DESIGN LAMELLAR SECONDARY SETTLING TANK USING NUMERICAL MODELING

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Decantoarele lamelare sunt bazine cu adâncime mică de sedimentare, utilizate în special pentru obținerea unor eficiențe mari de sedimentare, apropiate de cele teoretice. Lucrarea prezintă un model de proiectare al unui astfel de decantor, utilizat pentru separarea flocoanelor de nămol activ într-o instalație model de laborator pentru epurarea biologică a apelor uzate prin procedeul combinat peliculă biologică – nămol activ. Proiectarea clasică este corelată cu modelarea şi simularea numerică pentru obținerea geometriei optime a decantorului.

Lamellar settling tanks are sedimentation basin with small sedimentation depth, used for obtaining high efficiencies, closed to the theoretical ones. The paper presents a model for lamellar settling tank design used for activated sludge removal in a laboratory model installation for combined biological wastewater treatment. Classical design is correlated with modeling and numerical simulation for obtaining the optimum geometry of the sedimentation tank.

Keywords: lamellar settling tank, design, modeling, numerical simulation

1. Introduction

Lamella settling tanks are often used in water treatment, but they can be found also in wastewater treatment as primary, secondary or tertiary settling tank. It has been proved that, in conventional tanks, small depths lead to an increase in separation efficiency. For this reason, solutions have been adopted for the development of lamella settling tanks based on the theory that sedimentation process depends more on the sedimentation area than on the retention time, [1], [2].The concept of the lamellar settler is based on the fact that the surface load (m3/m2/day) of a freefall settling tank does not depend on its depth. It is therefore possible to increase the capacity of a settling tank by using plates inclined at a certain angle.

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Lamellar settlers are designed for the continuous separation of solid particles from water and they have two basic purposes: to increase the settling area and to obtain a laminar flow.

There are very few theoretical studies about lamellar settling tank. Kowalski and Miesko considered a theoretically simplified mathematical model to obtain cross-current sedimentation process computer simulations, [3]. The same authors present the design of sedimentation tanks and installations utilizing the Boycott's effect, [4]. Three major types of configuration of lamella installations are presented: counter-current, cross-current and parallel flow. Cross-current sedimentation is investigated and a computer-assisted design of a cross-current tank with the capacity of 100m^3/h is made. Latsa et al., [5], present a two-phase model for the simulation of sedimentation processes using continuity and momentum equations for the pure-clear liquid and the sludge phases. Gidaspow et al., [6], use the principles of conservation of mass and momentum for each phase for quantitatively describing the sedimentation of colloidal particles in lamellar electro settler. Lekang et al., [7], present an evaluation of lamellar settling tank using the 22 days experimental study for measuring inlet and outlet water values of the sedimentation basin, the feed used, fish growth and collected sludge. Saleh and Hamoda developed an extensive experimental study at Al-Awir sewage treatment plant in Dubai using a pilot-scale inclined plate settler which received a mixed liquor stream from the high-rate activated sludge aeration tank, [8]. A comparison between conventional settling tank and lamella settling tank is made.
Barsan and Ignat, [9], present a study regarding optimal design of lamella settlers inserted into cylindrical or parallelepiped tanks, adopting as criterion of optimization the minimization of the critical settling velocity depending on the geometrical elements of installation and the entering velocity in the tank.

This paper presents a theoretical study concerning the design of lamella secondary settling tank, using modeling and numerical simulation of the flow in the settler.

2. Mathematical model

An open rectangular lamellar settling tank made of Plexiglas is part of the pilot scale plant for hybrid biological wastewater treatment operating at 0.1 m^3/h. The dimensions of the tank are: length L= 0.483 m, width, B= 0.975m, height H=0.72 m. Five removable Plexiglas plates of 6 mm thickness are placed inside of the tank to form a lamellar settling tank, fig.1. The lamellae are arranged in parallel with an inclination angle of 60º to enable a larger settling area for the decantation of suspended solids. The plates are fixed at b=35 mm perpendicular space from each other and the length of each plate is adjusted to reach the horizontal line at 105 mm from the top level of the tank, except the first one, and the vertical line at 100 mm from the inlet.

The influent mixed liquor from aeration tank flows directly into the inlet chamber, uniformly distributed over the inlet weir. The water level in the tank is 5cm above the plate settler module. As the inflow passes between the plates, the solid particles slide along the inclines of the lamellae towards the bottom of the tank, while the clean water rises to the surface of the settler. The distance traveled by a particle before settling is less than in a conventional settling tank, thereby increasing clarification capacity. An air-lift system enables the settled solids to be discharged and recirculated in accordance with needs. The clean clarified water in the upper part of the settling tank falls to a collection weir located along the length of the settling chamber. From this weir, it is recirculated to the inlet chamber of the pilot plant.

