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AN INNOVATIVE THERMAL PROTECTION SYSTEM WITH OPPOSING JET THROUGH EXTENDED NOZZLE AND FILM COOLING FOR REUSABLE LAUNCH VEHICLES

Abstract

Reduction of aerodynamic heating of RLV is one of the key factors for designing reusable launch vehicles (RLV) or hypersonic cruise vehicles. In order to reduce the aerodynamic heating, these vehicles must have thermal protection system (TPS). TPS are classified into the passive cooling and the active cooling. Active cooling method is expected to be more reusable for RLV. Innovative thermal protection systems with opposing jet through extended nozzle and film cooling for reusable launch vehicles has been proposed by the present authors. At first the method with opposing jet through extended nozzle, which is attached to the top of semi-sphere surface, is experimentally tested in high enthalpy flows. Flow Mach number is 6.6, unit Reynolds number is 1.1 x 105 and pitot pressure is 27kPa at high enthalpy mode of 23 MJ/kg. Experiments have been conducted by changing extended nozzle length from 0 to L/D=1 (where L is length of the nozzle and D is diameter of semi-sphere model) and total pressure of opposing jet. The results show significant reduction of aerodynamic heating has been realized when higher total pressure of opposing jet is applied with moderate longer length of extended nozzle. Also the same flow fields have been simulated by solving axisymmetric Navier-Stokes equations. Numerical results also show good agreements with experiments. Also numerical results are quite useful to understand the flow mechanism to realize reduction of aerodynamic heating with opposing jet through extended nozzle. The opposing jet, which is injected from extended nozzle, pushes back bow shock wave against upstream and moves flow reattachment point of dividing stream line on the body surface downstream region. Also injected coolant gas tries to cover the front surface of the body. Also experimental study of film cooling in high enthalpy flow has been conducted. Two-dimensional flat plate whose front nose is semi-circular configuration, is set in high enthalpy flow of 20.5 MJ/kg. At the shoulder of semi-circular configuration coolant gas of helium is injected parallel to free stream and surface heat flux distributions on the flat plate is measured. The results show film cooling in high enthalpy flows are quite effective especially in attached flow area. For reduction of aerodynamic heating in separated region opposing jet through extended nozzle is quite effective and for reduction of aerodynamic heating in attached flow region film cooling is quite effective in high enthalpy flows.Also those combination will be highly recommended.