Research into filtering properties of lavsan fabrics for dehydrating red mud of low-silicon bauxite

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Abstract. The research was carried out on lavsan and lavsan-capron filtering fabrics for dehydrating red mud of low-silicon bauxite. The filtering properties and clogging capacity of the synthetic fabrics were evaluated. Keywords: filtration, lavsan fabrics, red mud, adhesion, filtering properties.

1. Introduction

Dehydration of various process suspensions through filters is a standard procedure [1-4]. The separation of inhomogeneous matters is carried out through a porous partition. The choice of such partitions depends on different factors: the physical-chemical properties of the inhomogeneous fluids to be separated, the nature of the technological process and the requirements for the final products [5-7]. When separating various mineral suspensions through filters, the filter systems can be based on the filtering partitions, fabrics which are made of natural and synthetic fibres [8-12]. In most cases, the filters provided with synthetic fabrics are likely to contribute to improving both technological and economic performance of the dehydration process. Employing synthetic filtering fabrics is far more advantageous and productive for filtering sludge suspensions in comparison to those natural fibre fabrics which become quickly clogged, as well as for filtering corrosive media, since cotton fabrics rapidly lose their original filtering properties and resistance. The research by means of an example of processing and filtering red mud analyses the filtering capacity of lavsan fabrics of item numbers 56278, 86030, 56271, 56050 and lavsan-capron fabrics of item numbers 86036, 86035, 86017.

Lavsan filter fabrics are successfully employed for filtering neutral, slightly acidic and alkaline pulps. Such fabrics are characterized by high wearing feature and temperature resistance. In terms of tensile strength (74-87 kgf/mm²), lavsan fibres are superior to other synthetic fibres, including polyamide ones. Lavsan fibres have a high initial elastic coefficient, which is 4-5 times more than that of capron fibres. They are resistant to caustic alkalis and mineral acids at low concentration, but are destroyed by concentrated mineral acids and ammonia solution.

Lavsan fabrics have different types of weaving. They are of square weave and serge weave. According to the structure of the lavsan fibres as a base for filter fabrics, the fabrics belong to filament ones, consisting of a number of elementary fibres. The filtering properties of fabrics are greatly influenced both by the type of fabrics construction and by the structure and length of fibres: their porosity, thickness and degree of thread twist and their number per unit area. In the combined lavsan and capron fabrics, nylon threads are included. Nylon (polyamide) fibresavourably differ from other fibres with their high resistance to abrasion and repeated deformation. The fibres are resistant to
alkalis, microorganisms, but are not sufficiently resistant to acidic media. Fabrics made of polyamide fibres are subject to hydrolysis in solutions of mineral and strong organic acids. In water, such fabrics are hydrolysed at temperatures above 150°C. Polyamide fibres are characterized by high temperature resistance (with the melting point 218°C). The strength of the fibres is significantly reduced at temperatures above 120°C, and at 150°C the strength of nylon is decreased to 75%.

2. Materials and methods
The red mud of Bogoslovsky Aluminum Plant results from chemical degradation of low-silicon brauxite of Severouralsky deposit. Visually, the red mud is a loose, homogeneous according-to-its-grain-size substance.

Crystal optical, thermal and X-ray phase analyses were applied to determine the mineralogical composition of the red mud.

The mud particles have well-observable screened layers. In some cases, they rim the entire particle, and in others, they are located on separate parts of its surface. Thickness of the layers reaches 0.024 mm with the colours ranging from light grey to slightly bluish. The layers are mainly hematite.

According to the analysis results, the red mud is mainly represented by hydrargillite, diaspore, kaolinite, kaolin-halloysite, hematite, hydrohematite, while calcite and opal are a comparatively smaller amount. All mineral compositions in red mud have a finely dispersed and micro-lamellar shape, when their particles attain the average size of thousandths and hundredths of a millimetre.

The filtering properties of the synthetic fabrics were tested with a laboratory filtration unit. In the course of the experiments, the filtering process was carried out by the method of lower infiltration with a horizontal arrangement of the filter surface. As a filter element, a filter frame was used. It performed as a perforated support where a drainage bottom layer - a metal net with a filter fabric - was located. The filter frame tightness was ensured by applying a fixed block. When testing synthetic materials, the frame was constructed in the following sequence: the metal net was a support for the filter fabrics blocked with a sealing ring made of vacuum rubber, and the filter layer was fixed with clamps.

The experiment was carried out under the following required conditions: the thickness of the sediment equal to 10 mm, with the temperature of 20-22°C, and the ratio of L:S=1:1 (liquid substance: solid substance), the vacuum value equal to 665 hPa. The evaluation of the filtering properties of the fabrics was carried out on the basis of the analysis of the retention potential (muddiness coefficient) and permeability (coefficient of efficiency). The values of the coefficients (Table 1) were calculated through the ratio of the filtration rate and the content of solid particles in the filtrate, respectively, to similar indicators obtained for standard cotton fabrics (filter diagonal fabric, item number 2074).

