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ISSN 0543-5846
METABK 53(1) 44-46 (2014)
UDC – UDK 628.336.42:541.57:666:76:536.45=111

GRAVIMETRIC AND DILATOMETRIC RESEARCH OF ELEMENTS ACTION ON THREE DIMENSIONAL FILTER BY THEMAL EFFECTS

Received – Prispjelo: 2013-02-03
Accepted – Prihvaćeno: 2013-05-30
Preliminary Note – Prethodno priopćenje

In the work there are presented the results of studying the filtering elements weight changes when heated. For all the variants of filtering elements at the primary stages of heating there is characteristic increasing their linear dimensions due to their thermal expansion. It was established that using hydrolyzed ethyl silicate as a binder, as well as water solution of liquid glass with addition of aluminum powder in the refractory material permits to obtain filtering elements without high-temperature solid-phase sintering.

Key words: filter, binder, refractory material, high-temperature

INTRODUCTION

Alongside with widely known in metallurgy methods of refining there is more widely used a relatively new *filtration* method of metals and alloys refining characterized by its high efficiency and availability [1, 2], as it does not require great capital investment and simply fitting in the existing technological processes. The essence of the method consists in passing a metallic melt through a filtering unit, as a result of which through physical-and-chemical, adhesion and adsorption, mechanical and other phenomena there takes place the melt refining from non-metallic inclusions [3].

There exist two principal schemes of the process of metal filtration refining: 1) filtering through flat (two-dimension) filters (plates, meshes) and 2) filtering through three-dimension filters. The first ones, due to their small height (width), permit to clean the melt mainly from large nonmetallic inclusions mostly of exogenous character, whose dimensions are larger than r the filter pore channels.

Reducing the opening (channels) size or using a multi-layer filter increases the refining effect, but this is limited by the possibility of the melt passing through the filter channels due to the increasing counter-pressure connected with non-moistening the filter surface with the filtered melt. Two-dimension filters do not permit to clean efficiently a metallic melt from fine-dispersed inclusions whose size is much smaller than their openings. Besides, in metallic melts fine-dispersed inclusions both numerically and volumetrically make the largest part of nonmetallic particles. This drawback of two-dimension filters cannot be eliminated by any methods of activation of nonmetallic particles interaction with the filter surface. It's worth noting that two-dimension filters are widely used in iron foundry, as when filtering iron it is important not to have rough nonmetallic particles in the metal whose size exceeds the size of graphite inclusions, because the graphite inclusions themselves in a metallic matrix are also the point of concentrating inner tensions and originating cracks.

EXPERIMENTAL STUDIES

When filtering liquid steel, the filter used is to keep a lot of different in size nonmetallic inclusions, especially fine-dispersed. That's why the most suitable for steel refining are three-dimension filters which are practically deprived of the abovementioned drawbacks and present either an integrate block of ceramic foams or a granular filter composed of bulk elements in the form of granules (lumps) of a certain size [4]. They are characterized by:

- high complex refining ability not inferior to ceramic foams,
- simplicity of the technology of manufacturing filtering elements in the form of granules of available and cheap materials,
- a unique possibility to vary the filter structure depending on the nature of the filtered melt and the impurity removed,
- a possibility to control the degree of refining and regulating the filter efficiency due to changing the bulk elements size and the height of the filtering layer, etc.

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The objects of studying were filtering elements of magnesite in the form of granules with diameter 14 - 20 mm [5, 6], obtained using as binders: water solution of liquid glass and hydrolyzed ethyl silicate (Table 1).

