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New method to calibrate a spinner anemometer

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Abstract

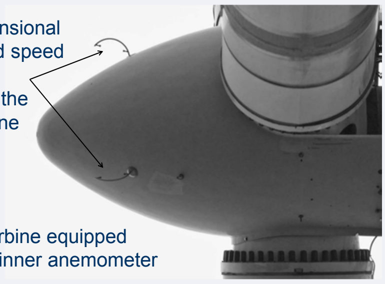
The spinner anemometer is a wind sensor, based on three one dimensional sonic sensor probes mounted on the wind turbine spinner, and an algorithm to convert the wind speeds measured by the three sonic sensors to horizontal wind speed, yaw misalignment and flow inclination angle. The conversion algorithm utilizes two constants k_1 and k_2 that are specific to the spinner and blade root design and to the mounting position of the sonic sensors on the spinner. [1] [2]

The two constants are calibrated by means of two different test and instrument set-ups. Both calibrations consider the rotor of the wind turbine to be stopped during calibration in order for the rotor induction not to influence on the calibration, so that the spinner anemometer measures "free" wind values in stopped condition. The calibration of flow angle measurements is made by calibration of the ratio of the two algorithm constants $k_2/k_1 = k_\alpha$.

The calibration of k_α is made by relating the spinner anemometer yaw misalignment measurements to the yaw position when yawing the wind turbine in and out of the wind several times. The calibration of the constant k_1 is made by comparing the spinner anemometer wind speed measurement with a free met-mast or lidar wind speed measurement at hub height.

Measurement set-up

One dimensional sonic wind speed sensors visible on the wind turbine spinner.



A wind turbine equipped with a Spinner anemometer

For angular measurement calibrations:
- wind turbine equipped with a spinner anemometer
- yaw position measurement.

For wind speed measurement calibration:
- wind turbine equipped with a spinner anemometer
- hub height horizontal wind speed measurement.

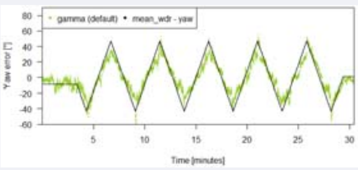
In this case, a cup anemometer on a up-wind met-mast is used [4]. Another option is to use a nacelle based, or a ground based, lidar.

Spinner anemometer installation kit: [5]

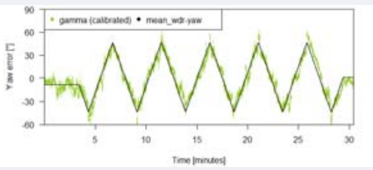
Calibration of flow inclination and yaw misalignment measurements

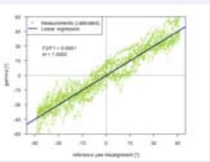
Acquiring the data-set:
The calibration of angular measurements of the spinner anemometer is made by yawing the stopped wind turbine in good wind conditions (> 6 m/s), several times plus minus approximately 45º with respect to the mean wind direction. Simultaneously, measurements of the spinner anemometer and the nacelle yaw position sensor are recorded at minimum 1 Hz sampling frequency (20 Hz in this case). This procedure takes a couple of hours.

Before calibration



After calibration





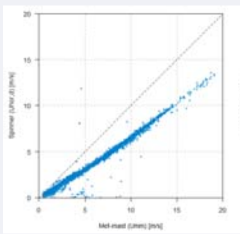
Finding the calibration constant k_α
The value of k_α is found in an iterative procedure that correct the measurements [3] with a guess of k_α to optimize to one the slope of the scatter plot between the yaw misalignment (gamma) and the yaw misalignment introduced by artificial yawing, which is the mean wind direction minus the yaw position.

The scatter of the data is due to natural wind direction variations during the test.

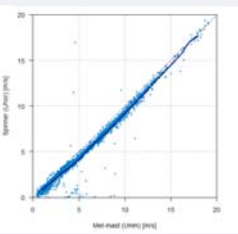
Calibration of wind speed measurements

Acquiring the data-set:
Calibration of wind speed measurements can be made during operation to find the NTF (Nacelle Transfer Function = free wind minus rotor induction at rotor centre) [4] [7]. Alternatively, the wind turbine can be stopped for one day in good wind conditions, free to yaw into the wind. Ten minute averages of spinner anemometer horizontal wind speed and met-mast wind speed are recorded.

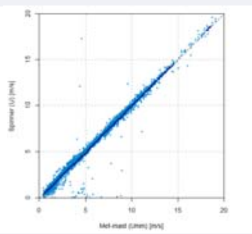
Before calibration

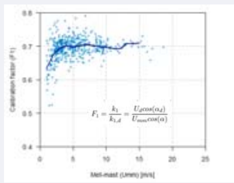


After calibration



After application of NTF





Finding the calibration constant k_1
The calibration of wind speed measurements is made by relating the free horizontal wind speed at hub height, to the horizontal wind speed measured by the spinner anemometer. A set of k_1 values is calculated from the measurements, and an average for wind speed above 5 m/s is used to avoid turbulence.

Using the nacelle transfer function (NTF) as defined in [6] to compensate for the rotor induction during operation, the estimate of the free wind speed by the spinner anemometer measurement is seen to be very accurate (see above, right plot).

Conclusions

- A spinner anemometer can be calibrated for yaw misalignment measurements by solely use of a yaw position sensor, and by yawing the wind turbine in and out of the wind plus minus 45º . So, no met-mast or lidar is required.
- The spinner anemometer, thanks to the rotor rotation, is offset-free when measuring angles (such as yaw misalignment and flow inclination), which reduces yaw misalignment measurement uncertainty significantly.
- The calibration of the spinner anemometer for wind speed measurements needs an additional free wind speed measurement (met-mast or lidar) at a distance of 2-4 rotor diameters from the rotor. The calibration can be made in stopped conditions, or in operation at relatively high wind speed (low induction).
- The wind speed calibration, determined by the nacelle transfer function is only influenced by the induction at the spinner due to the rotor. This induction function can be determined, and the spinner anemometer wind speed measurements can be corrected with the induction function to find the free wind speed.

References

1. Spinner anemometer - an innovative wind measurement concept, Pedersen T.F., EWEC 2007 Milan.
2. Aerodynamics and characteristics of a spinner anemometer, Journal of physics: Conference Series 75 012018, 2007, Pedersen T.F., Sørensen N., Evevoldsen P.
3. Calibration of a spinner anemometer for yaw error measurements, Wind Energy, 2014 (article submitted for publication). Pedersen T.F., Demurtas G.,
4. Vindmølleafprøvning Nordtank NTK 500/41, Mæling af Effektkurve, Technical report Risø -I-889 DA, Risø national laboratory, Roskilde, Denmark, November 1995. Paulsen U.S.,
5. Spinner anemometer user manual version 9.27-3, Metek Meteorologische Messtechnik GmBH.
6. IEC 61400-12-2, Power performance of electricity producing wind turbines based on nacelle anemometry, Annex D - Nacelle wind speed transfer function measurement procedure. 2013.
7. IEC 61400-12-1, Power performance measurements of electricity producing wind turbines, Chapter 5, 2005.