Paper ID: 31742
oral

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Interactive Presentations (IP)

Author: Dr. Daixian Zhang
China Aerodynamics Research and Developement Center, China, dxzhang_iaf@sina.com

Mr. Yong Huang
China Aerodynamics Research and Developement Center, China, yhuang_iaf@sina.com
Mr. Yubiao Jiang
China Aerodynamics Research and Developement Center, China, ybjiang_iaf@sina.com
Mr. Guoqiang Li
China Aerodynamics Research and Developement Center, China, gqli_iaf@sina.com

NUMERICAL INVESTIGATIONS ON AERODYNAMIC DRAG REDUCTION OF HIGH ALTITUDE AND HIGH SPEED VEHICLES USING AN ENERGY DEPOSITION METHOD

Abstract

Characteristics of air flow over flight vehicles at high altitude(∼50 km) and high speed(Ma=0∼20) are investigated numerically for a direct insight into the mechanisms of aerodynamic drag reduction sustained by an energy deposition. An energy deposition model is performed to charaterize the energy release into air plasmas. And a Park's two-temperature model is adopted to denote the non-equilibrium between translational-rotational energy mode and vibrational-electronic energy mode in the air plasmas. To solve the control equations a combination of AUSM^{+}-up and LU-SGS schemes is implemented and a dual-time-step implicit method is performed to increase the temporal accuracy. The dynamic evolution of air flow sustained by energy deposition is simulated and the effect of Mach number on drag reduction is focused on. It is indicated that the location of peak pressure near wall will move downstream due to energy deposition and the values of peak pressure will drop soon after several times of fluctuations. Besides, up to 65% of aerodynamic drag is reduced when the Mach numbe is 5; however, only 14% reduction of aerodynamic drag is observed with a Mach number of 20. Consequently, the influence of energy deposition on air flow will become weaker relatively with the increment of Mach number. In addition, the time interval needed for a disturbance wave induced by energy deposition arriving at a bow shock is decreased with the increment of Mach number and a much swifter recovery of stability is observed in a flow of higher Mach number. The similarity and regularity of drag evolution curves are observed in simuation results. It is indicated that probable technical methods can be developed for building the communication links between a communication station and a flight vehicles during reentry blackout. A concept of building reentry blackout communication using a pulsed laser energy deposition method is introduced.