The fiscal metering of transported CO_2-rich mixtures in CCS operations

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Abstract

Transport of captured CO_2 to permanent storage sites plays an important role in the CCS chain. The pressure and temperature conditions during transport of CO_2 by pipelines are very similar to the critical conditions of CO_2-rich mixtures. However, the physical properties of mixtures of CO_2 with impurities can vary significantly in the vicinity of critical conditions, and therefore, small changes in pressure and temperature in the pipelines can result in significant changes in the physical properties of CO_2 containing impurities. This can challenge the fiscal metering of CO_2-rich mixtures as the uncertainty of flowmeters strongly depends on the physical properties of the transported fluid. Moreover, the accuracy requirements of EU ETS for fiscal metering of CO_2 mixtures in CCS is required to be in the range of ±1.5% by mass. Accordingly, in this work the performance of suitable flowmeters for CCS applications is evaluated.

A Coriolis mass flowmeter was selected here, as it can directly measure mass as well as density of the transported fluid. The chosen flowmeter is an OPTIMASS 6000-S08 provided by KROHNE Ltd with twin V-shaped measuring tube, 1/2 inch diameter and operating in the range of 0.6 to 600 kg/h mass flow rates. To evaluate the performance of the selected flowmeter, a unique flow loop has been designed and constructed based on comparing totalized mass flow shown by the flowmeter with the mass measured using high accuracy weighing scale [1]. The set-up has previously been calibrated using pure CO_2 both in the gas and dense liquid phases at pressure and temperature ranges representative of CO_2 pipelines. The studies showed that the set-up and the selected flowmeter are in good agreement with both the specification provided by manufacturer as well as EU ETS regulations [1].

In this paper, we evaluate the performance of Coriolis meter in the presence of impurities by using CO_2 mixtures representative of different capture technologies, i.e. post-combustion, pre-combustion and oxyfuel. The conditions studied include temperatures between 288 K to 295 K, pressure ranges from 1.5 MPa to 6.1 MPa and flow rates from 0.6 kg/h to 32.1 kg/h with the turndown ratio of approximately 10 to 50. During the tests, pressure, temperature, mass flow rate, volumetric flow rate, density and fluid velocity are recorded. The recorded flow rate measurements were in good agreement with the weighed values, and moreover, within the regulation requirements stated by EU ETS. Furthermore, the density measurements reported by the Coriolis meter were compared by those obtained using a high pressure and high temperature (HPHT) U-shape vibrating-tube densitometer (Anton Paar, model DMA HPM) at temperatures of 293, 303 and 313 K and at pressures up to 30 MPa. The accuracy of measured density in this flowmeter was reported to be ±1.0 kg/m^3. The results show density reductions due to the presence of impurities in both densitometer and flowmeter measurements.

[1] 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,” Applied Energy, vol. 165, pp. 759–764, Mar. 2016.