CO_2 CAPTURE FROM FLUE GAS USING CALCIUM LOOPING - INFLUENCE OF FLUE GAS ON THE CAPACITY SORPTION AND THE METHODS CALCIUM SORBENT REGENERATION

WYCHWYTYWANIE CO_2 ZE SPALIN METODĄ WAPNIOWEJ PĘTLI CHEMICZNEJ - WPŁYW SKŁADU SPALIN NA POJEMNOŚĆ SORPCJI ORAZ METODY REGENERACJI SORBENTU WAPNIOWEGO

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In the history of the Earth changes in the severity of the greenhouse effect occurred repeatedly, each time causing global climate change. The sources of these fluctuations were the result of many factors. Warming, which is now observed, mainly due to human activities, occurs as a result of gradual increase in air temperatures due to increased emissions of greenhouse gases into the atmosphere. These gases constitute a barrier for the part of the solar energy reflected from the Earth, resulting in an equilibrium between the heat reaching our planet and the one which has been emitted.

With the development of Polish energy and ensuring energy security of the country, a significant amount of CO_2 emitted into the atmosphere becomes a real problem. This is the result of burning coal as a primary source of energy production. Hence the problem to develop effective technology for CO_2 capture from flue gases and its development is very current. In 2007 Poland adopted Directive 3 x 20, which was jointly developed with other EU members, stating that:

- reducing greenhouse gas emissions by 2020. At least by 20% in comparison to 1990;
- rationalizing the use of energy and consequently reducing consumption by 20%;
- increasing the share of energy produced from RES to 20% of total energy consumption on average in the EU in 2020.

The problem of reducing CO_2 emissions from energy conversion has become the basis of research, both in the economic and technical context.

There are different technologies which reduce CO_2 emissions to the atmosphere and the suggested subject of this dissertation concerns issues related to the capture of CO_2 using calcium sorbents, and this method is a technology with great application potential enabling the control of carbon dioxide emissions into the atmosphere. This method is one of the most effective methods of capturing carbon dioxide both after the combustion process (*post - combustion*) and before - in the gasification process and it is the subject of research in many scientific centers.

The aim of this dissertation was to analyze the process of capturing carbon dioxide by the use of calcium sorbents from the gases simulating the flue gases. For the reference gas composition

assumed a 15% CO_2 in N_2, which then it was further modified by additives of steam and different SO_2 concentrations. Sorption capacity for six calcium sorbents from different parts of Europe and one dolomite were determined. The optimum sorbent particle's size was set - 300 - 600μm for end use in a fluidized-bed reactor.

As part of the research, the work was performed at the laboratory scale and also at macro scale - three-tubular reactor built for research on the sorption and desorption of calcium sorbents presented in this dissertation.

The influence of temperature, the residence time of the sorbent in the carbonation and calcination processes and SO_2 and H_2O impurities in gas simulating flue gases on the sorption capacity for CO_2 were researched. Chemical analyses of selected sorbents after the calcination and carbonation process in selected cycles and process conditions and also research of sorbents' structures, XRD-analysis - a method of X-ray powder diffraction specifying the size of the crystal structure, SEM and EDS analyses - scanning microscopy defining the distribution of chemical elements included in the studied sorbents and also degradation studies of calcium sorbents pores by the use of mercury porosimetry.

As a result of the research, the relationship between the concentrations of carbon dioxide in the flue gases and calcination and carbonation temperature. It shows the change in the internal structure of sorbents in subsequent cycles of process from raw sorbent by calcination, regeneration to re-capture processes for regenerated sorbent. The analysis of the results of research on the sorbents' structure at different CO_2 sorption-desorption stages allowed to assess the causes of sorbents' deactivation in subsequent cycles. In this dissertation, there were subsequently performed studies on the effectiveness of three methods for the regeneration of sorbents after 24 carbonation – calcination processes in the selected, in the first part of the research, temperatures.

The regeneration was performed with the use of three different methods: water hydration, water vapor and the two-step regeneration - hydration plus the initial carbonation with the use of gas of 50% CO_2 concentration at low temperature (patent application P406868).

In the final part of the dissertation, there were the researches on the capture of CO_2 from a gas having a carbon dioxide content greater than 70% by the use of calcium sorbents i.e. the possibility of applying this method in the OXY technology (Oxy-Fuel Combustion) and OEA (oxygen enriched atmosphere) for cleaning the exhaust gases was researched.

The result of work is the development of optimal parameters of CO_2 separation from flue gases, sorbents' regeneration technology and the mechanism of regeneration.