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Calculation of open Hydrocyclons

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ABSTRACT: The article discusses the use of hydrocyclones for cleaning liquids, and provides formulas for calculating the main parameters of a hydrocyclone.

KEY WORDS: hydrocyclone, pump, particles, clearance, impeller, pressure loss rate, flow.

I. INTRODUCTION

Hydrocyclones are used in the processes of clarification of wastewater, thickening sludge, enrichment of milk of lime, washing sand from organic substances, including oil products and fat, i.e. in oil fields, car farms, glass, foundries, etc. When clarifying wastewater, small-sized apparatuses provide a greater cleaning effect. When thickening sediments of mineral origin, hydrocyclones of large diameters (over 150 mm) should be used. For mechanical treatment of wastewater from suspended solids, open and pressure hydrocyclones may be used.

Hydrocyclones are extremely simple and inexpensive devices, using the centrifugal force. They are compact, easy to use and have high operational efficiency.

Hydrocyclones were first used in 1939 to coax the suspension and enrich the coal. In metallurgy, hydrocyclones were used to cool the inner surface of rolls and to separate particles into water. In the chemical industry, hydrocyclone separates intermediate products or suspensions in the form of suspensions.

250 mm hydrocyclones are used for the separation of fuels and heat distributors in the Gallogen atomic reactors, for the separation of products that are not insoluble in corrosion. Under high temperatures and pressure, hydrocyclones are no substitute, as they do not have moving or compacting parts, and it is advisable to use hydrocyclones to reduce the amount of water required for production, drainage, and washing water, as it reduces the size of the insulators.

The construction of new water economy complexes, based on the modern requirements of technical science, raises the question of optimization of operation of the previously constructed water facilities. Particularly, the water source of irrigation networks is very important for rivers with high waste transport. According to operational water management organizations, currently about 30% of irrigation networks are spent, while 60% to 70% of individual systems are spent on their operation and maintenance costs. By 1953 the volume of saline canals in sedimentation was more than 130 million m3, and in 1980 it was 770 million m3. An increase in the amount of annual cleaning results in an increase in the fight against the result, but not the cause of the muddy sinking.

At the same time, the literature emphasizes the importance of wastewater that affects the process of soil formation and soil fertility, with irrigation water access to irrigated areas. Measures that can reduce the amount of canal cleaning canals can be divided into two groups:

1. Reduction of sediment flow to canals;
2. Maintain and enhance the transport capacity of channels.

II. PROPOSED METHOD

There are several types of hydrocyclones, which determines the scope of their application, these are hydrocyclones-classifiers, hydrocyclones-thickeners and hydrocyclones-separators. Classification hydrocyclones are used to separate grains by size; hydrocyclones - thickeners - to separate part of the water from the grains; hydrocyclones-separators - for the enrichment of minerals in mineral suspensions. Hydrocyclones are widely used in the coal and ore industries as dressing agents, classifiers; in the pulp and paper industry for pulp cleaning; in water use systems; in the glass-ceramic industry for clay enrichment; in the oil and refining industries. The choice of a hydrocyclone as the basic apparatus for classification schemes is due, first of all, to high separation efficiency and productivity at relatively small sizes and cost. In addition, as practice shows, the operation of hydrocyclones does not

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require large expenditures and additional personnel for maintenance. Hydrocyclones can be successfully used as thickeners, brighteners, classifiers in many technological cycles of industrial production[1,2,3].

Open for the release of floating, settling coarse impurities with a hydraulic particle size of more than 0,2*mm/s* and coagulated suspension and pressure for the separation of coarse impurities of mineral origin from wastewater. For the calculation and design of plants with open cyclones, the same parameters for water and pollution are set as for sedimentation tanks. The hydraulic particle size of the particles that must be selected to ensure the desired cleaning effect is determined when the height of the water layer is 200 *mm*. For multi-tier hydrocyclones, the sedimentation layer should be equal to the height of the tier. The separation of impurities from wastewater is effectively carried out under the action of centrifugal and centripetal forces in open and pressure hydrocyclones. Open hydrocyclones are used to isolate particles with a diameter of> 0,1*mcm* from suspensions during the purification of coarsely dispersed impurities [1,2,3].

