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DOUBLE PISTON PROVER USABLE AS FLOWRATE COMPARATOR FOR VARIOUS GASES

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Abstract: For the calibration of small flowrates and for use with different gases, a novel double piston prover with a spindle-stepper motor drive has been developed.
The piston prover allows flowrates being generated with a very good reproducibility and flowrate constancy, and it therefore also makes possible the calibration of meters under test which generate a constant flowrate like critical nozzles.
By means of this principle, it was possible to realize for the first time a flowrate comparator which can also be used for the measuring of gas flows.

Keywords: flow rate measurement, primary standard, comparator principle.

1. BASIC INFORMATION

For quality assurance in industry and research as well as at public authorities, the traceability of measurement and testing devices to the SI units is of increasing importance. For this purpose, PTB develops fundamental apparatuses which are at the head of the calibration chains in Germany. For the calibration of gas measuring instruments, different volumetric methods, as for example a bell prover, are used at PTB.

For the calibration of small flowrates and for use with different gases, a novel double piston prover with a spindle-stepper motor drive has been developed [2].

The piston prover allows flowrates being generated with a very good reproducibility and flowrate constancy, and it therefore also makes possible the calibration of meters under test which generate a constant flowrate like critical nozzles [1].

By means of this principle, it was possible to realize for the first time a flowrate comparator which can also be used for the measuring of gas flows.

2. Description of the principle

For the following explanation please refer to Fig. 1 shown below.

To generate stable pressure and temperature conditions during the calibration of a meter under test, the calibration flowrate Q is generated by means of a flowrate control R_Q. The gas passes through the piston/cylinder system Z1, the connection pipe with the flowrate indicator M_Q and the valve V, the piston/cylinder system Z2 and the meter under test.

To generate volume flows (Q_{K1} and Q_{K2}) through the two piston/cylinder systems (Z1 and Z2), the mechanically coupled piston bars with equal diameters d_k are driven into (Z2) and out of (Z1) the cylinders respectively at a velocity v_k . Thereby, the velocity v_k follows from the spindle pitch s and the step frequency f of the stepper motor used in micro step operation.

$$Q_{K1} = Q_{K2} = \frac{\pi}{4} d_K^2 \cdot f \cdot s \tag{1}$$

With increasing Q_K the flowrate in the connection pipe or in the flowrate indicator M_Q decreases. The flowrate in the flowrate indicator M_Q is zero if $Q_{K1} = Q$ because then, the piston/cylinder system Z1 takes up the entire volume flow Q generated by the flowrate control. The constant flowrate through the meter under test, however, continues as the piston/cylinder system Z2 gives off the flowrate $Q_{K2} = Q$.

The prover can also be used as a comparator for the measuring of unknown flowrates if the flowrate indicator is bound into a control circuit controlling the piston flowrate Q_K in such a way that the flowrate in the connection pipe is negligible.

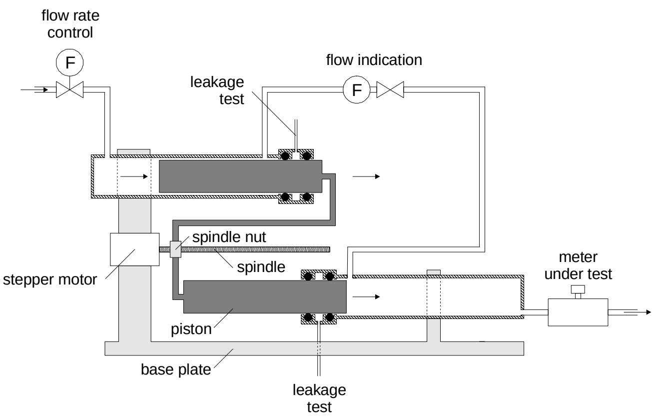

Fig. 1. Outline of the flow comparator

The new flow comparator allows the calibration of flowrate measuring instruments such as orifice meters, laminar flowrate meters, thermal mass flow meters, soap bubbles measuring devices but also calibration of flowrate controls (mass flow regulators) and sonic nozzles [2].

The main advantages of the principle are:

- Before and during a calibration, the pressure and temperature conditions are stationary (the run-in time of the meters under test is unlimited).
- Due to the calibration of the piston outer diameters and measurement of the spindle, the uncertainty of the volume is very small.
- During a calibration, the interior tightness can be detected.
- The measurement of constant flowrates predetermined by the meters under test is possible.

Table 1. Properties of the flow comparator.

Property	**value / range**
Flowrate range	Q_{min} = 5ml/h to Q_{max} = 5 l/h
Uncertainty	U < 0.05% (k = 2, Q > 0.02 Q_{max})
Piston diameter	d = 16 mm
Maximally displaced volume	V = 44 ml
Uncertainty of the piston diameter	U = 0.5 µm (k = 2)
Utilizable piston length	l = 220 mm
Measuring time	t > 25 s
Spindle pitch	1 mm/revolution
Number of steps per revolution (stepper motor)	10 000
Gas types:	inert gases (air, fuel gases, noble gases)

REFERENCES

[1] R. Kramer, B. Mickan: "Traceability in Gas Flow Measurements", Proceedings of the PITCON Conference, Chicago, USA, 7.-16. März 2004, Published by CD-ROM, session 8500-800, 09.03.2004

[2] E. von Lavante, R. Kramer, B. Mickan: "Flow Behaviour in Sonic Micro-Nozzles", 11th International Conference on Flow Measurement, FLOMEKO' 2003, Groningen, The Netherlands, 12-14 May 2003, CD-ROM, Poster Session, p. 61