DEPARTMENT OF MECHANICAL ENGINEERING
Purdue School of Engineering and Technology

SPRING 2004 SEMINAR SERIES

Date: Thursday, March 11, 2004
Time: 11:00 am - 12:00 pm
Room: ET 137

Reception at 10:45 am (cookies and refreshments served)
Everyone is invited

Nozzle Flow Characteristics at Ultra-High Pressures

Dr. Charles Merkle
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Abstract. The flow of a perfect gas through a converging-diverging nozzle is a common topic of study in Mechanical Engineering in both undergraduate and graduate classrooms. Many of these familiar characteristics, however, change dramatically when the working fluid has significant real gas effects. In the present talk, which is stimulated by an interest in designing ground test facilities for true enthalpy testing up to Mach 12, we look at the flow characteristics in a wind-tunnel nozzle in which the stagnation pressure exceeds 2000 Mpa. At these conditions, enthalpy is strongly dependent upon pressure as well as temperature and the density of air exceeds that of water. Simulations in this regime require advanced equations of state for air (and demonstrate need for additional properties measurements) and describe unique flow conditions. As compared with a perfect gas, the stagnation temperature in high pressure air rises dramatically, the divergence angle of the supersonic section is very small, Mach number variations are larger, and heat transfer to the walls is very high as is the hazard of wall combustion because of the large partial pressure of oxygen. Results obtained from axisymmetric CFD calculations for both perfect gases and high pressure are compared to understand key phenomena.

About the Speaker. Prof. Merkle received his Ph.D. degree from Princeton after taking the M.S. and B.S. degrees at Rensselaer and Case. He has broad expertise in the fields of fluid dynamics, combustion, propulsion and drag reduction that has included both experimental measurements and computational simulations. Hs career includes more than a decade of experience in industry in both large and small corporations. He was on the faculty at Penn State University from 1979-1997 where he rose through the ranks to become Distinguished Alumni Professor of Engineering. From 1997 to 2003 he served as the H.H. Arnold Chair of Computational Mechanics at UTSI. He assumed his current position in the Fall of 2003. His current research is in Computational Mechanics and includes algorithm development, code implementation and physical applications for a broad range of conditions and working fluids. He works in close collaboration with experimentalists using computational simulations as an aid in designing experiments and interpreting results, while using the results for code validation and extension.