ANALYSIS OF HYPERSONIC VISCOUS FLOW ABOUT BLUFF CYLINDERS PLACED ONE AFTER ANOTHER

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Abstract

The flow structure about two bluff cylinders placed one after another in hypersonic viscous flow has been studied. The grid equations approximated the Navier-Stokes equations were solved numerically by application of the implicit monotonized scheme of second-order accuracy, the modified Newton's method, and the Christoffel-Schwarz grid-transformation technique. The similarity conditions of developing fully subsonic zone with recirculating between the cylinders have been discussed. The changes of temperature, pressure and velocity fields in the wakes behind the cylinders, as well as skin friction and heat flux along cylinder surfaces have been analyzed.

Nomenclature

Q = vector of dependent variables, Eq. (1)
q = heat flux vector
Re = Reynolds number, \( \rho u r / \mu \)
r = radius of the cylinder
T = temperature
u, v = \( x \)- and \( y \)- velocity components
x, y = Cartesian coordinates
\( \gamma = \) specific heat ratio, \( c_p / c_v \)
\( \Delta = \) distance between the cylinders
\( \eta = \) curvilinear coordinate
\( \lambda_i = \) eigenvalue
\( \mu = \) viscosity coefficient
\( \zeta = \) curvilinear coordinate
\( \rho = \) density of fluid
\( \tau = \) viscous stress tensor
\( \tau_{\varepsilon} = \) regularization parameter, Eq. (11)

Subscripts

c = Cartesian coordinate system
w = wall value
\( \infty = \) freestream value

Introduction

The structure of incompressible viscous flow between the cylinders in tandem was studied in detail by many researchers (i.e., see a review of Blevins'). It was found that drag on downstream cylinder was very sensitive to the distance between the centers of cylinders, \( \Delta \), and it even changed sign at \( \Delta r < 2 \). The case of compressible viscous flow between the cylinders has not been discussed yet. The Reynolds number can play a fundamental role in studying aerothermodynamic characteristics of the bluff bodies. In