Study on Filtering Properties of Synthetic Fabrics Used for Dehydration of Non-Sulphide Gold-Bearing Pulps

V I Salamatov¹, N O Tyutrin¹, O V Salamatov²

¹ Machine Technology and Materials Department, Irkutsk National Research Technical University, 83 Lermontov st., 664074, Irkutsk, Russia
² CEO of the East-Siberian branch of Sever Minerals Company.

e-mail: salamatov_52@mail.ru

Abstract. Different types (disk, cartridge, filter-press, drum) of filters are used for dehydration of various technical suspensions. A key element of these filters is a filter membrane. Cotton and synthetic fabrics are used as filter membranes. Bases on non-sulphide gold-bearing pulp filtration, the article presents results of the study on filtering properties of mylar and mylar-nylon fabrics. Filtration kinetics for various pulps differing in the content of solid was studied. For the experiment, the authors used cotton (Article 2074 filter diagonal) and synthetic (Article 86006) filter membranes. Filtration stages and modes were identified. Conditions for initial filtering layer formation were studied.

1. Introduction
Dehydration of various technical suspensions in filters is widespread [1-5]. Heterogeneous systems are separated through a porous membrane which is chosen by physicochemical properties of the heterogeneous system, the nature of the technological process and requirements to final products [6-10]. When separating various mineral suspensions, natural and synthetic fabrics are used as filter membranes [11-13]. In most cases, synthetic fabrics improve technical and economic dehydration parameters.

2. Problem statement
For filtering slurry suspensions or aggressive substances, synthetic fabrics can be used instead of natural ones which become clogged quickly and lose their filtering properties and strength [1]. Filtering properties of mylar fabrics (Articles 56278, 86030, 56271, 56050) and mylar nylon fabrics (Articles 86036, 86035, 86017) were studied on the example of gold bearing slurry pulp filtration [14-17].

Mylar filter fabrics are suitable for filtration of neutral, weak acid and alkaline pulps. These fabrics have high wear and heat resistance coefficients. The tensile strength (74-87 kg/ mm²) of mylar fibers is higher than that of other synthetic fibers, including polyamide ones. Mylar threads have a high initial modulus of elasticity which is 4-5 times more than that of nylon. Mylar threads are stable in low concentrated caustic alkalis and mineral acid solutions but they can be destroyed in concentrated mineral acids and ammonia solution.
3. Methods
Mylar fabrics have plain or twill weaving. By their structure, they belong to filament fabrics consisting of a number of elementary fibers. Filtering properties of fabrics are greatly influenced by the type and nature of weaving, fiber length, porosity, thread thickness and thread twist degree, and the number of threads per area unit. In mylar-nylon fabrics, there are nylon threads. Polyamide fibers have higher resistance to abrasion and multiple deformations. The fibers are resistant to alkalis, microorganisms, but not sufficiently stable in acidic environments. Fabrics from polyamide fibers are hydrolyzed in solutions of mineral and strong organic acids. In water, these fabrics are hydrolyzed at temperatures above 150° C. Polyamide fibers are highly resistant to heat (their melting point is 218°C). Fiber strength decreases at 120°C. At 150°C, nylon strength decreases by 75%.

Ore of the Kuranakh ore field consists (Table 1) of fragments of sandstones, mudstones, calcareous rocks, quartz metasomatites, single fragments of dike rocks. All rocks are wind-blown, quartzous, iron-rich. Gold is in a dispersed state. It is linked to iron hydroxides and quartz. Gold weight is 5 microns.

### Table 1. Mineralogical composition of ore of the Kuranakh ore field

| Minerals and groups of minerals | Weight, % |
|---------------------------------|-----------|
| **Barren minerals**              |           |
| 1. Carbonates, quartz, feldspars | 81,0      |
| 2. Clay minerals                 | 13,0      |
| 3. Pyroxene, mica                | 0,4       |
| 4. Accessory minerals            | 0,3       |
| **Ore minerals**                 |           |
| 5. Iron oxides                   | 5,29      |
| 6. Titanium oxides               | 0,1       |
| 7. Sulphides                     | ore grains|

The ore sample is a non-sulphide gold-bearing product containing iron hydroxides. As a result, it is red-brown. Ore density is 2,63-2,68 g/cm3. Table 2 shows the chemical composition of the ore sample.

