Effect of inlet and outlet pipes geometry on turbulence in swirl sedimentation tanks

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With the development of the industry and increasing quantity of waste water purification technology require improvement and new solutions. This leads to constructing purification apparatus like sedimentation tanks (Ochowiak et al., 2022). This system uses gravitational force to pre-treat sewage containing easily settable suspensions with a density exceeding 1 kg/m^3. It helps protect sensitive to contamination apparatus used in the further recovery process (Ochowiak et al., 2017). One of the modifications is the design and construction of an inlet and outlet pipe that can introduce turbulence caused by centrifugal force. Swirl sedimentation tanks apart from high efficiency are also characterized by lower size thanks to high and thin body (Czernek et al., 2021).

The purpose of this research was to construct 3 sedimentation tanks with different designs (Fig. 1) of inlet and outlet pipes and analysis of image anemometry. It was performed by particle image velocimetry (PIV) analysis that uses dispersion of the laser to determine the velocity field. Pipes with different geometry were placed in tanks and set up in the unit (centric and non-centric), the velocity of the liquid injection by pump (referred by producer as 20, 60 and 100%). The process was carried out using water and solid particles of polyamide with diameter equal to 100 μm.

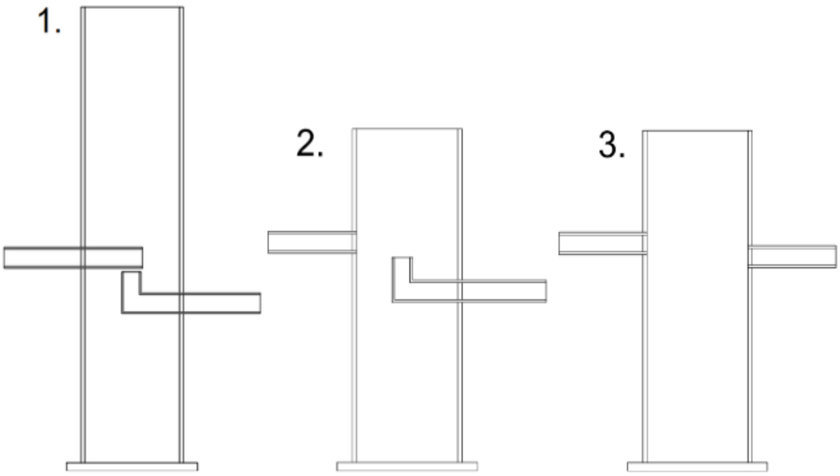

Figure 1. Swirl sedimentation tanks:
a) different geometry and non-centric arrangement of inlet and outlet pipes, b) different geometry and centric arrangement of pipes, c) same geometry and centric arrangement of pipes.

On the basis of Figure 2, it was concluded that flow and velocity fields are repetitive for sedimentation tank with identical geometry of the inlet and outlet pipes and their centric arrangement (No 3). Eddies have similar geometry and occur mainly at the inlet and velocity fields have similar characteristics. Apparatus containing pipes with different geometries and centric arrangement (No 2) is characterized by more stable velocity fields for the inlet surface. For the non-centric pipes in tank number 1, changing the velocity of the liquid injection velocity has an impact on the creation of eddies. They show up on the whole tested surface and have varied velocities.

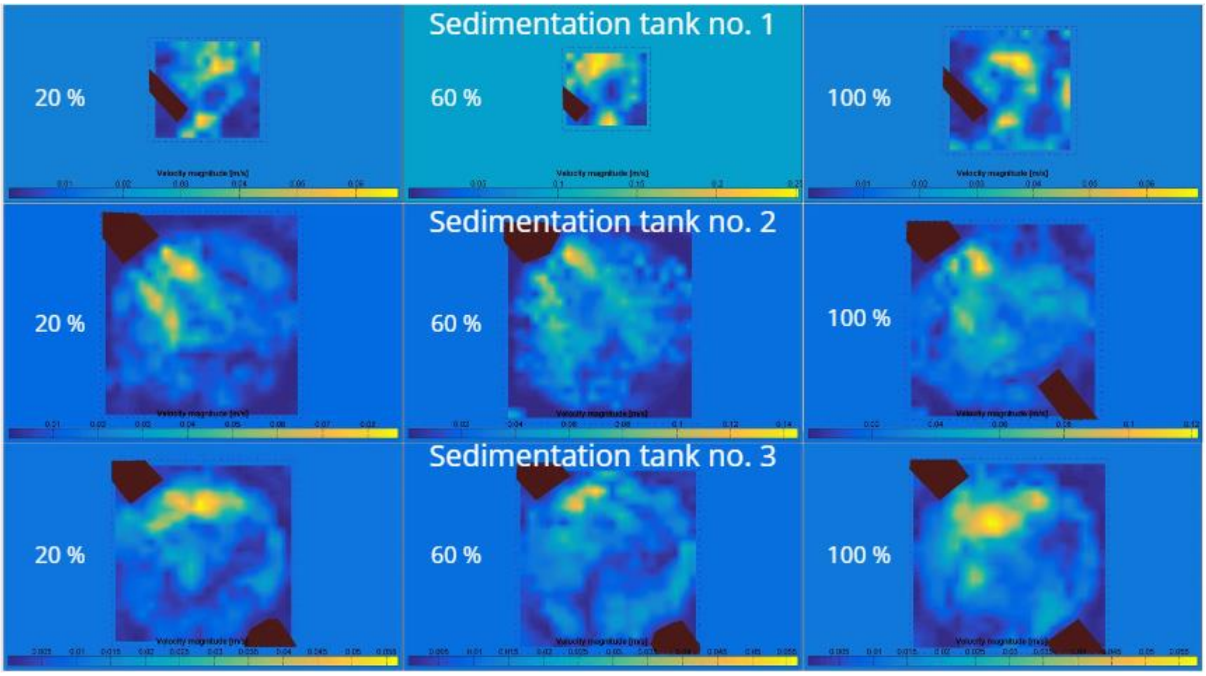

Figure 2. Exemplary velocity fields for horizontal surfaces of inlet pipe.

The data obtained makes it possible to conclude that the design of the tank has a meaningful impact on creating flow disruption. Appropriate application of geometry, arrangement of inlet and outlet pipes and the velocity of injected sewage allows optimization of water pre-treatment process. Analysis of real processes allows to match specific characteristics to planned results. The meticulous consideration and implementation of these design components play a pivotal role in achieving the desired efficiency and effectiveness in the treatment process. For instance, the tank's geometry can affect turbulence and mixing within the sewage, impacting the overall treatment performance. Additionally, the positioning and sizing of inlet and outlet pipes can regulate the flow dynamics, influencing the distribution and movement of contaminants within the tank.

In summary, a comprehensive understanding of how the tank design influences flow disruption, coupled with an astute analysis of real-world processes, empowers engineers and designers to optimize the pre-treatment of water. This optimization, achieved through the strategic application of geometry, inlet and outlet arrangements, and controlled velocity, underscores the significance of meticulous design in ensuring efficient and effective water treatment processes.

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