TABLE 2. Physicomechanical Properties of VN6 Alloy Specimens after Interaction with Molten Nickel

Specimens	Density, g/cm^3	Hardness HRA	Tr. rupt. str., MPa	Impact str., kJ/m^2
Starting	14,72	88,5	1550±40	20,1±0,3
After treatment with melts:				
1	14,43	86,9	2150±50	35,6±0,4
8	14,42	86,9	2370±50	42,8±0,4

ferentiated properties. Using the phenomenological theory of the metallic melt migration process [1], it is possible to exercise control over the mass transport of additions and their depth of penetration.

The above-described character of local alloying is exhibited by composites capable of absorbing metallic melts, in particular certain hard metals, including those of the WC—Co, WC—Ni, TiC—Co, and TiC—Ni systems. Some composites, such as those of the W—Ag, WC—Cu, and Cr_3C_2—Cu systems, do not absorb metallic melts. The main phenomenon occurring during the interaction of these materials and molten metals is interdiffusion of elements. Mass transport of elements in such parts obeys the laws of diffusion in multicomponent heterophase systems.

LITERATURE CITED

1. A. F. Lisovskii, Migration of Metallic Melts in Sintered Composite Materials [in Russian], Naukova Dumka, Kiev (1984).
2. I. N. Chaporova and K. S. Chernyavskii, Structure of Sintered Hard Metals [in Russian], Metallurgiya, Moscow (1975).

CHARACTERISTICS OF FILTERS FROM LOOSELY POURED METAL POWDERS

Sh. M. Sheikhaliev and Yu. A. Timchenko

UDC 621.762

Filter elements from sintered metal powders — P/M filters — are being successfully used for the purification of gases and liquids from mechanical and other contaminants. However, where a high degree of regeneration by flow reversal is required for the purpose of extraction of valuable or other products, such filters are not very effective. The presence of blind and very fine pores sharply reduces flow rates, making the filters unsuitable for operation after as few as four or five regeneration cycles [1]. Apart from this, the sintering of a number of metal powders presents considerable difficulties.

In recent years [2] attempts have been made to employ filters in which a loosely poured metal powder acts as the porous medium (granular filters). Such filters have good hydrodynamic and regenerative characteristics, are simple and inexpensive, and require no special presses or furnaces. Yet no information is available in the literature on their basic filtration characteristics.

In the work described below an experimental study was carried out of the key operating characteristics of granular filters from metal powders. The testing apparatus (Fig. 1a) consisted of a filter F through which a liquid was passed under a head generated by the pressure of gas from a cylinder 1 in a hermetic tank 2 with a receiver 3. To ensure a uniform concentration of mechanical contaminants, the liquid was agitated during testing with a stirrer 4. Flow rates of the liquid under filtration and regeneration conditions were measured by means of flow meters M_1 and M_2, respectively, and heads of the liquid by means of gauges G_1 and G_2. For regenerating the filter by flow reversal, valves V were used.

The filter (Fig. 1b) was a cylindrical housing 1 made of PTFE, containing loosely poured metal powders 3 and 4, which were supported by screens with apertures of a size slightly

Moscow Engineering-Physical Institute, Branch No. 2. Translated from Poroshkovaya Metallurgiya, No. 2(278), pp. 37-41, February, 1986. Original article submitted February 27, 1985.

0038-5735/86/2502-0109$12.50

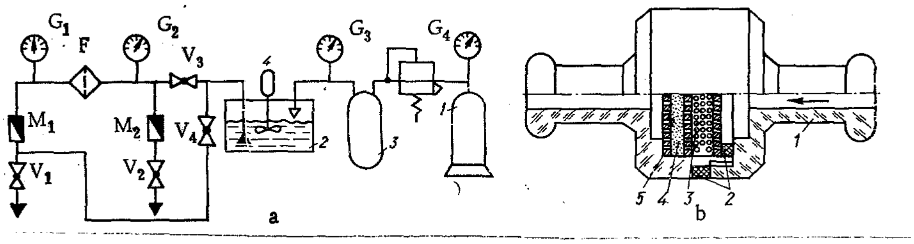

Fig. 1. Diagrammatic representation of apparatus (a) and granular filter (b) for purification of liquid. For description see text.

smaller than the particle diameter. On the high-pressure side the filter was provided with sealing gaskets 2. The degree of compression of the powders in the tests was constant.

