Graph-based Deep Learning Method on Analyzing Complex CO_2 Capture Inventions

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Abstract. Carbon capture and storage (CCS) are critical processes in all chemical and power plants. CCS requires highly complex technologies with transdisciplinary features. Flue gas emitted after combustion has the highest CO2 content during the final production phase and may be harmful to the environment if released to the air. Thus, studying the post-combustion CO2 capture innovations are the main goal of this research. The integrated CCS solution is a complicated system, including special machine designs and special varieties of chemicals or absorbents. In this research, related patents are systematically analyzed through both macro and micro informatics, organized in graphical forms to explore the state-of-the-art transdisciplinary technological trends and issues. The domain ontology exhibits the framework of our studies in hierarchical manner followed by macro analysis showing patenting statistics such as distributions by years, countries, and leading assignees. Text mining approaches for patent informatics, e.g., k-means technology clustering, keywords extraction, patent theme-scape graph generation and life-cycle analysis, are presented as the micro-analysis to discover critical technology themes in the overall patent database as well as the individual patent. Towards the end of this paper, some economically viable technological innovations for CO2 capturing are depicted. This patent informatic research has transdisciplinary significance as the knowledges and innovations are of high values to environmentalists, governments, private sectors, and end-users towards an eco-sustainable world.

Keywords. Text mining, carbon capture and storage (CCS), post-combustion, chemical absorption, semantic analysis, knowledge ontology

Introduction

The world today is facing severe environmental issues and people are experiencing erratic weathers manifestation, such as floods and storms that seem to get increasingly severe and fatal. CO_2 is the most prevalent greenhouse gas (GHG), accounting for more than 70% of worldwide GHG emissions causing climate change [1]. The reduction of

CO_2 emissions becomes critical and best remedy to stop or slow down global warming. Tall orders have been made by European Union (EU) to reduce CO_2 at least 40% by 2030 compared to 1990, and by 30% compared to 2005 [2]. By 2050, the subsequent goal is to enter to a climate-neutral or carbon-neutral phase with net-zero ozone depleting substance outflows and compensating for any additional emission [3]. With these initiatives, for instance, UK government hopes to achieve 80% CO_2 reduction by 2050
[4].

For this goal to materialize, huge commitment is deemed to significantly reduce CO_2 content emitted into the environment. One of the viable ways is to enmesh and store the CO_2, i.e., carbon capture and storage (CCS). Flue gas are waste emitted from combustion or burning and has the highest content of CO_2. The process of CCS in a nutshell is: first, the CO_2 is harvested from exhaust fumes, then it will be compressed at a pressure of around 100 bar before being transported, injected, and stored. Several techniques of capturing CO_2 such as post-combustion, pre-combustion, and oxyfuel combustion are common in plants and power generations. The extraction of CO_2 from flue gas is the core of post-combustion capture [5] and the basis of CCS infrastructure [6]. Pre-combustion capture involves partially oxidizing fossil fuels and reacting them with steam to produce synthesis gas (CO and H_2O), which is then transformed to CO_2 and H_2. Next, H_2 will be utilized as a fuel, while CO_2 is gathered using various procedures prior to combustion [6]. Meanwhile, for oxyfuel combustion technique, the fossil fuel will undergo combustion in oxygen rather than air, hence the flue gas emitted consisted of CO_2 and contaminants like Sox [6]. The impediment of this method is the requirement of a highly concentrated oxygen environment, which tends to change the chemistry of the flue gas and cause troubles such as corrosion, fouling, potential plant leaks, high maintenance costs, and safety management issues [7].

This research contributes the construction of domain ontology, patented technology clustering and main trends of CO_2 captures using chemical absorption. Macro-data analyses, such as patents applied/published/granted over the years and the top assignees and/or leading companies in key technology development are investigated. A total of 878 patents from the Derwent Innovation patent database are systematically identified and analyzed for technology trend discovery. Fig. 1 illustrates the knowledge ontology we have defined, consisting of chemical processes, equipment/machines, and chemicals (e.g., absorbents), based domain literature. The intention is to obtain a comprehensive patent analysis, within the ontology frame, identifying current technical innovation trends and projecting future possibilities of technology development. The study is to provide a comprehensive overview of the state-of-the-art technologies for postcombustion CO_2 capture with chemical absorption.

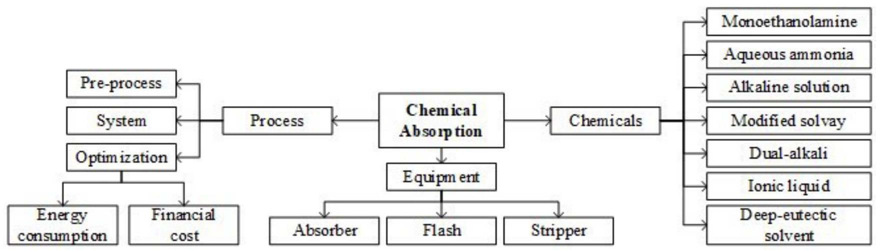

Figure 1. The ontology schema of $CCCC$ capture with chemical absorption approach.