Hypersonic and High-Enthalpy Wind Tunnel, Kashiwa, The University of Tokyo

Overview

The predecessors of this facility were the Supersonic Air Flow Laboratory and the High Temperature Air Flow and Combustion Laboratory, which were built in early 1960 at the former Institute of Aeronautical Research, The University of Tokyo (now the Institute of Space and Astronautical Science, JAXA) at Komaba Campus II. In 1989 they were transferred to the Faculty of Engineering, The University of Tokyo. In order to expand education and research on hypersonic (ultrahigh-speed) and high-enthalpy (ultrahigh-temperature) flows, which are frontiers in fluid dynamics, relocation was planned to Kashiwa Campus, where the Graduate School of Frontier Sciences is located. In 2006, a new large-scale experimental facility was inaugurated in the Transdisciplinary Sciences Laboratory building.

Wind tunnel performance

The Kashiwa wind tunnel features a one-heater two-operation mode, merging the hypersonic and combustion wind tunnels of the Komaba era. The heater of the combustion wind tunnel is used for the hypersonic wind tunnel, reducing the installation and operating costs of the facility, and at the same time enabling research on the fusion of high-speed and high-temperature flows.

Table 1: Performance characteristics of the Hypersonic and High-Enthalpy Wind Tunnel, Kashiwa, UTokyo.

Item	Hypersonic WT	Combustion WT
Mach no., *M*	7, 8, 9	2 (user-set)
Nozzle exit	200mm Ø	User-set
P0	1MPa	0.7MPa
T0	600-800°C	Up to 1500°C
Max. Re_D	1.8-4.7×10^5 (nozzle exit Ø)	
Unit Reynolds no.	0.9-2.4×10^4 (cm^{-1})	
Visc. interf. param.	0.01-0.02 ($M/\sqrt{Re_D}$)	
Flow rate	Up to 0.39kg/s	Up to 1kg/s
Ventilation time	30sec	100sec
Model		User-set
Storage pressure	Design pressure 5MPa(G)	
Capacity	4m^3×1	
Heat storage material	Alumina pebbles	
Heating method	City gas burner	
Exhaust	Vacuum chamber, 180m^3 (Ø7m sph. tank)	Open to atm. (muffled exhaust stack)

Features of the facility

This facility is unique in the world, as a hypersonic and high-enthalpy wind tunnel installed in a university for the purpose of student education and research. In the combustion wind tunnel mode, airflow is open to the atmosphere, allowing researchers to conduct experiments freely, including at the nozzle section. The airflow is characterized by a high temperature, is non-plasma, and is aerobic, enabling research not only on flow in high-speed engines, but also on high-temperature materials. In the hypersonic wind tunnel mode, the airflow in the measurement section is characterised by a relatively low Reynolds number despite the high Mach number (see Fig. 1). This means that a special flow environment is generated in which viscous and compressibility effects are counterbalanced. The wind tunnel is therefore suitable for the study of such viscous interference effects, and also opens up new possibilities for the study of flows around various objects flying at high altitudes and very high speeds (e.g. spacecraft and meteorites). Indeed, the viscous interference parameters realised in this wind tunnel cover the most critical flight conditions of atmospheric entry vehicles (see Fig. 2).

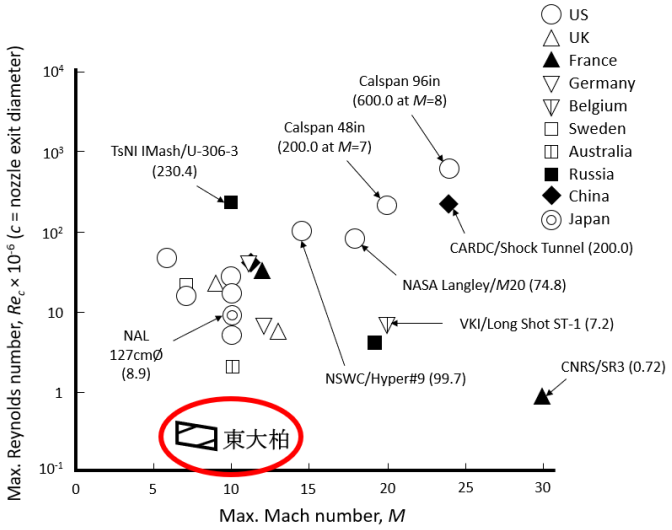

Fig. 1: Positioning of this facility among hypersonic wind tunnels around the world. (Adapted from Kubota et al., "Thermo-Gas Dynamics of Spacecraft," University of Tokyo Press, 2002. Japanese: 久保田ほか, "宇宙飛行体の熱気体力学," 東京大学出版会, 2002.)

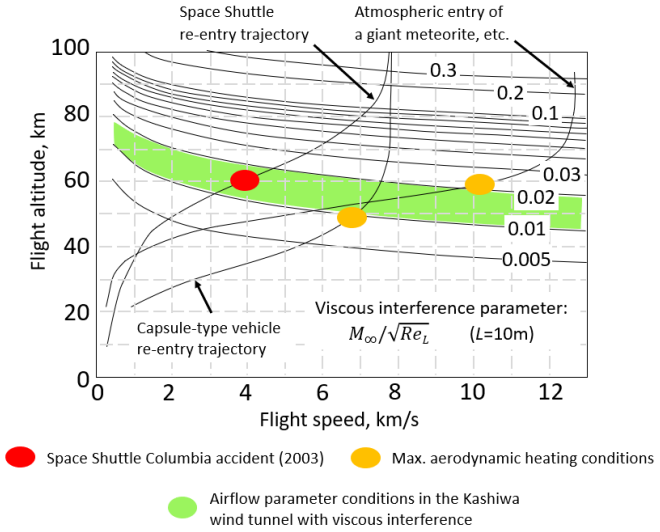

Fig. 2: Trajectories and viscous interference parameters of various atmospheric entry bodies.

Present operations

Installation of this facility was completed in March 2006. It is intended as a platform for hypersonic and high-enthalpy airflow experimentation by as wide a range of researchers as possible, regardless of affiliation or research field.

Contact

Suzuki Laboratory, Department of Advanced Energy, Graduate School of Frontier Sciences, The University of Tokyo, Kashiwanoha 5-1-5, Kashiwa City, Chiba Prefecture, 277-8561, Japan. http://daedalus.k.u-tokyo.ac.jp/

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