ACTIVATED CARBON AMMONIA AND NATURAL GAS ADSORPTIVE STORAGE

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Introduction

The storage of different gases (NH_3, CH_4, H_2, ets) in solid sorbent filled containers have a great interest from the economical and environmental viewpoint. The present experimental work is devoted to the measurement of the dynamics of adsorption and desorptions of NH_3 and CH_4 on activated carbon fibres. The pure-component isotherms of ammonia on activated carbon fibre "Busofit" and it composition with $CaCl_2$ have been published in [1].

Five different experimental set-up were testing using active carbon-fibre sorbent beds with and without of metal chlorides as chemicals. This work aims to determine the best types of active carbon fibres and its composition with different binders to charge, store and discharge of natural gases and ammonia. The impact of heat of adsorption on ammonia and CH_4 performance during discharge, while the gas outflow rate is dictated by the energy demand of the application is a key problem. The efficiency of the rate of gas discharge can be improved by different way of heat and mass transfer enhancement in the porous media. One of the possibilities of such enhancement is realisation of heat transfer with two-phase fluid motion in the sorbent bed with evaporation-condensation cycle as a micro heat pipe mechanism. A good possibility of organizing the two-phase heat transfer in the sorbent media is the use of special type heat exchangers (heat pipe type) inside the storage vessel to heat and to cool the sorbent bed.

The key part of complex compound/ammonia sorption vessels is the combination of an active carbon fibre and metal chlorides films as an important part of reactors, which usually consist of the individual reaction beds. By designing a complex compound/ammonia sorption storage vessels we want to reach two goals: a high COP and a high capacity of gas stored with regards to a small volume.

These goals could be reached using the combination of metal chloride ($CaCl_2$) films on the surface of active carbon fibers reacting with ammonia and heat pipe heat exchangers to heat and to cool sorbent beds.

The Experimental Set-up

The experimental set-up № 1 has been designed which operates according to the constant volume method. This method gives us a possibility to study the adsorption phenomena under the conditions of a heat transfer through a heat exchanger wall, Figure 1.

The experimental set-up consists of an adsorber with a sorbent bed 5 and the thermocouples 4 inside the bed. The adsorber 6 is heating by electric heater and cooling by the heat exchanger 3. The adsorber 6 is attached to the evaporator/condenser 1through the valve 12. The evaporator/condenser 1 is disposed inside the thermostat 16 and is connected with a pressure gauge 8, vacuum pump 7 and the gas canister 15 through the valves 9-11. The deviation of sorbent bed mass during adsorption/desorption could be recorded using the balance after the cycle.

The temperature of a sorbent bed during adsorption in maintained constant by the heat exchanger and can be varied between the 10 °C up to 160 °C.

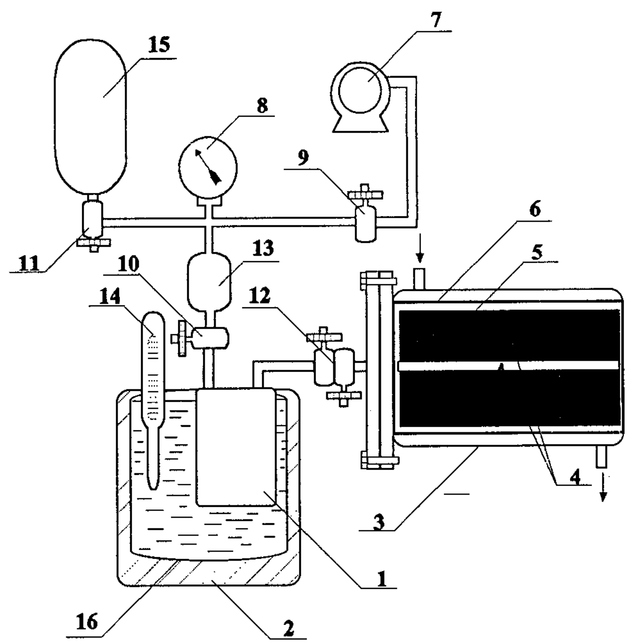

Figure 1. The experimental set-up № 1: 1 – evaporator/condenser; 2 – thermal insulation of the thermostat; 3 – heat exchanger; 4 – thermocouples; 5 – sorbent bed; 6 – adsorber; 7 – vacuum pump; 8 – pressure gauge; 9-12 – valves; 13 – control volume; 14 – thermometer; 15 – ammonia vessel; 16 – thermostat.

