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 (1 blow/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 ....
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

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

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**Hypersonic Wind Tunnel**

- Study on High-speed Flow around a Body
- Study on High-temperature Flow

**Pebble-type Heater**

**Hot Shutoff Valve**

**High Enthalpy Combustion Wind Tunnel**

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

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

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**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.
- Maximum Blockage Ratio ~ 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)

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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).

- **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 to hypersonic speeds in the hypersonic wind tunnel.

- **Air Cooler**: An air cooler is a water-cooled heat exchanger to cool the air of the hypersonic wind tunnel before exhausting to the vacuum tank.

- **Cooling Tower**: Cooling tower (outside) is an airtight chamber for the observation, e.g., Schlieren images. The model injection system is installed in the test section. The air of the hypersonic wind tunnel flow is exhausted to the vacuum tank.

- **Pebble-Bed Heater**: Pebble-bed heater is selected to produce 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 air from the high-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.

- **Compressor & Vacuum Tank**: Compressor and vacuum tank 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**: 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.

- **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 with respect to the test section box as the observation window. 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.

- **Test-Section of High-Enthalpy Wind Tunnel**: High-temperature air from the heater is injected to the atmosphere as a 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.

- **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. The measured data are provided to users.

- **High-Pressure Tank and Vacuum Tank**: Both tanks are installed outside. High-Pressure Tank (cylindrical tank, 4m³, right-side one in the picture) can store the high pressure (max. 5MPa) dry air produced by the compressor. The stagnation pressure of the air flow is controlled by the regulator. The temperature of air is raised by the Pebble-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, 180m³, 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 Vacuum Pump before experiment. The air of the hypersonic wind tunnel flow is exhausted to the tank.

- **Test-Section of High-Enthalpy Wind Tunnel**: High-temperature wind tunnel can store the high pressure (max. 5MPa) dry air produced by the Compressor. The stagnation pressure of the air flow is controlled by the regulator. The temperature of air is raised by the Pebble-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 pressure in the vacuum tank is decreased using the Vacuum Pump before experiment. The air of the hypersonic wind tunnel flow is exhausted to the tank.

- **Test-Section of M2F**: The Operation process of the wind tunnel are displayed on the main board graphically. The measured data are provided to users.