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CO_2 Purity in Coal Fired Oxyfuel Processes

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1. Introduction

Besides the post- and pre-combustion processes, the oxyfuel process is one of the most promising processes for carbon capture from coal fired power plants due to its specific advantages. All these processes cause a net efficiency loss of roughly about 10 %-points. The main characteristic of the oxyfuel process is that combustion takes place in an atmosphere of almost pure oxygen and recirculated flue gas instead of air. The combustion occurs at higher oxygen concentrations compared to the air blown case and therefore no problems concerning the combustion, like unburnt carbon or too high NO_X emissions, are expected.

The purity of the separated untreated CO_2 at the oxyfuel process is lower compared to post- and pre-combustion processes. The reduction of the amount of impurities is, besides the minimisation of the efficiency loss, the main objective to increase the feasibility of the oxyfuel process for CO_2 capture. In the oxyfuel process the CO_2 concentration in the flue gas reaches values of about 80 – 90 vol.-% on a dry basis. Therefore the CO_2 can be easily separated from the flue gas. The purity of the separated CO_2 depends mainly on fuel composition, air ingress, combustion stoichiometry and oxygen purity. CO_2 purities for transport and storage between 85 and 99.9 vol.-% are achievable at reasonable CO_2 capture rates with moderate efforts.

2. Motivation

The main impurities in the oxyfuel process are nitrogen, oxygen and argon. Additional but to a much smaller extent SO_X, NO_X, CO and ash occur. The impurities are caused by the purity of the oxygen, delivered by a cryogenic air separation unit, the combustion process and air ingress. One of the most critical factors for CO_2 transport is to control the water content in the pipeline. If the pressure drops, e. g. at throttles or valves, free water may precipitate and form carbonic acid. CO_2 dissolves in water to form carbonic acid solution which is corrosive to many materials. To reduce corrosion special material could be used but at the cost of much higher investments. Also hydrates may cause ice plugs which could clog the pipeline system. The water content must be that low that no free water can condense.

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Traces of oxygen may cause significant damage to the CO_2 infrastructure due to corrosion if wet sections prevail. Due to the presence of oxygen in the storage site geochemical reactions (e. g. oxidation of iron and subsequent precipitation) and increasing growth of bacteria could occur. This could lead to clogging of the pores and a reduction of the injectivity. An increased purity influences the costs and reduces the capture rate. Therefore it is essential to know which CO_2 purity is necessary for transport and storage. The amount of permissible impurities depends on the design of the pipeline network and in particular the geology of the storage formation. To define the required CO_2 purity for capture and storage, the research project COORAL was originated.

3. Work content

COORAL is the acronym derived from the German project name "CO_2-Reinheit für Abscheidung und Lagerung – CO_2 purity for capture and storage" of a collaborative research project funded by the German Federal Ministry of Economics and Technology and partners from the industry. The project deals with the whole CO_2 chain from production at the power plant via transport and injection to the storage site. The first step in the project was to estimate the possible impurities in the separated CO_2 for oxyfuel, post- and pre-combustion processes. Focus of this paper is the quantification of impurities of the coal-fired oxyfuel process. Three different scenarios for the oxyfuel process developed in the COORAL project are presented in table 1. The scenarios serve as a starting point for the simulations and experiments performed within the project. The scenarios will be adapted during the project to the respective state of knowledge. The given concentrations apply to the state after the CO_2 processing unit and compression, i. e. the pipeline inlet interface.

The possibilities to influence the CO_2 impurities by operation of the power plant, CO_2 separation processes and additional CO_2 treatment are investigated. The effects caused by impurities on the transport chain, the injection chain and the geological storage site are examined. The required CO_2 purity at the power plant results from the requirements of pipeline transportation as well as of geological storage. At the end of the project an optimum between economic and plant specific demands and a specification of the required CO_2 purity for capture and storage should be developed.

Table 1: Scenarios for different CO_2 purities from the COORAL project.

	Zero Emission	Concentration	Distillation
CO_2 in vol.-%	85.0	98.0	99.94
O_2 in vol.-%	4.70	0.67	0.01
N_2 in vol.-%	5.80	0.71	0.01
Ar in vol.-%	4.47	0.59	0.01
NO_X in ppm	100	100	100
SO_2 in ppm	50	50	50
SO_3 in ppm	20	20	20
H_2O in ppm	100	100	100
CO in ppm	50	50	50

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