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RESEARCH OF POSSIBILITY RESEARCH OF COUNTER – CURRENT AND CO – CURRENT MULTIFLUX SEDIMENTATION

In this article, authors propose modernization the Dorr settlers by filling them with lamella packets. After taking a lot of tests on the laboratory stand to the research of counter – current and co – current multiflux sedimentation, there was defined an exploration of efficient of the sedimentation with lamella packets and without the. The results of the investigations, description of laboratory stand and final conclusions from this work also presented.

Introduction. To make a requirements of European Union about cleaning all gutters letting down to rivers, the southern region of Poland needs 7,8 mld zl from Native Program of Cleaning Municipal Gutters. However for building canalization will be appoint only 3,5 mld zl.In a southern region of Poland hardly 31 % of all gutters are cleaned. The rest gutters are letting down to rivers and streams, which in many cases are the source of fresh water.

In conformity with the pre – access agreement in December 2005 in Poland should be cleaned 69 % of all gutters , in 2010 – 86 %, in 2013 – 91 %, and two years later 100 % gutters.

In the southern region of Poland is 210 sewage plants (most of them should be modernized),and it's also a must to build 160 new sewage plants. It's even better seen, at the case of canalization. In our province nowadays is not more than 5,2 thousand kilometers of sewers, and to make the requirements combined with European Union, there's a need to build another 15 thousands kilometers.

In this article there are included proposals of modernization the Dorr settlers by filling them with lamella packets. At the University of Mining and Metallurgy in Cracow there were made a lot of tests on the laboratory stand to the research of counter – current and co – current multiflux sedimentation, there was an exploration of efficient of the sedimentation with lamella packets and without them. Also there is specified an aspect of the profits, including the adaptation of lamella packets in Dorr settlers in existing sewage plants as well as new build plants. It was presented also the results of the investigations, description of laboratory stand and final conclusions from this work.

Modernization of the Dorr settlers by filling them with lamella packets. By settlers we call an objects or devices to take from the sewages easily sediment suspension with concentration larger than 1 g/cm3. Working of the settlers can be exposed as a keeping the sewage in the condition of very slow flow, thanks to that results, on the principle of gravity sharing out two phases: water and suspended fraction. Sediment that falls down is raked outside the settler and the clarified sewages are taken to the other departments of the sewage plant.

Most of the sewage plants in Poland are equipped with round Dorr settlers but without lamella packets. Efficiency of the work of these pre- settlers depends on: hydraulic load of the settler surface, time of keeping the sewages, configuration of the settler, type of sewages, type of suspension, temperature and participation of the sewages. Efficiency can be risen by putting inside the settler lamella packets angled at 60^o to the bottom.

General, specific features of the Dorr settler construction fulfilled with lamella packets:

– Packs of the lamella packets are the layer located in the zone of clearing the suspension, where also takes place the process of the easy sedimentation the pieces of the solid phase.

– In order to extortion the flow of the whole suspension through the ducts of the lamella packets the layer is separated from the rest of the settler with vertical partition standing out the layer of the suspension and held by the construction keeping the packets. Flow of the suspension is counter – current to the direction of the suspension flow.

– In the Dorr settlers the lamella packets are the surface in a shape of the ring, which is located from the edge of the overflow chamber to the center of the settler or to the wall of the settler, when the overflow chamber is shoved away from this wall. Lamella packets are fulfilling the settler partly (in the settlers with the peripheral propulsion of the sweep – off gear) or almost fully, besides the area taken by the construction elements of the drive of the sweep – off gear. Complete fulfilling the settler is the special case, the bordering case of the partly – fulfilling.

