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Extended Abstract

Performance of Coriolis Flowmeter for Metering of CO_2 with Impurities in CCS Applications

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EXTENDED ABSTRACT

Transportation of CO_2 by pipelines plays an important role in carbon capture and storage (CCS) operations, as the captured CO_2 from power plant / industries needs to be transported to the geological storage locations. However, the CO_2 stream may contains impurities, e.g. nitrogen, hydrogen, argon, oxygen and other gases, depending on the capture technology used. The presence of impurities can impact the thermophysical properties of the CO_2-rich mixture, particularly density and viscosity. This impact can be significant in the vicinity of the critical point of CO_2-rich mixtures. The temperature and pressure conditions likely to be experienced in the transportation of CO_2 with impurities by pipelines are close to the critical point of CO_2-rich mixtures. Therefore, small gradients in pressure and temperature can significantly change the physical properties of the mixture. This can challenge the precise flow measurement of CO_2 mixtures, as the performance of the flowmeters is strongly dependent on the thermophysical properties of the transported fluid [1]. This is particularly important as European Union Emission Trading Scheme (EU ETS) regulations state that the uncertainty of fiscal metering in CCS must be within the range of ±1.5 mass percent.

Under DECC-funded COMET project at Heriot-Watt University, a unique mass flow rig was designed and constructed based on the gravimetric calibration, i.e., comparison of mass recorded by the flowmeter with the mass measured by high robust weighing scale. The chosen flowmeter is OPTIMASS 6000-S08, provided by KROHNE Ltd with twin V-shaped measuring tubes which can work up to 600 kg/h. Briefly, the main components include the Coriolis mass flowmeter model OPTIMASS 6000-S08 from Krohne with twin V-shaped measuring tubes and flow range up to 600 kg/h, a gas-driven CO_2 pump model Maximator M22 with a cooling jacket, a pressure pulsation dampener model PulseGard SoG-SS with a PTFE/EPDM membrane, a back-pressure control valve model High-Tech EL-Press P-522C from Bronkhorst Ltd, source and receiving cylinders with 5 litres volume and 30 MPa design pressure, two pressure relief valves with the set pressure of 10 MPa, a robust weighing balance model ViBRA HJ-K with an accuracy of ±0.1 g. The flow rig was then calibrated using pure dense liquid CO_2. The trials conducted at different pressure, temperature and flow rates demonstrated that Coriolis meter can achieve an average measurement accuracy of 0.1% with an experimental measurement error of 0.025% [2].

Accordingly, in this work, the performance of the Coriolis mass flowmeter was evaluated for CCS applications using several gas mixtures representing the fluids captured by different technologies, i.e. pre-combustion, post-combustion and oxyfuel processes. A binary mixture of 1.97 mol% nitrogen and balanced CO_2 representing post-combustion, a multi-component mixture of 1.5 mol% hydrogen, 1.0 mol% nitrogen, 0.5 mol% argon and balanced CO_2 representing pre-combustion, as well as two multi-component mixtures with oxygen, nitrogen and

argon as impurities with 2 mol% and 15 mol% representing oxyfuel, were used to investigate the performance of the chosen flowmeter. The tests were conducted in start / stop operations at different conditions of constant pressure and transient operations of ramp-up and depressurisation conditions. In addition to the mass and volume flow rates, the operational pressure and temperature as well as velocity and density were recorded for the test monitoring. The differential mass collected in the receiving cylinders then, were compared to the differential mass recorded by the mass flowmeter to obtain the deviation of each test. Experimental operation conditions are temperature and pressure from 288.6 to 293.3 K and 1.00 to 6.10 MPa with the flow range up to 32.1 kg/h and turndown of 53.5. The deviations of conducted tests varied within the range of -2.1% to +0.7% and -2.0% to +2.0% for the post-combustion and pre-combustion fluids, respectively. The Absolute Average Deviation (AAD) for both fluids was 1.0%. For oxyfuel fluids, the deviations vary in the range of -1.8% to +1.8% with AAD of 1.5% and -0.3% to 2.3% with AAD of 1.4% for oxyfuel I and II, respectively. In the investigated work, although the impurities can increase the uncertainty of flow measurement in CCS applications, they can still be within the range of EU ETS requirements with a suitably sized Coriolis mass flowmeter.

REFERENCES

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[2] C.-W. Lin, M. Nazeri, A. Bhattacharji, G. Spicer, and M. M. Maroto-Valer, "Apparatus and method for calibrating a Coriolis mass flow meter for carbon dioxide at pressure and temperature conditions represented to CCS pipeline operations," Appl. Energy, vol. 165, pp. 759–764, Mar. 2016.