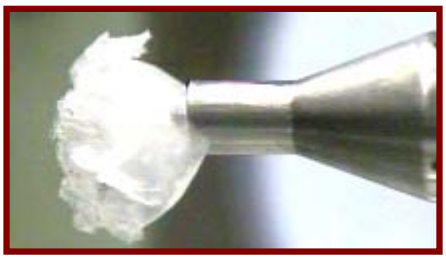
THE UNIVERSITY OF TOKYO
Graduate School of Frontier Sciences (GSFS)
Division of Transdisciplinary Sciences

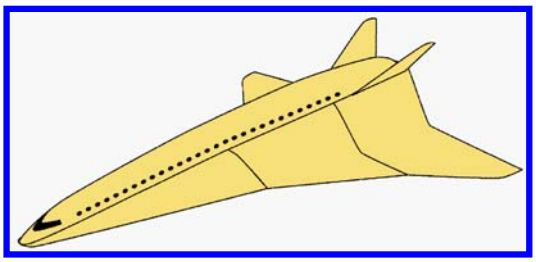
Hypersonic and High Enthalpy Wind Tunnel Kashiwa Campus, The University of Tokyo

http://daedalus.k.u-tokyo.ac.jp/wt/wt_index.htm
(mostly in Japanese)

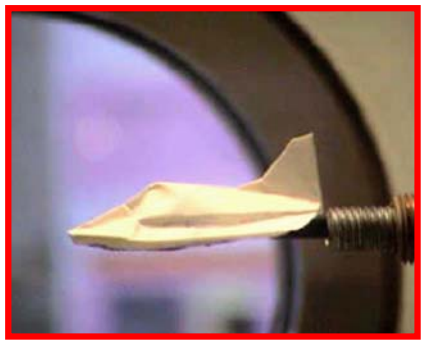
1. **Open** to Education/Research Projects on Hypersonic Aero-thermodynamics
2. Promote **Collaboration** among Various Fields in relation to High-speed / High-temperature Flows
3. Safe, Easy & Frequent Operation (1blow/hour): **Encourage** Studies on Innovative Concepts



For Planetary Science

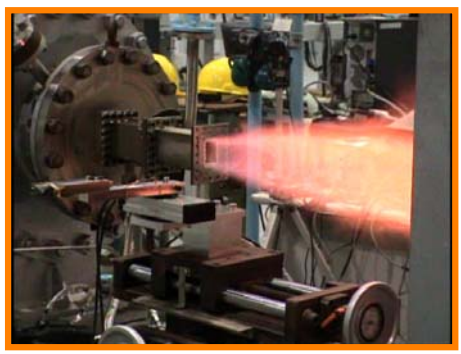


For High-speed Aerospace Transport



Encourage Young Students & Scientists

For Innovative Spacecraft



For High Temperature Material Test

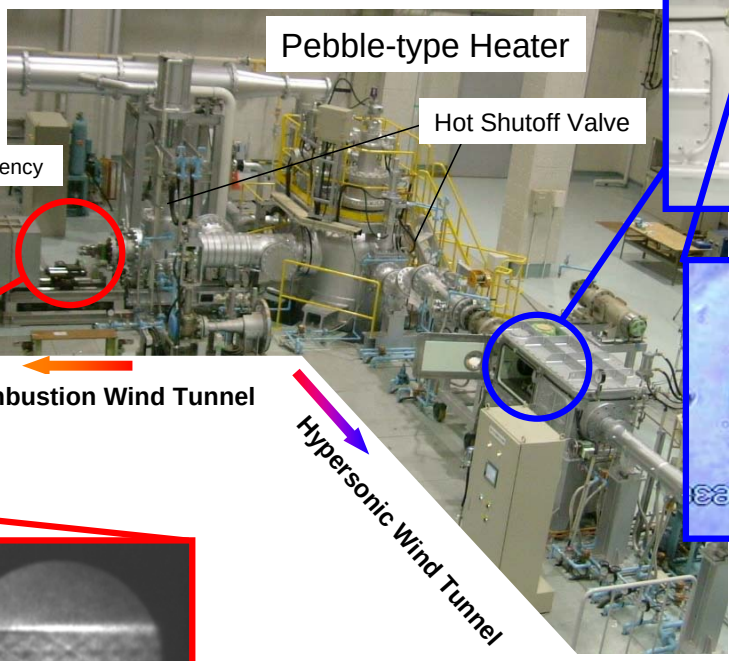
And more .....

