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2nd Post Combustion Capture Conference (PCCC2)

Membrane Implementation Strategies for Carbon Dioxide Capture on Natural Gas Turbines and Coal Power Plants

Bouchra Belaissaoui^a, Yann Le Moullec^b, Gilles Cabot^c, David Willson^d, Eric Favre^{a,*}

^aLRGP-CNRS Université de Lorraine, 1 rue Grandville 54001 Nancy, France

^bEDF R&D, Département Mécanique des Fluides, Energies et Environnement, 6 quai Watier- BP 49 78401 Chatou, France

^cStanbridge Capital, 37 East 18th Street, New York, NY 10003, USA

^dUMR 6614 CORIA, INSA de Rouen, Avenue de l'Université, BP 08, 76801 Saint-Etienne du Rouvray, France

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1. Introduction

Energy saving is the main challenge for post-combustion CO₂ capture technology. In this strategy, both CO₂ capture ratio and CO₂ purity should be high enough (typically above 90%) [1]. Today, absorption in a chemical solvent (such as monoethanolamine, MEA) is considered as the best currently available technology and taken as a reference for post combustion capture. The corresponding energy consumption is of approximately 4GJ_{th} (thermal basis)/ton of recovered CO₂ (including compression requirement). A target of 2 GJ_{th}/ton is often mentioned according to the European Union recommendations [2].

Membrane processes have shown growing interest as an alternative to the reference technology. However they remain energy intensive when both high CO₂ purity and capture ratio are imposed and when diluted CO₂ flue gas are to be treated [3]. Consequently, for diluted CO₂ flue gases containing 5 % and 15% CO₂ typical of a natural gas turbine flue gas and coal combustion respectively, a multi-stage membrane processes or hybrid systems are needed to achieve the capture targets [4,5]. Nevertheless, design studies on hybrid processes based on a membrane unit for carbon capture are scarce [6].

In this work, two hybrid processes are investigated (through simulation) for CO₂ capture on natural gas turbine and coal power plant respectively: (i) A hybrid process combining flue gas recycling, combustion in oxygen enhanced air (OEA) and CO₂ capture by membranes (ii) A hybrid membrane / cryogenic separation based on a first step CO₂ pre-concentration with a membrane unit and a second step CO₂ cryogenic condensation. For each hybrid process, a parametric analysis has been performed regarding the process parameters and the membrane CO₂ /N₂ selectivity, covering current and prospective material development. Finally, the optimal operating conditions are identified and the potential improvement of the overall efficiency is discussed.

From the membrane material point of view, an improved selectivity (100 in place of 50) does not offer significant benefit in term of energy requirement while the membrane surface area increases. Thus, for this hybrid process, already commercially available membranes with a selectivity of 50 seem to be appropriate.

4. Conclusion

In this study membrane implementation scenarios for carbon capture on natural gas turbine and coal power plant have been investigated. Two hybrid processes have been evaluated.

The energy requirement of both hybrid processes is shown to be competitive compared to the reference technology, namely, chemical absorption in MEA. These promising results call for a more in depth analysis and several unexplored issues have to be considered for future works. Importantly, a technico-economical analysis, including capital costs (membrane area, compressors...) should be undertaken in order to better evaluate the potential of these hybrid processes for CO₂ capture.

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