CONTROL AND CHARACTERIZATION OF A
200 N·m AND 2 kN·m TORQUE TRANSFER CALIBRATION SYSTEM

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Abstract: For the dissemination of this quantity torque standard systems are normally operated manually, originating high consumption of man-hours in the development of a calibration. This work presents the control and characterization of a Torque Transfer Calibration System and the benefits of the automatic control system.

Keywords: Torque, metrology, control, characterization.

1. INTRODUCTION

Normally, in a torque transfer system the torque application is performed with manual operation. In this type of systems the torque load required is achieved using motor start and stop control buttons, which also applies for motor speed, applied torque load and motor spinning direction. This manual process required many man-hours for a calibration. CENAM designed, build and put into operation a manual torque transfer calibration system for 200 N·m and 2 kN·m ranges for the collective transport system Metro (Mexico City), this paper presents the control system and the characterization of the reference torque standard.

2. OPERATION OF THE TORQUE TRANSFER CALIBRATION SYSTEM

The operation is based on the direct coupling of the calibration instrument to the standard transducer. For this purpose, flexible and rigid couplings are used and the whole system is supported by an ball bearing (Fig. 1) [1]. The manual operation is performed using buttons for start and stop of the motor, a 3 positions interrupter for spinning direction selection and 2 potentiometers, one to change the motor speed and the other to set the load. All the process requires manual data acquisition.

Figure 1. Torque transfer calibration system as build.

2.1 Calibration procedure

Firstly, the standard transducer and the calibration instrument are coupled and mounted in the system using all required accessories. Using the manual control system, the measuring points are set. Eight points are selected on the calibration instrument's range (from 10% to 100%), all measurements are written down in a logbook. Preloads, at 100% load, are applied (Fig. 2).

This procedure is applied increasing and then decreasing the load for three different mounting positions of the calibrating instrument and in clockwise and anticlockwise directions. A total of 112 measurements are made for one calibration. Since the process is manual the calibration is long and requires a large number of man-hours. This procedure is based in the DIN 51309 standard.
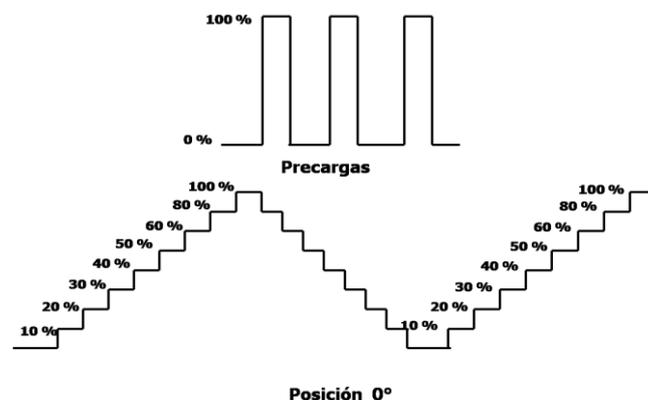

Figure 2. Example of the calibration procedure at 0° position.

3. TORQUE TRANSFER CALIBRATION SYSTEM AUTOMATIZATION

3.1 Control logics

The control logics frame was designed as follows:

a. To start the motor from 0 up to 100% of the calibrating instrument's range. To stop the motor. After 15 s to start the motor in the opposite direction down to 0. To wait 15 s and repeat the cycle to perform 3 preloads.

b. To start the motor and to stop at 10% of the instrument's range. To wait 15 s and take the measurement. To continue in this way up to 100%.
c. The previous activities are repeated in descendent mode from 100% to 0%.
d. The metrologist rotates the calibration instrument to 120° and performs the previously described activities and does the same for 240°.
e. The same procedure is executed for clockwise and for anticlockwise directions.

3.2 Equipment and material used

Software: Windows Vista, Lab VIEW version 2011, NI-DAQ version 6.1.
Hardware: PC Pentium, PC-DIO 24 PNP card, Interface card, PC – control system Power card.

3.2.1 Programming software

The programming software used was Lab VIEW, as it is a versatile and ease to use program. It works in Windows; uses blocks diagram notation and graphic language "G".
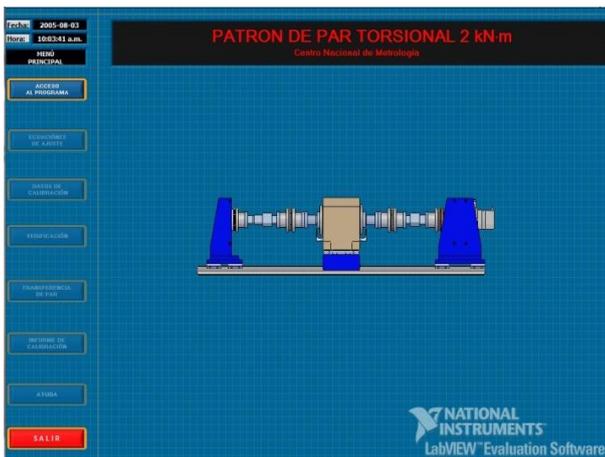

Figure 3. Main screen of the control program.

