Dangerous fly ash as a solution for global warming

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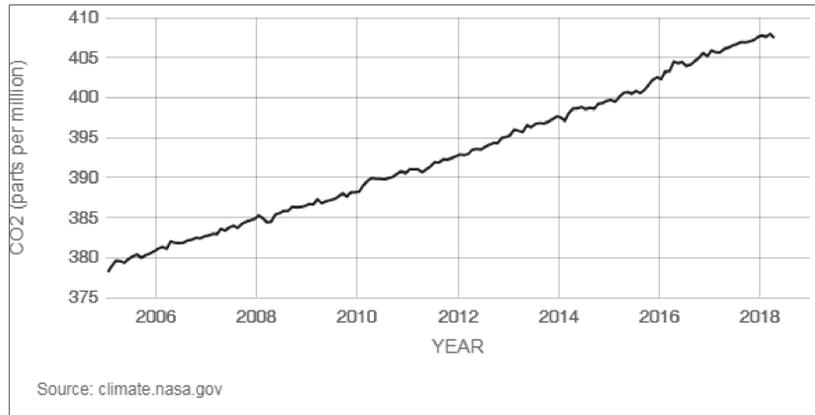Technická 5, 166 28 Prague 6, Czech Republic.

Background

Fig. 1: The concentration of CO_2 in the atmosphere.

Global warming is mainly caused by continual rise of CO_2 emissions in the atmosphere, as it can be seen in Fig. 1. Combustion fossil fuels, except CO_2 and other pollutants, produces also fly ash, which is captured by ESP or Baghouse filtres. This material is dangeours for humans but it can be used in the post-combustion CO_2 capture to mitigate climate changes. One of the post-combustion technlogy is adsorption, which was tested in this study. This process has quite high financial demand and for that reason various ways are tested to decrease the cost. One of the possibility is to find low-cost adsorbent, which can be fly ash.

Material and methods

Fly ashes from power plants in the Czech Republic were tested in high-temperature sorption of carbon dioxde. For all samples characterization including pore size distribution, specific surface area, XRF analyses and apparent density was done. The measurement principle is based on carbonate looping method. The measurements of sorption properties were performed in a laboratory apparatus with fixed-bed reactor in 10 cycles for both samples. One cycle of the measurement consisted of calcination and carbonation part. Calcination was performed with increasing temeperature up to 900 °C in the nitrogen atmosphere and carbonation run at 650 °C in the atmosphere of 12 %mol. CO_2 in N_2. The gas mixture used in carbonation part simulated desulphurized flue gas. The arrangement of the laboratory apparatus is shown in Fig. 3. The amount of captured/released CO_2 was analyzed in an infrared analyser ASEKO AIR LF. And then the measured data were calculated to the amount of sorbed/desorbed CO_2 in grams per 100 g of the fly ash.
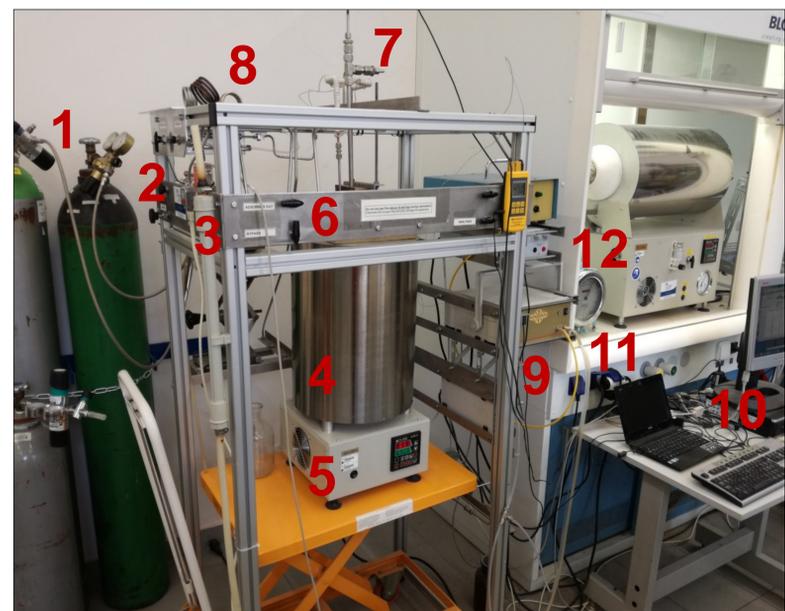

Fig. 2: Fly ash Z 30.