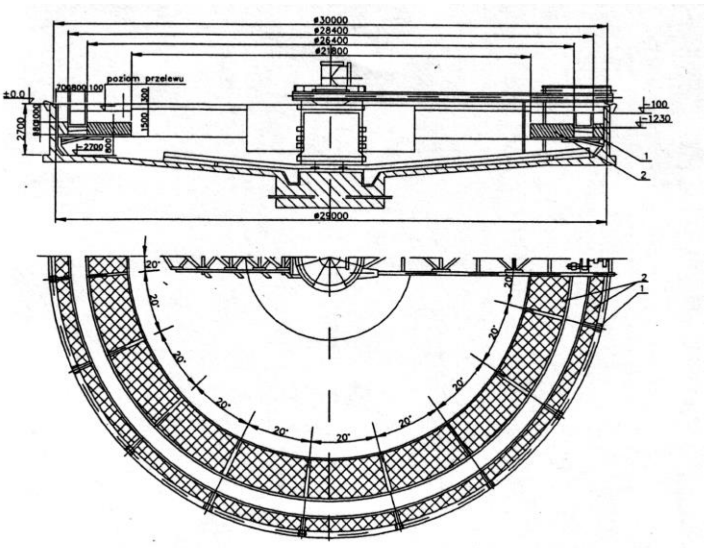

Fig. 1. The Dorr settler with the ring of lamella packets:
1 – support construction, 2 – lamella packets

In the area of the settler with lamellas with those specific features shown above we can mark out three different sedimentation zones: firstly, the zone of the settler without lamellas between the place of the entry the suspension and the vertical partition (which is only when the settler is fulfilled), secondly, the zone located under the lamella – surface and thirdly the zone collected with many elementary spaces in the ducts of lamella packets.

Purpose and the range of the article. This article includes the analysis of the possibility investigation of the sedimentation process through the modernization Dorr settlers by fulfilling them with lamella packets.

Exploration of the sedimentation process. The exploration was in the model of lamella – settler. Main part of this model was pipe made of organic glass, length 2 meters shared into two pieces: the top one used to clarifying the suspension and the bottom one to sludge thickening. The settler can be multi – angled.

Preferred angle is 60º. Vertical stand of the settler (90º) is traditional, not the multiflux thickening process.

Main purpose of the exploration was to find the dependence between the efficiency of the sedimentation η and the surface loading q – (η = f (q)). The surface loading is the quotient between suspension flow rate Q and sedimentation surface area F

$$q = \frac{Q}{F} = \frac{Q}{F_1 + F_2} \tag{1}$$

Calculation of the sedimentation surface area in the ducts of the lamella

Sedimentation surface is the sum of throws of the surface, on which can locate fragments of solid phase. There are two surfaces like these:

– surface of the bottom of lamella: field of circle x sine of the angle the lamella:

$$F_1 = \frac{\pi d^2}{4} \cdot \sin\alpha \qquad (2)$$

– surface of the throw the bottom, angled surface equals mat field of throw x cosine of the angle the lamella:

$$F_2 = d \cdot l \cdot \cos\alpha \qquad (3)$$

So surface loading q equals:

$$q = \frac{Q}{F} = \frac{Q}{\frac{\pi d^2}{4} \cdot \sin\alpha + d \cdot l \cdot \cos\alpha} \qquad (4)$$

For an angle 60º we've got:

$$F = F_1 + F_2 = \frac{\pi \cdot (40 \cdot 10^{-2})^2}{4} \cdot \frac{\sqrt{3}}{2} + 40 \cdot 10^{-2} 0,9 \cdot \frac{1}{2} = 10,86\,\text{cm}^2 + 180\,\text{cm}^2 = 190,86\,\text{cm}^2$$

$$F_2 = \frac{\pi \cdot (40 \cdot 10^{-2})^2}{4} \cdot \frac{3}{2} + 40 \cdot 10^{-2} 0,9 \cdot \frac{1}{2} = 10,86\,\text{cm}^2 + 180\,\text{cm}^2 = 190,86\,\text{cm}^2 \qquad (5)$$

For calculating the surface loading there was also needed the measurement of the suspension flow rate. This suspension flow rate was appointed by measuring the time of fulfilling the cylinder with its capacity 0,5 dm3.