3.2.2 Control stage

To develop the PC´s interface with the system, a digital input/output interface card PCDIO24 PNP from National Instruments was used. The card works in a virtual instrumentation programming environment (Lab VIEW) and a power stage.

The card handles digital input and output; it has 3 ports (A, B y C) and 24 digital lines or 24 digital input and output channels. The ports can be configured as input or output, and is TTL logics compatible.

For the card operation use was made of NI-DAQ DRIVER Software de National Instruments, interface handler. NI-DAQ is a function library called by the program during its interface operation. Some including functions are: Data acquisition, Digital, input/output, Counts/Operation time.

3.2.3 PC- control system interface card

To perform the connection between the output of the PCDIO 24 card (installed in PC CPU) and the power stage an interface card was produced. In the 8 pin connector, 1 and 2 pins carry the electrical power difference (5 V dc) and the ground (electrical supply for the computer), 3 to 8 pins are for digital outputs.

3.2.4 Power stage

In the power stage 2 electrical contactors 127 V/60 Hz are integrated to the existing control system and are controlled by the power card.

3.3 Control Program

The program follows the calibration procedure (2.1) and the control logics (3.1). The calibration starts with the preloads (3 preloads at maximum load). The automatic program performs the 3 first series at 0º position. The measuring range is divided into 8 points proportional to the operation time and measurements are taken in each point. The first reading is taken at 10% of the maximum range and the 8 points are evenly distributed up to 100% of the defined operation time.

The program stops after the 3 first series to allow the rotation of the instrument under calibration to 120º and then continuous according to the calibration procedure (2.1). The same series is repeated for 240º.

The calibration process requires an open program, capable to perform the calibration in automatic mode but able to adjust itself to fit all different measurement ranges, from 1 N·m up to 2 kN·m.
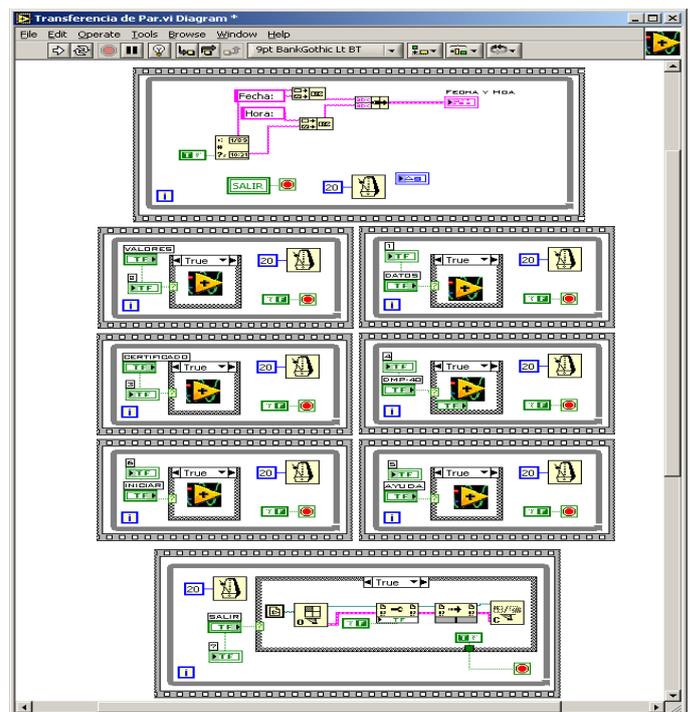

Figure 4. Control program.

4. TORQUE TRANSFER CALIBRATION SYSTEM CHARACTERIZATION

The objective of this study is to evaluate the transfer system for the reliable measurement of torque. The main part consists in a calibration of the whole system in situ, at normal operation conditions.

4.1 Characterization

For the characterization is necessary to perform tests with reference torque transducers, ensuring that it isolates a factor of influence or effect on each test. The most important characteristics to measure are: a) torque stability b) elapsed time between torques, c) repeatability, d) hysteresis e) reproducibility, f) resolution (stability of lecture) g) combined expanded uncertainty of the whole system.

The characterization of the torque transfer system was made using two torque standard transducer in the range up to 200 N·m and 2 kN·m.