### Table 2. Chemical composition of ore of the Kuranakh ore field

| Components | SiO2 | Al2O3 | CaO | MgO | S0,05 | Fe2O3 | Ag | Ni | Pb | Zn | Cu | TiO2 |
|------------|------|-------|-----|-----|-------|-------|----|----|----|----|----|------|
| Mass fraction, % | 71,4 | 6.51  | 2.16 | 0.13 | 0.01  | 6.12  | 0.015 | 0.004 | 0.08 | 0.02 | 0.03 | 0.4 |

SiO2 has the largest mass fraction (71,4 %). There are a lot of aluminum and iron oxides. The ore sample contains small amounts of lead, zinc, copper and nickel and large amounts of carbonates, feldspars, and clay-mica minerals.

The mass fraction of sulphides (ore grains) is insignificant. These are pyrite, pyrrhotite, chalcopyrite.

Table 3 shows granulometric properties of a non-sulphide product.

### Table 3. Granulometric properties of ore of the Kuranakh ore field

| Classes, metals | +1,65 | +1,17 | +0,59 | +0,30 | +0,16 | +0,074 | -0,074 |
|-----------------|-------|-------|-------|-------|-------|--------|--------|
| Output, %       | 4,4   | 13,0  | 8,2   | 8,4   | 18,2  | 14     | 33,4   |

4. Research results
Filtering properties of synthetic fabrics were studied using filtration equipment in a laboratory setting. Slurry was filtered by a suction method under horizontal position of the filtering surface. A filter
frame served as a filtering element. A draining metal substrate was put on its perforated base covered by filtering fabrics.

When testing small samples of synthetic fabrics, a metal mesh, filtering fabric, a vacuum rubber sealing ring, and a filtering membrane were clamped to ensure hermeticity of the filtering frame.

The experiment was carried out under the following constant conditions: sediment thickness was 10 mm, temperature was 20–22°C, ratio of L:S was 1:1, vacuum value was 665 HPA. Filtering properties of fabrics were assessed by their retentivity (muddiness coefficient) and permeability (performance coefficient). Coefficient values (Table 4) were determined by comparing filtration rates and filtrate content of solid for synthetic and cotton fabrics (Article 2074).

A cotton filtering diagonal is widely used for dehydration of mineral suspensions. Twill weaving is typical of Article 2074. Threads are mobile enough to ensure effective cleaning during regeneration. However, filtration capacity of twill fabrics is worse than that of cross-woven ones.

Table 4. Comparison of filtering properties of synthetic and cotton fabrics used for filtering a non-sulphide pulp

| Name of fabrics, Art. | Performance coefficient, Cw | Muddiness coefficient, Cq | Clogging coefficient, Cp |
|----------------------|----------------------------|--------------------------|--------------------------|
| Mylar               |                            |                          |                          |
| 56278               | 1,19                       | 1,09                     | 0,343                    |
| 86030               | 1,22                       | 2,66                     | 0,611                    |
| 56271               | 1,22                       | 0,968                    | 0,449                    |
| 56050               | 1,13                       | 0,465                    | 0,870                    |
| Mylar-nylon         |                            |                          |                          |
| 86036               | 1,12                       | 1,29                     | 0,420                    |
| 86035               | 1,13                       | 0,968                    | 0,289                    |
| 86017               | 1,64                       | 0,957                    | 0,471                    |
| Filter diagonal, Art. 2074 | 1,0                       | 1,0                      | 1,0                      |

At the same time, cotton fabrics and filter diagonal become clogged quickly. They are destroyed in aggressive environments which speaks for their worse filtering properties in comparison with filtering properties of synthetic fabrics. Interaction of the solid pulp phase and filter fabrics surface was estimated by sediment adhesion to the fiber. An adhesion value determines the ability of filter fabrics to resist various kinds of deposits (granular, smearing, gel-type, cementing, organic). Relative stability of synthetic and cotton fabrics was assessed using a clogging coefficient (Cp).

The studies have shown that all tested mylar and mylar nylon fabrics have similar permeability coefficients.

Various contents of dispersed particles in the filtrate obtained were observed for synthetic fabrics. Muddy filtrates were typical of Article 86036 (Cq = 1,29). Article 86036 contained a bit more dispersed particles than cotton fabric (Cq = 1,129) and Article 56278 (Cq = 1,09).

Measurement of the adhesion force made it possible to establish that the clogging coefficient for all groups of synthetic fabrics is lower than the clogging coefficient for cotton fabric (Article 2074). The clogging coefficient reflects a life of the filter membrane in the industrial environment. Article 86035 has the lowest coefficient (Cp = 0,289). Article 56050 has the highest coefficient (Cp = 0.870).

