ADVANCED BALLISTIC RANGE TECHNOLOGY

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Introduction

Optical images, such as experimental interferograms, schlieren, and shadowgraphs, are routinely used to identify and locate features in experimental flow fields and for validating computational fluid dynamics (CFD) codes. Interferograms can also be used for comparing experimental and computed integrated densities. By constructing these optical images from flow-field simulations, one-to-one comparisons of computation and experiment are possible. During the period from February 1, 1992, to November 30, 1992, work has continued on the development of CISS (Constructed Interferograms, Schlieren, and Shadowgraphs), a code that constructs images from ideal- and real-gas flow-field simulations. In addition, research connected with the automated film-reading system and the proposed reactivation of the radiation facility has continued.

CISS

The three codes that were used to create optical images from two-dimensional, three-dimensional, and axisymmetric flow-field solutions have been consolidated into one code, the CISS code. With the assistance of Adrian Borja of San Jose State University, CISS has been incorporated into FAST, a flow-field imaging code. CISS has been used for a wide variety of flow-field simulations, and it has been used to predict the visibility of flow features at test conditions. An estimate of the errors introduced by the approximations used in the image construction has also been completed. This work is detailed in Ref. 1.

Film Reading

Work on the automated film-reader has been reported in Ref. 2. Also included in this paper is a discussion of the importance of reducing measurement errors by improving the film-reading accuracy and by removing the systematic errors that are introduced by facility calibration errors. The effect of these systematic errors can be minimized by maintaining a history of the residual errors (the difference between the experimental and calculated trajectories) and then by subtracting these errors from the experimental data.

Reactivation of the Radiation Facility

Free-flight facilities, such as the radiation facility at NASA Ames Research Center, can be used for a wide variety of scientific studies ranging from impact studies to flow visualization and radiation measurements. Currently, the aero range at NASA Ames Research Center is unavailable for these types of studies due to testing in the 16-inch shock tunnel; the radiation facility can not be used since it is not operational. To preserve free-flight test capabilities at NASA Ames, the feasibility of reactivating the radiation facility has been investigated.

A two-phase reactivation was considered. The first phase included renovation of the pumps, rotary pistons, and roots, mounting the light-gas gun onto the gun rail, fabrication and installation of a minimal test section, and installation of an existing model catcher. Most of the required instrumentation is either available or can be borrowed from the aero facility. It was proposed that one shadowgraph station be activated.

With this minimal expenditure of funds and personnel, the ballistic range capabilities at NASA Ames Research Center could be maintained, and the expertise required for operating this type of facility could be preserved. The reactivated radiation facility could be used for instrumentation development and for a wide range of scientific studies, including flow-field visualization, surface measurements, and impact studies. Radiation studies could also be performed by adding elements, such as argon, to the test gas.

In the second phase of the reactivation, a shock tunnel for counterflow would be added, and the combined velocity of the model and counterflow would be on the order of 11-12 km/sec. This would allow radiation studies to be performed without the addition of contaminants. The gun would be optimized, allowing for better performance, and more shadowgraph stations would be added so that some estimate of the dynamics of the model could be obtained.

Currently, part of the first phase of the reactivation is being performed under the direction of Robert J. Miller of the Thermo-Physics Facilities Branch at NASA Ames Research Center. A small test section with no shadowgraph capabilities is being installed. With this level of reactivation, only impact testing will be possible.

Future Work

A user's manual for CISS will be written, and this manual and the code will be distributed to other researchers. This distribution will be used for testing the assumptions and algorithms used in CISS. Furthermore, continuing assistance in the installation of CISS into FAST will be provided.

For the reactivation of the radiation facility, design studies for the final system will continue. Calculations will be used to estimate the intensity of the radiation at varying test conditions, and the counterflow portion of the radiation facility will be designed to provide appropriate test conditions for radiation studies.

Boundary-layer and swerve estimates will be used to define the diameter and shape of the test section, and methods for improving the performance of the light-gas gun will be investigated. In addition, new shadowgraph and more accurate timing systems will be designed for both the aero and radiation facilities.

References

1. Leslie A. Yates, "Images Constructed from Computed Flow Fields," AIAA Paper 92-4030, presented at the AIAA 17th Aerospace Ground Testing Conference, Nashville, TN, July 1992.

2. Leslie A. Yates, "Development of an Automated Film-Reading System for Ballistic Ranges," AIAA Paper 92-4000, presented at the AIAA 17th Aerospace Ground Testing Conference, Nashville, TN, July 1992.