Towards the Improvement of a Blow-Down Type High Pressure Air Flow Calibration Rig

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A blow-down type high pressure air flow calibration rig has been established at Center for Measurement Standards (CMS) in Taiwan since 1996. The facility consists of a primary standard which adopts the gravimetric method and a secondary standard which utilizes master meter method using sonic nozzles, having a capacity of flow from 15 m3/h to12000 m3/h under standard condition and pressure from 1 bar to 60 bar. During flowmeter calibration, the air pressure in the upstream storage tank drops continuously due to the blow-down design, leading to a corresponding temperature drop. Measures have been taken to improve the facility’s performance and reduce the thermal effect during meter calibration. Capacity of the 2nd-stage air storage tank was increased from 7 m3 to 22 m3, and the original sonic nozzle bank was replaced by new sonic nozzle array consisting of seven nozzles which can be operated independently. The throat diameters of the new nozzles range from 2.312 mm to 11.56 mm, having nominal actual flow rates of 3 m3/h to 75 m3/h, and the three largest ones have to be operated simultaneously to achieve the maximum flow rate. Two additional sonic nozzles were installed downstream of the nozzle array as the check meters.

Tests show that increasing the storage tank capacity cuts the rate of temperature drop by about 25 %. Calibration of the new nozzles by the primary, gyroscope weighing system shows that the nozzles operate across laminar to turbulent regimes, and the transition takes place at the Reynolds number around 106. Positive dependence of transition point on the nozzle diameter was also observed. An unofficial bilateral comparison with PTB through a 6” turbine meter was conducted to verify the capability of the modified calibration rig. The En values across the range of flow tested were all less than unity, suggesting that the measurement results are equivalent and CMS’s uncertainty claim of 0.18 % is adequate. Further improvement of the facility by installing two additional heat exchangers to recover the heat loss during calibration process is underway..