This experimental set-up is used to make the measurements of:

1) adsorption capacity of the sorbent bed;

2) ammonia mass changing during adsorption/desorption;
3) kinetic curves during the cycle;
4) heat of adsorption

Two “Busofit” modifications were tested for a short cycles adsorption/desorption (10 min). The results of these are presented on Table 2.

Three different modifications of the active carbon sorbent beds based on “Busofit” were examined. The experimental data are presented on the Tables 1-3 and on Figures 2-3.

Table 1.
“Busofit”/ammonia sorption/desorption parameters.

	Sample1 “Busofit T”	Sample 2 “Busofit TM”	Sample 3 “Busofit T*“
Full adsorption capacity, kg/kg	0,287	0,295	0,340
Dynamic adsorption capacity, kg/kg	0,180	0,186	0,244

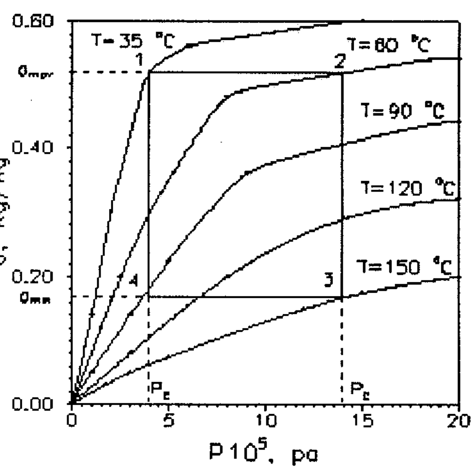

Figure 2. The sorption isotherms for “Busofit”/ammonia are shown on Figure 2.

Table 2.
Full “Busofit” adsorption capacity for different gases for 120 min of adsorption.

	“Busofit TM*”	“Busofit T**”
Full adsorption capacity, kg/kg	0.295	0.432
Dynamic adsorption capacity, kg/kg	0.190	0.320

Table 3
Full “Busofit” and “Busofit”/$CaCl_2$ adsorption capacity for different gases for 120 min of adsorption.

	№ 2 Sorbent “Busofit”	№ 2 Sorbent “Busofit”-$CaCl_2$
Acetone, kg/kg	0.61	
Ethanol, kg/kg	0.60	
Ammonia, kg/kg	0.62	0.85
Methane, kg/kg	0.51	
Methanol, kg/kg	0,55	

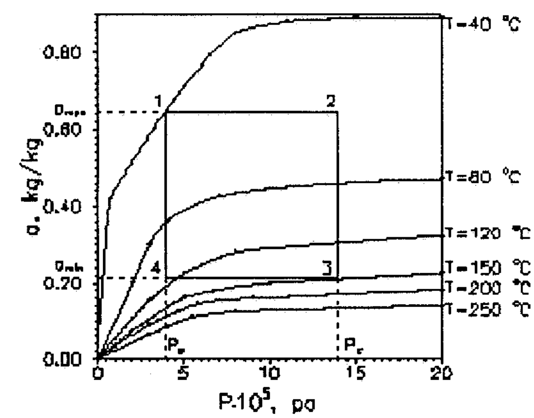

Figure 3. The sorption isotherms for “Busopfit”-$CaCl_2$/ ammonia are presented.

The time of full adsorption 95 % for 6 combinations of active carbon and different gases was 120 min.

Following the received experimental data two small models of setup № 2 and № 3 were tested. The results on full “Busofit” adsorption capacity for the different storage gases are presented on Table 3.

Conclutions

The fulland and dynamic adsorption capacity of NH_3 and some another gases (acetone, ethanol, methanol, CH_4) on the active carbon fibre “Busofit” and composition “Busofit”-$CaCl_2$ was analyzed. “Busofit” is very promising sorbent for the fast cycles of the storage vessel desorption.

To stimulate the short cycles of adsorption/desorption heat pipe heat exchangers are used.

References

1. Vasiliev L.L., Kanonchik L.E., Antuh A.A., Kulakov A.G., Rosin I., *SAE Technical Paper*, Series 941580.