The suspension flow rate is counted from this formula:

$$Q = \frac{0,5}{t} \qquad (6)$$

Sedimentation efficiency is counted at the base of the measurement concentration the suspension flown to the stand to the research (the feed) sn and the concentration the suspension taken in the overflow of the lamella model sp. Efficiency of sedimentation is counted from this formula:

$$\eta = 1 - \frac{s_p}{s_n} \qquad (7)$$

The laboratory stand. The laboratory research model of a settler was composed of two parts – the pipes made of organic glass with diameter equal 42 mm and the supporting structure which was the fiberboard supported by a steel pedestal.

Pipes from the organic glass with length equal 1 m were connected by a special element, which enables rotation of both connected pipes. The lower section was screw – threaded both sides to enable the montage the rotated element as well as the brass spigot equipped with pouring valve ended with a graduated diameter outflow tip. Brass spigot was proposed to easily disassemble to clean the laboratory stand. The spigot was ended with a silicone pipe used to take the suspension out through the peristaltic pump to the measuring cylinder. All joining elements were equipped with rubber seals.

In the lower section – in its half distance – a clamping ring was put on in order to stiffen the stand elements. This element was also used to change the inclination angle of the stand.

The upper section was from the one side threaded to join with the rotating element of the construction, to the other end of the section was glued the overflow tank made of organic glass. The dimensions of the overflow tank were: diameter equal 5 cm and length equal 20 cm. The connector pipe, draining the clarified suspension, was attached to the tank 5 cm above the surface connecting the tank and the pipe. A distance from feed inlet to the place where the connector pipe was attached was equal 1,1 m.

Along the side surface of the upper pipe the connector pipes were attached to within the distance equal 0,6 and 0,9 m. The ends of the sections were equipped with the elastic pipes to assure the gravitating flow and also with the rings to open or close the pipe.

Pipes joined in that way were put on a special fiberboard, in which at the bottom were made holes to change the angle of the whole pipe, on the lower part of this board was made a special leading ditch to change and stabilize the angle of combined two parts of the pipe.

There was also made a hole in the center of the fiberboard to put the element combining both parts of this pipe.

In a support construction, which was the fiberboard the holes were drilled so as to reach the change of the pipe inclination angle in every 5° within the range of 45° to 90°. There was a possibility to put a pin (to stabilize the upper section of the pipe) into every upper hole in order to set a proper inclination angel.

The ring located in the lower part of the pipe had welded the part of the bar to easily change the angle of the whole pipe. The same thing was done to the element that joined the pipes together. For this element and also the ring there were adapted plastic rests to regulate and easily change the angles of the pipe. The feed was supplied to the system through a brazen tube placed in a flange connecting two pipes. The tube was perforated, a right angle bended and placed directly in the middle of the pipes. A silicon duct filled with the suspension taken from the tank and pumped by the peristaltic pump was attached to the tube.

The scheme of the research system. The suspension to the research was prepared in the tank (1), which was equipped with a mixer (2) with a changeable and adjustable rotation number. The valve (3) was used to draining of the tank (1). The suspension was pumped from the tank (1) through the peristaltic pump (4) and elastic duct (5) to the sedimentation system placed on the vertical fiberboard (6), which was fixed to the supporting structure.

Two sections of pipes made from the organic glass joined together with a flange (13) were the sedimentation system. The upper section of the system was a model of the suspension – clarifying zone, whereas the lower section is a model of the sludge – thickening zone.

Along the flange in a distance equal 0.6 and 0.9 m were two places to take out the clarified suspension. The third point of the taking out the suspension was a medium – sized container placed in the highest part of the pipe in a distance equal 1,1 m from the flange.

Flange (13) was joined with the turning tip combined with the vertical fiberboard (6). Thanks to this tip it was able to set up and fasten the sedimentation system at the different angles in every 5° within the range of 45° to 90°.

The clarified suspension flowed from the upper part of the system section by the connector pipe (9) and elastic duct (14) to the outer tank. In order to find suspension concentration and flow rate from the elastic duct (14) the sample of suspension was taken periodically. The samples were taken to the cylinder and it was necessary to measure the time of cylinder filling in order to find the suspension flow rate.