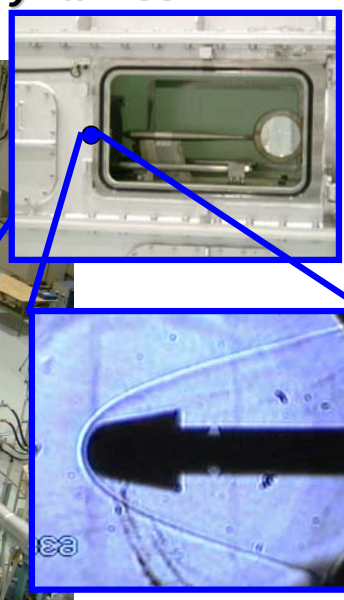
Hyper

A Powerful Tool for Hypersonic & High-temperature Gasdynamics

In FY2007
- 400 Tunnel Blows in Total
- 12 Research Projects
  (4 from Other Universities
  3 from JAXA etc.)

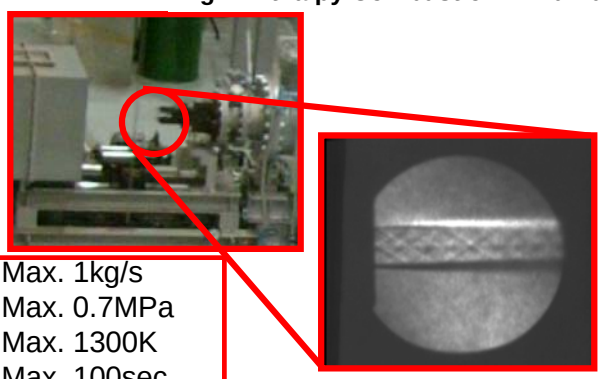
JAXA: Japan Aerospace Exploration Agency





Study on High-speed Flow around a Body

Mach 7,8
200mm dia.
Max. 0.95MPa
Max. 1000K
Max. 60sec

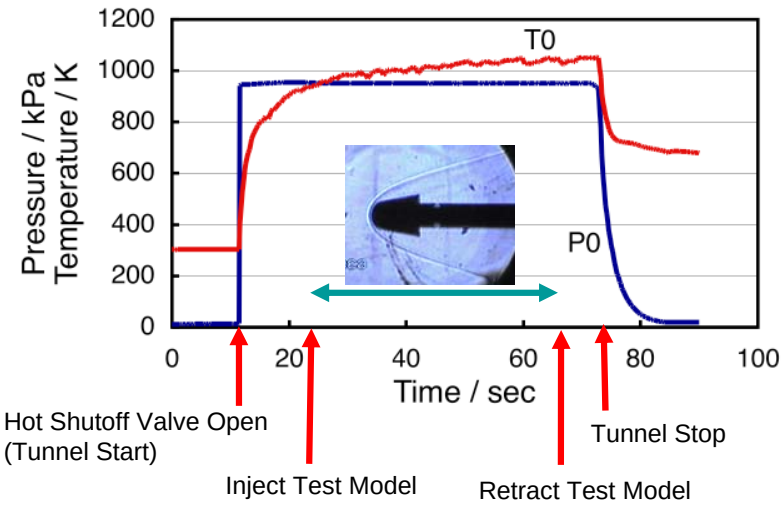


Max. 1kg/s
Max. 0.7MPa
Max. 1300K
Max. 100sec

Study on High-temperature Flow

	Hypersonic WT	Combustion WT
Mach Number	7, 8	Depend on users
Nozzle Exit	200mm dia. Uniform Flow Core 120 mm dia.	Depend on users
Stagnation Pressure	Max. 0.95 MPa	Max. 0.7 MPa
Stagnation Temperature	Max. 1000 K	Max. 1000 degC
Unit Reynolds No.	1 ~ 2 X10^4 (1/cm)	—
Mass Flow Rate	Max. 0.39kg/s	Max. 1kg/s
Test Duration	60 sec	100 sec (or more)
Reservoir	5MPa(G), 4m^3 (X1)	
Heater	Pebble Type + City Gas Burner	
Exhaust	Vacuum Tank (7m dia.)	Open to Atmosphere via Silencer