Table 1 **Characteristics of the materials used for preparing filtering elements in the form of granules**

Filtering element			Binder	Note
No	Granule base	Material of the outer layer		
1	Magne-site	MgO	Liquid glass	Melted MgO
2	Magne-site	Y_2O_3	Hydroly-zed ethyl silicate	Y_20_3 layer on mag-nesite gra-nules was obtained by the method of cladding
3	Magne-site with alumi-num powder	MgO +$A1_{por}$.	Liquid glass	Original mixture composition: 70 % MgO and 30 % Al powder [7]
4	Fused alumina	$A1_20_3$	sulfite alco-hol liquor	Ceramic granules

For comparison there were studied ceramic granules of fused alumina obtained by solid-phase sintering (at 1 900 °C) in industrial conditions using a binder of sulfite-alcohol liquor (variant 4). Magnesite filtering elements variants 1-3) were obtained by the method of pelletizing. Filtering elements of Y_20_3 (variant 2) were obtained by the method of cladding a rare-earth oxide on the surface of magnesite granules. In both cases (variants 1-3) the granules were not subject to sintering.

Wet granules were initially dried in the air, after which they were placed in a dryer, and immediately before filtering they were tempered at the temperature ~900°C. In this connection there were carried out gravimetric studies of changing filtering elements weight when heated initially till 200, and then till 900°C. The granules studied in the number of 5 from each variant were preliminarily weighed, then placed on special trays into a muffle furnace. After achieving the needed temperature filtering elements were kept in the furnace within an hour, after which the furnace was turned off. The granules cooled to the room temperature were again weighed.

RESULTS AND DISCUSSION

The averaged data of filtering elements weight changes are presented in Table 2.

As can see from Table 2, the loss of mass m granules with liquid glass is 5 to 6 times as large as those with ethyl silicate (variants 1 and 2, respectively). This is conditioned by the fact that liquid glass is used in the form of a water solution, and hydrolyzed ethyl silicate - with an organic solvent. A characteristic feature of variant 3 is the presence in the filter material of aluminum powder. High dispersion of the latter requires an increased rate of the binding solution when granulating. That's why these filtering f granules mass loss at 200°C

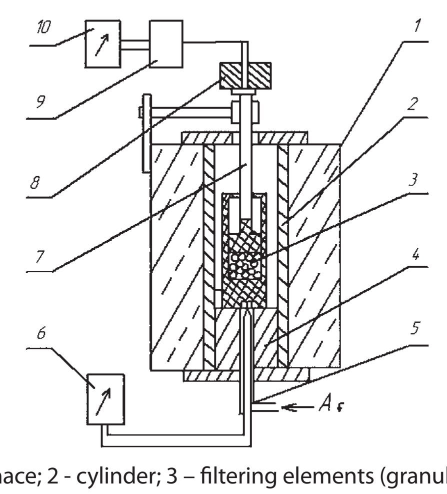
Table 2 **Filtering elements weight changing when heated**

Filterig element (variant No)	Weight changing / % mass.	
	At the granules heating temperature	
	200°C	900°C
1	-1,40	-2,40
2	-0,33	-0,49
3	-2,63	+6,57
4	-0,85	-0,85
Note: signs "+" and ' '-» mean respectively increasing or decreasing the mass of filtering elements when heaft		

almost 2-3 times exceed the similar indicator for variants 1-2. But at the temperature 900°C these granules weight, on the contrary, increases by 1...9 % relative to the original, which is conditioned by the aluminum powder oxidation. The share of the latter in the composition of the filtering material can be 5... 30 %, and as $A1_20_3$ mass is about 2 times larger than that of the aluminum consumed, the increase of weight due to aluminum powder oxidation can be equal to the mass share of the latter in the filtering material. Ceramic granules (variant 4) when heated up to 200 Cloose the adsorbed water, and at the further heating their weight does not change.

Dilatometric measurements were carried out at the set whose scheme is presented in Figure 1.

