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Invited Lecture: Aerothermal Concepts for Configuration Design of Lifting Body of Hypersonic Reusable Vehicle

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Abstract

The aerothermal analysis of a Hypersonic Reusable Vehicle (HRV) is of greater interest than its aerodynamic analysis. The convection coefficient, wall heat flux (q''_w), and wall temperature (T_w) on aero-thermally critical surfaces are obtained. This study is validated using CFD simulations for obtaining the radiation equilibrium surface temperatures of the lifting body, whose critical surfaces include, stagnation and Swept-Back Leading Edge (SBLE). Convective heat flux to SBLE surface ($q''_{w,SBLE}$) is obtained as a sum of the following the two ($q''_{w,SBLE} = q''_{w,2D-stag} + q''_{w,fp-0°}$): (i) heat flux for 2-D stagnation region ($q''_{w,2D-stag}$) – that incorporates the velocity component normal to the surface (which reduces with increasing sweepback angle, Λ); (ii) heat flux for flat plate at 0°-incidence to the flow ($q''_{w,fp-0°}$) - that incorporates the velocity component parallel to the surface (which increases with increasing Λ). The results reveal that there exists a temperature-minimized-sweepback angle ($\Lambda_{HT\text{-}min}$), which differs in concept and value from the drag-minimized sweepback angle ($\Lambda_{Drag\text{-}min}$). The results also illustrate that beyond a certain Λ ($\Lambda_{trans}\sim 60°$), sharpening the radius of SBLE-surface (r_{SBLE}) reduces T_w. This effect observed for $\Lambda>\Lambda_{trans}$, is termed as the Thermally Benign Sharp SBLE Effect, which peaks approximately at, (Λ_{trans}+90°)/2.

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Shripad P. Mahulikar is a Professor in the Department of Aerospace Engineering, Indian Institute of Technology Bombay (IIT-B). He obtained B.Tech. & integrated M.Tech. (by research) in Aerospace Engineering from in 1990 and 1991, respectively. Thereafter he worked in Defense Research & Development Organization, India, as Scientist 'B' & 'C' from 1992 – 1995. He then migrated to Australia & began working as Research Associate in the Australian National University Canberra. He then moved to Nanyang Technological University, Singapore, to continue research on micro-flow, where he earned Ph.D. in 1999. He received the A. von Humboldt Fellowship (in 2003, 2007, 2009), the Outstanding Reviewer Award from the ASME Journal of Heat Transfer (in 2007), and DFG-Mercator Chair Professorship in Hamburg University of Technology (Dec'2011 – Dec'2012). He is recently nominated for the Finland Distinguished Professorship program for his research in, Non-Equilibrium Thermodynamics of Dissipative Structures.