Optimization of Around-the-End Hydraulic Mixer Using COMSOL Multiphysics®

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Abstract

After rapid mixing of waste water and coagulant, an effective slow mixing during a reasonable retention time will cause to grow the size of flocs up which will settle out easily. Around-the-end hydraulic mixer with barriers is one of the efficient facilities that have been used in water treatment plants for this purpose.

Generally retention time, basin volume and total energy loss are used to calculate the average shear rate or velocity gradient (G, s-1) [1]. COMSOL Multiphysics® can be used to find further details such as dimensions of barriers and distance between them. A uniform field of G is needed to achieve efficient mixing and chemical coagulation. This can be achieved by proper selection of barrier dimension and spacing.

The distribution of G-values with different barrier configurations was investigated using COMSOL Multiphysics®. Optimization consisted of the evaluation of different barriers arrangements and dimensions ratios. Figure 1 shows the selected type of barriers as well as dimensions. Figure 2 presents the 3D geometry of all evaluated design options and the different dimensions ratios which were evaluated in this study.

The tested hydraulic mixer model configuration imitates a water-treatment process where flow enters from the left and leaves the mixer at the right. Two different physical systems were used in the modelling process: 1) turbulent flow (k-ω) was assumed and solved with a stationary solution to determine velocity distribution of the flow around barriers; 2) transport of diluted species with time dependent solution was used in the determination of retention time.

Simulations were carried out assuming turbulent flow conditions. Discharge, depth and width of basin (W) as well as the numbers of barriers are same for all evaluated options. Furthermore, as shown in Figure 1 the distance between barriers (B) was assumed equal to the opening slots' width. Figure 3 combine snapshots of velocity and G value distributions profiles for all evaluated options. The presented profiles clearly show that there is a relationship between flow velocity and velocity gradient G values with the distance between barriers and opening slots' width (B) parameter. For the simulated dimensions ratio B=W/8 the G value distribution profile shows substantial areas of high G, in these areas floc break-up would most certainly occur. Nevertheless, most of the evaluated dimensions ratios (B=3W/8, B=W/2, B=5W/8 and B=3W/4) show mostly areas of low G values in these areas flocculation efficiency or particle aggregation is low and already flocculated particles can sediment within the mixer.

According to the obtained results the best design is the one which presents the following ratio: B/W = ¼. When designing the mixer structure, keeping B and W constant will enable the control of G magnitude via flow depth control for different discharges.

Reference

[1] Bratby, J., 2006. Coagulation and Flocculation in Water and Wastewater Treatment (Second Edition), IWA Publishing, p255.

Figures used in the abstract

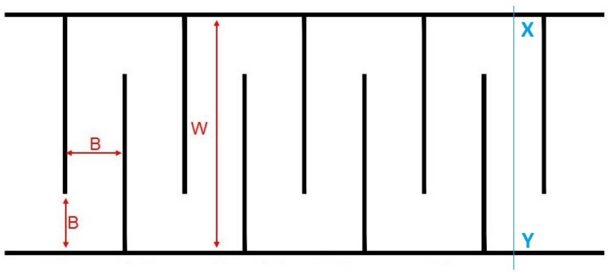

Figure 1: Depiction of selected type of barriers system and their dimensions.

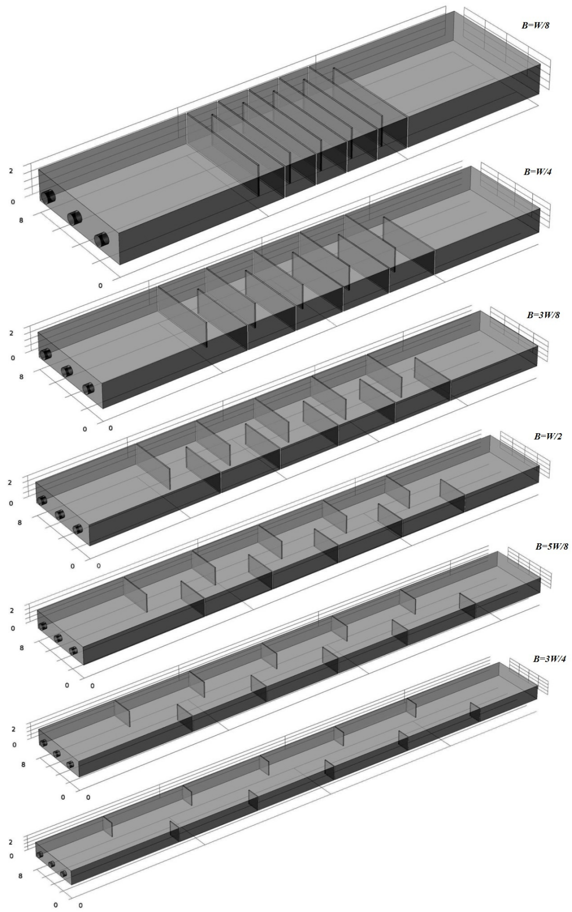

Figure 2: Depiction of the 3D geometry of evaluated systems with different dimensions ratios.

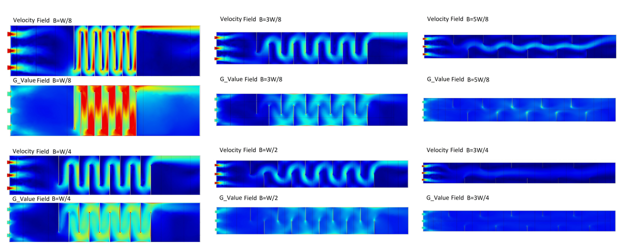

Figure 3: Flow velocity and G value distribution fields.