Typical Operation Sequence at Hypersonic Wind Tunnel



- Model is injected after the steady hypersonic flow has been obtained.
- Pitch Motion Control (-10 deg ~ 10 deg). Model is retracted before the tunnel stops.
- Very Smooth Flow Start, Very Quiet Operation.
- Maximum Blockage Ration ~ 5 % (Max. dia 4~5cm in case of hemisphere)
- Relatively Long Test Duration (Max. 60 sec)
- Relatively Short Startup Time (1st Blow 3 hrs after "Switch ON")
- Short Turn-around Time (1 Blow / Hour)

July 2008

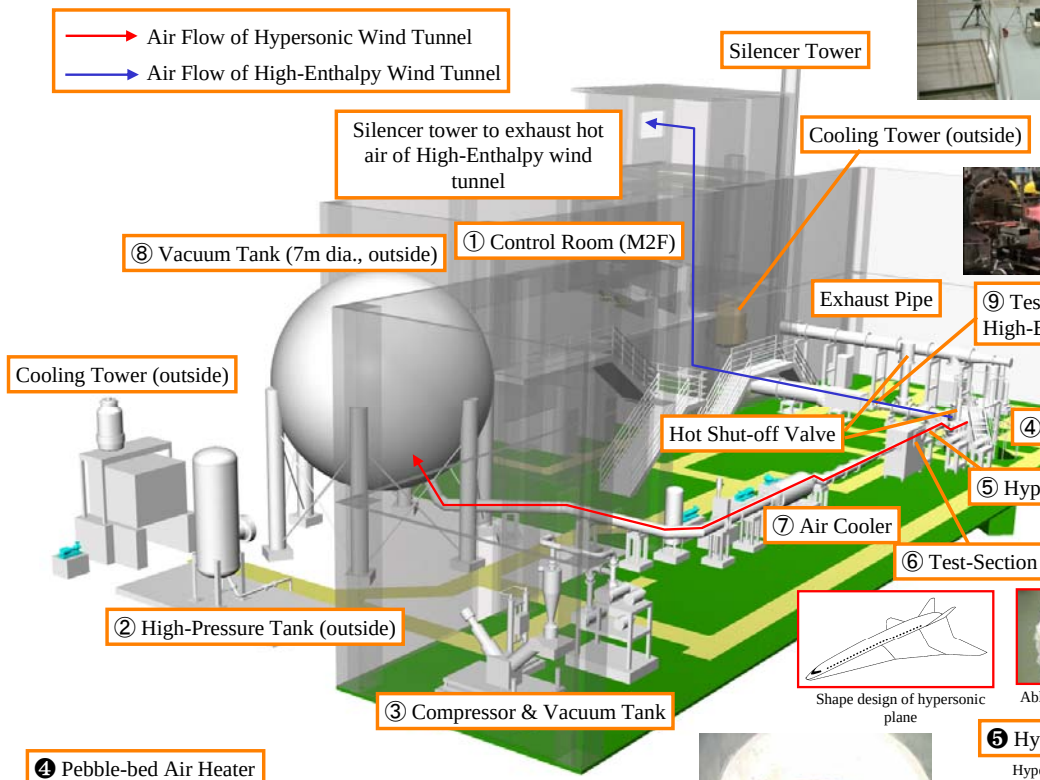
UT Kashiwa Hypersonic and High-Temperature Wind Tunnel

Two mode operation is possible using a high-pressure and high-temperature air generator, that is, Hypersonic Wind Tunnel mode (very high speed flow) and High-Enthalpy Wind Tunnel mode (very high temperature flow).

❶ Control Room

All wind tunnel facilities and measurement systems can be remotely controlled from the control room. Users can set the flow parameters in the control room, that is, the stagnation pressure and temperature, angle-of-attack of the test model and so on. The operation process of the wind tunnel are displayed on the main board graphically. The measured data are provided to users.

Overview of the facility



Experiment on the high temperature material using hot jet

❾ Test-Section of High-Enthalpy Wind Tunnel

High-temperature air from the heater is injected to the atmosphere as a free jet flow. The flows are exhausted to outside through the silencer tower. Users can setup the supersonic nozzle and test-section layout freely, depending on the objectives of each experiments.

❼ Air Cooler

Air cooler is a water-cooled heat exchanger to cool the air of hypersonic wind tunnel before exhausted to the vacuum tank.