Openhydrocyclones are usually designed for wastewater treatment from heavy impurities. Typically, hydrocyclones are used in combination with other treatment facilities. A decisive influence on the working effect of an open hydrocyclone is exerted by the physical properties of the particles (size, shape, density, etc.) for which it is intended to be retained, as well as the geometric dimensions of the hydrocyclone and the hydraulic mode of its operation.

A modified hydrocyclone with a conical diaphragm and an inner cylinder (Fig. 1) eliminates the accumulation of suspended particles under the diaphragm and their periodic removal with clarified water. The initial suspension is fed tangentially to the lower part of the zone bounded by the inner cylinder. The upward flow at the upper edge of the cylinder is divided into the main flow, which moves in a spiral to the central hole in the diaphragm, and the additional flow entering the gap between the walls of the hydrocyclone and the cylinder. In the additional stream, suspended particles released in the upstream are transported.

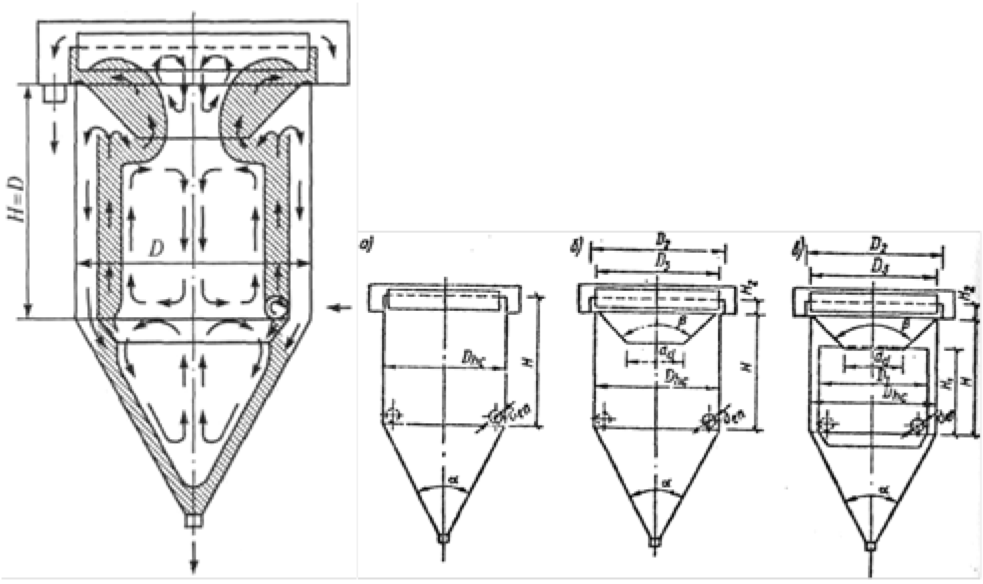

Fig. 1. Open hydrocyclones: a - without internal inserts; b - with a conical diaphragm; c - with a conical diaphragm and an inner cylinder

The main calculated value of open hydrocyclones is the specific hydraulic load q_{hc} ($m^3 / (m^2\ h)$), determined by the formula:

$$q_{hc}=3,6 \cdot K_{hc} \cdot U_o \qquad (1)$$

where: U_o is the hydraulic particle size of the particles that must be selected to ensure the desired effect, *mm / s*; K_{hc} is a proportionality coefficient depending on the type of hydrocyclone and equal for hydrocyclones: a) without internal devices 0.61; b) with a conical diaphragm and an inner cylinder of 1.98; c) multi-tiered with central outlets

$$K_{hc} = \frac{0{,}75 \times n_{ti} \times (D_{hc}^2 - d_d^2)}{D_{hc}^2} \qquad (2)$$

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Here n_{ti} is the number of tiers, $D_{hc}$is the diameter of the hydrocyclone, *m*; d_d is the diameter of the circle on which the bells of the outlets are located, *m*; d) multi-tiered with peripheral selection of clarified water

$$K_{hc} = \frac{1{,}5 \times n'_{ti} \times (D_{hc}^2 - d_d^2)}{D_{hc}^2} \quad (3)$$

