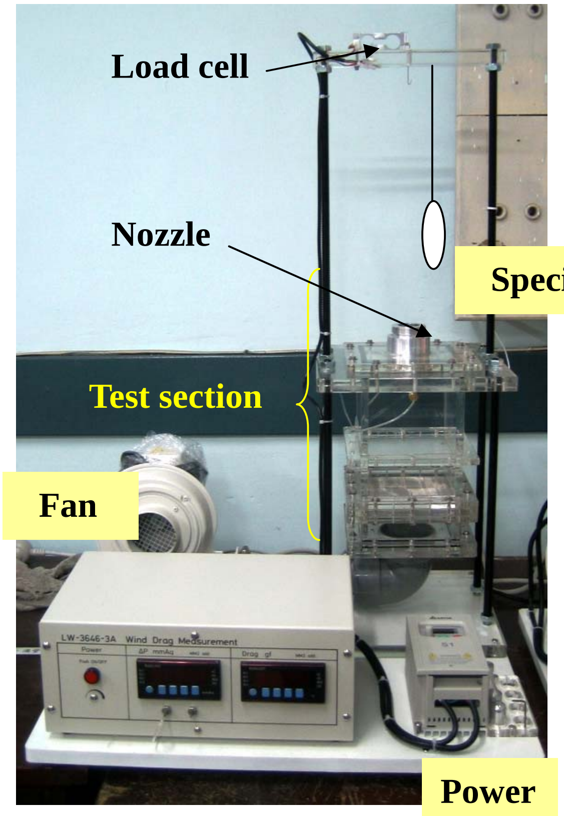
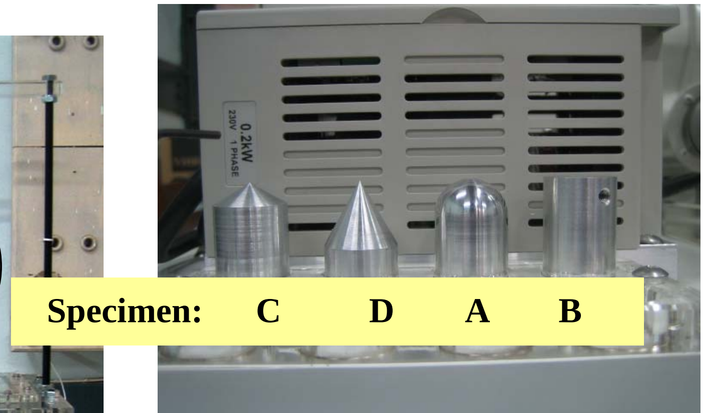
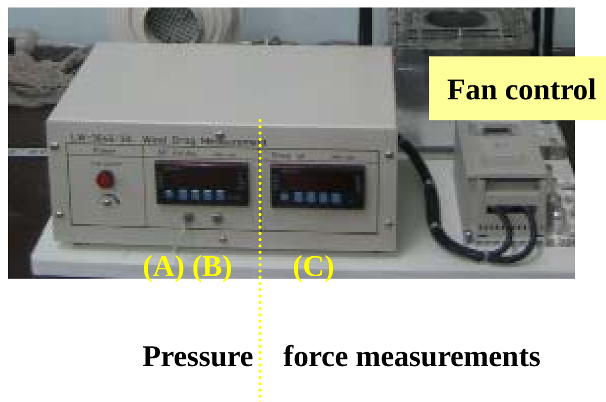
Form drag measurement of a blunt body

June 07-11, 2011

報告有點長 但是請大家用心寫.







Operation of the system:

- Power on the system. You will hear a clap that results from the loading of an electric magnet installed in the fan system as a safety stop for overrun current.
- Check zero pressure difference between the pitot tube (A) and the atmosphere (B)—open to the ambient. **Identify pitot tube in the test section.**
- Hit the green “Run” on the fan control box. Then slowly increase the fan speed until the panel reading reaches 15.0 giving a steady and (nearly) uniform flow at the nozzle.
- To shut down the fan, gradually decrease the fan speed to stop it, or you can hit the red “Stop” button on the control panel.

Calibration: (TA demonstration)

(1) Uniform velocity profile across the nozzle:

Increase the panel reading of fan speed up to 25. Take 5 measurements of the flow velocity with a constant-temperature hot-wire anemometer (CTA) at different radial positions across the nozzle. Write down the locations and the velocities.

