A practical way of high level torque calibration for the wind turbine nacelle test

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Summary
A new method of mechanical torque calibration based on the electrical measurement is presented. No calibration machine is needed and the calibration is easy to be repeated. Absolute torque uncertainty is expected to be within 2%. An uncertainty within 1% is considered achievable for the efficiency calculation.

1. Introduction
During a wind turbine nacelle test, the input mechanical torque is a very important measurement for the analysis of the drive train behaviour. An accurate torque measurement is in some cases vital for the analysis, especially for the efficiency calculation. The rated input torque of a modern MW class wind turbine can easily reach a multi-MN-m level, and therefore much higher than the highest traceable calibration capacity current available in the world – 1.1 MN-m owned by the PTB [1]. A new method is proposed in this paper that calibrates the high level torque with the help of electrical measurement.

2. Calibration Procedure
Torque measurement is carried out on the shaft adapter between test bench and the turbine drive train, while the electrical power measurement is instrumented between the turbine generator and the converter.

The power levels along the drive train in both tests are shown together in Fig. 3. Since the turbine operates in both tests on similar working points (rotating speed and electrical power), the power losses in both tests can be considered identical, against certain uncertainty introduced.

\[ \frac{P_{mech.A} + P_{mech.B}}{2} = \frac{P_{elec.A} + P_{elec.B}}{2} \] (1)

As a result, the relation between the mechanical and electrical powers can be established as in Equation (1). This can be used a foundation for the torque calibration, because the mechanical power is a results of torque and rotating speed, while the rotating speed is available.

The tests can be repeated on at least two different torque levels before the calibration can be carried out for the torque measurement. The calibration requires no additional calibration machine and is easy to be carried out and regularly repeated.

2. Uncertainty Analysis
The major sources of the uncertainty include the electrical power measurement, the noise of the torque-measuring signal and the assumption of identical power loss. Early studies show that an absolute torque uncertainty lower than 2% is expected. For the
calculated efficiency, the uncertainty lower than 1% is achievable.

3. References