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Upgrade of an arc-heated test facility for ultrafast transitional flow simulation

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Aerodynamic properties are important for the designing of new near-space cruise vehicles, which rely on both numerical simulations and ground tests. For the long-term flying vehicles in upper near-space regime, the precision of rarefied aerodynamic characteristics predicted by numerical simulation largely depends on some uncertain parameters such as surface accommodation coefficients, chemical reaction rates etc. These coefficients still needs experimental measurements and calibrations. However, in these studies, ground simulation of absolute flow velocity is necessary to fulfill the binary scaling law [1], which might be difficult using conventional ground testing facilities, because long-time generation of ultra-high speed flow over 7 km/s requires the ability of continuous high-energy input density in the range of several tens of MJ/kg, together with large vacuum exhaust capacity around 100 m^3/s for a mass flow rate near 0.1 g/s. An arcjet thruster testing system developed in the Institute of Mechanics, CAS has been lately reconstructed, aiming to generate 7 km/s transitional flow over 10 minutes. The vacuum chamber was enlarged to 2.5 m in diameter and 5 m in length. Four cryogenic pumps (leybold CoolVAC10000 and CVI TM500) together with four turbo molecular pumps (KYKY3500) and corresponding backing pumps are equipped, which provide a continuous exhaust capacity of 50 m^3/s for nitrogen flow. The arc heated source is also redesigned to improve the heating efficiency. Flow characteristics of the ultrafast rarefied flow were investigated experimentally. Preliminary experimental results together with discussions will be presented.

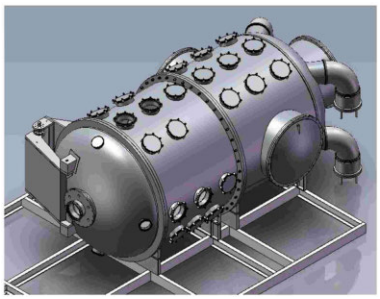

Fig. 1 Schematic illustration of the ground testing system

References

1. Shen C. Rarefied Gas Dynamics, Fundamentals, Simulations and Micro Flows. Springer-Verlag Berlin Heidelberg, Berlin (2005)