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ORIGINAL ARTICLE

Z. M. Hu · R. S. Myong · Y. R. Yang · T. H. Cho

Reconsideration of inviscid shock interactions and transition phenomena on double-wedge geometries in a $M_\infty = 9$ hypersonic flow

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Abstract Shock polar analysis as well as 2-D numerical computation technique are used to illustrate a diverse flow topology induced by shock/shock interaction in a $M_\infty = 9$ hypersonic flow. New flow features associated with inviscid shock wave interaction on double-wedge-like geometries are reported in this study. Transition of shock interaction, unsteady oscillation, and hysteresis phenomena in the RR $\leftrightarrow$ MR transition, and the physical mechanisms behind these phenomena are numerically studied and analyzed.

Keywords Shock/shock interaction · Hypersonic · Double wedge · Hysteresis · Oscillation

1 Introduction

The flow about a hypersonic vehicle is generally characterized by the intense shock waves, thin boundary layers, and their mutual interactions. These flow phenomena can be very critical in the aerodynamic point of view, especially for the increase and unsteadiness in aerodynamic forces and heating loads. One of the important aerodynamic issues associated with supersonic/hypersonic flight is the shock/shock interaction phenomena which has gained attention since Ernst Mach reported two different shock wave reflection configurations in the late 1870s. The possible dependence of the shock interaction pattern on the preceding variations in the flight velocity of a supersonic/hypersonic aircraft should be accounted for in designing intakes and flight conditions.

Despite the remarkable advances in hardware and software for CFD tools and extensive ground test facilities, to completely study a hypersonic flow problem is impossible. On the one hand, there is no single ground-based facility capable of duplicating the hypersonic flight environment. Two of the severely restricted parameters that may be flowfield-related are the total temperature and the Reynolds number of the freestream flow. On the other hand, without sufficient ability to adequately represent hypersonic flow experimentally, the challenge for hypersonic CFD predictions becomes even more difficult because substantial experimental data for a variety of flows and flight conditions are not available [1]. Key issues for CFD related to hypersonic aerodynamic design, such as high-temperature effects, heating, turbulence, and viscous interactions, are not well modelled by CFD thus far. In this article, inviscid shock/shock interactions on double-wedge geometries are studied via analytical and numerical methods.

Shock/shock interactions on double-wedge-like geometries in hypersonic flows are considered a fundamental research problem related to hypersonic flight. Edney [2] used shock polar diagrams and classified

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Z. M. Hu · R. S. Myong (✉) · Y. R. Yang · T. H. Cho
Department of Mechanical and Aerospace Engineering, Research Center for Aircraft Parts Technology,
Gyeongsang National University, Jinju 660-701, South Korea
E-mail: myong@gnu.ac.kr

Z. M. Hu
E-mail: bighumin@126.com