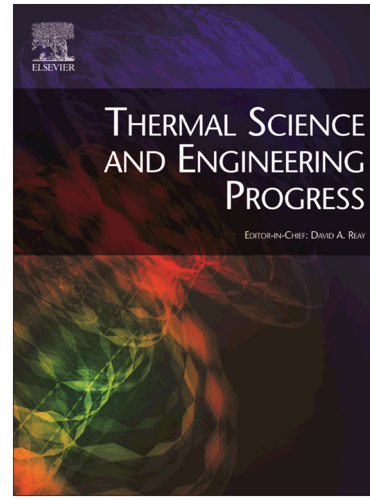

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Intensified Carbon Capture using Adsorption: Heat Transfer Challenges and Potential Solutions

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Abstract

Up to 25% of the total European Union (EU) CO_2 emissions that contribute to global warming are from industry, and while improved energy efficiency and process integration continues to play a role in minimizing these, it is carbon capture (CC) that in future will contribute most to mitigation, until nuclear energy and renewable technologies take over from fossil fuels. One of several CC methods is to use gas-solid adsorption, where the CO_2 is adsorbed ~~into~~ onto a solid. As with the more common absorption process, regeneration is required, and typically a single bed is employed to adsorb CO_2 while regeneration and removal of the CO_2 takes place in the second bed – carried out by pressure swing adsorption (PSA) or temperature swing adsorption (TSA). Collaborating in an EPSRC-funded project with Heriot-Watt University, where hydrotalcite-based adsorbents are being synthesised, and Sheffield University, where modelling is being undertaken, Newcastle University is examining the intensification of CC using a TSA-based process involving swirling or toroidal fluidized beds. As well as improving adsorption, it is believed that recovered waste heat could be used for desorption using a similar intensified technology. This paper discusses the potential sources of CO_2 that are being addressed, and how they will be integrated with the capture and desorption processes where fluidization will be used for the adsorption process. It also describes preliminary work on fluidization of the particles using additive-manufactured miniaturized fluid beds.

Keywords: Heat transfer, Carbon Capture, Adsorption, Fluidization, Additive Manufacture

Nomenclature

d_p Average diameter of adsorbent particle (m)

h_{max} Maximum heat transfer coefficient ($W.m^{-2}.K^{-1}$)

k_g Thermal conductivity of fluidizing gas ($W.m^{-1}.K^{-1}$)

Greek Letters

ρ_p Adsorbent particle density ($kg.m^{-3}$)

ρ_{sb} Bulk density of the adsorbent particle bed ($kg.m^{-3}$)