Using CO_2 absorber as a humidifier in a pressurized CO_2 capture system

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Abstract

Offshore gas turbine cycles represent a large portion of CO2 emissions from the oil and gas industry in Norway. In addition to the increased energy penalty and cost related to CO2 capture, the increased size and weight of equipment are also challenges to implement CO2 capture techniques. It is essential to make the capture unit compact for offshore applications. Increasing the operating pressure of a capture unit (named as Pressurized CO2 Capture in this study) can lower the volumetric flowrate of flue gases and thus reduce size of equipment along the flow paths. In addition, high pressure is favored by some capture technologies e.g. the energy consumption for CO2 capture can be reduced for absorption. While a novel method to achieve pressurized conditions for flue gases have been proposed in the CleanOFF Hub project, this study presents an idea of using CO2 absorber as a humidifier in a Pressurized CO2 Capture system. Humid Air Turbine is a well-know technique to increase the mass flow of gases passing through gas turbines by adding water/steam to the gases. One method of adding the water/steam is to use a humidifier (packed column) where the gases directly contact with water to achieve a saturated state. Since the CO2 absorber is also a packed column that is operated above ambient pressure in a Pressurized CO2 Capture system, the absorber can thus be used as a humidifier that adds water vapor to the pressurized CO2 lean flue gases.

Introduction

Motivations for pressurized CO2 capture:

- Smaller volume flow of flue gases (smaller equipment)
- Higher pressure is favored for capture (low energy consumption for capture)

How to achieve pressurized condition?

- CO2 content in gas turbine exhaust gases is low
- Direct compression of flue gases means expansive power is wasted

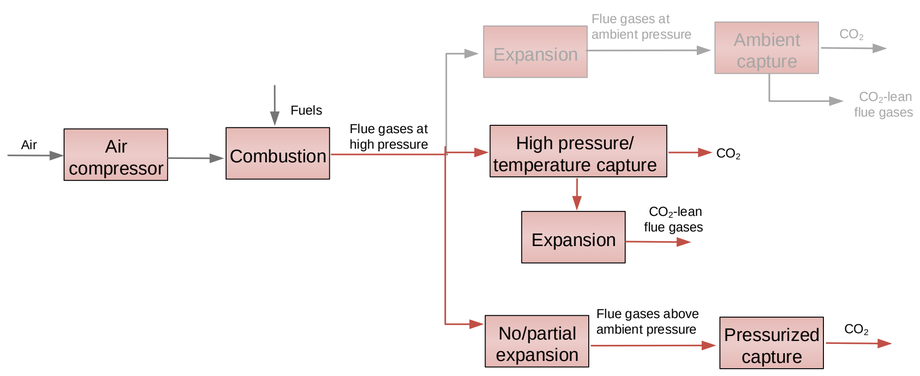

Figure 1 Routes of CO2 capture from gas turbine cycles

CO2 absorber as a humidifier

- **The expansion takes place prior to water wash (preheating can be used)**
- **Absorber works as a humidifier tower to increase water flow**
- **Overall thermal efficiency further increases by around 0.5% points**
- **More power can be produced if the absorber can be operated at higher temperature**

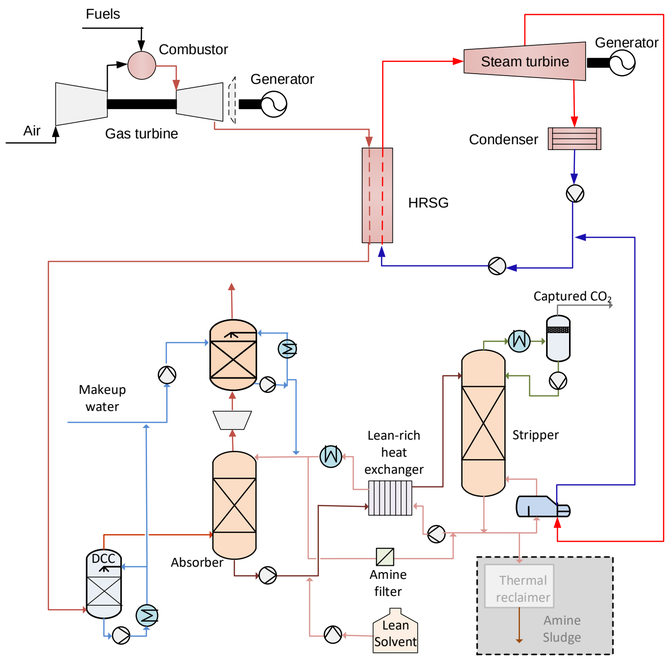

Figure 4 Using the absorber as a humidifier in the solvent based pressurized CO2 capture scheme

A novel scheme of gas turbine cycles for pressurized CO2 capture

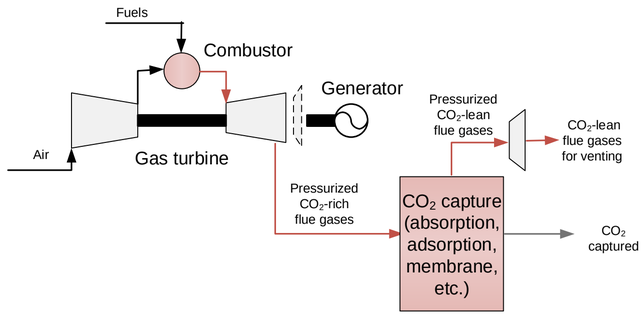

Figure 2 A novel scheme of gas turbine cycles for pressurized CO2 capture

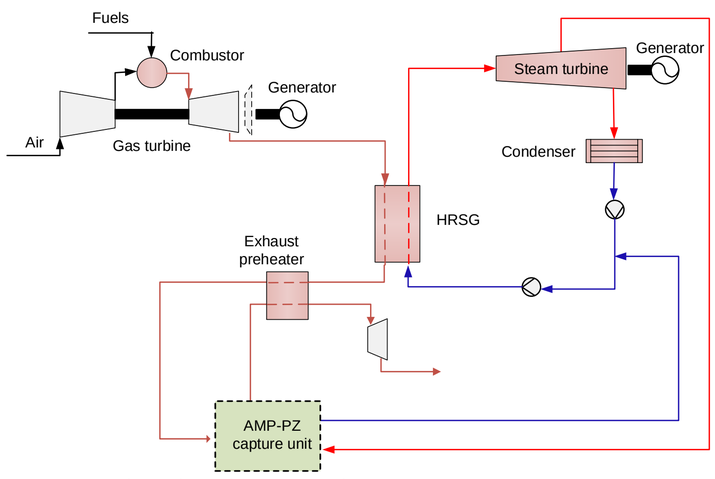

Figure 3 Solvent based pressurized CO2 capture

- **Absorber diameter is reduced by 35%**
- **Heat consumption for CO2 capture decreases by 15%**
- **Overall thermal efficiency increases by 0.5% points**
- **Solvent emissions are considerably reduced**

Conclusions

- Pressurized CO2 capture can be achieved by capturing CO2 from flue gases that partially or even do not expand through gas turbines
- The absorber is pressurized and can be used as a humidifier that increases the expansion power
- The process scheme can also be used for other capture technologies such as membranes and adsorption
- This study is mainly based on thermodynamic analyses. Dialogues with gas turbine vendors are necessary to evaluate the feasibilities of realizing this novel scheme

Acknowledgements

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