Aerodynamics

- Message
  In the development of aircraft such as large aircraft, stealth bombers, hypersonic aircraft, reentry vehicles, and MAVs (Micro Air Vehicle), the solution of aerodynamic problems and the evaluation of aerodynamic performance are performed by wind tunnel testing and numerical simulation. We have been working on the research of the aerodynamics relevant to the aircraft from low speed to transonic and hypersonic flows.

- Members

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Many facilities are available in our laboratory: towing tank, circulating water tunnel, low turbulence wind tunnel, Gottingen type low-speed wind tunnel, open circuit type low-speed wind tunnel, small wind tunnel, smoke wind tunnel, transonic and supersonic wind tunnels, and hypersonic gun tunnel. These facilities support educational and research opportunities on various flows from low-speed to hypersonic. Special instruments for flow visualization can also be used in each wind tunnel. Furthermore, some of the innovative measuring devices have been being developed to enhance the understanding of the flows. Our research interests are as follows.

- **Space Planes and Hypersonic Vehicles**

  Research areas consist of a combination of experimental, theoretical, and computational programs addressing shock/boundary-layer interaction, shock/shock interaction, laminar-turbulent transition, hypersonic wind tunnel improvements, improvements of glow discharge technique for visualizing three-dimensional shock-waves and measuring velocity fields.

  **Key Words**
  - Shock/Boundary-Layer and Shock/Shock Interactions
  - Hypersonic Wind Tunnels
  - Hypersonic Flow Measurement and Visualization

![Flow around hypersonic vehicle](image1)

![Flow visualization around reentry vehicle](image2)
Boundary layer transition and separation

It is important to make flight performance of aircraft better. Especially, boundary layer flows around wings strongly affect the performance of aircraft such as stall and drag. Hence, the study of the boundary layer is indispensable. We have been investigating the behavior of boundary layer flows.

- **Low turbulence wind tunnel**
- **Wing model with sweepback**

Characteristics of unmanned vehicles at low Reynolds numbers

Small unmanned airplanes such as micro air vehicles, nano air vehicles and aircraft for the exploration of Mars fly at low Reynolds numbers. These vehicles also characterized by the use of low-aspect-ratio wings. We have been focusing on the characteristics of the low-aspect-ratio wings in low Reynolds number flows. Furthermore, our interests include active flow control technologies for the performance improvements.

- **Aerodynamic forces and moment measurement**
- **Flow around low-AR wing**
Recent research achievements by graduate students (Prof. Itoh)

- Journal and Conference Papers
Basic aerodynamic research with low-speed wind tunnel

Research topics
- Research on aerodynamic characteristics of Gurney flap
- Research on aerodynamic characteristics of UAV
- Wake integration method for aircraft design
- Investigation of aerodynamic characteristics on the airfoil constructed with flat panels

High lift device (Gurney flap)
The Gurney flap was used for a rear wing of a high-speed racing car at first. It composes of a small plate that has the height of about 1 ~ 2% chord length of airfoil. And it is attached vertically at the trailing edge. The Gurney flap doesn’t need power, and it is simple structure. So it is considered one of the effective devices as the high lift device. We have been working on the evaluation of the aerodynamic characteristics of this flap for the application of aircrafts.

Wake integration method
The wake integration method is an excellent technique that could measure the lift and drag coefficients along the model span. Also this method is able to separate and evaluate the profile and induced drag. Thus this technique is very effective for the aircraft design. The objective of our research is the application of this method to a comparatively small low-speed wind tunnels.

Göttingen type wind tunnel
- Type: Göttingen type (Free jet test section)
- Test section: 1.0 m in inner diameter of octagon
- Velocity: 2 ~ 53m/s
- Measurement devices: 6 components balance, Wake survey system, Smoke generator, Stereo PIV system

Low-speed wind tunnels
- Small wind tunnel (30 × 30cm)
- 1.5m low speed wind tunnel (150 × 150cm)
- Smoke wind tunnel (15 × 150cm)
- Blow down type wind tunnel (60 × 60cm)
Aerodynamic research with transonic and supersonic wind tunnels

Research topics
- Visualizations around the airfoil flow with focusing schlieren method
- Aerodynamic investigations in the transonic airfoil flow utilizing the cryogenic wind tunnel
- Development of diaphragmless shock tube
- Research of the optical diagnostic techniques (LIF etc) for the high speed wind tunnel.

High Reynolds number flows
The cryogenic wind tunnel utilizing the cryogenic operational gas (total temperature is about 108 K) is important to investigate the transonic airfoil characteristics since it is able to get the full scale Reynolds number. We have been working on the improvement of the wind tunnel measurement techniques (wind tunnel correction method etc) with the cryogenic wind tunnel and a shock tube.

Focusing schlieren method
The sharp focusing schlieren method can visualize slice images of the flow fields, and it has a possibility to investigate the three-dimensional complex flow fields and shock waves. In the present research, we are working on the qualitative observation and quantitative investigation around airfoils in the high speed flow field with this method.

Diaphragmless shock tube
- Length: High pressure section 3000mm, Low pressure section 7500mm
- Test section: 150 × 60mm (Slotted wall)
- Driven section: Quick opening valve
- Testing time: Several milliseconds
- Measurement devices: Schlieren system, Focusing schlieren system, PDI system

High-speed wind tunnels
- Shock tube (15 × 6cm)
- Transonic wind tunnel (40 × 35cm)
- Supersonic wind tunnel (15 × 15cm)
- High Reynolds number wind tunnel (30 × 6cm), (Cryogenic wind tunnel, Joint operation in school)
Publications (Aerodynamics, Masashi KASHITANI)

【Journal and Proceedings】
・Preliminary Study on Lift Coefficient of Biplane Airfoil in Smoke Wind Tunnel, AIAA 2008-0349.