Where n'_{ti} is the number of pairs of tiers; $d_d$is the diameter of the hole of the middle diaphragm of a pair of tiers, *m*. The performance of one device is determined by the formula:

Where q_{hc} is the specific hydraulic load, $m^3 / m^2 \times h$; $D_{hc}{}^2$ - hydrocyclone diameter, m.

$$Q_{hc} = 0{,}785 \times q_{hc} \times D_{hc}^2 (4)$$

Based on the total volume of wastewater Q_w determine the number of working units of cyclones *N*:

$$N = \frac{Q_w}{Q_{hc}} \quad (5)$$

After assigning the diameter of the apparatus and determining their number, the main dimensions of the hydrocyclone are determined. In each case, the angle of inclination of the generatrix for conical diaphragms in open hydrocyclones is set taking into account the properties of the precipitate, but not less than 45 °. Diaphragms in open hydrocyclones can be made of both steel and non-metallic materials. In the channel of the proportional water distribution device of a multi-tiered hydrocyclone, the velocity of the upward flow must be at least 0,4*m/s*.

III. RELATED WORK

Centrifugal separation of fine grained material is carried out in liquid or gaseous medium. The separation of the bulk phase grains of the pulp being processed depends on their hydraulic size.

Separation of large-phase grained particles of the pulp, processed in the centrifugal separation, as if they were weighed under gravity, depends on their hydraulic size. Therefore, when the pulp has different densities of minerals, their relatively mild absorption and the geometric size of the particles occur. The centrifugal separators used in the production center can be divided into four groups: cyclone dust mounts; air and circulation separators; hydrocyclones; centrifuges. There is insufficient information on the principles of operation of the structure of the following equipment, application areas [4,6,7,8].

The design and operation of the out-of-class classroom equipment is similar to the type of fluid and gas movement in them. However, in all types of equipment there is a single, slightly less precise hydrodynamic element, which gives the concentration of the internal rotating current, the direction of which is proportional to its axis of rotation (the geometric axis of the side apparatus).

In cyclones and hydrocyclones, this flow is caused by internal shear, while centrifugal separators are circulated through the inner coke, in centrifuges it penetrates the inside of the rotor, through which the bulk of the pulp passes through the entrance.

Thus, the separation from the center to the extruding classifiers begins at the moment of discharge of the pulp, continues in the external flow and ends in it.

IV. EXPERIMENTAL RESULTS

The operational efficiency of centrifugal pumps is determined by the clearance of the sealing elements of the impellers. When pumps operate on natural water sources, the size of the impeller clearance increases due to cavitation-abrasive wear from the effect of a suspension flow. This leads to a decrease in the water supply of the pumps compared to the design water supply during the growing season.

To reduce the wear rate of the parts of the impeller sealing assembly and increase the pump overhaul life by reducing the pressure drop in the gap, 7 end vanes are installed on the outer sides of the impeller disks, i.e. impellers. In order to reduce the flow of abrasive particles into the space between the impellers and the gap, purified water is supplied from a hydrocyclone connected to a spiral pump outlet (Fig. 2). Impellers 2 have curved outlines and are made 7 *mm* thick, 7,5*mm* wide and 85,5 *mm* long. They are installed between the diameters of the disk D_3 = 300 *mm*and D_4 = 382 *mm*.

To supply clarified water to the space between the impellers 2 and the sealing ring 3 (at point C), holes 7 are drilled in the pump casing, the connection goes to the hydrocyclone 5 using the tube 6. The hydrocyclone 5 is fed from a spiral pump outlet device at a pressure of H = 70 *m*. century Inlets and outlets of water from the hydrocyclone 5 are carried out using rubberized hoses with fittings for threaded connections, which made it easy to assemble and disassemble during operation.

