A BLUNTED CONE IN A SUPERSONIC HIGH-ENTHALPY NONEQUILIBRIUM SUPERSONIC AIR FLOW

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To study heat resistance of materials and their high-melting-point coatings we used the high-enthalpy supersonic wind tunnel VAT-104 (WT). This WT is equipped by an inductive high-frequency heater of the test gas and an Eiffel chamber.

A specific advantageous feature of the gas heating method is the absence of flow contamination. It was experimentally demonstrated that the presence of contaminants in the incoming gas flow can appreciably affect the final result of the heat transfer and durability of the TPM sample. VAT-104 provides high stability of the flow parameters during a long-time experiment (hundreds of seconds), good reproducibility of the flow parameters from one test to another and makes it possible to control flow parameters during the experiment. The plasma generator provides test gas heating to the temperature $T_0 = 5000 - 7000$°C (stagnation enthalpy $i_0 = 10 - 40$ MJ/kg), gas flow rates up to $G = 4$ g/s and stagnation pressures up to $P_0 = 50$ kPa (0.5 bar). The basic parameters of the VAT-104 heater were studied with the use of contact and optical diagnostic methods. It was shown that the translational and rotational temperatures in the wind-tunnel settling chamber coincide within the experimental error (10%).

This study was performed on the side surface of a cone with a bluntness radius R_w = 10 mm and an apex half-angle of 10°. The supersonic nozzle of diameters of critical and exit sections D_k =15 mm and D_e, =49.5 mm respectively and of semi disclosing corner of a supersonic part of a nozzle 15° was used. The stagnation point of the cone model was located at a moderate distance from the nozzle exit: $L = 10$ mm. The model tip was located inside the Mach cone of the jet escaping from the wind-tunnel nozzle approximately up to the length $S_w/R_w = 6$ along the generatrix of cone: those experiment conditions for the high-enthalpy no equilibrium air flow were applied for the first time.

Models used in experiment were made of steel. For the definition of the heat flux distribution q_w model was equipped by heat-capacity gages. Pressure distribution measurements p_w were performed on an identical model in the same points where calorimeters have been established, by means of the induction pressure gauges established into the model. For the distributions measurements of q_w and p_w, we used a specially developed high-speed mechanism. The model was inserted into the flow within 0.2 s. As a result, data on the heat flux and pressure on a canonical body in a no equilibrium supersonic (M = 4) high-enthalpy air flow was derived.

Numerical investigations for the conditions of the tests were performed at the Institute of Mechanics at the Lomonosov Moscow State University. Features of the flow in a heater and near the model in the WT working section were revealed. It has been shown, that calculated values of the heat fluxes on the model surface and pressure and those obtained in WT experiments qualitatively agree.

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