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CO_2 purification. Part I: Purification requirement review and the selection of impurities deep removal technologies

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ABSTRACT

Depending on the reference power plant, the type of fuel and the capture method used, the CO_2 product stream contains several impurities which may have negative impacts on pipeline transportation, geological storage and/or Enhanced Oil Recovery (EOR) applications. All negative impacts require setting stringent quality guidelines for each application and purifying the CO_2 stream prior to exposing it to any of these applications.

In this paper, the CO_2 stream specifications and impurities from the conventional post-combustion capture technology are assessed. Furthermore, the CO_2 restricted purification guidelines for pipeline transportation, EOR and geological storage are evaluated. Upon the comparison of the levels of impurities present in the CO_2 stream and their restricted targets, it was found that the two major impurities which entail deep removal, due to operational concerns, are oxygen and water from 300 ppmv to 10 ppmv and 7.3% to 50 ppmv, respectively. Moreover, a list of plausible technologies for oxygen and water removal is explored after which the selection of the most promising technologies is made. It was found that catalytic oxidation of hydrogen and refrigeration and condensation are the most promising technologies for oxygen and water removal respectively.

1. Introduction

Amongst the several initiatives approached to reduce carbon emissions, Carbon Capture and Storage (CCS) technology deemed to be very useful because it would allow the continued use of fossil fuels and the protection of the environment simultaneously. It is considered to be very promising in achieving the target of the Intergovernmental Panel on Climate Change (IPCC) because of its immediate and substantial impact on the CO_2 level in the environment (Stangeland, 2007). However, CCS technology appears to face some challenges which need to be addressed. These challenges are classified as: technical, financial, regulatory or public support. The focus of this paper is on a specific technical challenge, which is the need for CO_2 processing, following the capture process, in order to remove harmful impurities, such as sulfur oxides, nitrogen oxides, oxygen, carbon monoxide and water (Anheden et al., 2004). If CO_2 streams were not purified to the right level, some possible threats faced include corrosion of pipelines and unwanted side reactions with hydrocarbons. To avoid these threats, it is important to know what critical impurities are present in the CO_2 stream and to what extent is their removal recommended prior to their exposure to pipelines, EOR or geological storage. The amount of purification will vary depending on the type and level of the impurities, which are reliant on the capture technology, the type of fuel used and the reference power plant.

In this paper, the CO_2 stream specifications and impurities from the conventional post-combustion capture technology are assessed. Furthermore, the recommended purification levels for pipeline transportation, EOR and geological storage are evaluated. Finally, a preliminary assessment of the different technologies for the impurities deep removal is conducted.

2. Background

CCS technology includes capturing CO_2 from large point sources (i.e. power generation, refineries, and industrial applications), compressing it and transporting it to be stored in geological reservoirs or depleted oil and gas reservoirs, used for Enhanced Oil Recovery (EOR) or for Enhanced Coal Bed Methane Recovery (ECBM) (Cormos, 2011). The CO_2 capture concept is similar to that of the removal of H_2S and SO_2 from separation and thermal processing of sulfur containing fuels.

Three major technological routes are considered for capturing CO_2 from power plants: pre-combustion, post-combustion and oxy-fuel combustion. Pre-combustion is the process of removing the carbon element from the fuel before its combustion (Cormos,

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