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A POSSIBILITY TO USE FIBERS WITH HIGH SiO_2 CONTENT AT HIGH TEMPERATURE

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ABSTRACT

The possibility to prepare high temperature filters on the basis of fibers with high SiO_2 content was studied. The inorganic fibers were drawn from bentonite clay alloyed with Na_2O. The SiO_2 content in them was increased to 96-99.95 % by leaching. Alumo-chlorine-phosphate binder was used for the preparation of the filters. It was found that the optimal amount of binder should be from 14 to 28 %. Shrinkability, air permeability and tensile characteristics of the filters synthesized were determined.

Keywords: *bentonite clay, fibres with high SiO_2 content, filters.*

INTRODUCTION

Recently, the inorganic fibers and particularly these with high content of SiO_2 have been intensely studied. They are widely used as adsorbents [1-6], carriers of catalysts [7] and filtering materials [8-10]. The use of various filters is mandatory in many branches of industry – metallurgical, chemical, automobile, aircraft, textile, etc. the filtering surface can be made from various materials but should obey certain requirements.

The fibers used to manufacture filters provide possibilities to intensify the processes and improve the quality of the filtering. The high thermal resistance of the glass inorganic fibers allows their use at temperatures higher than 500°C where organic fibers can not be used.

In this respect, the aim of the present work is to study the possibility to synthesize filters from fibers with high content of SiO_2 for filtering hot gasses at 800-1000°C and study their properties.

EXPERIMENTAL

The fibers used to prepare the filters were obtained from yellow bentonite from the Kurdjali region (Bulgaria) with additive of 12-20 % Na_2O, at drawing temperature 1020°C - 1100°C. They had the following composition: SiO_2 - 51.71 %, Al_2O_3 - 12.17 %, Fe_2O_3 - 4.76 %, CaO - 8.34 %, MgO - 4.01 %, R_2O - 19.01 %. Heat resistant fibers with high content of SiO_2 were obtained by the method of leaching, by extraction of the easy melting components from the composition of the initial glass fibers. The leaching was carried out by stationary method at constant ratio liquid to solid phase 1:50 (1 g fibers in 50 ml H_2SO_4). Depending on the conditions for the acid treatment, the content of SiO_2 in the leached fibers was from 96 % to 99,95 %.

To increase the number of pores during sintering and ease the forming process, special binders were added to the initial material. The binder selected was alumo-chloro-phosphate binder (ACPB). The use of

ACPB makes it possible to use the fibers at temperatures 1000-1200°C.

Several series of samples were prepared containing different amounts of fibers and ACPB. The filters were obtained by the method of two-sided pressing in tempered steel die on a hydraulic press "Carl Zeiss Jena" (Germany). After homogenization, the material obtained was pressed under different pressures (196, 392, 490, 588, 784, 980, 1470 KPa) to study the effect of the pressure on some properties of the filters. The samples obtained were 25 mm in diameter, 7-33 mm height and 5, 8 or 9 g weight. They were subjected to low-temperature sintering at 250°C to impart initial strength, followed by high temperature sintering at temperatures 1000-1200°C.

The samples synthesized were studied for their shrinkage, air permeability and compression strength.

Fig.1 shows the test installation used for the determination of air flow.

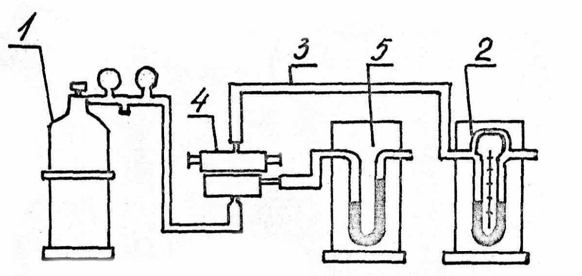

Fig. 1. Schematic diagram of the laboratory installation for determination of air permeability: 1 - Bottle of compressed air 2 - Laboratory rheometer; 3 - Tubing, 4 - Fixing device for the filtering element; 5- Mercury manometer.

