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Solvent-based post-combustion CO_2 capture for power plants: A critical review and perspective on dynamic modelling, system identification, process control and flexible operation

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HIGHLIGHTS

- Critical review on dynamic modelling, identification and control of the PCC process.
- Classification of the existing studies according to the approaches used.
- Comprehensive analysis of the advantages and limitations of current studies.
- Summary of research achievements and challenges for flexible operation of PCC.
- Prediction of the future research opportunities in solvent-based PCC process.

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ABSTRACT

Solvent-based post-combustion CO_2 capture (PCC) appears to be the most effective choice to overcome the CO_2 emission issue of fossil fuel fired power plants. To make the PCC better suited for power plants, growing interest has been directed to the flexible operation of PCC in the past ten years. The flexible operation requires the PCC system to adapt to the strong flue gas flow rate change and to adjust the carbon capture level rapidly in wide operating range. In-depth study of the dynamic characteristics of the PCC process and developing a suitable control approach are the keys to meet this challenge. This paper provides a critical review for the dynamic research of the solvent–based PCC process including first-principle modelling, data-driven system/process identification and the control design studies, with their main features being listed and discussed. The existent studies have been classified according to the approaches used and their advantages and limitations have been summarized. Potential future research opportunities for the flexible operation of solvent-based PCC are also given in this review.

1. Introduction

Greenhouse gas emissions represented by CO_2 and the resulting global climate change have become the most serious environmental problem facing humanity in this century [1]. Fossil fuel fired power plant is the largest stationary source of CO_2 emission since the majority of electricity around the world is generated there [2] and this trend will not change in a foreseeable future [3]. In this context, the technology of Carbon Capture and Storage (CCS) remains a critical solution to make deep and rapid reductions in CO_2 emissions. According to the prediction of Global CCS Institute in 2018 [4], 14% of cumulative CO_2 emissions reduction must be achieved through CCS to reach the Paris target of 2 °C by 2060 [5]. More than 2500 CCS facilities with average capture capacity of 1.5 Mt CO_2/year need to be operating by 2040, if the target is to be achieved [4].

Compared with other CO_2 capture technologies, the use of amine-based solvent for post-combustion CO_2 capture (PCC) can directly remove the low concentration CO_2 from flue gas, which is mature in technology, relatively low in cost and easily retrofitted to existing power plants. Therefore, it has been regarded as the most promising technology for power plant CO_2 capture [6–10]. A typical mono-ethanolamine (MEA) solvent-based PCC process is shown in Fig. 1.

Prior to CO_2 absorption, the flue gas must go through desulfurization, denitrification, dust removal and cooling processes as they will

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