NASA TECH BRIEF

Ames Research Center

Experimental Verification of Computer Spray-Combustion Models

Analytical models are widely used to study and analyze various aspects of the combustion processes occurring in utility boilers, turbojet engines, rocket engines, and other devices based on combustion of a spray of fuel. Computer-aided studies based on analytical models are especially necessary where experimental testing of full-scale combustion devices is impractical and expensive.

The formulation of an analytical model which represents the complete performance of a spray-combustion device is based on a clear understanding of the processes of atomization, mixing, vaporization, and combustion which occurs in the device. A number of combustion models have been suggested, but the efficacy of their formulations have never been thoroughly verified, primarily because it has not been possible to devise valid experiments in which all pertinent initial and secondary conditions are adequately controlled. For example, up to the present, the vaporization aspects of analytical models of spray combustion have not been verified principally because propellant dropsizes as obtained from actual injectors operating at combustor conditions have not been available. Lack of these data leads to considerable uncertainties in comparisons between the results obtained from computations with the models and actual combustion devices; consequently, the use of analytical models for definition of combustor design has been impaired.

A number of NASA-sponsored programs have generated a considerable body of experimental cold-flow data, relating spray dropsizes to injector design parameters. These data were obtained by spraying molten wax, allowing the droplets to freeze and harden as they pass through air, then collecting, sampling the frozen wax "sprays," and obtaining dropsize distributions by standard sieving techniques. In a subsequent program, the same wax was used as a fuel with gaseous oxygen in an experimental rocket combustor which was equipped with a single, well-characterized like-doublet injection element to avoid problems of adjusting fuel spray dropsizes to accommodate variations in the physical properties of the fuel. Thus, dropsize relationships obtained in prior work could be used in direct comparisons between predicted and experimental combustion behavior; in effect, the comparisons provided a check on the validity of the spray vaporization and droplet formulations in a combustion model.

A report has been prepared in which are listed the results of correlations of computed values with values obtained from experiments with the rocket combustor. Correlations were made as follows: Calculated combustion efficiency parameters for several initial spray-mass-median droplet sizes were superimposed on plots of the experimental parameters vs characteristic chamber length (L^*); there was derived therefrom an "effective" mean droplet diameter with a behavior that matched the experimental burning profile, and then this diameter was compared with the mean dropsize calculated from the empirical correlation for the injector conditions. The agreement was good enough to suggest that the technique offers an excellent method for evaluating the validiy and ranges of applicability of combustion models.

(continued overleaf)

Notes:

1. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference:
   NASA CR-114479, (N72-30959), Study of Spray Disintegration in Accelerating Flow Fields.

2. No additional documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B73-10031

Patent status:

NASA has decided not to apply for a patent.

Source: William H. Nurick of
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