as working medium, The mixture is high temperature gas, mainly contains CO_2 and H_2O. Through the establishment of radiation - convection - steady - convection model, combine with ansys to calculate the result, We can get the conclusion that the radiant heat of nozzle inlet section has a major effect on temperature distribution of the nozzle shell, we must be introduced into the temperature field solution during the nozzle structure design. Through the above conclusions, we can obtain relevant evidence and algorithms in the similar situations with nozzle structure design.

2. The structural scheme of the supersonic nozzle

The supersonic nozzle is used in high-speed free jet wind tunnel for engine test with high temperature and pressure air as working medium, the exit diameter of nozzle is Φ 1.6 m, and the Mach number is 4.0, and the design temperature of this nozzle is 875k, the maximum flow of airflow is 230kg/s and the design pressure 2.2MPa, and the work hour is less than 90 seconds. The initial structure scheme of the nozzle uses cooling water for the design, the thickness of shell is 3mm and the material is 0Cr18Ni10Ti, The material has good flexibility and strength and thermal conductivity below 400 ℃, and it is used for the initial nozzle with much density of heat flow. The stainless steel shell has 5mm wide cooling water channel, and it is connected through the half shell. The Main effect of outer shell bear internal pressure, the presser of the inner shell is passed to the outer shell by half shell part. and cooling water only pieces of the inner shell and half of them run. half parts using 0Cr18Ni10Ti materials, the cooling water is only running between the inner shell and half shell, the material of the half shell is 0Cr18Ni10Ti and the initial part of nozzle is shown in Fig.1,2.

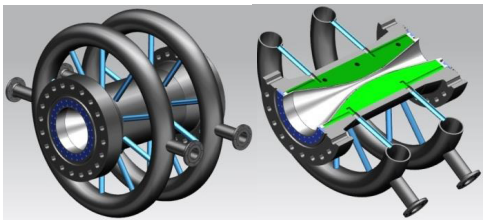

Fig. 1. The first section of the supersonic nozzle

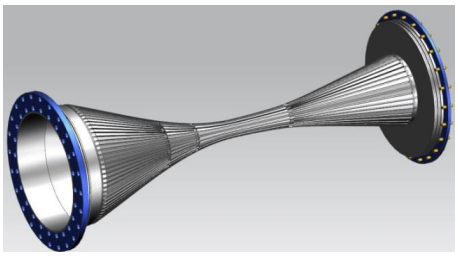

Fig. 2. The inner shell with cooling channel