The lower part of the system was ended with a straight – run valve (12). In the researches only the bottom part of this stand was used (the clarifying section).

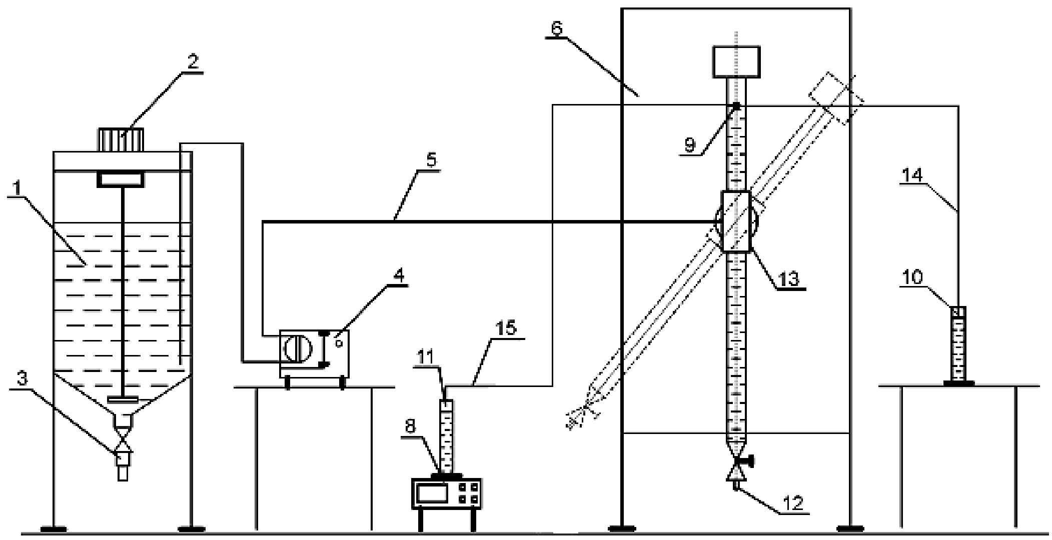

Fig. 3. The scheme of the laboratory stand to the research of counter – current and co – current multiflux sedimentation

Research methodology. A suspension with proper concentration to the research was prepared in the tank (1). After a several minutes of mixing the suspension in the tank, the peristaltic pump (4) was witched on and it started pumping the suspension to the sedimentation system.

The measurement can be initiated if the volume of suspension, equal triple volume of the whole system, flows through the sedimentation system, then were taken the samples of feed from the tank (1) and the feed (clarified suspension) from the duct connected with pipe connector (9). Feed was taken to the measuring cylinders.

During taking the feed from the overflow time of fulfilling the measuring cylinder was counted with the clock to calculate the suspension flow rate. Marking the weight of the solid phase in the pattern was released with the filter method.

Patterns of the suspension were taken every 5, 10 or 15 minutes depending on the planned experience time.

Results of the exploration. There were eight measurements taken on laboratory stand described above for two setups of the pipe imitating the single lamella packet. During the measurements there were also adapted Pix and Praestol (floculant and coagulant) as a sources helping with the multiflux sedimentation.

Final conclusions in the range of made measurements. After making these measurements described above we have came to those conclusions:

– in most cases adapting the floculant and coagulant (no matter if it was angle 60º or 90º) sedimentation efficiency was lower than without those sources

– results of some measurements are different, it is caused different samples of suspension taken from the same place (piaskownik) but during the changeable atmospheric circumstances (rain or its lack)

– there were made an experimental measurements for the presupposed surface loading q = 0,1 [m/h] and efficiency was about 0,8

– some results can be burden with mistakes (first measurements), because filtration was done on the filters gravitationally, the other measurements were made with a pressure extortion and the other type of filters

