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Development and calibration of dynamic pressure sensor for motor pressure range

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Summary:

Reliable dynamic pressure measurements are essential in control and optimization of modern combustion engines. To ensure reliability of dynamic pressure measurements, dynamic pressure sensors should be calibrated using dynamic pressure calibration methods. VTT has developed solutions to improve reliability of dynamic pressure measurements: A new dynamic pressure sensor for harsh engine environments, a secondary dynamic pressure calibrator for industry use and an option to heat dynamic pressure sensors during calibration.

Keywords: Dynamic pressure, Dynamic pressure sensor, Pressure calibration, Traceability, Pressure sensor

Introduction

To ensure reliable performance of dynamic pressure sensors, they need to be calibrated using dynamic calibration methods that are traceable to the International System of Units (SI). Despite of this, dynamic pressure sensors are usually calibrated using static pressure calibration methods, because traceable dynamic pressure calibrations are not readily available. Currently, only two National Metrology Institutes offer traceable dynamic pressure calibration services: VTT MIKES from Finland and LNE/ENSAM from France.

VTT Dynamic pressure sensor and developments in dynamic pressure calibration

Recently, VTT has further developed solutions to improve the reliability of dynamic pressure measurements. These solutions include a new dynamic pressure sensor for harsh engine environments, a secondary dynamic pressure calibrator and an option to heat sensors during calibration.

The VTT dynamic pressure sensor is based on a remote reading of the bending membrane. The sensing element is not in direct contact with the bending membrane, which makes the sensor very durable. Besides durability, a major advantage of the sensor is its unique patented capacitive sensing technology. This innovation enables reliable static calibrations of sensor even though the sensor is used under dynamic pressures. This in turn makes the calibration of the sensor cost-effective, because unlike dynamic calibrations, static calibrations can be carried out using existing pressure calibration instrumentation. As shown in results, a static calibration of the VTT pressure sensor gives comparable results with the dynamic calibration.

Fig. 1. VTT Dynamic Pressure Sensor

Unlike VTT dynamic pressure sensor, typical commercial dynamic pressure sensors cannot be calibrated reliably using static calibration techniques. Primary dynamic pressure calibration techniques are laborious and require high-level of expertise. Therefore, VTT MIKES has developed the secondary dynamic pressure calibrator, which is easy to use, compact and

relatively simple to manufacture. The calibrator creates a few millisecond long half-sinewave shaped pressure pulses. These pulses are typically repeated once a few seconds. Traceability of this calibrator to SI is based on a reference sensor calibrated using the VTT MIKES dynamic pressure primary standard.

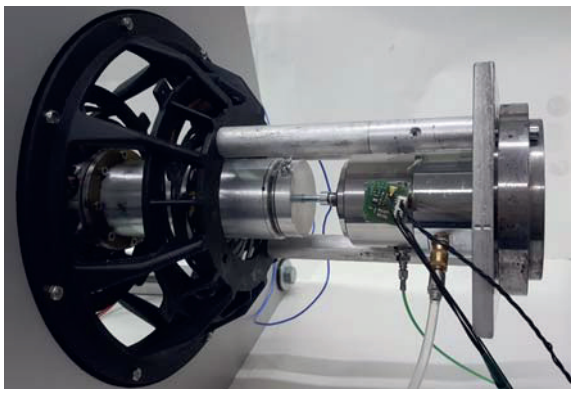

Fig. 2. VTT MIKES secondary dynamic pressure calibrator

Dynamic pressure sensors are typically used in high temperature environments. Therefore, in order calibrate them at temperatures that corresponds environment they are used in, heating option for sensors under calibration has been developed.

Results

In figure 3, static and dynamic calibrations of VTT Dynamic Pressure Sensor are compared with each other. Uncertainty of comparison is around 2% and difference between static and dynamic calibrations is around 0.5%. It can be assumed that VTT dynamic pressure sensors can be calibrated both dynamically and statically.

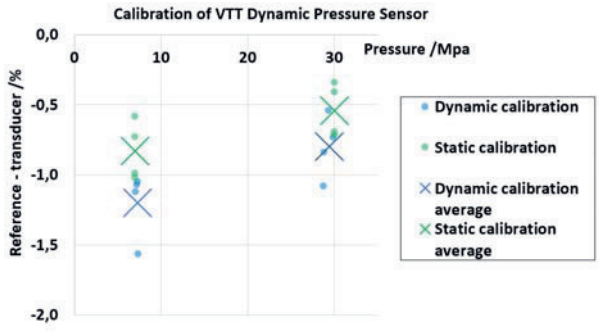

Fig. 3. Calibration of VTT MIKES Dynamic pressure sensor in with dynamic and static calibration

Calibration results in temperatures 20, 120 and 180 °C for VTT dynamic pressure sensor are shown in Figure 3. Sensor has sensitivity change of around 1 %/100 °C when heated.

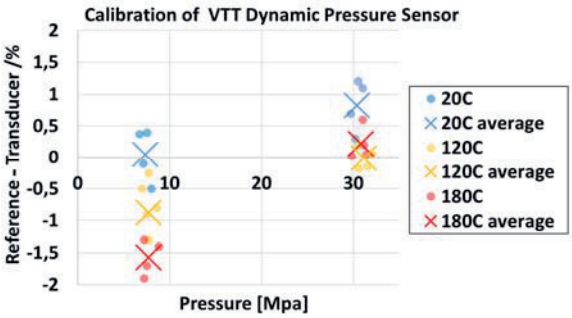

Fig. 4. Calibration of VTT MIKES Dynamic pressure sensor in different temperatures

Conclusions

VTT has developed solutions to improve reliability of dynamic pressure measurements. These solutions include a new dynamic pressure sensor for harsh engine environments, a secondary dynamic pressure calibrator for industry use and an option to heat dynamic pressure sensors during calibration. Based on initial calibration measurements, it is concluded that VTT dynamic pressure sensors can be calibrated both dynamically and statically. When heated, sensitivity of VTT dynamic pressure sensor changes around around 1 %/100 °C.