(2) Actual flow velocity at various fan speeds:

Gradually increase the fan speed with a +5 increment until +70 is reached. At each fan speed, write down the CTA measurement of the flow velocity (m/s) at the nozzle center. (結報問題 Q4 會用到)

Experiment Procedures:

- Hang the specimen A. Wait until it is in still position (No sway). Press the AZ bottom (Automatic Zero) on the force measurement panel (on the right, section(C)) to set the static loading as the load cell reference.
- Use the small hook to fix the specimen position around the nozzle center. (Make sure that you are not pulling the specimen downwards, which will affect the load cell measurement).
- Hit “Run” on the wind speed control box again to generate the flow. Slowly increase the reading to 15.0. Then, write down the readings of pressure difference and the drag. (預報 Q2) [Since we set the specimen weight as the zero reference of the load cell, a negative reading is obtained in relation with the total hydrodynamic force.]
- Check if the external stream affects the specimen motion (is it stable?)
- Then, increase the fan speed with a +5 increment up to 70.0. Write down the readings of both the pressure difference and the drag at each wind speed.
- At ONE fan speed between 25 and 75, ask help from TA to measure the air speed around the obstacle with CTA. (結報 Q7)
- When the wind speed exceeds a critical value, the specimen starts to wobble severely, indicating flow instability. Record this critical ‘transition velocity’. (結報 Q8)
- Gradually reduce the fan speed.

Now, carefully unscrew the specimen A and replace it with specimen B. When you tighten the second specimen, do not screw it to the dead point. Stop when you feel slight hindering force from the wrench.

- Change specimen A with specimen B, which is of different weight from Specimen A. So, set zero to the load cell again. Check if the pressure difference reads zero.
- Increase the wind speed from 15 to 70 with a +5 increment.
- Record both the pressure difference and the force at each wind speed. Pay attention to the onset of instability, i.e. record the wind speed and the pressure difference measurement when the specimen starts to wobble.

- Repeat the same procedures with specimens C and D. Remember to zero the load cell before the new set of measurements to complete Table A. **(請輪流操作不同試件)**
- Measure the sizes of the square channel and the nozzle. Measure the distance between the pitot tube and the nozzle exit. (結報問題 2).
- Measure the crosdiameter of each specimen, D.

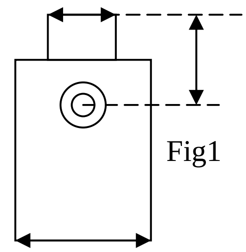


Fig1

Table A

Specimen	fan reading	20	25	30	35	40	45	…	70
A	Pressure (mm 汞柱高)								
	Reduced drag (克重)								
B	Pressure (mm 汞柱高)								
	Reduced drag (克重)								
C	Pressure (mm 汞柱高)								
	Reduced drag (克重)								
D	Pressure (mm 汞柱高)								
	Reduced drag (克重)								

預報問題

P0: Briefly state the principals of Pitot tube pressure measurement and hot wire anemometer.

P1: Derive an equation that relates the pitot tube pressure measurements with the local flow velocity.

P2: Derive a force balance equation that relates the load cell force measurement with the drag (mainly form drag).

P 3: Covert the pressure unit mmHg to Pascal and the force g to Newton.

P4: List the specimens (A-D) in the order according to the measured drag (based on your judgment and estimation)

結報問題 Be careful with the units!

Q1: Plot the flow velocity profile at the nozzle exit as a function of radial position of TA's measurements upon calibration.

Q2: Derive a relation between the flow velocity at the pitot tube and the nozzle exit, as illustrated in Fig1. (Hint: Note that the total mass flux is conserved. You will need the assumption of air incompressibility at the operating temperature and pressure.)

Q3: Calculate the estimated flow velocity at the nozzle exit from the pressure measurements (in Pascal) using the relations you derive in P2 and Q2.

Q4: Plot the estimated flow velocity as a function of fan speed, i.e. at the readings of 15, 20, 25….. Compare it with the values TA measured with CTA.

Q5: Plot the drag (in Newton) as a function of Reynolds number, $\mathrm{Re} = \frac{2R\rho U}{\mu}$, where $2R$ is the specimen diameter, ρ, μ are the air density and viscosity, and U is the estimated flow velocity.

Q6: Compare the drag on the specimens of different front surface. List the specimens (A-D) in the order according to the measured drag. Explain why you observe this trend.

Q7: Compare this reading with that TA measured at the same fan speed when there was no obstacle present. Is the current reading (with obstacle) higher or lower? Why?

Q8: For each specimen, compare the velocity at which the specimen starts to wobble/vibrate severely, i.e the onset velocity of instability. Explain why a certain shape of a blunt body enhances or suppresses the occurrence of instability.

Q9: **State** a few sources of error to the current design and **how you could improve it**.