The set was mounted based on Tamman's furnace 1 with a graphite heater. The studied filtering granules 3 were placed on the bottom of graphite cylinder 2 which was placed in the furnace on support 4. Graphite rod 7 with a piston tip was downed to the granules. On the rod there was fastened weight 8 of 2 kg mass. The granules were heated in the inert atmosphere with bringing argon from below. To measure the temperature there was used thermocouple 5 and potentiometer 6. The thermocouple junction was located in a special opening in the bottom of graphite cylinder 2. The studies maximum temperature was 1 580-1 590°C. The initial height of the gran-



1 - furnace; 2 - cylinder; 3 – filtering elements (granules);
4 - support; 5 -thermocouple; 6,10 - potentiometers;
7 - rod; 8 - weight; 9 - converter

Figure 1 Scheme of the set for dilatometric measurements of filtering elements when heated

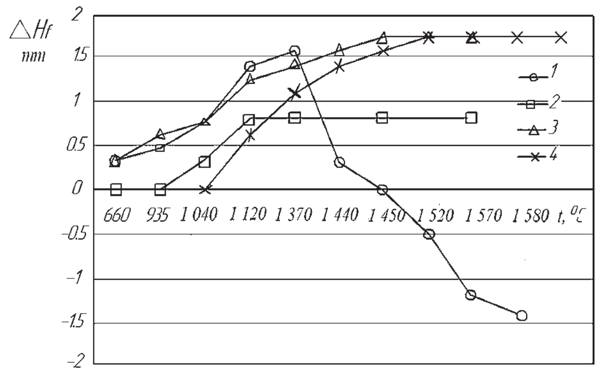


Figure 2 Changing the filter height when heated

ules layer was 45 mm. Change of the height was fixed with registration unit 9, converting rod 7 linear movements into electric signals on unit 10. The measurements were carried out with accuracy up to ± 1 mm. In Figure 2 there is shown changing the filter height when heated.

For each variants of filtering elements at the initial stages of heating there is characteristic the increasing of linear dimensions due to thermal expansion. Granules made using liquid glass as a binder have an extreme dependence of linear dimensions changing on temperature. As it can be seen in curve 1, at the temperature 1 370 °C the granules expansion stops and there begins their shrinkage. Replacing liquid glass with hydrolyzed ethyl silicate prevents the granules softening and their shrinkage (curve 2). The largest change of linear dimensions is characteristic of the filtering element made of sintered fused alumina (curve 4). Close to it characteristics belong to the filtering element made of mixture of magnesite and aluminum powder (curve 3). The presence of the latter prevents the filtering element softening in spite of using liquid glass as a binder.

In the work there is also suggested the process of making filtering elements of liquid glass and cold-solidifying mixtures by means of air-pulse pressing. By this method of mold forming within 0,01-0,08 sec there can be compacted a mold. The molding sand is compacted in two stages:

1 - due to the compressed air kinetic energy;
2 - due to the air mechanical action and directed to the pattern plate filtration flow.

When filtering the air the mixture conglomerates destroy and grains of sand lay more compactly, there also reduces the sand inner and outer friction.

At the moment of the air feeding in the space over the molding sand, in the bottom layers of the sand there is atmospheric pressure. As a result of pressure drop in the top layers of the mixture there occur compression stresses. These stresses are taken by the underlying layers of the sand. At the same time there occurs an intense air filtration into the bottom layers of the sand. With growing pressure drop there increases the filtering air speed and air-dynamic effect of the air to the sand. This increases compression stress in the sand. With growing compression stress there begins the process of the sand compaction. In all the layers there occur inertia forces directed forward to the moving sand. When pressure stabilizes over the sand, the compaction process slows down, the inertia forces are directed to the pattern plate and increase the value of compression stresses in the sand. The mold density depends mainly on the value of maximum pressure over the sand and on the speed of pressure growing. The studies showed a very low coefficient of lateral pressure.

The solidity on the mold achieved 85-88 units with the molding box height 0,2 m. The mold gas permeability was 75-80 units.

CONCLUSIONS

Thus, the carried out gravimetric and dilatometric studies showed that using the bonding materials studied permits to obtain filtering elements without high-temperature solid-phase sintering. When filtering great masses of a melt with the aim to preventing softening of filtering elements made using liquid glass as a binder, it is necessary to introduce into the refractory material no less than *5 %* of aluminum powder.

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Note: The translation of the N.M. Drag, Karaganda, Kazakhstan