Laboratory rheometer was used as air flow meter. It consisted of capillary tube connected to water manometer and the air flow can be measured depending on capillary diameter. The working capillaries were calibrated by measuring the amount of gas flown through it for certain period of time. A standard curve was then drawn giving the dependence of gas flow (l/min) on the pressure difference in mm H_2O. The standard curve was further used to calculate the volume of air flown through the different experimental samples. The air in the bottle was fed through a distributing tube to the filtering element tested which is fixed with a special device. Using the reducing valve of the bottle, certain pressure was applied under the filtering element and measured by mercury manometer. Thus, the rheometer gives the amount of air flown through the filtering element.

RESULTS AND DISCUSSION

Determination of samples shrinkage

The shrinkage of the filtering elements was studied as function of samples height and diameter. The results obtained are presented in Table 1.

Table 1. Dependence of samples shrinkage on the temperature and period of treatment.

T, ^{0}C	Soak-ing time, h	weight, g	Shrinkage, %	
			On height	On diameter
570	2	5	4	2
		8	3.7	2
		9	2.7	2
1000	2	5	8.7	6
		8	11.1	4
		9	16.6	8
	4	5	8.7	6
		8	11.1	4
		9	16.6	10
	8	5	8.7	8
		8	12.9	4
		9	20.8	12
1200	2	5	10.9	10
		8	14.8	6
		9	22.2	14
	4	5	13.4	10
		8	14.8	8
		9	23.6	16
	8	5	13.4	12
		8	16.6	9.2
		9	25	16

The data showed that the samples shrinkage at 570°C was insignificant. It increased at higher temperature to reach 8.7 % by height and 6 % by diameter at 1000°C for samples of 5 g fibers and 20.8 % by height and 12 % by diameter for the 9 g samples. The greatest shrinkage was observed when the samples were kept at 1200°C for 4 or 8 hours – 25 %. The increased shrinkage can be attributed to the fact that the higher temperatures strongly affect the sintering kinetics to make it much more rapid.

Determination of the air permeability

The effects of the amount of ACPB and temperature on the samples air permeability were studied.

The experiments were carried out at different air pressures beneath the filtering element. It was found that the content of binding substance had only insignificant effect on the air permeability of the filtering elements sintered at low temperature (250°C). The increase of the forming pressure within the range used for these experiments had also little effect on the air permeability. Therefore, it was concluded that air permeability depends mainly on the pressure of the air beneath the filter prepared under the mechanical conditions selected.

With the increase of sintering temperature up to 1000°C and content of ACPB 11-14 %, air permeability remained almost the same. This was confirmed by the data presented in Table 2 for samples of 8 g containing 9-55 % binding substance.

Table 2. Dependence of the air permeability of the filtering elements on moulding pressure 8 g fibers, sintering temperature 1000°C).

ACPB, %	P, KPa	V of air (m^3/m^2.min) at pressure Δp (mmHg):					
		5	7	8	9	10	11
9		0.5	0.9	1.0	1.5	1.7	1.8
11		0.4	1.0	1.0	1.4	1.5	1.9
14	784	0.4	0.8	0.9	1.2	1.6	1.8
18		0.3	0.7	0.8	1.1	1.4	1.7
28		0.3	0.6	0.7	1.0	1.2	1.6
55		0.2	0.4	0.7	0.8	1.0	1.5
9		0.4	1.0	1.1	1.4	1.6	1.9
11		0.3	0.9	0.9	1.3	1.5	1.8
14	980	0.3	0.8	1.0	1.1	1.4	1.6
18		0.2	0.7	0.8	1.0	1.6	1.5
28		0.2	0.7	0.6	0.9	1.3	1.4
55		0.1	0.5	0.6	0.8	1.0	1.2
9		0.5	0.7	1.2	1.3	1.2	1.6
11		0.3	0.6	0.9	1.2	1.4	1.7
14	1470	0.2	0.6	1.0	1.1	1.1	1.5
18		0.2	0.5	0.8	1.0	0.7	1.4
28		0.1	0.4	0.4	0.8	0.8	1.1
55		0.2	0.4	0.6	0.7	0.8	1.3

The effect of sample height (ranging from 7 to 33 mm) on air permeability was also studied. It was found that sample height did not affect air permeability in the range studied. This can be explained with the uniform porous structure if the filtering elements obtained.

