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Book Review

Combustion in High Speed Flows

Edited by J. Buckmaster, T. L. Jackson, and A. Kumar, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1994, 643 pp., $225.00

This book consists of papers presented at a meeting in 1992, organized by NASA Langley, on the subject of "Combustion in High Speed Flows," and a very interesting discussion at the end by an invited panel of well-known engineers and researchers. The purpose of the meeting was to give NASA a better understanding of some of the problems of hypersonic propulsion from discussion with university research people and government contractors, and to develop a better working relationship between them.

The 21 papers and 42 authors included cover the subjects of experiments, reacting shear layers, detonations, ignition structure, and unsteady behavior. The collection of papers will provide the reader with an overview of the confusion in the field of hypersonic propulsion that confronts NASA, university research, and contractors to the Government. What is the plan? A result of this lack of focused effort is that each group is working on a specialty of its own with little cohesive contribution to practical propulsion.

Because of the high cost of experimental work, and the fantastic advances in computer technology, the problem solution of choice is most often a computer model. But the question remains, is the answer realistic? It may be, if it can be checked against experimental data. But where are the experimental data? This question was debated by a Conference Panel in the last section of the book, and is candidly reported, word for word. We are listening to people who are outstanding in their fields, who are speaking their minds about the papers that were presented, and the real problems that they see. To quote the summary of the panel discussions, "The value of simple experiments designed specifically to aid modelling efforts—the scientific approach—is a recurring theme." A simplified theoretical approach is suggested which can be experimentally demonstrated, then modeled by computer.

The following are comments on a few selected papers.

Dennis Bushnell's keynote paper is an excellent description of many of the problems of hypersonic propulsion, including the lack of testing facilities. He also indicates that there is a performance division line between diffusion combustion and oblique detonation wave combustion as Mach number increases. He recognizes the difference between detonation wave and shock-initiated combustion, and the importance of chemical kinetics at the higher Mach numbers and expected flight path.

There are four papers on experimental and theoretical analyses of mixing in a supersonic stream. The major application would most likely be for diffusional burning.

A paper by G. F. Carrier et al. describes the use of a series of laser pulses in premixed fuel and air to produce an oblique shock detonation. The results to date offer some promise and need further examination.

Hertzberg et al. discuss ram accelerator experiments in the range of Mach 3 to 8.5. Accelerating thrust was obtained. More important, they were able to correlate theoretical results with test results. The work suggests that the ram accelerator may be another way of producing hypersonic conditions without making a big change in the air composition, as most ground test facilities do.

It is of considerable concern to the writer, and it was brought out by Paul Libby and others, that at least some of the problems of supersonic flow with combustion were experimentally explored in the 1960s, reported in SAE and AIAA journals and others, and almost totally ignored in today's investigations. One attendee at the Conference was quoted as saying that oblique-shock detonations have not been experimentally demonstrated. Not so, oblique-shock detonation, otherwise known as shock-initiated combustion or shock-induced combustion, has been experimentally demonstrated. In several papers, emanating from a small research group at AEDC, oblique shock-induced combustion was produced for a single shock, with upstream injected premixed fuel, and for a two-shock arrangement that simulated the inlet to a scramjet. (See Rubins, P. M., and Bauer, R. C., "Review of Shock-Induced Supersonic Combustion Research and Hypersonic Applications," *Journal of Propulsion and Power*, Vol. 10, No. 5, 1994, pp. 593–601.)

The book provides a good summary of the state of technology in producing a NASP aircraft, and many of its problems. Unfortunately, most of the authors of the papers presented appeared to be not sufficiently cognizant of the research of the 1960's, which could have answered at least some of their questions. In either case, the technical problems of hypersonic propulsion are tremendous. However, in the opinion of the writer, the concept of premixed combustion offers several physical and chemical advantages at the higher Mach number range, which should be explored in greater depth before the decision is made to design a flying vehicle. This subject was touched on by the panelists, but not considered as a serious alternative to the present day diffusion combustion research efforts.

Overall, the book will give the reader a glimpse into the current state of hypersonic propulsion research and development, and offer suggestions as to directions for future research. Efforts by NASA and other agencies to promote similar technical conferences should certainly be encouraged.

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