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Novel calibration facility for water flow with large temperature span

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Abstract
Danish Technological Institute (DTI) is extending the flowrate of the existing flow rig up to 1.000 m3/h in the temperature span from 4 – 85 °C and pipe dimension up to DN400, and thereby become a unique calibration facility. The new test rig will serve as the national primary standard for the field of water flow measurement and thereby replacing the current at DTI.

From 0.5 – 500 m³/h the test rig is based on gravimetric principle using a diverter principle. From 500 – 1000 m³/h the test rig is based on reference flow metering. The reference flow meters will consist of two high precision Coriolis flowmeters mounted in parallel. The reference flowmeters are placed in the same circuit as the gravimetric system. This setup allows for calibration of each reference flowmeter against the gravimetric method without dismounting the meters. This ensures low uncertainties and traceability to a primary standard and possibility to participate in international inter-comparisons.

The new flow rig will be highly digitalized with a high degree of automation. Communication with flowmeters under test will be flexible with both conventional analogue interfaces but also through industrial communication standards.

1. Introduction

There is a demand for calibration facilities with high flow combined with the possibility for use at different temperatures. This combination is the motivation for development of a new flow test rig at the Danish Technological Institute.

The new test rig is built upon the existing test rig, which is based on the gravimetric principle. The existing flow facility consist of three different test rigs covering an accredited flow range from 5 L/h up to 500 m³/h. Each test rig has its own diverter, weighing tank, and scale. Calibrations can be performed in a temperature range from 4 °C up to 85 °C.

The revamped test rig will be able to cover flows up to 1000 m³/h in DN400 pipes and with the option of 1 bar pressure difference across the test section (across a DUT) at the maximum flow rate. This enables the test facility also to be used for measuring k_v values and test of different types of valves e.g. regulation valves.
The temperature range will be the same as for the existing test rigs, 4 °C up to 85 °C.

The test rig will also be suited for dynamic flow measurement e.g. to assess the performance of domestic water meters under dynamic load changes.

DTI is partner in the EMPIR (European Metrology Programme in Innovation and Research) project METROWAMET [1], where assessment of dynamic performance of domestic water flow meters is one of the major aims of work packages 1. Hereby potential future test requirements will be integrated into both the test rig and the data acquisition system.

2. Reference flow metering

2.1 Reference flow metering
Traceability for flow rates above 500 m³/h is realised through reference flow metering with two DN200 coriolis flow meters. The maximum flow rate of 1000 m³/h is covered by mounting the two flow meters in parallel and splitting the flow in two with 500 m³/h as maximum flow rate for each meter, se figure 1.
In order to get a very low uncertainty state-of-the-art coriolis flow meters were chosen. These flow meters have a high accuracy in a very large flow range, see figure 2 below, and they are very stable. The stated accuracy is 0.05 % of the actual flowrate from 800 m³/h down to a flow rate of 28 m³/h.
The traceability of the reference flow meters is realised by calibrate them against the existing accredited gravimetric system. A very huge advantage is, that the flow meters can be calibrated separately without dismounting them. This means that they can be calibrated

in situ against the gravimetric standard on the large test rig.

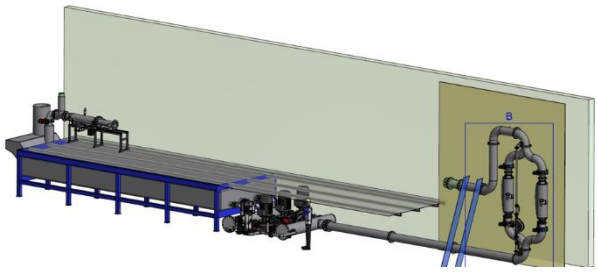

Figure 1, Three-dimensional view of the new test rig with the parallel reference flowmeter system shown on the right side of the figure.

