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Compression and liquefaction unit for measuring impurities in the CO_2

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Abstract

A new CO_2 Compression and Liquefaction Unit (CCLU) for measuring impurities in the CO_2 product has been built connected to the CO_2 capture pilot plant at SINTEF. The unit will be used to measure impurities in the CO_2 after compression and drying at the conditions relevant to CO_2 ship transport. The presentation will describe the CCLU in detail and give analyzing results from a short test campaign with 30 wt% MEA.

Keywords: CO_2 Compression and Liquefaction; Chemical Absorption; Carbon Capture; MEA;

Background

Quality of the CO_2 coming out from the capture unit can be crucial for transportation, storage and usage of CO_2. For example, besides strict limitation of compounds like O_2, N_2, NO_x, SO_2 coming from the flue gas, the Northern Light project also have limiting levels of amines and amines degradation products. For amines and ammonia, the level for transportation is $\leq$10 ppm and for degradation products like aldehydes it is $\leq$ 20 ppm. The knowledge about the amount and impact of these compounds are generally not well known. Typically, the compounds found in the exhaust gas leaving the absorber are also present to some extent in the CO_2 stream out of the desorber. The following compression stages produce knock out water in condensate drums and probably much of the impurities follow the water. In the last stage we get liquefied CO_2. Besides that, a small amount of water is soluble in the CO_2, the solubility of amines and amines degradation products in liquid CO_2 is usually unknown.

The CO_2 laboratory at Tiller, Trondheim, Norway is a highly equipped test facility for development of post-combustion CO_2 capture technologies, as well as a research lab for flue gas pre-treatment, analysis and emission research see Figure 1. For more information of the plant see Mejdell et al, 2011.

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Figure 1 The full height absorber and desorber inside the 30m heigh building.

The present work is a part of the EU Horizon 2020 project "Demonstration a refinery-adapted cluster-integrated strategy to enable full-chain CCUS implementation" (REALISE). In this project, the pilot is equipped with a compact CO_2 compression and liquefaction unit (CCLU), enabling liquefying of the CO_2 produced in the capture process in order to identify and quantify impurities in the CO_2 product. In the paper we present this unit in more detail and the results from a campaign performed during spring 2022.

Compression and Liquefaction Unit (CCLU)

The rig was designed based on simulations using ASPEN Plus and includes 3 compressor stages with cooling after each stage. The rig is designed for processing of 10-20 kg/h CO_2. The PI&D of the CCLU is shown in Figure 2.

The CO_2 from the stripper is going into the first compression stage at 1.5 bar and leaves it at approximately 5 bars by using a Haskel gas booster. The gas is then cooled down to 30°C and the condensed water is separated out in a knockout drum. The gas is then sent to a second Haskel booster which increases the pressure to about 14 bars and a third booster which gives about 35 bars. There are knock-out drums after these two compressors as well.

The produced CO_2 is then dried in the two dryers installed in parallel, and then condensed and cooled down to about –5 °C by using Lauda Integral IN 250XTW cooler before it is stored in a CO_2 tank (Carbo-Mizer 450 from Linde).

It will be possible to take out samples for analysis before the CO_2 is stored, and also liquid samples from the knockout drums.

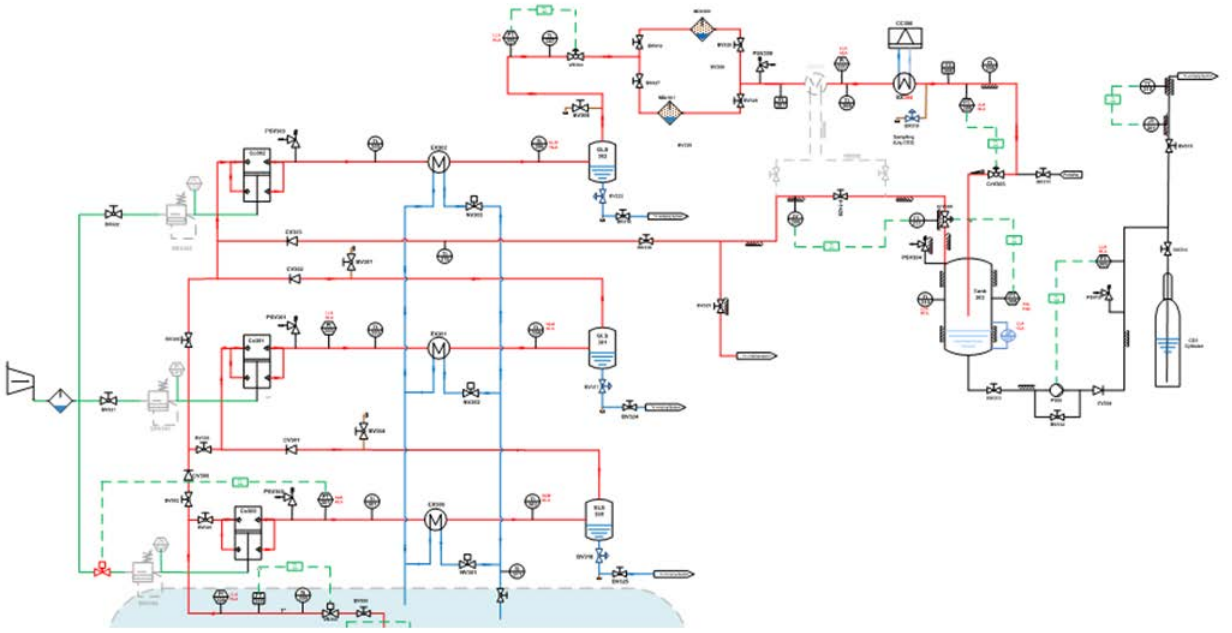

Figure 2 PI&D of the CCLU

The design parameters of the CCLU compression train are:

CO_2 gas into the compressor 1:
- Flow: 10 - 20 kg/h
- Pressure: 1.5 – 2.0 bar
- Temperature: 15 - 25 °C

CO_2 gas into the compressor 2:
- Pressure: 4.5 – 6.0 bar
- Temperature: 15 - 30 °C

CO_2 gas into the compressor 3:
- Pressure: 12 – 16 bar
- Temperature: 15 - 30 °C

CO_2 gas into the dryers:
- Pressure: 35 – 45 bar
- Temperature: 10 - 30 °C

In Figure 3 a photo is shown during the installation of the CCSU. The rig is built inside a cabinet with ventilation and CO_2 alarm.

Figure 3 Photo of the CCLU installation

Analyses

The CO_2 gas will be sampled after the dryers before the liquefaction and analysed for impurities. In addition, liquid samples of the knockout water after each compressor stage will be analysed.

A part of the REALISE project is to develop analytical methods for the compressed CO_2 and these methods will be used during the campaign.

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Reference:
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