The following figures show the results obtained from the analysis of the main factors of influence that contribute to the combined expanded uncertainty of the torque transfer system.
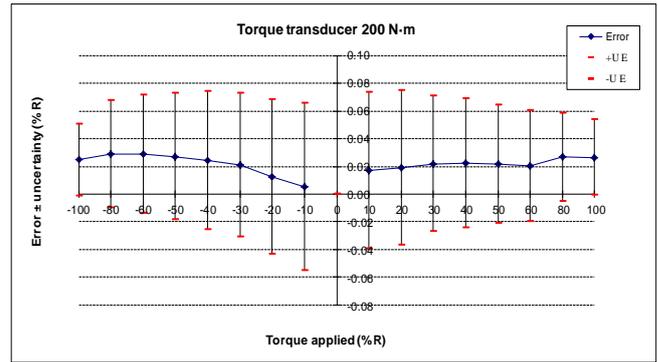

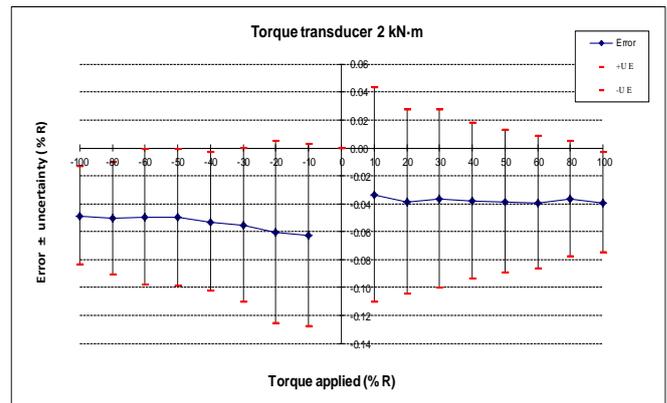Figure 5. Factors of influence, transducer 200 N·m.

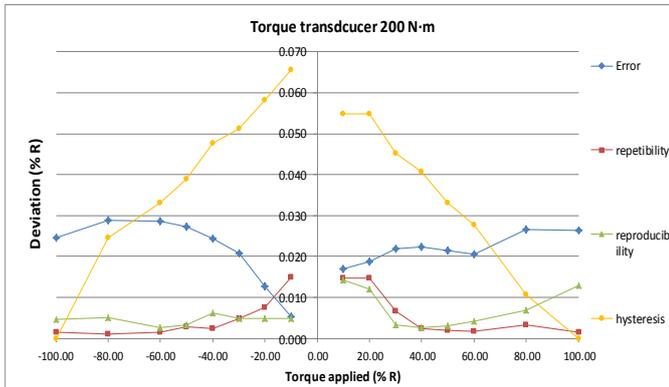Figure 6. Error and uncertainty of the 200 N·m torque transducer.

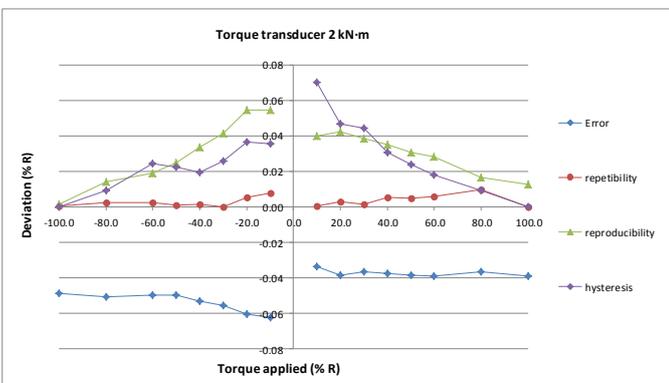Figure 7. Factors of influence, transducer 2 kN·m.

Figure 8. Error and uncertainty of the 2 kN·m torque transducer.

5. CONCLUSIONS

The control system and the results of the characterization brought a number of benefits to the operation and use of the torque standard. Some of the benefits are:
I. Considerable calibration time reduction of instruments.
II. Minimum metrologist intervention during a calibration.
III. Better control over the process influence variables.
IV. Better control on the data acquisition, ensuring better measurement quality.

The characterization proves that the reference torque standard is adequate for torque meters and medium accuracy torque transducers calibrations.

6. REFERENCES

[1] Jorge C. Torres-Guzman, Eric E. Torres de León, Fernando Martínez Juárez, Design, Construction and Start Up of a 200 N·m and 2 kN·m Torque Transfer Calibration System, *XX IMEKO World Congress*, September, 2012, Busan, Republic of Korea. (Submitted for presentation).