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.

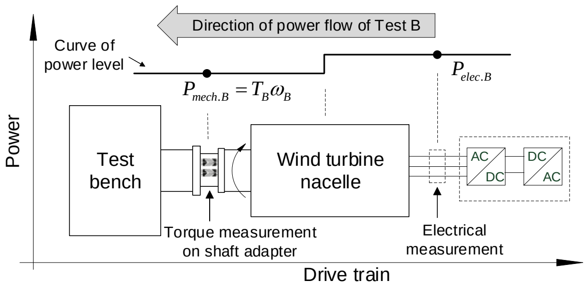

Fig. 2: Power loss along the transmission in test B

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

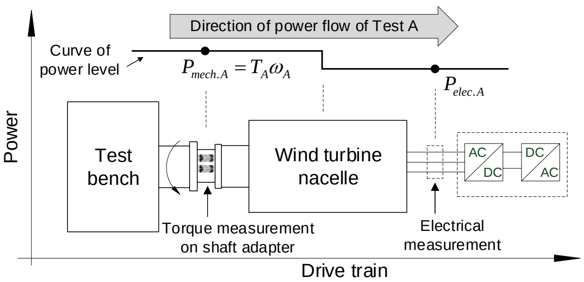

Fig. 1: Power loss along the transmission in test A

Two tests denoted as test A and test B should be carried out, shown in Fig.1 and Fig.2. In test A, the test bench drives the turbine drive train and operates at a certain working point. In test B, the turbine takes the turn to drive and the test bench operates in generator mode. The system rotates in the opposite direction in test B but keeps the same speed level as in test A. The electrical power of the turbine is tuned in test B to be as close as possible to test A.

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.

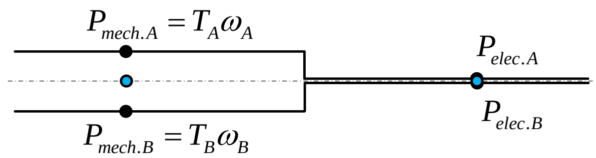

Fig. 3: Relation between the torque and electrical power

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.

$$(\bar{P}_{mech.A} + \bar{P}_{mech.B})/2 = (\bar{P}_{elec.A} + \bar{P}_{elec.B})/2 \quad (1)$$

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

[1] C. Schlegel, H. Kahmann, R. Kumme, MN·m torque calibration for nacelle test benches using transfer standards, Acta IMEKO, December 2016.