REFERENCES

1. Volkov V.I. Filtering turbulence mode // Increase of environmental safety of automotive engineering: Article collection. – Barnaul, 1999. – P. 72–77.
2. Evstigneev V.V., Volpe B.M., Gorkol D.A. Development of principles of generalized SHS-technologies of dispersed composite material // Altai STU works. – 1993. – Issue 1. – P. 3–18.
3. Tubalov N.P., Lebedeva O.A., Vereschagin V.I. Porous composite ceramic materials obtained by self-propagating high-temperature synthesis in the system F_2O_3-Al_2O_3-Al // Novye Ogneupory. – 2003. – № 9. – P. 40.

Received on 14.11.2006

UDC 66.796.2

PURIFICATION OF GAS AND LIQUID MEDIA BY METAL-CERAMIC SHS-FILTERS

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Industrial samples of fine filters of gas and liquid media from mechanical microparticles have been developed. Porous permeable cermets obtained by self-propagating high-temperature synthesis are the basis of filters.

On the basis of self-propagating high-temperature synthesis (SHS) the technology of obtaining porous permeable materials which may be used for fine purification of liquids and gases was proposed [1–3]. Scale of alloyed steel, metal powders and ferrosilicon were used as original components of batch [4].

The principle stages of the process of obtaining porous materials is the diagram, Fig. 1, including grinding original materials, powder screening, batch preparing, component matching and gauging , synthesizing and product improvement.

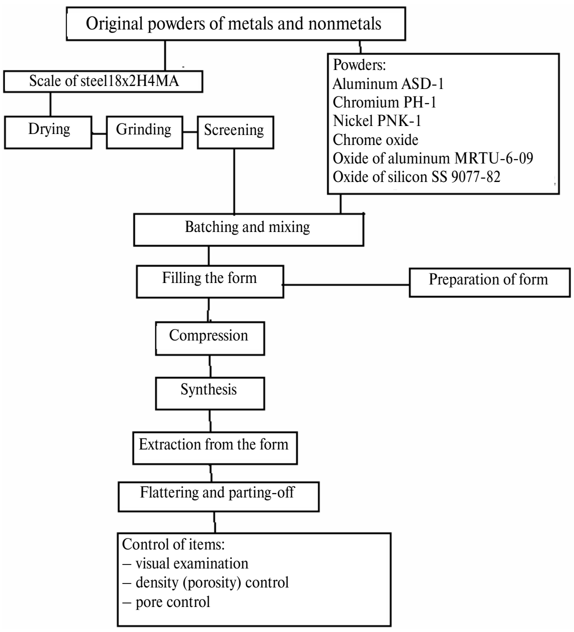

Fig. 1. *Diagram of technology of obtaining porous permeable product by SHS method*

Technological experiments showed that the highest efficiency of grinding is achieved at its carrying out in two stages; at the first stage the foregrinding occurs, at the second stage fine grinding with obtaining rather narrow required fraction (through the sieve) occurs.

Investigation of scale powders obtained by processing original material at the grinder KID-100, showed that the primary type of material decomposition is intercrystalline fracture; particles of the obtained powder of various fractions have similar morphology repeating morphology of crystal grains of ferrite of original material.

On the basis of the extracted fractions of steel scale powder the reaction mixtures of constant concentration composition were prepared; samples of porous material were later prepared from them.

Filters for purification of gas media

The determining properties of material for gas purification are average pore size (Fig. 2) and mechanical strength at compression and bending (Fig. 3). This implies that at increase of steel scale concentration from 45 to 60 % by mass the mechanical strength decreases.

Filtration of exhaust gases in porous materials may be divided into several stages. Firstly, solid particles which should be separated from the flow of exhaust gases are supplied to the surface of filter, then they abut to filter surface and at the next stage penetrate filter surface and are trapped in pores. The larger particle size the high the probability of its trapping in porous wall. The absorption factor of solid particles by porous SHS-filter owing to engagement may be presented as:

$$\delta_n = \frac{\delta_{ст}}{2\delta_{сл}^2 \cdot \sqrt{3}} \left(\tau_{ст} \cdot \bar{\upsilon} + \frac{3r_{тч}^2}{\delta_{ст} + \delta_{сл}} \right), \qquad (1)$$

where δ_{cm} is the thickness of multilayer filter wall; $\delta_{cл}$ is the layer thickness; τ_{cm} is the time of gas traveling through filter wall $\overline{V}$ is the average rate of exhaust gases at filtration; $r_{mч}$ is the radius of angular spherical solid particle.

