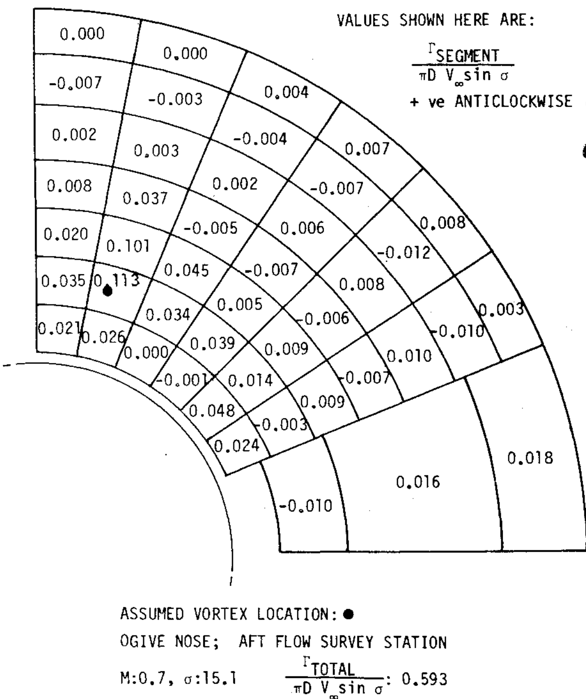

Fig. 3 Distribution of circulation within leeside wake.

information, the relative importance of core and feeding sheet in the leeside quadrant.

Circuit integrations for the ogive nose at $M=1.15$ and $\sigma=15.1$ and 20.7 deg have shown that the vortex feeding sheet can contain 21-35% of the circulation in the leeside area under these conditions for the aft flow survey location. This percentage may be compared with values of 40-60% from tests[1] at higher supersonic Mach numbers. Other results are given in Table 2. Most of the data for Γ_s/Γ_t lie in the range 0.21-0.35. (Subscripts s and t refer to sheet and total values.) The values are more reliable for the aft flow survey location since at that point the development of the flow pattern into a core and feeding sheet was more easily observed. Changes in flow condition are seen to have little systematic effect on the ratio Γ_s/Γ_t.

Concluding Remarks

As part of an effort to improve prediction methods for the aerodynamic characteristics of missiles, flow survey tests have been performed which contribute some new information on the characteristics of symmetric body vortex systems at transonic speeds. The test program has included experiments on a tangent ogive forebody with a high nose semiapex angle and also a body with an ellipsoidal nose.

Values of vortex strength, and vertical and lateral location have been deduced from the velocity vector information obtained in the leeside wake of the body. The relative importance of the feeding sheet and vortex core has been assessed. It was found that the former can contain 21-35% of the circulation in the leeside quadrant.

References

[1] Oberkampf, W.L., "Prediction of Forces and Moments on Finned Missiles in Subsonic Flow," AIAA Paper 79-0365, 17th Aerospace Sciences Meeting, New Orleans, La., Jan. 1979.

[2] Mendenhall, M.R. and Nielsen J.N., "Effect of Symmetrical Vortex Shedding on the Longitudinal Aerodynamic Characteristics of Wing-Body-Tail Combinations," NASA CR-2473, Jan. 1975.

[3] Wardlaw, A.B., "High Angle of Attack Missile Aerodynamics," AGARD-LS-98, March 1979.

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Ignition Delay Studies on Hybrid Propellant Grains

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Introduction

IN hybrid rockets, the propellant grain consists of a mixture of ground solid fuel, finely divided metal powder, fractional percents of additives used for increasing the burn rate, and a polymer as binder. In the past, several hypergolic hybrid fuels associated with nitric acid have been developed and their ignition delays measured as a function of physical and chemical factors.[1-4] However, not much effort was given to the simulation of actual rocket conditions by embedding the hypergolic solid fuels in a binder and measuring the ignition delays. Recently, solid amines[5] have been used with various binders in hypergolic hybrid propellant grains. The hypergolic combustion of propellant grain containing a mixture of tetraformal trisazine and OH-terminated polybutadiene with HNO_3 has recently been reported.[6] The use of several other fuels and binders has been reported in the literature.[7-9]

In the present investigation, the ignition delays of some of the hydrazones embedded in a polymer matrix have been measured as a function of: 1) weight of the propellant grain, 2) polymer binder type, 3) polymer binder loading, and 4) metal loading.

Experimental

Materials

Furfuraldehyde pehnylhydrazone (FPH) was prepared following the procedure described earlier.[2] Formaldehyde phenylhydrazine polymer (FORPH) was prepared by reacting phenylhydrazine with a little excess of formaldehyde solution. The yellow solid mass (polymer type) was separated from the beaker, washed with an alcohol-water mixture and dried in vacuum. Commercially available phenolformaldehyde (PF) was used in the present study. The nitric acid having 91% HNO_3, 7% NO_2, and 2% H_2O by weight was used in all experiments.

Propellant Grains

The polymeric binder, formaldehyde phenylhydrazine or phenolformaldehyde, was melted and mixed with fuel powders until a homogeneous mixture resulted. The mixture was then transferred into a test tube and allowed to solidify at 5°C for three days. The cured propellant grains were cut to size and used in the form of a tablet for measuring ignition delays (ID). The grains are easily processed and have good physical properties. All ID's were measured by using the setup described in Ref. 4.

Results and Discussion

The experimental results showing the minimum ignition delays for furfuraldehyde phenylhydrazone and benzaldehyde phenylhydrazone taken in the polymer matrix are given in Table 1. The FPH/FORPH-HNO_3 system gave the least ID at 300 mg weight of the propellent grain using 0.55 ml of nitric acid.

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