FINAL STAGE OF THE MN·M TORQUE PROJECT

NEWSLETTER NO. 5 – JANUARY 2019

Welcome to the fifth and last edition of the newsletter for the EMPIR MN·m Torque project. With a successful torque calibration under rotation of the torque measurement in the nacelle test bench of the Center for Wind Power Drives (CWD) at RWTH Aachen, the project was drawn to an end last August. The present newsletter gives a short overview on the project results and the final outcome.

INTRODUCTION

As wind energy is still in competition with fossil energy sources in terms of costs, a precise and reliable efficiency determination is required. For the efficiency determination of a wind turbine on a nacelle test bench, the mechanical input power is to be measured traceably and with a low measurement uncertainty. To enable this, a torque calibration procedure and suitable transfer standards were developed within the scope of the EMPIR MN·m Torque project. The project's results include a good practice guide, design studies for a multi-component sensor and for a force lever system with a measurement range up to 20 MN·m.

FINAL STAKEHOLDER MEETING

On August 30, 2018 the project's results were presented to the stakeholders of the project (Figure 1). In three hands-on workshops the participants of the final meeting got the chance to experience the results of the project in reality: a multi-component measurement using masses and a lever arm, DAQ and telemetry system of the 5 MN·m torque transfer standard and a first presentation of the concept for a 5 MN·m torque calibration machine, which is currently developed at PTB.

FIGURE 1 FINAL MEETING OF THE MN·M TORQUE PROJECT FOR STAKEHOLDERS AND THE PROJECT CONSORTIUM AT PTB IN BRAUNSCHWEIG IN AUGUST 2018.

GOOD PRACTICE GUIDE

The project's main objective is the precision improvement of torque measurement in nacelle test benches. Based on the output of the first torque calibration in a nacelle test bench tested at the Center for Wind Power Drives of RWTH Aachen, a good practice guide was developed. This guide on how to realise a traceable torque measurement under rotation in nacelle test benches can be found on the project's webpage: https://www.ptb.de/emrp/ind14-goodpractice.html.

The guide explains the torque calibration procedure for nacelle test benches under various torque and rotational speed loads using a torque transfer standard. Condensed information about the measurement setup, the zero signal determination, and the load cycle including how to apply the torque and additional loads is given.

CHARACTERISATION MAPS

So-called characteristic maps (Figure 2) were used to investigate the relation between the rotational speed and the applied torque.

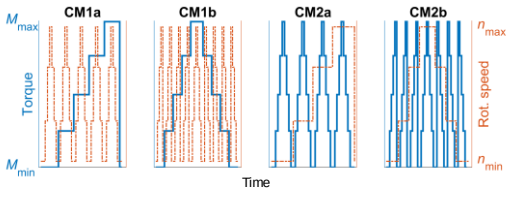

FIGURE 2 MAPS WITH VARYING TORQUE AND ROTATIONAL SPEED LOAD.

These special load cycles are designed to cover the operation range of the nacelle test bench to be calibrated. The operation range during the calibration procedure is limited by the device under test being installed; the points of resonance were deliberately not considered.

MULTI-COMPONENT EFFECTS

Due to the simulation of wind loads for authentic tests, additional mechanical loads on the drive train cannot be ignored. While the effect of random control influences in a pure torque mode is accounted for in the torque measurement uncertainty, the effect of purposely applied multi-component loads is to be analysed separately. Therefore, an additional test procedure for multi-component loads was developed and investigated. An example is given in Figure 3.

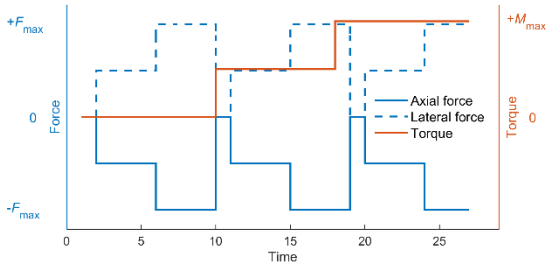

FIGURE 3 LOAD CYCLE TO ANALYSE MULTI-COMPONENT EFFECTS.

MULTI-COMPONENT SENSOR DESIGN

In order to measure occurring loads within six degrees of freedom directly at the nacelle's rotor hub, a multi-component sensor was designed. The executed design studies focused on the torque measurement in the MN·m range with low crosstalk on the other measuring bridges. Two designs are shown in Figure 4: the upper transducer is a multi-layer spoked wheel, while the lower design is an integrated transducer with an individual measuring gauges for each measurement component for all six degrees. The challenges of this kind of sensor to be tackled are heavy weight and large dimensions.

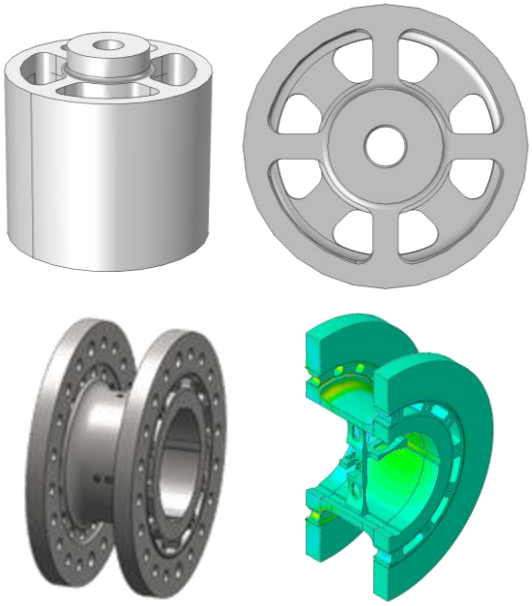

FIGURE 4 DESIGN STUDIES MULTI-COMPONENT TRANSDUCERS.