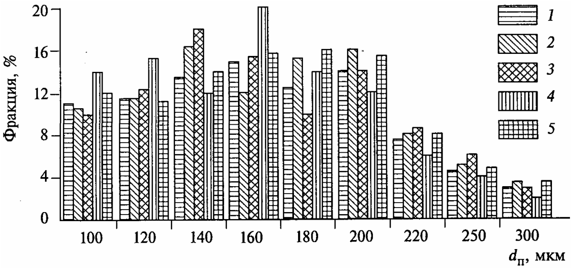

Fig. 2. *Histogram of pore size distribution in material samples on the basis of different fractions of steel scale powder: 1) <50 mm; 2) 500...100; 3) 100...160; 4) 160...200; 5) 200...250 mkm*

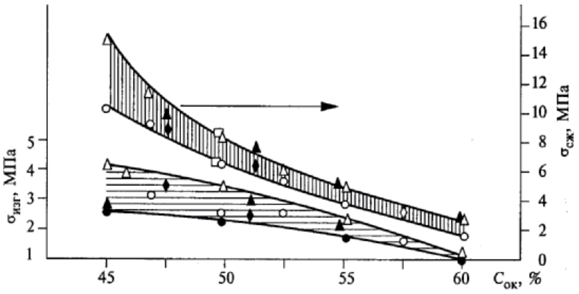

Fig. 3. *Dependence of mechanical strength of SHS-materials on concentration of scale ($C_{ок}$) of steel in batch*

Theoretical velocities of solid particle moving may be calculated on the basis of the above given dependences for conditionally accepted spherical particles and when testing filters for gas purification it is sensible to determine deposition rates of particles of different origin.

Service properties of SHS-filters were studied. According to the aim and tasks of investigations the main directions are singled out:

1. Studying structure and characteristics of solid particles.
2. Studying structure and physical-mechanical properties of SHS-filters.
3. Estimating efficiency of applying SHS-blocks for filtration exhaust gas solid particles.

Constructing filters for gas purification from solid particles it was necessary, on the one hand, to select block dimensions, their porosity and wall thickness and, on the other hand – to keep the acceptable exhaust back pressures and at the same time support filtration efficiency. To estimate the influence of porosity, wall thickness and amount of filters on quality of exhaust gas purification and exhaust back pressures the special tests were carried out at stand with diesel 4ЧН13/14.

Tests were carried out with blocks having wall thickness 10, 12, 14 mm made by SHS-technology of the material having the same average diameter of pores equal to 180 mkm. Wall thickness of 10 mm from such material allows purifying gases from solid particles practically for 75 % in total power mode. However, by conditions of consistency of performance and mechanical strength the variant with wall thickness equal 12 mm turned out to be more preferred.

Table 1. *Composition and characteristic of porous SHS-blocks for filtration of solid particles of diesel exhaust gases*

Block	Composition of batch components, wt.%					Average size of pores, mkm	Maximum deviation of density of distribution, %	Maximum deviation of size from the average one, %	Mechanical strength at compression, MPa
	Fe_2O_3	CrO_2	Cr	Ni	Al				
1	45	17,5	5	5	27,5	300	16	20	8,4
2	47,5	18	5	5	24,5	260	10	16	8,6
3	47,5	18	7	5	22,5	180	8	12	9,7
4	47,5	18	7	12,5	15,0	150	6	10	12,2
5	50	18	7	12,5	12,5	120	5	7,5	12,2

Quality of exhaust gas purification from solid particles at increase of wall thickness of filter medium grows by 3 % per 1 mm of thickness.

Quality of three-stage purification is the highest and reaches 91 % in the mode when diameter of solid particles is significant and at one-stage purification quality reaches only 75 %.

Thus, the experimental material was obtained. It gives an idea of the ways of improving filters of exhaust gas purification on the basis of porous SHS-materials.

Experimental data show cogently the efficiency of applying porous SHS-cermet as filter elements in comparison with known filters.

Filters for liquid purification

The investigated effective voltages in cylindrical filters on their sizes and external, excess pressures showed the applicability of the developed filters of liquid media in conditions of industrial use.

The model of hydromechanical process of filtration of polydisperse suspension subject to pore clogging at moving of dispersed phase particle through porous layer was considered as the working model of liquid fine filtration. The filtration process is continuous. Let us assume that liquid motion in pores of filter bed obeys to the law of Gagen-Pouaseile. At the model input the mass of contaminated liquid and at the output the mass of dispersed phase being in filtrate by the time was taken. Measurement of filter hydraulic resistance determined by the Darcy equation solved relative to filtration factor was used for filtration engineering control.

In order to make filter elements the accessory was used (Fig. 4 and 5). To determine liquid permeability index the experimental facility was used (Fig. 6).

