PREPARATIONS FOR TEST OF CALIBRATION PROCEDURE

NEWSLETTER NO. 3 – JUNE 2017

Welcome to the third edition of the newsletter for the EMPIR MN·m Torque project. The first half of the project was dominated by the preparation of the tests at the nacelle test bench in Aachen at the Chair for Wind Power Drives. Other investigations have also been pushed towards the busy second half of the project. This issue of our newsletter gives you a short overview of the current state of work.

CURRENT TORQUE MEASUREMENTS

Precise torque measurements are needed in nacelle test benches to control the facility as well as test the efficiency of new nacelles. A survey, which was already mentioned in the last issue of the newsletter, was conducted to find out more about current torque measurements in nacelle test benches. The needs of customers and operators are not met by the state of the art as the measurements are affected by a series of influences. A calibration of the test benches is, therefore, necessary.

An overview of the influences on the torque measurement as well as first recommendations for a calibration procedure have been summarised in a conference contribution (see list of publications below). The influences range from temperature to rotation. The calibration proposal includes:

- basic information for the recording of the data during the calibration
- a procedure to determine the zero point
- the definition of the typical testing range and the derived calibration points
- general comments for the evaluation of the calibration data

The recommendations will be considered to develop a calibration procedure that is used within the project at a later point of time with the transducer shown in Figure 1.

ESTABLISHING A MN·M TORQUE TRANSFER STANDARD

New torque transfer standards must be found or developed to carry out a calibration of nacelle test benches. Two different ways are utilised to establish this standard within the project: a combination of numerically simulating existing deformation bodies and using this to extrapolate calibration results to a larger range and the design of a transducer that measures the reaction force at a defined distance.

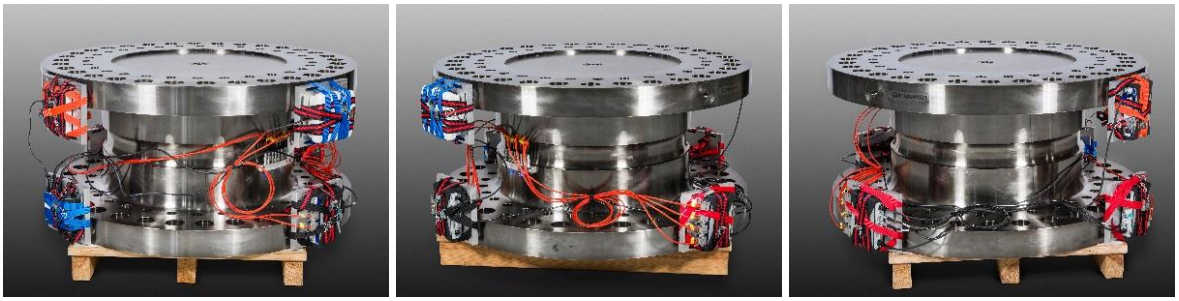

FIGURE 1 360° VIEW OF TORQUE TRANSFER STANDARD WITH 5 MN·M MEASURING RANGE EQUIPPED WITH THE ENTIRE MEASRUEMENT AND DATA TRANSMISSION DEVICES

NUMERICAL SIMULATION OF DEFORMATION BODIES AND STRAIN GAUGES

In the search for what makes a transducer suitable to be used as a torque transfer standard in nacelle test benches, a report with recommendations for the use of commercial torque transducers as transfer standards in the MN·m range was prepared. It was found that hollow shaft transducers with flange connections are most suitable for calibrations of NTBs. Furthermore, additional measurement bridges to monitor multi-component load states are advisable. Concerning the transducer calibration result, a very good linearity, a small interpolation error and very small creep of the measurement signal are required for the purposes of extrapolation and the calibration of a nacelle test bench.

A 5 MN·m torque transducer was chosen for the calibration test at RWTH Aachen. Two finite element models this sensor were established and compared. One example is shown in Figure 2. These numerical investigations together with measurements in the kN·m range serve as a basis for the extrapolation method that is to be developed.

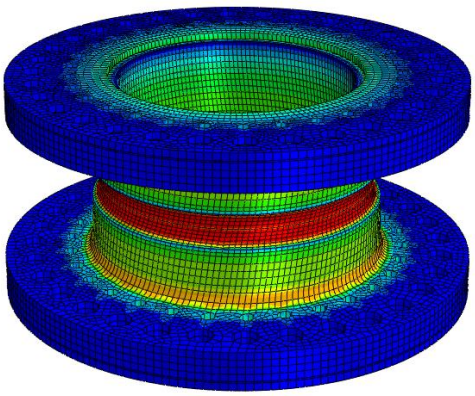

FIGURE 2 FINITE ELEMENT MODEL OF TORQUE TRANSFER STANDARD

DESIGN OF A FORCE LEVER SYSTEM

Force lever systems are torque sensors consisting of several force transducers which are connected to the drive train of a nacelle test bench and to each other. These systems make it possible to measure torque in the MN·m range with calibrated transducers.