Determination of the compression strength

Fig.2 shows the data obtained from the compression tests of the filters as function of the moulding pressure at both sintering temperatures - 250°C and 1000°C.

The 5 g samples sintered at 1000°C showed higher strength than the 8 g samples obtained under the same conditions, which probably means that the former underwent better densification.

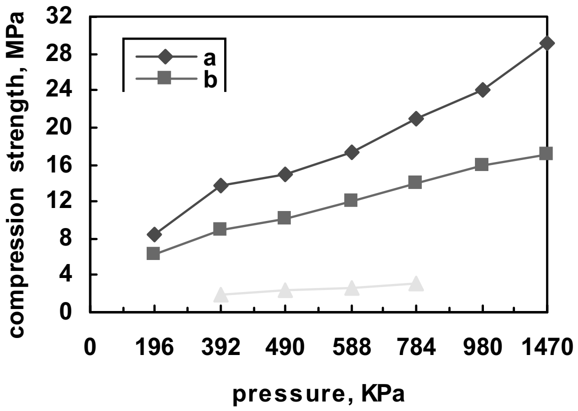

Fig. 2. Dependence of compression strength on moulding pressure: a) 5 g fibers, 1000°C; b) 8 g fibers, 1000°C.

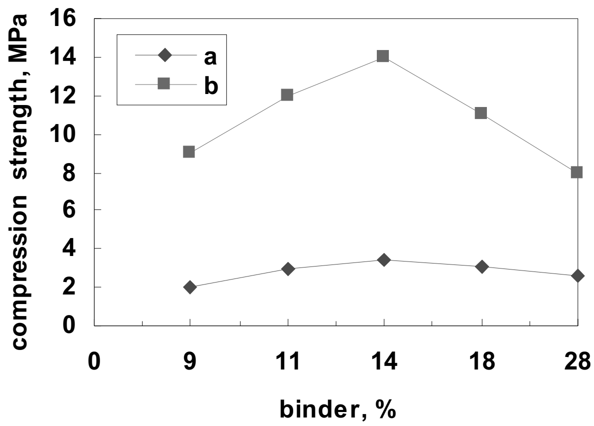

Fig. 3. Dependence of compression strength on the content of ACPB at pressure of 392 KPa, 5 g fibers and sintering temperature: a) t - 250°C, b) 1000°C.

The results obtained for the compression strength as function of the ACPB content are presented in Fig.3.

As can be seen (Fig. 3) for the lower sintering temperature (250°C), the mechanical strength first slightly increased with the increase of binder content and then gradually decreased. The best mechanical properties were observed for the samples containing 11 %, 14 % and 18 % ACPB. At the higher temperature (1000°C), samples' strength increased 3-6 times. This effect can be explained with certain welding of the composite material and, on the other hand, with the possibility for closing fiber micropores existing at this temperature (which increases the mechanical strength). Strength about 14 MPa were observed for the filtering elements. The decrease of the compression strength for samples containing more than 14% ACPB can be attributed to the destruction of the fibers induced by ACPB. Probably, at higher temperature, chemical interactions occur between ACPB and the fibers, i.e. a limit of 14% ACPB content was established, above which ACPB has destructive effect on the fibers.

CONCLUSIONS

High temperature filters were developed on the basis of fibers with high content of SiO_2 obtained from bentonite clay and alumo-chloro-phosphate binder.

The effect of temperature on the samples shrinkage was studied. The shrinkage was found to be insignificant up to 570°C – 2-4 %. The highest shrinkage was observed when samples were treated at 1200°C for 4 or 8 hours: up to 25 % by height and 16 % by diameter.

The influences of binder concentration, moulding pressure and sintering temperature on the air permeability were investigated. It was found that temperatures of 250°C and 1000°C, as well as pressures from 196 to 1470 KPa had practically no effect on the property studied.

The compression strength of the filtering elements was determined at 250°C and 1000°C. The highest strengths showed the samples obtained at high moulding pressure (988-1480 KPa) and 1000°C sintering temperature and containing from 14 % to 28 % additive of ACPB.

Taking into account the good mechanical properties combined with high air permeability and low shrinkage, it may be concluded that ACPB is suitable for preparation of high temperature filters.

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