Filtering fineness and completeness were determined for samples with different porosity made of powders with different particle diameter. The results of measurement are given in the Table 2 and in Fig. 7, 8.

Table 2. *Dependence of fineness and completeness of liquid filtering on properties of original powders*

Particle average size, mm	Material porosity, %	Pore diameter, mkm	Filtering fineness, mkm
0,050...0,100	29,0	24	7...9
0,100...0,160	31,0	32	15...18
0,160...0,200	34,5	54	20...25
0,200...0,250	36,6	75	35...45
0,250...0,315	38,4	128	50...65
0,315...0,500	40,1	160	75...85
0,500...0,800	44,0	220	100...110

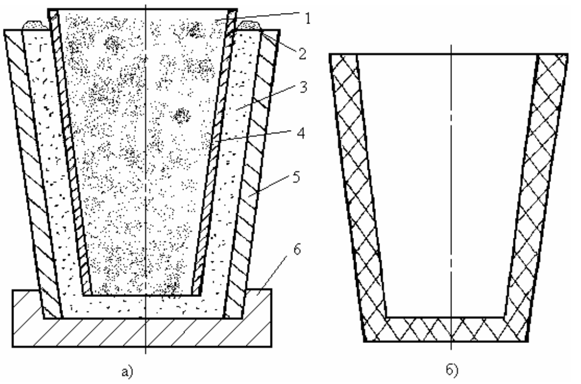

Fig. 4. *Conical configuration of mold: a) mold assembly; 6) filter element; 1) termite; 2) powder batch; 3) internal insert; 4) metal form; 5) filling of internal cavity; 6) bottom*

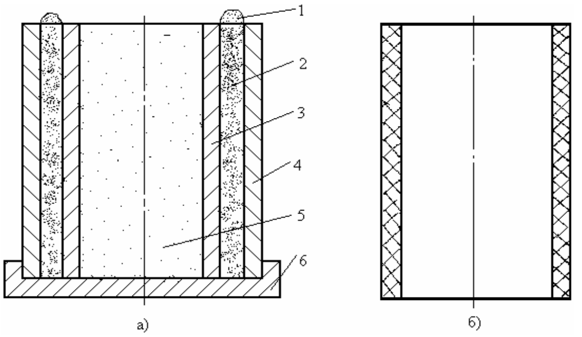

Fig. 5. *Cylindrical configuration of mold: a) mold assembly; 6) filter element; 1) termite; 2) powder batch; 3) internal insert; 4) metal form; 5) filling of internal cavity; 6) bottom*

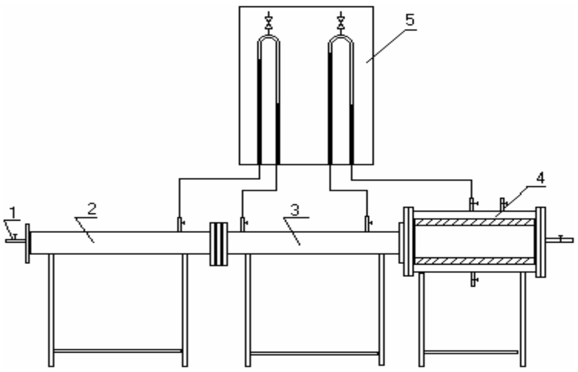

Fig. 6. *Diagram of experimental setup for defining permeability index: 1–3) transmission channel tubes; 4) measuring cell with filter medium; 5) monometers with sensors*

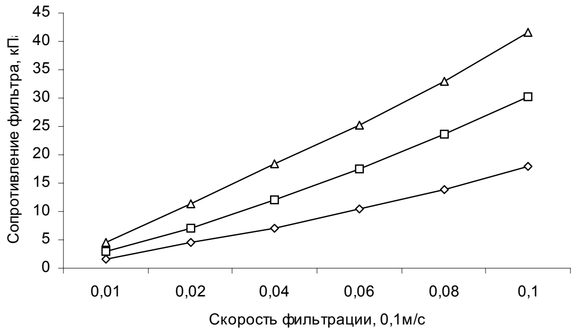

Fig. 7. *Dependence of hydraulic resistance of filter on filtration rate at filter fouling factor by 30 %. Filter wall thickness: Δ – 10 mm; □ – 7 mm; ◊ – 5 mm*

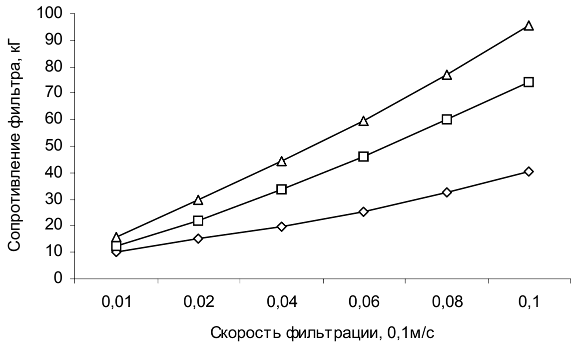

Fig. 8. *Dependence of filter resistance on filtration rate at filter fouling factor by 50 %. Filter wall thickness: Δ – 10 mm; □ – 7 mm; ◊ – 5 mm*

Industrial samples of filters are given in Fig. 9, 10.

