The UNSW Anechoic Wind Tunnel

Con Doolan, Danielle Moreau, Manuj Awasthi and Chaoyang Jiang

School of Mechanical and Manufacturing Engineering, UNSW Sydney, New South Wales, 2052, Australia

SUMMARY

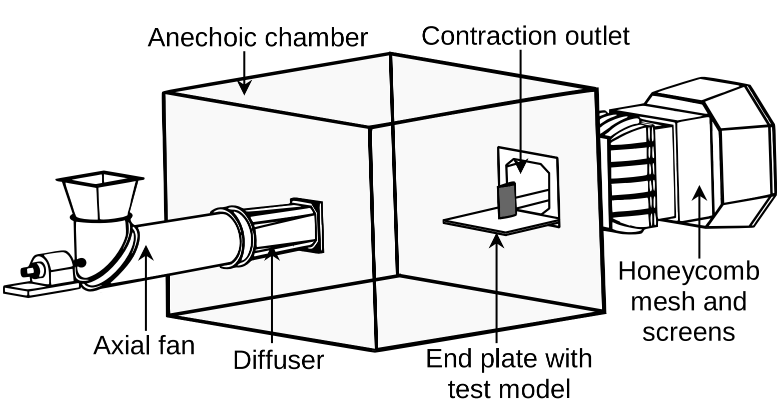
This paper will describe the anechoic wind tunnel facility located at the University of New South Wales (UNSW) Sydney. The wind tunnel construction, including the inlet contraction and fan system, will be described along with the design of the anechoic chamber and muffler system. The model mounting system is located in an open jet, with integrated force measurement system via a turntable mount. Aeroacoustic measurements are performed with an aeroacoustic microphone array, whose design, construction and signal processing will be explained. Aerodynamic measurements using hot-wire, pitot and PIV systems are used and integrated with acoustic measurements. A remote microphone measurement system has been used with a novel calibration methodology to measure the turbulent wall pressure spectra in a variety of configurations. In addition to an extensive description of the construction and performance of the wind tunnel, selected results from recent airfoil self-noise experiments will be included to demonstrate the acoustic measurement performance of the facility.

1 UNSW ANECHOIC WIND TUNNEL DESIGN

The UNSW Anechoic Wind Tunnel (UAT) is a facility used in the fundamental study of aeroacoustic phenomena. The UAT is an open jet type wind tunnel with a 0.455 m × 0.455 m test-section surrounded by a 3 m × 3.2 m × 2.15 m anechoic chamber. The chamber walls are acoustically treated with 0.25 m thick Melamine foam, creating an anechoic environment above 300 Hz. The facility is a suction type open jet tunnel that originally contained an axial fan downstream of the test-section (see Fig. 1(a), which shows the original design). Air is drawn through a bell-mouth inlet consisting of a honeycomb mesh and four turbulence reduction screens and then accelerated through a 5.5:1 area ratio contraction. The maximum velocity in the original facility was approximately 23 m/s and the free-stream turbulence intensity at 20 m/s was 0.67% [1].

Recently, the UAT has been upgraded with a more powerful AirEng centrifugal fan to provide flow velocities up to 70 m/s in the test-section (see Fig. 1(b)). A new silencer was also designed consisting of two separate diffusers to expand the flow leading to the fan and a curved, constant cross-section duct to block the line-of-sight between the fan and the anechoic chamber. The inside walls of the entire duct-work are lined with 20-gauge perforate panels backed with a 100 mm fiberglass insulation to absorb noise.

(a)



(b)

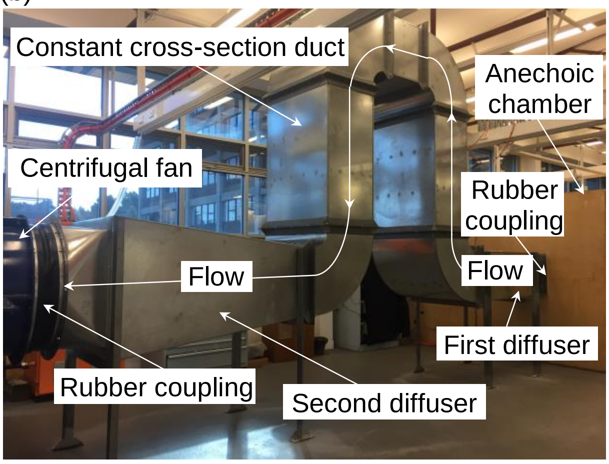


Figure 1: (a) Original UAT design. (b) The new UAT fan-silencer system.

2 INSTRUMENTATION AND EXAMPLE MEASUREMENTS

The UAT is equipped with a flow and noise measurement suite. Pitot-probes, single- or cross-hotwire probes and a PIV system are used to characterise the velocity field around the test models. To ascertain the spatial organization of the flow field, the probes are traversed using a Dantec Dynamics three-axis traverse system. Aerodynamic forces and moments on test models are also measured using a JR-3 75E20A4 six-component force balance.