❷ High-Pressure Tank and ❽ Vacuum Tank

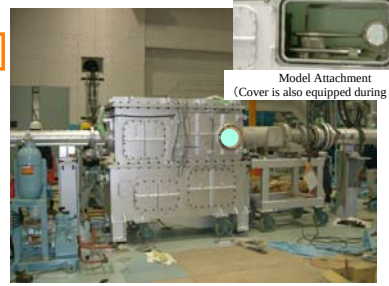
Both tanks are installed outside.
High-Pressure Tank (cylindrical tank, 4m^3, right-side one in the picture) can store the high pressure (max. 5MPa) dry air produced by ❸Compressor. The stagnation pressure of the air flow is controlled by the regulator. The temperature of air is raised by ❹pebble-bed heater. The maximum flow duration is about 60 seconds for the hypersonic wind tunnel and 200 seconds for the high-enthalpy wind tunnel, respectively.
The vacuum Tank (Spherical tank, 180m^3, left-side one in the picture) is 7m in diameter and very low pressure level at less than 100kPa can be kept for several days. The pressure in the vacuum tank is decreased using the ❸Vacuum pump before experiment. The air of the hypersonic wind tunnel flow is exhausted to the tank.

❻ Test-Section of Hypersonic Wind Tunnel

In the section, the hypersonic flow around the test model is observed and measured. This section is an airtight chamber because the pressure inside is much lower than the atmospheric pressure during the experiment. There are windows (200mm dia.) for the observation, for example, Schlieren images. The model injection system is installed in the test section. The model is injected to the hypersonic flow after the flow establishes stably. The Angle-of-attach with respect to the uniform flow (i.e. pitch angle) can be controlled from -10 degree to +10 degree from ❶Control Room remotely. Due to the constraint of the blockage ratio, the model size is limited to about 4cm in diameter.

Shape design of hypersonic plane

Ablation experiment of ice



Model Attachment
(Cover is also equipped during tests)

Test-Section of Hypersonic wind tunnel
(Flow comes from right to left, and the circle on the test section box is the observation window. The nozzle section is seen on the right hand side of test-section.)

❸ Compressor & Vacuum Pump

Compressor and vacuum pump are used to charge the air in the high-pressure tank and to reduce the pressure in the vacuum tank, respectively. Both are installed in the special compartment to avoid the spillage of the noise and vibration to the outside.

Compressor

Vacuum Pump

❹ Pebble-bed Air Heater

Pebble-bed air heater is selected to produce the high-temperature gas with the heat exchange between the air and pre-heated pebbles. The heater looks like a high pressure tank as shown in the right picture. The height is about 3m. The wall inside the heater is covered by heat-resistant bricks. Alumina pebbles are filled in the heater. The air from ❷High-pressure tank is introduced to the heater from the bottom to the top, after the pebbles are pre-heated by the burner at the top of the heater, producing very high temperature air at more than 1200°C. Such high temperature air is necessary not only for the experiments with hot air but also for energizing the air to accelerate to hypersonic speeds in the hypersonic wind tunnel.

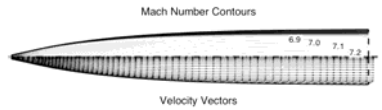
View of the inside of the heater when it is vacant. (The wall is covered with the heat-resistant bricks and the metal grid to sustain the pebbles is seen at the bottom.)

Pebbles filling the heater

Pebble size

❺ Hypersonic Flow Nozzle

Hypersonic Nozzle converts the thermal energy obtained through the heater to the kinetic energy. The air through the very narrow throat accelerates expanding to the wide exit. Since the degree of acceleration depends on the area ratio between the throat and the outlet, the nozzle throat for the hypersonic wind tunnel is very narrow. The diameter of the nozzle exit is 200mm. The curve of the bell-shaped nozzle is smooth and carefully designed to produce the uniform flow at the test-section. Two types of the nozzles (Mach 7 and 8) are available.



A result of computational simulation of the flow in hypersonic nozzle (the throat is on the left-hand side, the exit is on the right-hand side) : The uniform and parallel flow is seen in the downstream of the nozzle exit except the vicinity of the wall in the Mach number contours (upper half of figure) and the velocity vector plot (lower half of the figure).

Jun. 2008 UT-Kashiwa WTWG (Jun. 2006 for Japanese ver.)