Development of turning-filtering mechanism of centrifuges

E S Karataeva¹ V A Lashkov², A A Brodt³ and M N Akhlyamov⁴

¹Federal state autonomous educational institution of higher professional education «Kazan (Privolzhsky) Federal University», Engineering institute, Kazan, Saidashev str, 12, Russia
²,³²¹Federal State Budget Educational Institution of Higher Education «Kazan National Research Technological University», Kazan city, Karl Marx str, 68, Russia
⁴OOLLС “PLKGROUP”, 420141, SalihBatyev str, 19, office 6

e.s_karataeva@mail.ru

Abstract. Analysis of the literature revealed a lack of filtering centrifuges, which include the difficulty of regenerating the filtering surface. The presented constructive solutions for its elimination provide only local, but not complete regeneration of the filtering surface. The authors investigated the regeneration of filter elements when the blades rotate around the axis as a result of the engagement of parts of the rotary device. In order to exclude shock loads in the process of turning, various cam designs are considered, the best of which is a fork cam.

Separation of heterogeneous liquid systems (suspensions) in many enterprises is carried out in the field of centrifugal effect (in centrifuges). Regardless of the principle of operation, centrifuges have a common drawback which lies in the difficulty of regenerating the filtering surface. Incomplete removal of dispersed particles from the filtering surface, their introduction into the pores of the filtering element and compaction by centrifugal forces leads to an increase in the separation resistance.

In this regard, it became necessary to find a technical solution for the effective regeneration of the filtering surface. The literature presents various structures of regenerating units, based on: mechanical removal of the sediment layer, the effect of the hydraulic wedge and hydraulic shock with back pressure pulsations in the additionally formed gap, changing the geometry of the filtering element and breaking the integrity of the compacted layer, etc. Analysis of the literary sources allows for the conclusion that in these technical solutions there is a local, but not complete regeneration of the filtering surface. On the basis of the conducted research, a promising direction was identified to restore the activity of the filtering surface, consisting of individual elements (blades), with the possibility of alternate rotation with acceleration around its own axis (Fig.1.).
A centrifuge consists of a body and a rotor coaxially placed in it, the cylindrical surface of which is formed by a set of perforated elements. The elements are installed with the possibility of rotation on their axes; for this purpose, toothed gears are fixed on one of the semi-axes of the elements.

A feeder with a loading opening is placed inside the rotor. The rotor is enclosed in a shell with holes for draining the liquid phase. The shell is provided with a toothed sector. The teeth of the sector are engaged with the toothed gears located in this area. The discharge box is provided in the shell.

During operation of the centrifuge, the rotor and the feeder with the shell are driven into rotation. The initial suspension is fed into the feeder, which is thrown onto the surface of perforated blades under the action of centrifugal force, where the separation of the liquid and solid phases takes place. The filtering process continues within one rotation of the rotor relative to the feeder with the shell. At the end of one rotation the toothed gears engage with the toothed sector of the shell.

A rotation with acceleration of the filtering elements around their axes at 1800 takes place, resulting in the sediment is discharged into the discharge window. The unloaded element occupies its working position, on the filtering surface of which the initial suspension is fed. Due to the rotation of the blades at 1800 their filtering surface reorients relative to the direction of the centrifugal forces and their continuous centrifugal regeneration is ensured.

The analysis of the centrifuge operation revealed the shortcomings of the rotary device of the system of the filtering elements regeneration, which are as follows:

- between-centers distance between the rotor and the blade can not be arbitrary and depends on the modulus of the tooth and the number of teeth;
- a module of the tooth and the number of teeth should be chosen so that when the last tooth leaves the gearing, the retainer without impact falls on the fixing surface (otherwise, these structural elements collide (Fig.2).
Fig. 2. Results of the analysis of the work of a toothed pair in the system ADAMS, fixing the strike of the retainer on the guide

To eliminate the shortcomings, studies were carried out with various parts of the rotary device — cams: a cross-shaped cam with a retainer, a modified cross-shaped cam with a retainer and one pin; a cross-shaped cam with a retainer and two pins; a forked cam.

It was found out when turning the cross-shaped cam with a retainer and one pin:
- there is a rebound from hitting the linear part of the cam to the engagement of the pin and tooth;
- the angle of rotation of the blade is random and depends on the friction on the axis of the blade;
- contact of the fixing surface occurs with a rebound.

To eliminate the rebound when turning with a modified cross-shaped cam with a retainer and one pin, the lead-in part of the cam was changed from straight to radial.

In order to streamline the rotation of the filtering element, an additional pin was inserted into the structure. As a result, the rotation of the elements became more predictable, but the rebound of the fixing device was not eliminated (Fig. 3).

Thus, all the considered mechanisms have one common drawback. Different geometry elements that are responsible for the rotation and fixation of the blade lead to the impact interaction of their surfaces.

Still the task in hand was solved by the use of a forked cam. When using this device, it became necessary to determine the geometry line of the axes centers. As a result of mathematical processing, the following relations between the angles were obtained:

\[ \beta = \beta_0 - (\beta_0 t), \]
\[ \theta = 90 - \varphi_0 + t\varphi_0 + \arctg((l/2\sin\beta)/(R_c - l/2\cos\beta)), \]
\[ R = \sqrt{(R_c - l/2\cos\beta)^2 + (l/2\sin\beta)^2}, \]
\[ \varphi = \varphi_0 - \varphi_0 t, \]

where \( l = 10; R_c = 78; \beta_0 = 90; \varphi_0 = 12. \)
Fig. 3. Cross-cam operation: a - with one pin; b - with two pins

The expression for the linear variation of the angle $\beta$ can be given by a more complex dependence, providing smooth acceleration at the terminal parts of trajectory

$$\beta = \beta_0 - \beta_0 (\sin (t \cdot 180 - 90) + 1)/2.$$

The results of calculations and constructions are presented in Fig.4.

Fig. 4. Line drawing of cam centers

The resulting solution is scaled and recalculated to any size (angle of rotation, fork arm, between-centers distance.

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