Initially, a study was made of the characteristics of granular filtration layers of a bronze powder of fractions 200-300, 120-200, 80-120, 63-80, and 40-63 μm, produced by electric-pulse atomization of a molten metal jet [3]. The filters were employed for purifying water contaminated with iron hydroxide (1-1.5 g/liter). The amounts of filtrate were assessed by the intensity of color of the aqueous solution obtained after treatment in an acid medium with potassium thiocyanate [4], which in turn was measured with a photocolorimeter. To determine the numbers and sizes of particles in the water before and after purification, the solutions were passed through paper filters, which were then examined under the microscope. Measurements were made, with a relative error not exceeding 10%, by the method proposed in [5]. The impurity contents of the filters were determined from the weights of the powder before and after purification.

According to [1], the key characteristics determining the effectiveness of operation of a filter element are its stopping power, filtration rate, hydraulic resistance, contaminant content, and regenerative ability. An experimental study was made of all these characteristics.

The relationship was established between the stopping power d_{st} and maximum pore size $d_{\pi max}$ of granular layers of thicknesses 2, 4, and 8 mm produced from spherical powders of fractions 120-200, 80-120, 63-80, and 40-56 μm, at a water flow rate of 60 g/sec. Maximum pore sizes were determined by the water expulsion method and by calculation.

At porosities of 0.16-0.51 the maximum pore diameter for spherical particles was determined with the expression [1] $d_{\pi max} = 0.88\pi^{-0.27} d_{\pi m}$, where $d_{\pi m} = (2/3)\cdot[\pi/(1-\pi)]\cdot d_{pm}$ is the mean pore diameter, and $d_{pm} = \sqrt{\dfrac{2d^2_{pmax} + d^2_{pmin}}{d^2_{pmax} + d^2_{pmin}}}$ is the mean fraction particle diameter (d_{pmax} and d_{pmin} are the maximum and minimum particle sizes, respectively).

At a layer thickness of 4 mm this relationship was found to have a linear character (Fig. 2), i.e., the ratio of the maximum pore size to the maximum size of particles passing through the filter was constant and equal to 2.5, corresponding to values of this parameter of 2-4 for sintered filter elements. It was also established that with increasing thickness of the filter layer its stopping power substantially improved only for powders of particle sizes larger than 80 μm (Fig. 2, curves I, II, and III).

A filter layer of thickness 8 mm produced from the 40- to 56-μm powder fraction stopped a substantial proportion of impurity particles larger than 17 μm (Fig. 3). The concentration of iron hydroxide after filtration did not exceed 10-30 mg/liter.

The particle size analysis of the filter element was chosen so as to ensure that the element had low hydraulic resistance and large debris holding capacity (Table 1).

The variation of the pressure drop (hydraulic resistance) on filters of various types is depicted in Fig. 4.

The resistance (blockage of a protective layer) grew with time for a filter from a powder of smaller specific surface. At the same time, there was a marked decrease in the hydraulic resistance of a filter from a coarser powder fraction. A filter from the 63- to 80-μm fraction (curve 2) became blocked the soonest, while a layer from 120- to 200-μm particles (curve 3) offered poor protection to a fine purification layer.

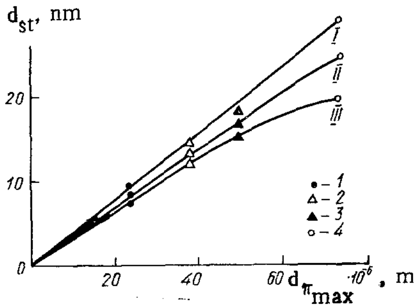

Fig. 2

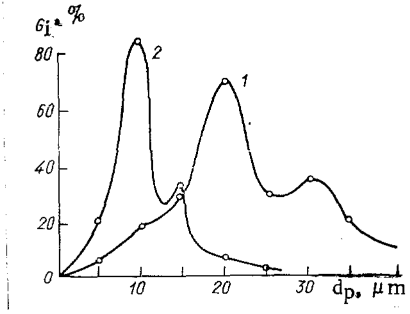

Fig. 3

Fig. 2. Variation of stopping power with maximum pore size for filter layers of thicknesses 2 (I), 4 (II), and 8 mm (III) from powder fractions 40-56 (1), 63-80 (2), 80-120 (3), and 120-200 μm (4).

Fig. 3. Curves of impurity particle size distribution G_i in working liquid before (1) and after (2) purification.

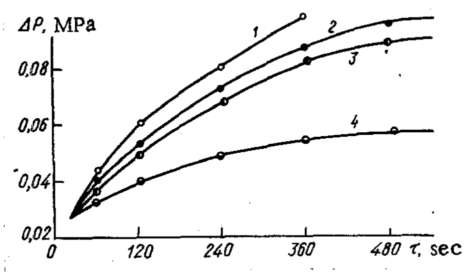

Fig. 4

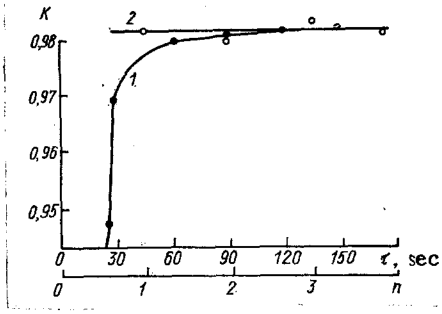

Fig. 5

Fig. 4. Variation of hydraulic resistance with filtration time. The curve numbers correspond to the filter numbers in Table 1.