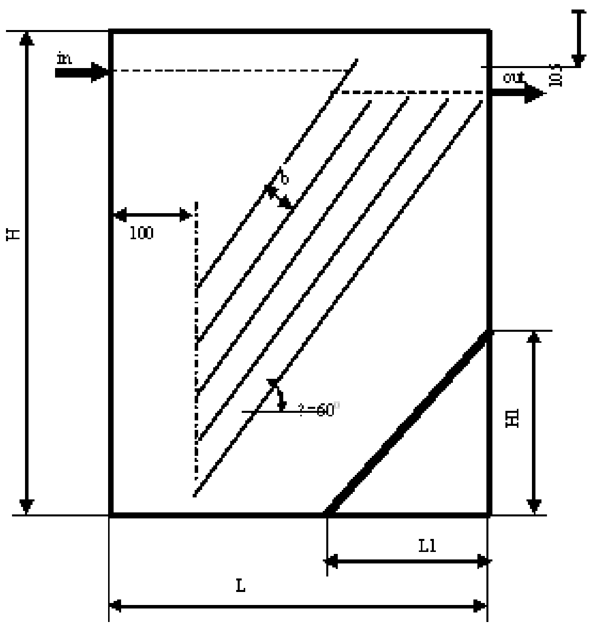

Fig. 1. Lamellar settling tank sketch

For designing the settler is considered 25% recirculated flowrate and thus the total inflow for settler is 0.125 m^3/h. Geometry of the settler is obtained using the designing method presented in [1] and [2]. The resulting residence time is 2.43 h.

A model for the theoretical predicting the flow in the tank is developed using the hypothesis of potential flow:

$$div(grad(\psi)) = 0 \qquad (1)$$

where ψ is the streamline function.

Thus, the two component of liquid velocity are:

$$v_x = \frac{\partial \psi}{\partial y}; \quad v_y = \frac{\partial \psi}{\partial x} \tag{2}$$

For the numerically integration of the Eq. (1) a customized program is written using FlexPDE software, [10]. FlexPDE is a "scripted finite element model builder and numerical solver". It means that from a script written by the user, FlexPDE performs the operations necessary to turn a description of a partial differential equations system into a finite element model, solve the system, and present graphical and tabular output of the results. FlexPDE has no pre-defined problem domain or equation list. The choice of partial differential equations is totally up to the user, [11].

3. Numerical results

Various geometrical configuration of the tank were evaluated Two configuration of the tank are presented below. In fig. 2 is presented results for the first configuration. If the entire length of the tank is considered one can observe that a circular movement appears in the lower right corner. In order to reduce this effect a plate is considered at the length L1 and the height H1 (see fig.1). The numerical results for the movement are presented in fig.3. One can observe that the movement in the tank is improved and the geometry is better than those obtained in the first case.

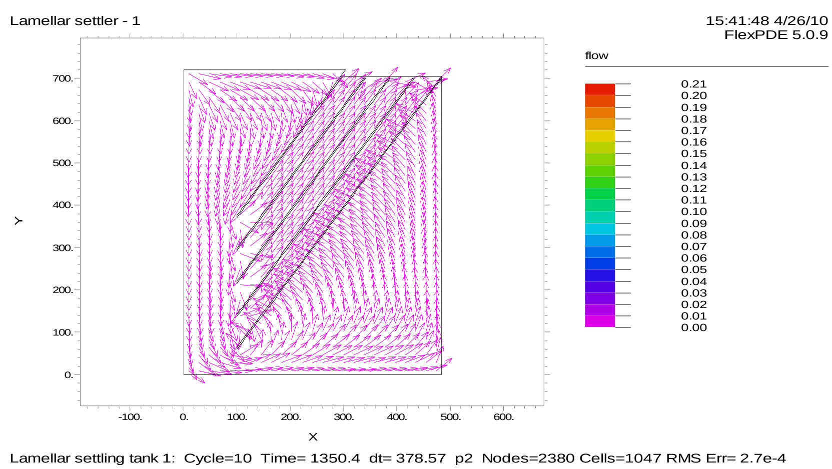

Fig. 2. Results for the first computational domain.

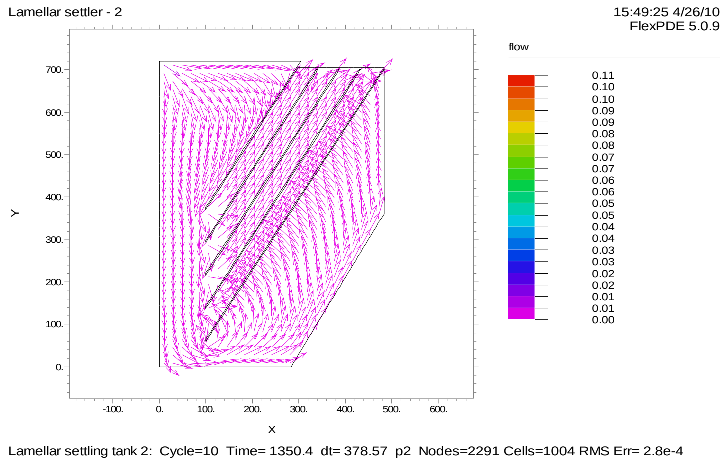

Fig. 3. Results for the second computational domain.

4. Conclusions

The paper presents a design method for secondary lamellar settling tank using a combination of the classical design and modeling and numerical simulation. In this way a optimum geometry of the settler can be chosen.

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