

3rd International Conference and Exhibition on Mechanical & Aerospace Engineering

October 05-07, 2015 San Francisco, USA



Ramesh K Agarwal

Washington University, USA

Shape optimization of axisymmetric bodies in hypersonic reactive flow for minimizing drag and heat transfer

A large design concern for high-speed vehicles such as next generation launch vehicles or reusable space vehicles is the drag and heat transfer experienced at hypersonic velocities. In this paper, the optimized shapes for minimum drag and heat transfer for axisymmetric bodies are developed using Computational Fluid Dynamics (CFD) software in conjunction with a multi-objective genetic algorithm. For flow field calculations, the commercial flow solver ANSYS FLUENT is employed to solve the unsteady compressible Reynolds Averaged Navier-Stokes (RANS) equations using several turbulence models, namely the Spalart-Allmaras (SA) model, the SST k- ω model and the transfer predictions. The hypersonic body shapes are optimized for minimum drag and heat transfer using a multi-objective genetic algorithm. Both cases with air in equilibrium and thermochemical non-equilibrium are considered. For air in thermochemical non-equilibrium, a seven species (N, O, N₂, O₂, NO, NO+ and e-) chemical reaction model is considered. The shape optimization results for a blunt body with a spherical nose are presented. Nearly 25~30% reduction in drag and 18~20% reduction in heat transfer are due to the fact whether the air is in equilibrium or in non-equilibrium.

Biography

Ramesh K Agarwal is the William Palm Professor of Engineering and the Director of Aerospace Research and Education Center at Washington University in St. Louis. From 1994 to 2001, he was the Sam Bloomfield Distinguished Professor and Executive Director of the National Institute for Aviation Research at Wichita State University in Kansas. From 1978 to 1994, he worked in various scientific and managerial positions at McDonnell Douglas Research Laboratories in St. Louis. He became the Program Director and McDonnell Douglas Fellow in 1990. He received PhD in Aeronautical Sciences from Stanford University in 1975, MS in Aeronautical Engineering from the University of Minnesota in 1969 and BS in Mechanical Engineering from Indian Institute of Technology, Kharagpur, India in 1968. He is the Author and Co-Author of over 400 publications and serves on the editorial board of 20+ journals. He has given many plenary, keynote and invited lectures at various national and international conferences worldwide. He continues to serve on many academic, government, and industrial advisory committees. He is a Fellow of sixteen societies including the Institute of Electrical and Electronics Engineers (IEEE), American Association for Advancement of Science (AAAS), American Institute of Aeronautics (AIAA), American Physical Society (APS), American Society of Mechanical Engineers (ASME), Royal Aeronautical Society and American society for Engineering Education (ASEE). He has received many prestigious honors and national/international awards from various professional societies and organizations for his research contributions.

rka@wustl.edu

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MechAero 2015 October 05-07, 2015