Fig. 5. Variation of coefficient of regeneration with regeneration time (1) and number of regeneration cycles (2).

The results obtained can be explained on the basis of data for sintered two-layer metallic filters [6]. A filter placed so that a layer of larger pore size is the first to be entered by a moving liquid has a much larger debris holding capacity than a filter in which the positions of the layers are reversed. In this case the layer from a coarse powder operates under conditions of bulk filtration and performs preliminary purification, thereby reducing the load on the fine purification by a two-layer filter element whose fine purification and protective layers were from the 40- to 56-μm and 80- to 120-μm fractions, respectively (curve 4). This filter had the maximum debris holding capacity (full and specific capacities of 348 mg and 62.5 kg/m^3, respectively).

The effectiveness of regeneration (permeability) of a granular filter was studied by the liquid blow-back method at a pressure drop across the layer of 0.17 MPa, as a function of duration and frequency of regeneration. Curve 1 in Fig. 5 shows that the optimum regeneration time was 90 sec. The permeability of the filter was virtually independent of the number of regeneration cycles. Incidentally, the permeability of a sintered filter falls very rapidly: In [1] the value of K was found to be 0.95 after the first regeneration cycle, 0.89 after the second, and 0.84 after the third.

The results of the experiments on the filtration of aqueous mixtures of iron hydroxide revealed some key design and operating characteristics of granular filters from metal powders. On the basis of these data, a filter was constructed for the purification of nitric acid (3 N) at a temperature of 80°C from mechanical impurities. The filter element was made from an N9 nickel alloy (∿17% Cr) powder produced by electroacoustic atomization. The weight loss experienced by the powder during 240 h of continuous operation did not exceed 0.3% of the total weight of the filter layer, which testified to its high corrosion resistance. The filter ele-

TABLE 1. Debris Holding Capacities of Single- and Two-Layer Filters of Porosity 0.4, Surface Area 7 cm^2, and Various Particle Size Analyses

Filter No.	Particle size analysis, μm	Holding capacity	
		full, mg	specific, kg/m^3
1	—56+40	90	16,3
2	—56+40; —80+60	120	18,8
3	—56+40; —200+120	100	17,5
4	—56+40; —120+80	348	62,5

Note. 1) Single-layer 8-mm-thick filter; 2-4) filters composed of two 4-mm-thick layers.

ment was assembled from two layers, a 4-mm-thick fine purification layer from the 40- to 56-μm fraction and a rough purification layer of the same thickness from the 120- to 200-μm fraction. For this filter the ratio $d_{\pi_{max}}/d_{st}$ was 2.5, the debris holding capacity 73 kg/m^3, and the effectiveness of regeneration by flow reversal 0.98 at a time of 90 sec.

CONCLUSIONS

The stopping power of granular filters from metal powders in the purification of water and nitric acid solutions from mechanical contaminants is comparable to that of sintered P/M filters. A protective layer from a coarser spherical powder fraction located under a fine purification layer improves the latter's hydraulic characteristics and increases its debris holding capacity. The coefficient of effectiveness of regeneration of such a filter by 90-sec flow reversal is equal to 0.98 and is virtually unaffected by the number of regeneration cycles.

LITERATURE CITED

1. S. V. Belov, Porous Metals in Machine Construction [in Russian], Mashinostroenie, Mowcow (1981).
2. K. H. Spitzer, "Method of filtration causing convertible (semifluidized) beds," U.S. Pat. No. 4157959, June 12, 1979.
3. Sh. M. Sheikhaliev and S. I. Popel', "Manufacture of powders and granules by the atomization of melts with an electric current," in: Manufacture, Properties, and Applications of Atomized Metal Powders [in Russian], Inst. Probl. Materialoved., Akad. Nauk Ukr. SSR, Kiev (1979), pp. 33-37.
4. Yu. Yu. Lur'e, Universal Methods of Analysis of Water [in Russian], Khimiya, Moscow (1973).
5. K. F. Rybakov, Filtration of Aviation Fuel [in Russian], Transport, Moscow (1973).
6. A. A. Gatushkin and S. M. Solonin, "Filtering properties of twin-layer sintered filters," Poroshk. Metall., No. 7, 32-37 (1966).