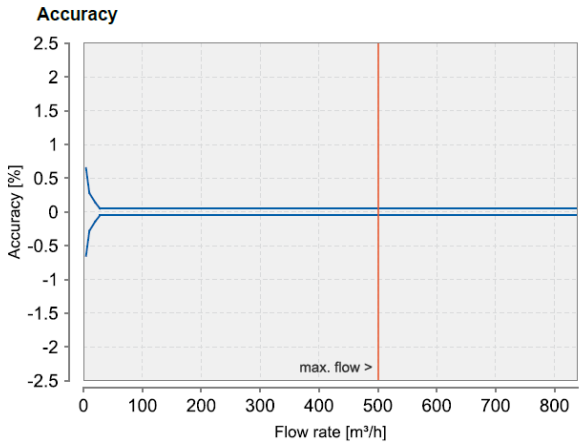

Figure 2, the graph shows the expected accuracy of the Coriolis flow meter as stated by the manufacture.

To cover low flow rates with reference flow meters a third reference flow meter is also installed. This flow meter covers the range down to 1.8 m³/h with a stated accuracy of 0.05 % of the actual flowrate.

The uncertainty of the existing gravimetric system is 0.05 % and the uncertainty of the reference metering system is expected to be in the size of 0.2 %.

2.1 Pumping system

In order to deliver a flow rate of 1000 m³/h three 55 kW pumps are installed. The large power of the pump is necessary as the pressure loss across the Coriolis reference flow meters have a size of approximately 1 bar at a flowrate of 500 m³/h. At the maximum flowrate (1000 m³/h) the flow is split in two at the parallel reference meter system and the flow through each meter is therefore 500 m³/h. The pressure loss in the piping system is estimated to 2.5 bar and with the required differential pressure capacity of 1 bar across the DUT, the total differential pressure, which the three pumps should be able to maintain is 4.5 bar. Beside the three pumps a smaller pump is installed in order to adjust the flow to specific flow rate within narrow limits. All pumps are equipped with frequency converters and can be controlled through the new automized system explained in the next section.

3. Digitalization

The revamped test rigs will be full automated and data acquisition from both measurement equipment mounted to run the test rigs and from DUTs will be digitalized and collected through network cables and stored in a database. Calibration certificates can then be generated automatically from the stored measurement data ensuring that errors arising from manual handling of data can be avoided. All measurement conditions such as humidity, air temperature, water temperature etc. will also be collected and stored together with calibration data from the DUT and from the reference meter or from the gravimetric system.

The automation of the test rig is realized through a Programmable Logic Controller (PLC) system and an industrial PC installed with a SCADA (Supervisory Control And Data Acquisition) software to run the PLC system. All valves will be quipped with actuators, so that they can be controlled through the SCADA system. All pumps can also be controlled and regulated through this system. Moreover there will be a regulation system to sustain a specific predefined flow rate.

The user can control the test rig through a client computer installed with client software. Standard calibration procedures are stored in the system and contains the overall setup for the system e.g. valve settings, data acquisition, target flow rates, duration of test etc. New procedures can be built from scratch or upon existing produces and stored.

Communication with flowmeters under test will be flexible with both conventional analogue interfaces but also through industrial communication standards e.g. ModBus. The control software will include possibilities to setup automatically test protocols which can be associated with the unique ID for the device under test and thereby reducing risk of setup-error between test. The test data from both reference test rig and device under test will be stored in a database for generating certificates and for temporal comparison of performance of device.

4. Dynamic flow patterns

As DTI participate in the METROWAMET project it is a demand that the new test rig should also be suited to perform dynamic measurement as it is stated in the project protocol., that it is necessary to have test rigs and protocols available for the verification of domestic water meters under dynamic load changes. Beside this the rig

must meet at minimum the specifications of OIML R49 (Section 4 “Metrological Requirements”). This dynamic ability is realised by installing a fast response weighing system consisting of load cells, load cell amplifier and fast acquiring data acquisition system.

5. Conclusion

At the time of writing the test rig is not finish and no tests has been performed. Consequently, there is still a lot of work to do to claim the CMCs (calibration and measurement capability) of the reference system and to get all the automized calibration procedures to work.
Issuing certificates based on data in a database by a push of a button is also left to do. Dynamic measurement is also an area that still needs a lot of investigation, however, together with a couple of other Metrology Institutes across Europe we are working together to solve this task and are very confident that we will succeed.

References

[1] https://www.ptb.de/empir2018/metrowamet/the-project/