DESIGN OF SLUG CALORIMETERS FOR RE-ENTRY TEST VEHICLES

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ABSTRACT

The slug calorimeter, [1]**,** particularly effective in high heat flux measurements arising in atmosferical re-entry conditions, offers great advantages compared with traditional solutions in terms of cost and durability.

In the Department of Aerospace Engineering (DIAS) of the University of Naples "Federico II" there is a long experience about measurments of the heat fluxes that occur in high enthalpy supersonic flows during the re-entry from space. Such expertise has been achieved mostly designing and testing several types of calorimeters in a small electric-arc wind tunnel named SPES (Small Planetary Entry Simulator) [2].

The paper deals with the design, manufacturing and test of a special version of the slug calorimeter specifically designed for an earth re-entry probe. Functionality, location and design of the calorimeters for the forebody and the afterbody are described. Methods of achieving one-dimensional heat flow in the forebody calorimeter design are covered. For the afterbody calorimeter the optimum design was determined to be a thermally insulated, small diameter, relatively thin disk of high thermal conductivity. The influence of thermocouple size, accuracy of thermocouple placement, heat losses and other considerations are discussed in relation to accuracy of the sensor. Derived equations are presented which may be used to convert the temperature responses into heat flux values.

Preliminary test are planned in the SPES facility to verify the soundness of the sensor design, using a simplified version of the probe instrumented heat-shield.

[1] Standard Test Method for Measuring Heat-Transfer Rate Using a Thermal Capacitance (Slug) Calorimeter, ASTM E457-72, Reapproved 2002.

[2] G. Zuppardi, A. Esposito "Blowdown arc facility for low-density hypersonic wind tunnel testing", Journal of Spacecraft and Rockets, Vol. 38, N.6, pp 946-948, Nov-Dec. 2001.