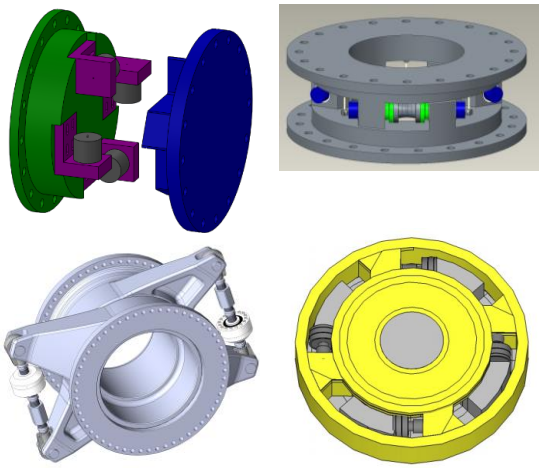

FIGURE 3 DIFFERENT DESIGN PROPOSALS

The partners developed several preliminary design options and refined them more and more (see Figure 3). In addition, each partner prepared a requirement list for the force transducers to be used in their designs; then, the most suitable commercial option for their design according to their former requirement list was selected. It is now tested which influences affect the measurements with such systems most and how they might be minimised.

MULTI-COMPONENT INVESTIGATIONS

Wind does more than turn rotor blades, it also shoves, bends and pulls at the wind turbine. These mechanical loads are also incorporated in nacelle test benches and the transfer transducer is subjected to them. It is the objective to develop a multi-component calibration procedure to find out which effects

are expected from these loads to the torque measurement.

Two torque transducers with additional multi-component capabilities were selected from a previously established list and their torque measurement signal has been calibrated. Furthermore, a loading system consisting of a lever, two hangers and two sets of mass discs was established (see Figure 4). This system is used to perform a multi-component calibration of the two selected torque transducers. The calibration procedure includes the vertical and horizontal orientation of the transducers whilst being loaded with masses on one or both sides. Thus, all six load components (torque, bending moments, longitudinal and lateral forces) are applied.

FIGURE 4 LOADING SYSTEM FOR MULTI-COMPONENT INVESTIGATIONS POSITIONED ON PTBS HEXAPOD

CALIBRATION PROCEDURE

The main objective of the project is to improve the precision of torque measurements in nacelle test benches. A calibration of the facilities is the best option to achieve this goal. A calibration test is planned within the project. Measurements will take place during two weeks in autumn 2017 at RWTH Aachen. The transducer shown Figure 1 will be used in the 4 MW nacelle test bench conducting a torque calibration with different rotational speeds and perform investigations of dynamic and multi-component effects.

To prepare the torque transfer standard for the measurements at RWTH, a data transmission system had to be installed. The system is based on WiFi transmission from the rotating transducer to a static access point. It is ensured that the system does not interfere with the mechanical transmission as for example by causing torque shunts. An autarkic energy supply is also guaranteed. Figure 1 shows the transducer fully equipped. Pre-test of the data transmission system in the environment of a nacelle test bench are scheduled to take place before the two-week-period of test calibration.

RECENT PUBLICATIONS

S. Kock, G. Jacobs, D. Bosse, and P. Weidinger, “Torque measurement uncertainty in multi-MW nacelle test benches,” in Conference for Wind Power Drives Proceedings.

S. Kock, G. Jacobs, D. Bosse, and J. Gnauert, “Conception of 5 MNm torque transducer for wind turbine test benches,” in 5. Innovation Messtechnik.

P. Weidinger, G. Foyer, C. Schlegel, and R. Kumme, “Extending the Torque Calibration Range – Necessity and Outline of a Mathematical Approach,” in Coomet Best Young Metrologist.

G. Foyer and S. Kock, “Measurement Uncertainty Evaluation of Torque Measurements in Nacelle Test Benches,” in 23rd TC3 IMEKO.

R. M. Lorente, N. Medina, M. A. Sáenz, and M. Á. Sebastián, “Torque Traceability for

Nacelle's Test Benches: a Design Proposal," in 23rd IMEKO TC3.

C. Schlegel, H. Kahmann, P. Weidinger, and R. Kumme, "New Perspectives for MN·m Torque Measurement at PTB," in 23rd IMEKO TC3.

P. Weidinger, C. Schlegel, and G. Foyer, "Characterisation of a 5 MN · m Torque Transducer by Combining Traditional Calibration and Finite Element Method Simulations," in SENSOR 2017.

PROJECT MEETINGS

PAST MEETINGS

A project meeting including a stakeholder meeting was held on 9 March 2017 in Aachen. The minutes of the meeting's public part can be found on the website in the Members Area.

FUTURE MEETINGS

A project meeting of the consortium in Aachen is planned for autumn 2017.

At the beginning of 2018, a webconference will be held to inform interested stakeholders about the results of the calibration test at RWTH Aachen.

The final meeting including also one or two days of stakeholder meeting will be held in Braunschweig in the summer of 2018.

INVOLVEMENT IN THE PROJECT

We are always looking for further input to our project to complete our overview of the needs and capabilities of the industry. If you are interested in working with us, please contact us via email or use the short questionnaire on our website to give us an idea of your capabilities in the field of torque measurement.

HOW TO CONTACT US

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THE CONSORTIUM

PTB Physikalisch-Technische Bundesanstalt Braunschweig und Berlin

CENER NATIONAL RENEWABLE ENERGY CENTRE ADItech

CEM CENTRO ESPAÑOL DE METROLOGÍA

CMI CZECH METROLOGY INSTITUTE

CWD Center for Wind Power Drives RWTH AACHEN UNIVERSITY

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