Wind Tunnel Calibration of Sonic- and Cup Anemometers

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In the past a lot of effort has been put into developing and refining suitable methods for anemometer calibration procedures and ways to classify cup anemometers (note DEWI Magazine article *Calibration and Classification of Cup Anemometers* No. 22 Feb. 2003), among these are Measnet harmonisation procedures and normative standards such as IEC 61400-121 Power Performance-Draft Standard. Additionally, the need for the investigation of alternative principles for wind speed measurements is evident. Wind measurements using sonic anemometers or SODAR are becoming more important to overcome the drawbacks of conventional cup anemometers such as non ideal behaviour due to turbulence or the increased costs of installing tall met masts. The ultimate goal should be a unified procedure/ process in which measurements using anemometers deliver reproducible results regardless of make, measurement principle, calibration facility, wind conditions and terrain. This is not only true for wind measurements and site assessments, but even more important for power performance measurements, because the power of the wind is proportional to the third power of the wind speed and thus even small uncertainties in measured wind speed will lead to unacceptable high uncertainties in the produced power. DEWI has calibrated approx. 7500 cup anemometers in the past 10 years and is accredited for this area according to EN ISO/IEC 17025:2000, DKD (the Accreditation Body of Deutscher Kalibrierdienst) and MEASNET.

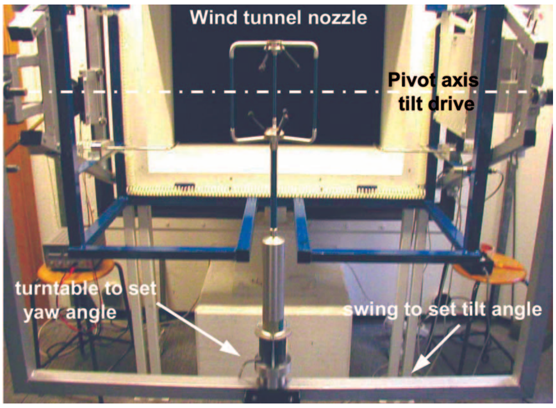

Fig. 1: Turn-table and tilt mechanism for sonic calibration

Basically, the calibration of anemometers is performed in a wind tunnel by exposing the anemometer to a laminar stream of air. The relevant calibration data are obtained by measuring the true wind speed and the indicated anemometer output signal for the most critical wind speed range between 4 and 16 m/s. The resulting data set is analysed by statistical means. The aim is to characterise the anemometer's behaviour with the least amount of parameters. In the case of modern cup anemometers this can be achieved quite well using a linear regression, thus only two parameters (slope and offset) are needed to characterise the anemometer within acceptable limits. For more information please refer to the Measnet Cup Anemometer Procedure under www.measnet.com.

For sonic anemometers, a different procedure is applied. Sonics are suitable for measurements of wind fluctuation or turbulence due to their fast dynamic response. But there might be unacceptable deviations for measurements of the indicated (average) wind speed. This is especially true when sonics are exposed to wind at varying yaw and tilt angles. In order to calibrate sonic anemometers in the wind tunnel, it is practical to perform the measurements in an automated sequence, so that data sets for numerous yaw and tilt angles in combination with varying wind speeds can be easily obtained. Great care must be taken when selecting the sequence parameters, in order to ensure that the data set and measurement time are still manageable. For instance an analysis for one complete yaw rotation at 5° steps and tilt angles ranging from -30 to +30 ° at 5° steps in combination with 5 different wind speeds will give a total of more than 4500 individual measurement points. If the data acquisition lasts 30 seconds at each point, then it adds up to a total of almost 40 h of net wind tunnel time. This shows that, wherever possible, a reduction of data is needed, either a reduction because of the symmetric geometry with respect to yaw angle, the reduction of angular resolution or the reduced amount of time spent at each measurement point. But even a reduced data set will still necessitate the use of an automated measurement and motion control system. DEWI has achieved this by utilising a new PXI data acquisition system from National Instruments used not only for cup anemometer calibration but also for research on sonics. The combination with a new control and evaluation software also sold by National Instruments called Lab View improves the calibration efficiency.

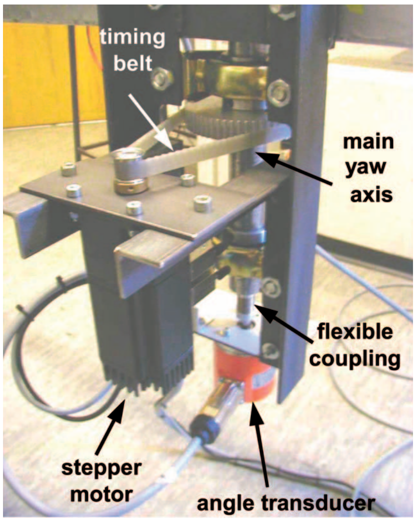

Fig. 2: Detail turn-table drive

The rotation of the sonic anemometer itself is realised with a self made automated turntable for yaw rotation in conjunction with a swing-like apparatus for tilt movement (see Fig. 1 and 2). This enables DEWI to perform sonic calibrations not only on a commercial scale but also to participate in research projects such as ACCUWIND (see http://www.ecn.nl/accuwind/)

Sonic wind tunnel calibration data show notable deviations from an ideal response. This is mainly due to the mounting arrangements of the ultrasonic transceivers which may influence the value for the indicated air speed as a function of yaw angle, tilt angle and sonic type. Even though manufacturers of sonic anemometers are steadily improving their equipment, there is still a lot of room for improvement until sonics are as widely accepted in the wind energy field as cup anemometers.

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