– some filters broke, what was automatically repaired by putting into the broken filter the other one and the process was continued. It was not forgotten about measuring the weight of the both filters after finished job. Firstly all filters were turned to scale and put into the exsiccator

– there were two measurements made with the vertical setup of the laboratory stand imitating lamella packets in real settlers, but there was a huge discordant between efficiency (0,357 – 0,654) at the same value of surface loading q = 1,5 [m/h] to make a constructive conclusion

– there is also a very high discordant between the concentrations of suspension, but it was unable to influence it because it depended on the atmospheric circumstances and so the changeable efficiency

– adapting the lamella packets brought the advantages like risen the efficiency of the sedimentation process

– measurements show that adapting multiflux lamella packets causes rising of the efficiency from about 40 %–60 % to about 80 %–90 % for the same circumstances of the suspension flow

– applying to the overflow concentrations we have got reduction of the concentration from 48 mg/dm3 to 14 mg/dm3

– last measurements prove that vertical setup of the pipe (lack of lamella packets) do not bring high efficiency of the sedimentation, but angling at 60º brings high efficiency about 70–80 %

– there was also made a measurement of granulation of the feed on the sedimentation scale and IPS – L, and made a diagram of dystrybuant rozkładu, during the measurement with sedimentation scale most of grains were about 5–100μm, while using IPS – L they were 5–80μm large

– at the base of results it is able to say that the highest efficiency is in the case of low surface loadings q = 0,1–0,2 [m/h], at the case of rest efficiency is about 0,4–0,6, but using a lamella packets reaching high surface loading 0,1–0,2 [m/h] needs too big surface of fulfill the settler. At the case big surface loadings it will be received too big value of flowing speed the suspension through the single duct of lamella packet

– to the settler modernization the best is to take a surface loading about 0,5–0,7 [m/h].

Very important thing for the devices like Dorr settlers is reaching as high as possible efficiency of sedimentation. The beginnings of the modernization the settlers by fulfilling them with lamella packets are dated at the beginning of this century. First trials of enchantment the sedimentation efficiency were based on reconstruction the old settlers by adapting the rectangular plates. In 1964 were taken first researches about the sedimentation in angled pipes, which took place of the horizontal, used to that time. These researches proved that the angled setup and also enabling self acting clearing is one of the best solutions. Basis of working the settler with lamella packets is not so different than settler without. Main difference is enlargement of the sedimentation area by putting the lamella packets. Multiflux settlers are use nowadays in a very high range. They have to be set in the most gainful place of the technological process, which is also required with their work conditions. Lamellas can be set as well in primary settlers as in incidental ones. Nowadays on the market there are a few producers making lamella packets. Each packet is specified by different parameters like: length, wide, height but especially the shape of a single lamella packet. There were made a measurements done on communal suspension from sewage refinery "Kraków – Płaszów". They had to proof, that fulfilling the Dorr settler with lamella packets will bring the rising of sedimentation efficiency. After entry Poland to the United Europe the law regulations about cleaning the sewages are very strict. In the settler case outrunning allowed concentration of the suspension is combined with financial punishments. In Poland there are a lacks of financial in the area of cleaning sewages in a refineries. Solution to minimalize the unnecessary costs is adapting lamella packets in already existing settlers. That's about 20 % of costs building new settler. Adapting lamellas in refineries in Poland is not a universal occurrence, the cause can be fact, that communal suspension doesn't have precisely selected pieces of solid phase.

Those measures were about to show, that communal suspension taken one day (sunny) has got differences comparing to the suspension taken the other day (rainy). They have got the different consistence, which is clearly shown in efficiency of sedimentation. Through its changeable parameters it is very hard to analyze it in a laboratory conditions. The measures were done using the "fresh" suspension, after 3 days it was replaced with a new one. The best surface loading to the modernization the Dorr settlers is about 0,5 – 0,7. The measures in the domain of the sewage sedimentation should be continued because this is an area not so deeply explored. Till now there were measurements based on model and industry suspension. This work is the firs one based on a communal suspension.

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