AIAA 2006-7962

On the Performance of AUSM based Schemes in Hypersonic Flow with Equilibrium Gas Effects

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The numerical schemes for hypersonic flow simulation require robustness, accuracy and efficiency. Hypersonic flow problems intrinsically have severe viscous dissipation in a boundary layer and strong shock waves and high enough temperature to violate perfect gas law. In this paper the numerical simulation of 2D steady laminar hypersonic flow is considered. The Navier-Stokes equations are employed, together with curve fit data of Srinivasan and Tannehill for equilibrium properties of air. Explicit first order cell centered finite volume is applied for discretization and AUSMD, AUSM+ and AUSMPW+ are used for inviscid fluxes to show robustness and accuracy of AUSM based solvers, and central difference approximate the viscous terms, and complete formulation to apply for both structured and unstructured grid is developed. Three test cases are studied; hypersonic flow with equilibrium gas effects over flat plate, wedge and blunt body to assessed their capabilities in hypersonic flowfields with equilibrium gas effects. Finally results obtained for these test cases are compared with validated references.

Nomenclature

A	=	Control volume area
a	=	sound speed
c_p	=	specific heat coefficient in constant pressure
c_v	=	specific heat coefficient in constant volume
e	=	internal energy
E	=	total internal energy per unit volume
h	=	enthalpy
H	=	total enthalpy per unit volume
K	=	heat conduction coefficient
L	=	reference length
M	=	Mach number
p	=	pressure
Pr	=	Prandtl number
q	=	heat flux
R	=	universal gas constant
Re	=	Reynolds number
t	=	time
T	=	temperature
u	=	velocity component in x direction
v	=	velocity component in y direction
γ	=	specific heat coefficients ration for perfect gas
$\tilde{\gamma}$	=	specific heat coefficients ration for equilibrium gas
μ	=	viscosity coefficient
ρ	=	density
τ	=	stress tensor
$\vec{F}$	=	vector of convection flux

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