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Extended Abstract

Online measurement of impurities in CO_2 by using electrical permittivity

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1 INTRODUCTION

Carbon Capture and Storage (CCS) is expected to be an important part of the effort of reducing the emission of greenhouse gases in the years to come. Depending on the capture process, there will be different impurities in the captured CO_2. These impurities can cause problems for the transport of CO_2 from the place of capture to the reservoir where it will be stored. To comply with CO_2 specifications, monitoring of impurities is crucial. Common impurities expected in the CCS streams are O_2, N_2, Ar, H_2O, SO_2, H_2 and CH_4. This work explores the use of electrical permittivity for measurement of impurities.

2 THE MEASUREMENT CONCEPT

The concept focuses on identifying changes in the stream concentration from the measured stream permittivity. The measured permittivity can then be compared to the dielectric constant of pure CO_2, or to a predetermined stream permittivity range. The hypothesis is that the measurement system can report a level of impurity if the difference between the measured and the reference permittivities is above a certain level. The method requires a contrast in permittivity between the CO_2 and the impurities. Impurities like water, where the difference in permittivity is larger, will be possible to detect in smaller quantities compared to impurities with permittivity closer to that of CO_2 [1].

In this work two metering principles were used, which allows technology intercomparison. The low-frequency electrical permittivity was measured using (i) contact electrodes and (ii) microwave resonance measurements. The impurity used for the tests was nitrogen since CO_2-N_2 mixtures are well documented and agree well with predictions from GERG-2008 EOS [2].

3 THE EXPERIMENTAL WORK

The experimental work was done at the thermal engineering laboratories of Sintef and NTNU in Trondheim, Norway. The equipment under test were installed in a temperature-controlled room. The fluids, CO_2 and N_2, were injected from feeding cylinders into the rig and permittivity was measured by electrode measurements using an Emerson's Roxar Multiphase Flow Meter and by microwave resonance measurements using a Roxar Watercut Meter. The two meters were installed horizontally in series. The rig has 8mm stainless steel tubing and includes temperature and pressure sensors and a pump for circulating the fluid. The tests encompassed liquid CO_2, at temperatures ranging from -6 °C to 3 °C and pressure between 40 bara and 80 bara. The mass fraction of nitrogen ranges from 0 to 1.1%. The measured permittivities were compared with theoretical values by Harvey and Lemmon [3] as implemented in REFPROP v10.

An approach to identify the presence of impurities is to measure the permittivity and compare this with the calculated permittivity of CO_2 at the actual temperature and pressure. This was investigated by looking at a series of test points with mass fraction N_2 of 0%, 0.6% and 0.8%. Results are plotted in figure 3. This deviation appears as expected to be proportional to the mass fraction of N_2 for both technologies.

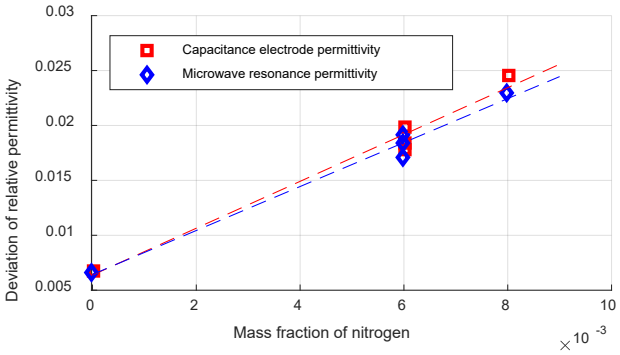

Fig. 1 - Deviation between measured relative permittivity of mix and calculated relative permittivity of CO_2 vs mass fraction of N_2.

The effect of N_2 on the measured permittivity is also seen in Figure 2, where measured and calculated permittivities are plotted for two test points. The temperature (-3 °C) and pressure (45 bar) are the same for the test points. Test point 1 is pure CO_2 and for test point 2 there is 1.1% mass N_2. The uncertainty of the measurements is indicated in the figure, the error bars are showing one standard deviation.

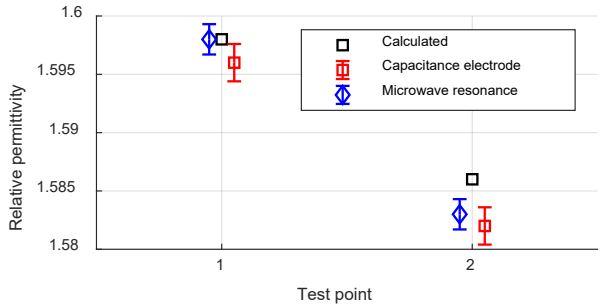

Fig. 2 – Theoretical and measured relative permittivity for two test points, without impurity (test point 1) and with 1.1% mass N_2 (test point 2).

4 CONCLUSIONS

This work demonstrates the feasibility of using electrical permittivity measurement to find impurities in CO_2 flow. The results indicate that nitrogen levels of 0.2%mass fraction can be feasible to detect using this concept for both technologies tested. The concept can be used for determining the presence of contamination but does not identify which impurity is present. The detectable level of impurity depends on the relative permittivity of the impurity.

5 REFERENCES

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