Fig. 9. *Filter element of diesel oil filter*

Conclusion

1. The developed cermet filters on the basis of SHS-materials for exhaust gas purification of internal combustion engines support efficiency of purification from solid particles for 75, 80 and 90 % at one-, two- and three stage purification respectively that allows fulfilling the requirements of the standard EVRO-3 for diesel.

Fig. 10. *Ready-assembled oil filter (on the left) and filter element*

2. To unify cylindrical filters they are recommended to be produced with wall thickness of 10...12 mm and to complete different filters both in chemical industry and in transport only of dimension sizes of filter cermet catalytic blocks depending on consumption of exhaust gases.
3. Cylindrical filter elements made of SHS-materials possess sufficient filtering properties. The carried out analysis allowed selecting samples of porous materials which trap solid particles with the size from 5 mkm and larger possessing specific capacity equal to 10^{-3} $m^3/(m^2{\cdot}s)$. These samples may be used for fine purification of both water and oil liquids from solid impurities. Change of thickness of filter element walls from 4 to 7 mm results in increasing hydraulic resistance of porous samples from 8 to 14,2 kPa at specific liquid consumption $4{\cdot}10^{-3}$ $m^3/(m^2{\cdot}s)$.

REFERENCES

1. Evstigneev V.V., Isaeva Zh.M., Prolubnikov V.I., Tubalov N.P. Estimating the efficiency of using cermet filters for technical liquid purification // Polzunovskii Vestnik. – 2005. – № 1. – P. 322.
2. Evstigneev V.V., Novoselov A.A., Prolubnikov V.I., Tubalov N.P. Simulation of treatment process of exhaust gases of chemical industries and diesel aggregates from solid particles by SHS-filters // Bulletin of the Tomsk Polytechnic University. – 2005. – V. 308. – № 1. – P. 138.
3. Evstigneev V.V., Kolesnikov D.V., Prolubnikov V.I., Tubalov N.P., Schetinkina N.Yu. The technique of determining hydraulic resistance of porous SHS-materials // Polzunovskii Vestnik. – 2005. – № 2. – P. 277.
4. Tubalov N.P., Lebedeva O.A., Vereschagin V.I. Porous composition ceramic materials obtained by self-propagating high-temperature synthesis in the system F_2O_3-Al_2O_3-Al // Novye Ogneupory. – 2003. – № 9. – P. 40.

Received on 14.11.2006

UDC 54.058:553.611.6

EFFICIENCY OF USING EAST KAZAKHSTAN NATURAL SORBENTS IN WATER PURIFICATION FROM IONS OF HEAVY METALS (Cu^{2+})

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Sorption properties of bentonite clays of East Kazakhstan have been studied by the example of model solutions containing ions of copper (Cu^{2+}). The mechanism of exchange and degree of ion extraction from solutions were established.

It is known that the efficient sorbent for heavy metal ions is synthetical resin ions (cations) possessing high exchange capacity of sorption. However, there is no industrial production of ionites in Republic of Kazakhstan and their import from foreign countries is non-value-added. Natural materials possessing considerably lower exchange capacity in comparison with cations but rather cheaper than ionites may be the alternative. It is in East Kazakhstan where there are rich deposits of bentonitic clays (Taganskoe deposit) which are useful for extracting ions of heavy metals and production of which does not require great material costs as their accessibility and comparatively low price (local material) are not the least of the factors.

Bentonitic clays consist of minerals of montmorillonite group divided into alkaline and alkaline-earth differences. Minerals of montmorillonite group form bentonitic formations characterized by presence of montmorillonite minerals and minerals close to them by crystal structure such as beidellite; high dispersity of mineral particles, exchange complex and high colloidal properties are typical for them. Bentonites were formed as a result of volcanic ash decomposition at change of micas, chlorites and rockforming minerals in the process occurring in hydrothermal conditions. Depending on composition of exchange complex there are alkaline (sodium and calcium-sodium) and alkaline-earth (calcium, magnesium-calcium, calcium-magnesium) ben-