FORCE LEVER SYSTEMS

The trend of wind turbines becoming larger and heading towards offshore results in increasing torque load. To measure in the MN·m range, so-called force lever systems were designed by the partners of the project. Force lever systems consist of several force transducers that are connected to the drive train of the nacelle test bench and to each other via a lever arm.

MEASUREMENT UNCERTAINTY BUDGET

In order to use the force lever system as a torque transfer standard, its measurement uncertainty was estimated based on FEM results and a priori knowledge about the force transducers and the lever lengths. Several publications have been made on this topic.

UPSCALING

The designs developed in the first half of the project with a measuring capacity of 5 MN·m were upscaled to an operating range of 20 MN·m. These new designs are shown in Figure 5. Every design's feasibility and performance were studied in FEM analyses. Thereby it was considered that the force lever system has to withstand all loads, torque and additional loads, applied by the nacelle test bench.

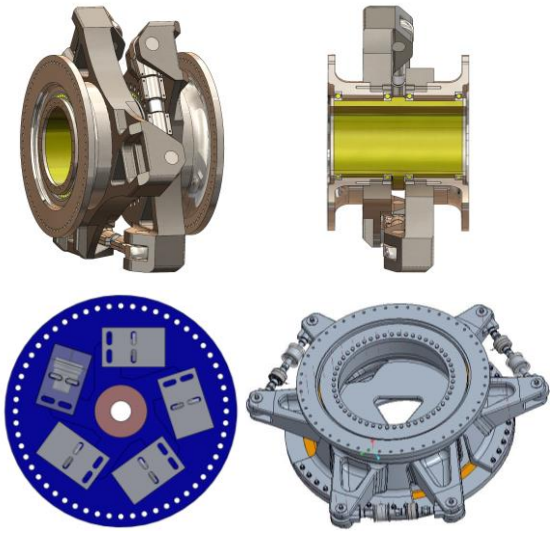

FIGURE 5 DESIGNS OF FORCE LEVER SYSETMS UPSCALED TO 15 MN·M AND 20 MN·M.

IMEKO WORLD CONGRESS SPECIAL SESSION

A special session about the project "Torque measurement in the MN·m range" was held at the 22nd IMEKO World Congress in Belfast in Northern Ireland. By five presentations of the project partners, an overview on the most recent outcome of the project was given. The associated conference contributions are listed in the publications section.

PUBLICATIONS

P. Weidinger, G. Foyer, S. Kock, J. Gnauert and R. Kumme, "Development of a torque calibration procedure under rotation for nacelle test benches" in Torque 2018

G. Foyer and H. Kahmann, "Design of a force lever system to allow traceable calibration

of MN m torque in nacelle test benches" in Sensoren & Messsysteme 2018

P. Weidinger, G. Foyer, S. Kock, J. Gnauert and R. Kumme, „Procedure for torque calibration under constant rotation investigated on a nacelle test bench" in Sensoren & Messsysteme 2018

G. Foyer and H. Kahmann "A finite element analysis of effects on force lever systems under nacelle test bench conditions" in IMEKO World Congress 2018

J. Gnauert, G. Jacobs, S. Kock and D Bosse "Measurement uncertainty estimation of a novel torque transducer for wind turbine test benches" in IMEKO World Congress 2018

S. Kock, G. Jacobs, D. Bosse and F. Strangfeld "Simulation method for the characterisation of the torque transducers in the MN·m range" in IMEKO World Congress 2018

R. M. Lorente-Pedreille, N. Medina-Martín, M. A. Sáenz-Nuño, M. A. Sebastián-Pérez "Sutdy of influences in CEM's new transfer standard for torque measurement in the MN·m range" in IMEKO World Congress 2018

P. Weidinger, G. Foyer, J. Ala-Hiiro, C. Schlegel and R. Kumme "Investigations towards extrapolation approaches for torque transducer characteristics" in IMEKO World Congress 2018

AWARDS

Dr.-Ing. Gisa Foyer was awarded with the György Striker Junior Paper Award for her presentation about "A finite element analysis of effects in force lever systems under nacelle test bench conditions" at the 22nd IMEKO World Congress.

Jonas Gnauert was awarded with the Hanns-Voith-Stiftungspreis 2017 for his outstanding master's thesis about a 5 MN·m torque transducer for nacelle test benches.

DETAILED PROJECT OUTPUT

More detailed outcome of the project can be found on the EURAMET website and on the project's website in form of a final publishable summary and a final publishable report next year.

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www.ptb.de/empir/torquemetrology.html

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 Chair for Wind Power Drives | RWTH AACHEN UNIVERSITY

Fraunhofer IWES

VTT MIKES METROLOGY

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