EURAMET TC-M, Dynamic Area Roadmap

Background

Industry and authorities are increasingly using dynamic measurements of force, torque and pressure – with only a static calibration of the sensors - for the development and quality assurance of their products (optimised concerning safety, weight, cost etc.) or tests. Typical examples for force are sensors to be used for crash tests in automotive and aerospace industries, for materials testing and machine monitoring and control as well as the field of vibration analysis of mechanical structures (modal testing). Examples for torque are safety relevant screw connections in automated production lines and engine power measurements. Examples for pressure are sensors to be used for fuel injection systems, explosion protection or ballistics. It is well known, that in many cases a static calibration alone is not appropriate - especially in those applications where a high accuracy is required. Consequently there is an increasing demand of industry and authorities for dynamic measurements of force, torque and pressure with a reliable traceability to the SI-units in accordance with internationally accepted written standards. Such traceable measurements should cover periodic and shock shaped excitation for all these measurands with large ranges of intensity and frequency. The required uncertainties are in the range of < 0.1% to < 2% depending on the frequency between 0 Hz and 10 kHz. The required amplitude ranges for the respective measurands are:

Force:	< 100 kN (periodic), 250 kN (shock)
Torque:	< 2 kN·m
Pressure:	< 20 MPa (pneumatic), 800 MPa (hydraulic)

Basic Science: Metrology

The basic science in this field is the development of new methods, facilities and transfer standards for the dynamic measurement of force, torque and pressure.

Grand Challenges: Environment, Health, Energy

Force, torque and pressure metrology are important quantities for many areas of trade and industrial and scientific research and require traceability for dynamic measurments. For the dynamic measurement of force, torque and pressure there are no Calibration and Measurement Capabilities (CMCs) available by NMIs [1]. To meet the requirements of the measurement of dynamic force, torque and pressure metrology in Europe national standards and transfer standards have to be developed to cover the future needs of industry and research.

Innovation (for industrial applications)

The prerequisites and the necessary steps are in principle quite similar for all three measurands due to the similarities of fundamental measurement techniques. Nevertheless each measurand force, torque and pressure needs different primary and transfer standards to cover the whole frequency and amplitude range.

On a primary standard level all three are firstly based on well established static calibrations. The high accuracy of the static calibration, however, cannot be applied for dynamic applications. Dynamic force, torque and pressure measurements are secondly based on dynamic measurements of displacement, velocity and acceleration of the moving masses for their definition and in order to determine contributions caused by inertia effects.

A first step towards traceable dynamic measurements is a detailed analysis of the dynamic effects of the set-ups and the sensors. These have to cover the complete measurement chain consisting of mechanical, optical and electronic parts (sensor structure and mechanical coupling, interferometer, filters and measurement amplifiers). Advanced modelling and characterisation of transducers and facilities and corresponding analytical and numerical (FE) analysis are the keywords here. Traceable high precision data acquisition from low to high frequency range will be necessary.

A second step is for each measurand to develop exciters for the set-ups with high precision and well defined signal shape avoiding unwanted disturbing motions (e.g. distortion or tiltings) for the whole amplitude and frequency range. By investigating and improving the measurement techniques for strain, acceleration and charge it will be possible to develop devices optimised for dynamic measurements.

Based on these developments new facilities and procedures will be installed to act as primary standards for dynamic measurements of force, torque and pressure. In order to fulfil the needs of industry and authorities for dynamic measurements traceability to the SI-units can then be provided by special transfer standards and procedures for dynamic calibration. The results and experiences of all these developments will be incorporated in future international written standards for dynamic measurements of force, torque and pressure.

References

[1] BIPM, Calibration and Measurement Capabilities, http://kcdb.bipm.org/appendixC/