Adhesion values depend on the pulp content. Table 5 shows adhesion values for disperse particles of pulps.
Table 5. Values of sediment adhesion to cotton and synthetic fabrics

| Fibers, Article | Adhesion, kg/cm² | Pulp I (non-sulfite) | Pulp II (sulfite) | Pulp III (gravity concentrate) |
|-----------------|------------------|----------------------|------------------|-------------------------------|
| Mylar 56278     | 1,38             | 2,33                 | 2,08             |
| 86030           | 2,63             | 4,09                 | 4,05             |
| 56271           | 1,83             | 3,05                 | 0,585            |
| 56208           | -                | 0,71                 | 1,52             |
| 56050           | 4,32             | 5,90                 | 5,38             |
| Mylar-nylon     |                  |                      |                  |
| 86036           | 3,77             | 2,35                 | 2,94             |
| 86035           | 2,87             | 1,96                 | 2,45             |
| 86017           | 6,70             | 3,20                 | 3,94             |

Evaluation of the force of interaction of dispersed phase particles with the fabric surface can be used for choosing filtering fabrics. For example, for a suction filter and a carousel filter, it is possible to use synthetic fabrics (Articles 56278, 86035) [2] with low adhesion values. For disk and frame filters, it is necessary to use filter membranes with high adhesion values (Article 56050) [3, 4].

**Fig. 1.** Dependence of the filtrate content of solid on the filter capacity (3 g/dl³)

**Fig. 2.** Dependence of the filtrate content of solid on the filter capacity (10 g/dl³)
Fig. 3. Dependence of the filtrate content of solid on the filter capacity (400 g/dl³)

Fig. 4. Dependence of the separation coefficient Cs on the pulp content of solid:
1. Chlorine fibers Art. 86006; 2. Filter diagonal and coarse calico

Fig. 5. Influence of suspension dilution on the filter membrane capacity (filter diagonal)
Figures 1-3 show dependencies of the filtrate content of solid on filtration duration at different initial values of concentration of the dispersed phase in suspension: 3 g/dl3, 100 g/dl3, 400 g/dl3.

According to the experiment, there are two separation stages. At the second stage, the number of dispersed particles in the filtrate decreases slowly due to the fact that at the first stage, the initial sediment layer is formed. Along with the filter membrane, this layer forms an initial filtering layer.

Filtering properties of the membrane and the porous system manifest themselves during the first contact of the filter surface and the slurry layer. The filtering material can pass through the liquid phase and retain dispersed particles. The separation coefficient (Cp) determines retentivity of the filtering membrane (Fig. 4). For chlorine filter fabric, the minimum value of Cp (0,88) corresponds to a suspension density value of 50 g/dl3. For a cotton membrane consisting of a filter diagonal and coarse calico, the lowest Cp value (0,77) corresponds to the content of solid of 25 g/dl3.

The structure of the initial layer is determined by the content of the solid. For low concentrated suspensions (3 g/dl3) which are usually filtered through clarification filters, the structure of the layer is formed by particles in through pores of the membrane. Membrane retentivity is determined by a gradual decrease in the number of pores due to penetration of particles whose size is smaller than the pores of the system.

An increase in suspension density is favorable for formation of arched deposition. For this type of filtering, the structure of the initial filtering layer is formed by particles on the walls of through pores and a surface sediment layer.

Various filtration modes correspond to various structures of the initial filtering layer.

Figure 5 shows the characteristic of the delayed ability of the filtering diagonal in a wide range of initial suspension density values. A deep filtration mode is typical of low concentrated suspensions (3,5, 10, 25 g/dl3). A slurry filtration mode is typical of dense suspensions (> 150 g/dl3). A transition mode is typical of suspensions with density values varying from 25 to 150 g/dl3.

5. Conclusion

The following conclusions can be drawn from the experiments:

All samples of synthetic filter fabrics have the same filtration speed rate as cotton fabric has. Synthetic fabrics have high quality filtrate (except for Art. 86030 Kq = 2,66), and higher resistance to clogging.

The filtration process includes two stages. At the first stage, a filtering layer is formed. At the second stage, the clarification process becomes stable.

Three filtration modes were identified. In the range from 25 to 150 g/dl3, suspension is filtered in a transition mode. For low-concentrated suspensions (suspension density is more than 150 g/dl3 (<25 g/dl3)), filtration is deep (slurry filtration mode).

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