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EDITORIAL
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Editorial: Advances in CCUS Engineering Technologies: Processes, Systems and Applications

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Editorial on the Research Topic

Advances in CCUS Engineering Technologies: Processes, Systems and Applications

CO_2 capture, utilization and storage (CCUS) has been widely recognized as a crucial part of the CO_2 emission reduction strategy in the fossil fuel dominated industries. As the world transits to net zero emission, its significance has been further emphasized to decarbonize almost all energy-related products and services, including power, steel, cement, chemical/petrochemical, and transport sectors. The editorial team anticipate that the 2020s will see CCUS's widespread application to fulfill its role and contribution to significant CO_2 emission reduction. This Research Topic is therefore designed to call for articles to communicate the state-of-the-art research with the focus on engineering solutions to advance CCUS technologies. The team collected four articles covering a wide range of research interests of CO_2 capture in natural gas and coal power stations, CO_2 utilisation in the steel industry, and potential CO_2 storage in heavy oil reservoir. Below are the brief introductions of each article.

Michailos and Gibbins present an interesting work of achieving up to 99% capture rate in amine-based post-combustion capture plants for combined cycle gas turbine flue gases. The work is based on Front End Engineering & Design studies carried out by Bechtel Corporation and further advanced to a 99% capture rate for achieving net-zero emissions fossil fuel power station. The results show that efficient operation at high capture levels appears to be feasible with minimal adjustments to the plant configuration, and minimal increase in specific energy requirements (3.77 GJ/t CO_2 at 99% capture vs. 3.50 GJ/t CO_2 at 95% capture). The article also suggests that capture levels higher than 95% would be attractive if CO_2 removal from the air is enforced by law in the United Kingdom.

Amine solvent development is of significant importance in advancing CO_2 capture technology. Li et al. introduce cyclic diamine of N-(2-Hydroxyethyl)-piperazine (HEPZ) for efficient CO_2 capture. The thermodynamic property of CO_2 solubility in aqueous HEPZ solutions is intensively investigated, leading to the development of a thermodynamic model for the HEPZ-H_2O-CO_2 system based on the electrolytic non-random two-liquid (ENRTL) activity model. The physical parameters for HEPZ and the interaction parameters for ENRTL, along with reaction constants of carbamate reactions, were regressed to validate the model. The thermodynamic model is then employed to predict the important capture performance indicators, including the CO_2 cyclic capacity, speciation and heat of reaction, helping the further development of HEPZ capture processes.

CO_2 utilisation through steel slag carbonation is an effective method for large-scale CO_2 emission reduction in the steel sector. The article by Liu et al. introduces two carbonation approaches, i.e., hot-stage carbonation and accelerated carbonation for CO_2 utilisation. The authors comprehensively investigate the mechanism on metal sequential leachability and the chemical/physical properties of carbonation products. The results indicate that hot-stage carbonation treatment facilitates particle agglomeration, minerals remodelling, and calcite formation, while the carbonation curing results in the formation of amorphous $CaCO_3$, calcite crystalline and Si-bearing hydrates. Hot-stage carbonation and accelerated carbonation curing can jointly prevent the leaching of harmful metals and facilitate promising high-volume steel slag-based binders with structural densification and CO_2 storage.

This research article also collects a multi-component thermal fluid (MCTF) study proposed by Yu et al., who introduces an innovative heavy oil development huff and puff technology that is widely used in China's offshore oilfields. The authors study 16 groups of core comparison experiments using an MCTF device, with original permeability, temperature and component quantitively investigated. A mathematical model is established and validated to investigate the influence of reservoir damage on heavy oil development, whilst the experimental study reveals that MCTF has an obvious damage effect on the reservoir. The simulation results show that reservoir damage could lead to a recovery drop by 6.9% during MCTF development, and MCTF huff and puff further improves oil recovery by 9.68%. The authors claim that the research is of great significance to understanding the principles of the MCTF huff and puff technique and helpful for promoting the development of offshore heavy oil reservoirs.

To sum up, the editorial team believes the research articles collected in this Research Topic will be of interest to CCUS peers. This would include but is not limited to: advanced process design to achieve net-zero emission fossil fuel use; advanced solvent development and amine model development; CO_2 utilisation *via* steel slag carbonation; heavy oil reservoir for CO_2 storage. The team also anticipates that CCUS technology deployment requires strong support from research and development, particularly the advanced engineering solutions to drive down the energy consumption and costs, which is believed essential for CCUS technology scale-up and wide deployment in the near future.

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KL writes the manuscript draft, KL, SY, HL, ML, and MW contributes to discussion and revision.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.