Far-field sound measurements are obtained using acoustic beamforming. Figure 2(a) shows a spiral microphone array in the UAT consisting of 31 GRAS 40PH ¼" phase-matched array microphones. Figure 2(b) is an example of a beamforming sound map obtained for a NACA0012 airfoil at a flow velocity of 18 m/s and an angle of attack of 9º. At a frequency of 5040 Hz, the acoustic source is located at the airfoil trailing edge where the airfoil is indicated by a solid green line and the flow is from left to right.

Measurements of wall pressure fluctuations are performed using a remote microphone method. With this technique, illustrated in Fig. 2(c), surface pressure fluctuations are transferred from a small tap in the model surface to a housing containing a GRAS 40PH ¼" microphone via flexible and metal tubing. A wall pressure spectrum measured beneath a turbulent flat plate boundary layer at a flow speed of 20 m/s is shown in Fig. 2(d). The measurement is in good agreement with the empirical wall spectrum model of Goody [2].

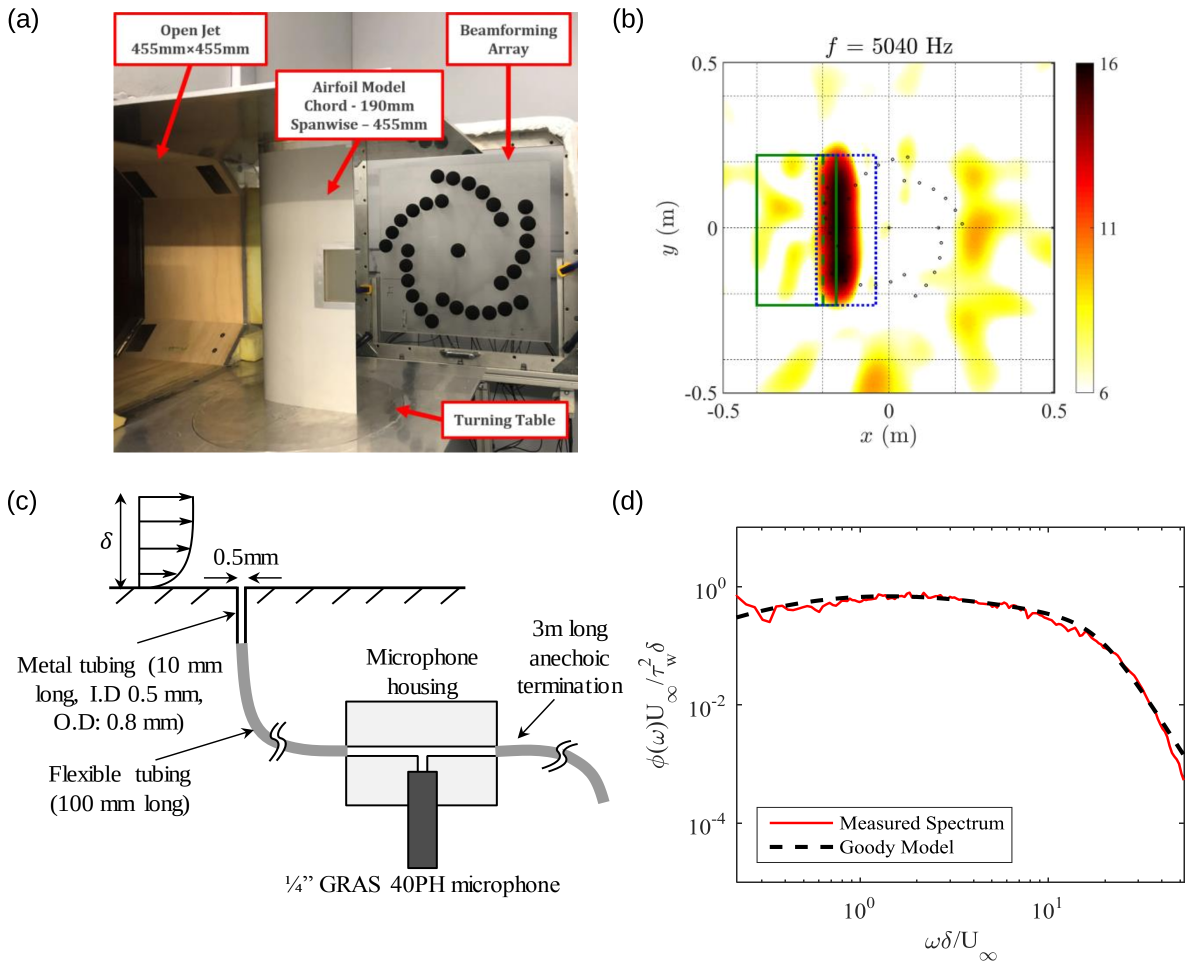


Figure 2: (a) Microphone array and airfoil model in the UAT. (b) Trailing edge noise beamforming result. Colorbar scale is in dB. (c) Remote microphone measurement setup. (d) Measured wall pressure spectrum.

REFERENCES

1. Awasthi, M., Moreau, D.J. and Doolan, C.J. 2018. "Flow structure of a low aspect ratio wall-mounted airfoil operating in a low Reynolds number flow." *Experimental Thermal and Fluid Science* 99:94-116.
2. Goody, M. 2004. "Empirical Spectral Model of Surface Pressure Fluctuations." *AIAA Journal* 42:1788-1794.