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Preliminary Investigation of Limits of Shock Train Jumps in a Hypersonic Inlet-Isolator

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Abstract: During the acceleration process of an air-breathing propulsion vehicle, when the Mach number is closed to the transition point of the combustion mode, the drag force increases and thrust-to-drag reduces. Thus, equivalence ratio and higher values of heat release are demanded. A shock train will form in an isolator and will climb upstream as the backpressure increasing. In now days, a jumping characteristic was found as the shock train climbs upstream, while the deep mechanism is still not clear. Few works focus on the limits that trigger a jumping of the shock train. This paper aims to investigate the boundary of the trigger condition for it, which is named as the limits of a shock train jumps. Numerical study was carried out in a Mach 5 inlet-isolator model, and the shock train jumping movements were captured. The results indicate a local throat-like shape was formed by the separated flow at the head of the shock train, and the contraction ratio of the local throat-like shape was reduced to a small value when shock train jumping occurred. Based on the numerical data, the minimum value of the contraction ratio was discussed with flow physics. The reason that the head of a shock train jumps upstream with separation zone was discussed by a theoretical analysis, which assumed that the core flow is compressed through an oblique shock, normal shock, and returns to sonic at the local throat that formed by the throat-like shape at the head of the shock train. Then, a coefficient of correction was set for the minimum value of the local contraction ratio, which is used to improve the robustness of this analytical method. At last, the analysis method for limits of shock train jumps was employed for the experimental results. The phenomenon that a varied contraction ratio of a local throat-like shape was reproduced in the experiment and the analysis method in this paper was validated.

Keywords: limit, shock train, jump, inlet- isolator

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