Fig. 3: The laboratory apparatus with fixed-bed reactor.
1 – pressure cylinders, 2 – ball valve, 3 – digital mass flowmeter with electromagnetic regulator, 4 – vertical furnace, 5 – digital regulator of the furnace, 6 – fixed-bed reactor, 7 – thermometer, 8 – spiral cooler, 9 – infrared analyzer, 10 – PC, 11 – wet gas meter, 12 – outlet from the apparatus

Results and discussion

Based on the characterization two samples (K31 and Z30) were chosen, because they reached the highest amount of CaO according to XRF; about 30 % wt. Their TGA curves showed very good thermal decomposition.

The sorption properties of chosen materials were tested in a fixed-bed reactor (Fig. 3). Both experiments were done under the same conditions mentioned above and the calculated data are shown in Fig. 4. This graph illustrates that the release of CO_2 in calcination steps is always higher then the capture in carbonation part, this suggests the sintering pores. Also from the curves one can see that after each cycle the sorption capacity decrease. The outcome is based on the sintering process which occurs during calcination/carbonation of material containing CaO, respectively $CaCO_3$. In general, sintering process affects the pore size together with BET surface because it causes clogging of pores and therefore the sorption capacity decrease. This statement is supported by the results of BET surface and pore size distribution before and after the measurement, which are stated in Table 1. Bet_1 identify BET surface before experiments and BET_2 after cyclic tests of sorption desorption and TPV is abbreviation for the total pore volume and the labelling is with the same meaning.

Tab. 1: The comparison surface characterization before and after tests.

The sample identification	BET_1	BET_2	TPV_1	TPV_2
	m²/g	m²/g	cm³/g	cm³/g
K31	8.021	7.215	0.1219	0.0674
Z30	11.461	9.431	0.1253	0.0489

Fig. 4: The sorption capacities of tested samples.

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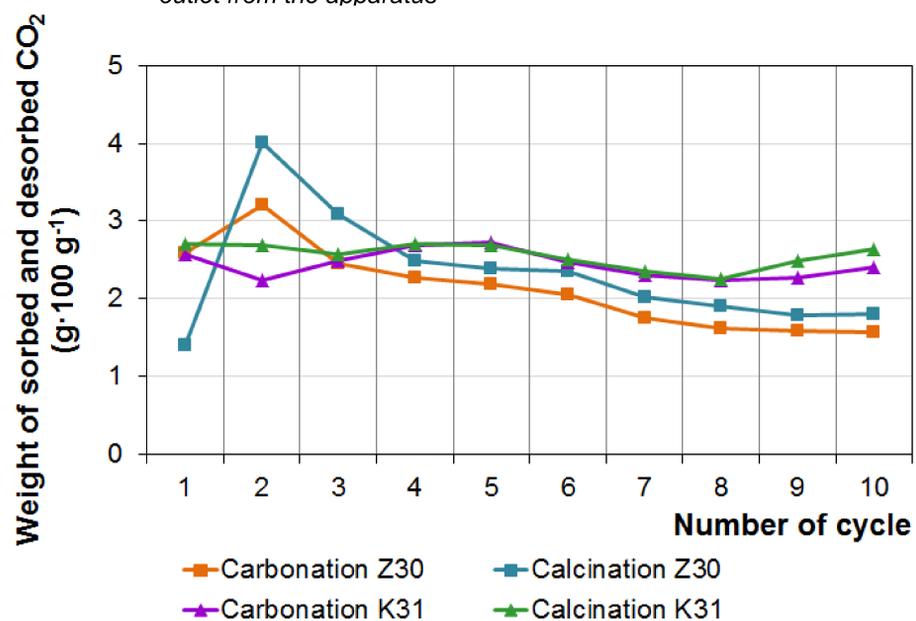
Conclusions

Two samples (K31 and Z30) were measured in the fixed-bed laboratory appartus. When the samples are compared K31 reached higher average capacity than the Z30. K31 contains higher amount of CaO (about 30 %wt.) and has better decomposition curve according TGA. From the comparison of BET surface with total pore volume before and after the measurements can be stated that they do not have important impact on the sorption properties. The biggest influence on the sorption capacity has the amount of free CaO and the decomposition at high temperatures. The average capacity for K31 was 2.44 g CO_2/100 g and during cycles the sintering occurs. The sintering surface will become more apparent at higher temperatures. Fly ash is considered as a waste material and therefore no long-term use is considered. However, if would be necessary it can also be used in cyclic sorption/desorption process to capture CO_2. In this case fly ash would be use as pre-cleaning of flue gas and then the flue gas would be led to the second cleaning stage were would be sorbent with higher sorption capacity, i.e. limestone.

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