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The hydrocyclone is a cylindrical body with an elongated conical bottom. Water is supplied into the housing through a tangentially located nozzle and acquires a strong rotational movement. In a rotating volume of water at a significant speed of rotation, large centrifugal forces that carry it in the radial direction will act on a solid particle in the water. The suspended particles suspended to the walls of the cylinder slide along it into the conical bottom, from which they are removed through the outlet. The clarified water is discharged from the center of the casing through the nozzle and is fed into the space before the pump seal (point C in Fig. 2).
The pressure loss in a hydrocyclone is expressed by the dependence:

$$h = \xi \frac{W_c^2}{2g} \quad (6)$$

where ξ = 1080-resistance coefficient;
W_c - flow rate in the cyclone:

$$W_c = \frac{4q}{\pi D_c^2} \quad \textbf{(7)}$$

From the above dependences, the diameter of the cyclone is calculated:

$$D_c = \sqrt{\frac{4q}{\pi}\sqrt{\frac{\xi_c}{2gh}}} \quad (8) \qquad (3)$$

Where q is the flow rate of the hydrocyclone.

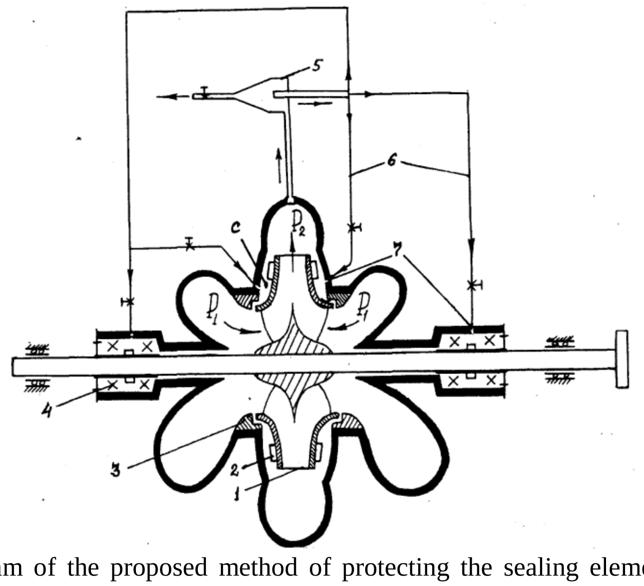

Fig. 2. Schematic diagram of the proposed method of protecting the sealing elements of the impeller of a centrifugal pump of type D cavitation-abrasive wear: 1 — impeller, 2-impellers, 3-sealing ring, 4-gland, 5-hydrocyclone, b-tube for supplying clarified water, 7- hole.

Taking ξ = 1080, h = 10 *m* and q = 12 *l/s* for the gap value s = 1 *mm* according to formula (8), we obtain the diameter D_c = 18 *sm*. To study the effect of clarified water on reducing the wear rate, purified water from a hydrocyclone was fed into one seal, i.e. to the left of the impeller. The right part of the impeller worked with impellers without supplying purified water. The dimensions of the hydrocyclone were taken in the following ratios [3]: the height of the cylindrical part $H_1 = 0{,}515D_c$; the height of the conical part $H_2 = 2{,}11D_c$; the diameter of the drain pipe $d_1 = 0{,}34D_c$; diameter of the inlet pipe d_2 = (1 ... 2) d_1; diameter of the sand hole d_3 = (0.1 ... 0.25) d_2; taper angle $\alpha = 30^0$[1,3,4].

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When the pump is operated with impellers without supplying purified water from a hydrocyclone, the wear of the sealing elements is reduced slightly. When clarified water is supplied from the hydrocyclone to the space between the impellers and the seal (to point C), the gap increase intensity decreases sharply[1,4].

If with a conventional pump design, the clearance increase for 3,5 months of operation is S = 3,15 *mm*, then for the proposed seal operation scheme this value will be S = 1,95 *mm*. In this case, the repair of parts will be economically effective after 3 months of operation, i.e. at the end of the irrigation season[4].

V. CONCLUSION

With the supply of clarified water from the hydrocyclone to the stuffing box, the wear rate of the protective sleeves and stuffing boxes decreased and their service life increased by 2.5 ... 3 times, which facilitates the work of maintenance staff and reduces the downtime of pumping units during the growing season.

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