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Adsorption and membrane processes for the enrichment of methane in mine ventilation air

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Authors:	Marek Tańczyk, Aleksandra Janusz-Cygan, Jolanta Jaschik, Artur Wojdyła, Elżbieta Sołtys, Anna Pawlaczyk-Kurek
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Abstract: Technologies for thermal utilization of ventilation air methane (VAM) require stabilization and/or increasing its concentration. This paper summarizes the results of research conducted at the IICh PAS in the area of adsorption and membrane processes for VAM enrichment. First of all adsorbents and membrane materials were selected and investigated for such processes. They were assessed in terms of CH_4/N_2 selectivity, as defined by Eqs 1 and 2, as well as adsorption capacity (adsorbents) and permeability (membranes). The properties of activated carbons and ZMS 5A investigated were presented in Table 1 and Fig. 1. In the case of membranes polyimide membranes, used in commercial UMS-A5 and CO-C05 UBE modules, as well as the Matrimid 5218/CMS composite membrane, were selected for membrane VAM enrichment process. The pressure swing adsorption process in two-bed (Fig. 2) and four-bed (Fig. 4) installations for VAM enrichment was also investigated. The process performance was presented in Fig. 3 and Figs 5-6, respectively. It has been found that in the case of the four-bed process with activated carbon G2X7/12 Takeda VAM can be enriched from 0.2 to over 1.2 vol.% with a recovery of at least 80%. The results of membrane VAM enrichment processes were summarized in Table 2. It was found that in the case of commercially available UBE modules UMS-A5 and CO-C05 the concentration of methane in VAM can be increased from 0.3 to 0.43 vol.% with moderate CH4 recovery (50-60%). Higher enrichment (up to 1,8 vol.% in a three-stage

system) can be obtained in the case of the hybrid Matrimid 5218/CMS. For an assessment of the energy efficiency of the PSA and membrane enrichment processes two factors were defined: the unit power necessary to generate the pressure ratio p_W/p_N in the separation process (Eq. 3) and the unit heat output of the ventilation air (Eq. 4). These factors were presented in Fig. 7 along with unit thermal power of the enriched gas for the membrane (triangles) and adsorption (diamonds) VAM enrichment processes. It was found that regardless of the separation method and process parameters, the potential energy gain from the utilization of enriched VAM is much lower than the energy expenditure related to the implementation of the enrichment process, which is primarily due to the low unit thermal power of the ventilation air.

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