3. Results and discussion
The filter diagonal made of cotton fabrics was successfully used for dehydration of mineral suspensions. The fabric (item number 2074) is of serge weave. The serge weave fibres are mobile enough to ensure the efficient cleaning during the regeneration process. However, serge fabrics are inferior to calico weave fabrics in terms of their filtering degree (table 1).

It is seen that cotton fabrics and filter diagonal fabrics quickly become clogged when filtering suspensions containing finely dispersed fractions, and in aggressive media they are destroyed. The data count in favour of filtering properties of fabrics made of synthetic fibres. The degree of interaction of the solid phase of the pulp with the surface of filter fabrics was calculated by the amount of sediment adhered to the fibres of the fabrics during the dehydration process. The indicator of the adhesion force determines the capacity of filter fabrics to resist various kinds of sediments (granular, greasy, jellylike, cementing, organic). The relative stability assessment of synthetic and cotton fabrics was done by the value of the clogging coefficient (Kp).

The studies showed that all tested lavsan and lavsan-capron fabrics had similar permeability both in relation to each other and in relation to filter diagonal fabrics.
Table 1. Comparative evaluation of the filtering properties of synthetic and cotton fabrics when filtering red mud.

| Fabric name, item number | Coefficient of efficiency, Kw | Muddiness coefficient, Kq | Clogging coefficient, Kp |
|--------------------------|-------------------------------|--------------------------|--------------------------|
| Lavsan                   |                               |                          |                          |
| 53278                    | 1.33                          | 0.67                     | 0.146                    |
| 86030                    | 1.20                          | 2.584                    | 0.243                    |
| 56271                    | 1.13                          | 1.064                    | 0.169                    |
| 56050                    | 0.87                          | -                        | 0.399                    |
| Lavsan-capron            |                               |                          |                          |
| 86036                    | 1.399                         | 0.671                    | 0.348                    |
| 86035                    | 1.266                         | 0.578                    | 0.265                    |
| 86017                    | 0.867                         | 1.009                    | 0.619                    |
| Filtering diagonal, item number 2074 | 1.0 | 1.0 | 1.0 |

For the tested samples of synthetic fabrics, a significant variation in the amount of dispersed particles in the filtrate obtained during clumping sediments on the filtrate was observed. Muddy filtrates were obtained for lavsan fabrics, item number 86030 (Kq = 2.584). Lavsan-capron fabrics, item number 86017 (Kq = 1.009) and lavsan fabrics, item number 56271 (Kq = 1.064) demonstrated a slightly higher indicator for dispersed particles in comparison to cotton fabrics.

Measurements of the adhesion strength of dispersed particles of red mud to the fibres of synthetic fabrics allowed concluding that the blockage capacity of the group of fabrics is significantly lower than that of cotton fabrics, item number 2074. The value of the clogging coefficient reflects the working service of the filtering partition under production-line conditions rather accurately. The lowest clogging coefficient was showed by the fabric, item number 56271 (Kp = 0.169), while the highest indicator was demonstrated by the fabric, item number 56050 (Kp = 0.399).

The strength of adhesion depends on the material composition of the pulps. Table 2 shows the values of adhesion of dispersed particles of different pulp compositions.

Table 2. The strength of adhesion of sediments to synthetic and cotton fabrics.

| Fabrics, item numbers | Adhesion, kg / cm² |
|-----------------------|--------------------|
|                       | Pulp I (non-sulfide) | Pulp II (Saralinsky) | Pulp III (gravel concentrate) | Pulp IV (red mud) |
| Lavsan                |                     |                     |                             |                   |
| 56278                 | 1.38                | 2.33                | 2.08                        | 0.925             |
| 86030                 | 2.63                | 4.09                | 4.05                        | 3.57              |
| 56271                 | 1.83                | 3.05                | 0.585                       | 1.06              |
| 56208                 | -                   | 0.71                | 1.52                        | 0.91              |
| 56050                 | 4.32                | 5.90                | 5.38                        | 5.57              |
| 86036                 | 3.77                | 2.35                | 2.94                        | 2.18              |
| 86035                 | 2.87                | 1.96                | 2.45                        | 1.51              |
| 86017                 | 6.70                | 3.20                | 3.94                        | 4.36              |

The evaluation of the interaction force of particles of the dispersed phase with the surface of fabrics allows concluding that it is advisable to use this type of filter fabric for a specific type of filter. Thus, for Nutsche filter, a revolving filter, it is possible to use synthetic filter fabrics [1] with low adhesion value (item number 56278 and 86035), for a disk and frame filters, it is required to use filter partitions with high adhesion to the sediment [2-3].
4. Conclusion

Thus, according to the results of laboratory tests of synthetic filter fabrics in the dehydration process of red mud, the following conclusions can be drawn:

- All types of tested samples of synthetic filter fabrics provide the filtration rate similar to standard cotton fabrics;
- According to the quality of the filtrate, all tested samples, except for fabrics, item number 86030 (Kq = 2.584), are as good as cotton ones;
- By clogging resistance capacity, the synthetic fabrics outperform the filter diagonal art. 2074.

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