CO_2 SEQUESTRATION IN COAL SEEMS – POSSIBILITY OR CURIOSITY

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Introduction

Carbon dioxide regarded as greenhouse gas originated from anthropogenic emissions is in focus of EU and UN policy on mitigation of this gas pollution. Developing industry all over the world produce bigger amount of this gas year by the year what is proved by the Kealing curve measured at Mauna Loa observatory. In this point of view one of the methods possible for solving the CO_2 mitigation problem is underground – geologic storage of this gas. The main topic in the scientific investigation and technical realisation is injection of gas to the mineral geologic structures such as inverted geosynclines or to the saline waters. It is done under bed conditions – usually in overcritical pressure for carbon dioxide. Another idea contained in geological methods is injection of CO_2 to the unmined coal deposits – abandoned collieries or deep coal beds (i.e. hard coal deposits).

The aim of the work is research the CO_2 sorption capacity by the use of numerical modelling of sorption process in hard coal samples (ex situ method). Consecutively, results of modelling are transformed to the field conditions. Multiple Sorption Model elaborated by the team is applied to the analysis of sorption capacity.

Samples and methods

Set of samples from different polish coal mines is used for the analysis of CO_2 sorption and in some of them sorption of CH_4 is also taken into account. Authors take into consideration wide range of coal starting from lignites up to anthracites. It is discussable to use all of this coal seems, because some lignites are located in the shallow layers and the risk of CO_2 leakage is big. However it is interesting what tendency appears within all the range of the coal types. In this analysis also are taken into consideration coal samples in the range of lignites, sub-bituminous, bituminous and anthracites. Short samples characteristic is presented in Table 1.

Table 1. Basic characteristic of investigated coal samples (Baran 2014, Baran 2015, Jodłowski 2007, Jodłowski 2014)

Sample		Be	Tu1	Tu2	Br	B82	A-K	Th	Vi	Wa	M85
		Li1	Li2	Li3	SB31	SB32	34	34	37	41	42
C^{daf}	%	65.9	70.2	75.9	79.6	80.88	86.4	86.4	87.6	89.1	92.41
V^{daf}	%	57.39	54.06	54.04	40.9	40.8	29.2	27.2	27.9	16.4	6.09
A^{a}	%	3.8	n.a.	12.3	15.5	2.48	6.15	7.89	7.78	8.92	3.7
W_a	%	21.1	8.3	8.3	1.65	3.76	1.55	1.13	1.25	0.9	0.81

descriptors: C - fixed carbon, V - volatile matter, A - ash, W - humidity, indexes: daf - dry and ash free state, a - analytical state

CO_2 sorption capacity of samples are calculated with application of Multi Sorption Model (MSM) with evaluation of modelling results on the basis of sorption isotherms measurements. Model gives possibility to estimate the distribution of sorbate between subsystems: absorption, expansion and adsorption. The most interested phenomena take place in the expansion subsystem hence it is a priori divided to 9 zones surrounding the average, dominant sub-micropore radius. Distribution of CO_2 molecules between subsystem has important role for estimation of storage capacity. Those ones which occupy absorption subsystem (R=0) penetrate coal deposit and are transported to long distance but with long time of percolation. Molecules located in expansion subsystem could move slightly faster, molecules in adsorption subsystem move to the inner-space and are localized, eventually molecules in free space (channels in butt-cleat macro structure) are transported quickly and create a risk of leakage. However, swelling of coal matter under sorption process cause closing the channels in butt-cleat structure after several days of CO_2 injection (Haljasmaa 2011)

Results

Finally, results of modelling by the use of MSM model leads to calculation of sorption capacity in the range of absorption, expansion and adsorption in the pressure achievable from measurements (3.84 MPa). In the next step this parameters are used for estimation of storage capacity on the basis of data on coal deposits size for different types of coal. After summing up these data and taking into account the date on size of coal deposits (Paszcza 2012) the volume of storage capacity was obtained at the level of 200 million tonnes for sub-bituminous (half of total capacity) and bituminous coals. Anthracites in Polish collieries are insignificant for this estimation. Storage capacity for lignite roughly estimated on the basis of coal deposits data (Naworyta 2016) gives the amount of CO_2 possible for storage on the level 674 thousands of tonnes.

Storage capacity of CO_2 in coal deposits is estimated for relatively small pressure, smaller by half from critical one but it has been proven that sorption capacity is not increased significantly with further increase of pressure (Huang 2018).

Conclusions

Despite many studies, CO_2 storage in coal deposits, including abandoned mines, does not contribute much to storage capacity. In particular in relation to lignites, sorption of CO_2 is rather an interesting scientific issue but not a technical possibility. Especially that the lignites do not cover deeply and under the impermeable coating of rocks. A phenomenon that may make the possibility of CO_2 injection into coal seams more attractive is the recovery of methane. Another possibility for the management of injected CO_2 is the subsequent underground gasification of coal, in which the CO_2 will be an oxidizing agent.

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