SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

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NUMERICAL ANALYSIS OF WAVE DRAG REDUCTION BY ENERGY DEPOSITION IN HYPERSONIC FLOW

Abstract

Wave drag, caused by the bow shock of blunt bodies, became an increasingly big portion of total body drag of today's hypersonic vehicles. How to reduce the wave drag aroused great interests in recent years. In this paper, we explored the wave drag reduction method of laser energy deposition by numerical analysis. Firstly, computational model was set up to simulate the bow shock before a hemisphere. The standoff distance and the stagnation pressure were compared well with the theoretical value and experimental data. Then, a single energy pulse was deposited instantaneously in the flow field before the bow shock. A blast wave was formed around the heated spot and convected downstream toward the bow shock. The process of blast wave expansion and interaction with the bow shock was simulated. The results showed that the normal part of the bow shock moved upstream when interacted with the blast wave, and thus reduced 3% of the time-averaged stagnation pressure. Lastly, repetitive energy pulse deposition was simulated. The results showed that, with the increase of the pulse frequency, the blast waves interacted with each other and formed a conical-shaped shock wave around the hemisphere, which acted like a virtual aero-spike. The time-averaged stagnation pressure was reduced to 67% of the original value, and thus the wave drag could be greatly reduced.