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# Electrified CO2 capture process through radiofrequency heating

Stratil O[1], Gonzalez-Olmos, R.[1],Pou J.O.[1],Fernandez-Garcia J[1,*]

*1 IQS School of Engineering. Universitat Ramon Llull. Via Augusta, 390. 08017 Barcelona, Spain*
**Corresponding author: javier.fernandez@iqs.url.edu*

**Abstract**

The problem of global warming and climate change is critical considering the reports from EPA, PBL Netherlands Environmental Assessment Agency and the Department of Energy & Climate Change in the UK, outcomes from COP29 among others. Aiming at new developments and greener approaches is the next target. Carbon Capture and Sequestration (CCS) technologies also face the problem of high energy consumption and low efficiencies with current CCS technologies. Chemical sorption with solid sorbents is one of the most promising processes to reduce the greenhouse effect, but it has the drawback of high energy consumption. Radiofrequency heating could overcome this considering its high efficiency. The use of electromagnetic energy to selectively heat magnetic materials acting as heating sources is well documented experimentally in catalytic reactors [1]. Comparatively, little investigation has been conducted into the potential applications of radiofrequency (RF) heating, which may be surprising given its high depth of penetration, intrinsic safety aspects, high efficiency and low installation and operating costs. This kind of heating from 'inside-out' in the material, is transferred directly in the material bulk and it has been observed that it leads to a controlled, near isothermal operation of a reactor bed, which can improve yield, reduce hot spots and improve the overall stability of the system. At present, due to its high efficiency, safety and fast heating times, the RF heating technology is increasingly being used in areas of industrial production in metallurgy for processing of metal slabs, as well as in civil and medical applications. In general, RF heating has an efficiency of 65– 85% [1]. Currently RF generators up to a 1 MW electrical output scale are readily available and several companies are providing this equipment even at a larger scale. The efficiency of these heat generators is typically in the range of 85–86%, which exceeds the efficiency of stand-along power plants. The problem of localised overheating can be resolved by using precise temperature control during temperature transitions under RF heating. It also has a lower sintering impact on the catalysts or sorbents and higher sorption capacities or conversions are observed for multiple reactions.

It was demonstrated that conventional heating mode (Electrical resistive heating) has 9 times higher heat losses to the environment during the heating step than RF heating. Using RF heating the transition time between the $CO_2$ sorption and desorption modes was reduced by a factor of three. The application of RF heating provided substantial energy savings as it drastically reduces the reactor non-productive time at high temperatures. The $CO_2$ desorption in a reverse flow mode further reduced the cycle time by 20% as it decreased the $CO_2$ partial pressure over the adsorbent that

substantially prevented $CO_2$ resorption. The reverse flow mode also allowed to obtain a higher $CO_2$ concentration in the purge gas than the one in the feed. The sorbent has shown a very stable performance with high $CO_2$ sorption efficiency. It is shown that by using RF heating an overall efficiency of process higher than 75% can be reached at relatively low operational costs. Energy savings of up to 30% compared to conventional heating methods and up to 20–30% compared to traditional electric resistance furnace can be obtained under RF heating. In addition, the RF heating process has the characteristics of easily achieving automatic control and short heating time. The short heating time could lead to additional savings as compared to conventional heating in the low electricity demand period.

RF heating also achieved high temperature cycles with lower energy consumption and also better performance of sorbent with multizone approach [2]. RF heating will be able to get constant temperature profile with zonal RF heating approach because the temperature is more constant and better controlled as it can be seen in Figure 1. RF heating is based on generating Foucault currents in metals, which is also known as Joule heating. This is a scalable method proven at both laboratory and industrial conditions. These results include experimental data with measured parameters that showed lower energy needs by 10 times less, better control of the temperature per sorption/desorption cycle and a less sintering effect on the sorbent as well compared to conventional heating. Utilization of desorbed $CO_2$ as feedstock would be the next step after the $CO_2$ capture process in order to integrate this $CO_2$ capture technology with utilization process.

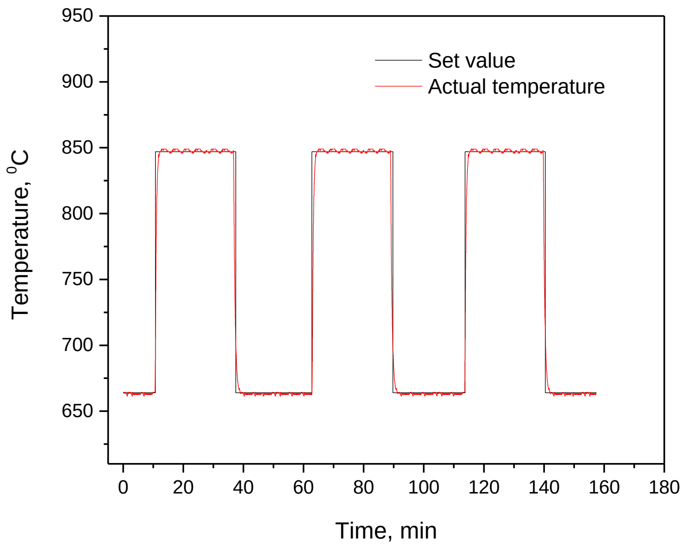


Figure 1. Temperature profile during multiple sorption-desorption cycles under RF heating.

**References**

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