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EXTENDED ABSTRACT

Simulate the Effect of Configuration and Number of Baffles in the Hydraulic Efficiency of Chlorine Contact Tanks

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1. Introduction

Chlorine contact tanks are commonly used to disinfect drinking water before distribution. These tanks are usually open compartments that are divided by a series of baffles. The separation of the compartments helps to control the flow of water through the tanks and improves the process of disinfection of the chlorine. The main purpose of chlorine contact tanks provides a suitable residence time for both micro-organisms and disinfectants to achieve the desired degree of inactive germs (Angeloudis, 2014).

In this study, the simulation of the 3D model of the CT-1 contact memory model using the ComsolMultiphysics 5.3a software is presented. The experimental model of this tank is located at the Hyder Lab of the Water and Environmental Research Center at Cardiff University of England (Fig. 1) (Angeloudis, 2014).

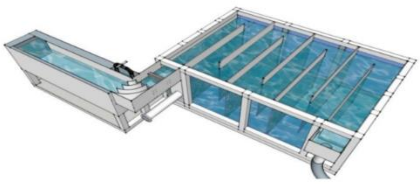

Fig. **1**. Geometric contact tank model CT-1

In this study, the three-dimensional simulation of the CT-1 contact tank model is performed using ComsolMultiphysics 5.3a software. The experimental model of this reservoir is located in the Hyder Laboratory of the Center for Water and Environmental Research at Cardiff University, England. Also, a three-dimensional simulation of the new arrangement of baffles in the MS4-C tank and the effect of the number of baffles in 5 modes of 1, 3, 5, 9 and 11 was performed on the hydraulic efficiency of the tank. The residence time distribution curve (RTD and flow curve (FTC) were extracted for each case to evaluate and compare their performance.

2. Methodology

In this simulation, the geometry is plotted in the Comsol software environment. The tank with dimensions of 3×2×1.2 meters has 7 baffles with dimensions of 1.2×1.63×0.012 m and the walls are spaced at the same distance of 0.365 meters. Also, the channel entrance level is 0.365 × 0.3 m and the water depth is 1.02.

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The produced mesh in this simulation has been Coarse. Simulation of the CT-1 tank model has performed over three stages. First, the steady-state simulation of the turbulent velocity field is performed, the simulation time for this stage 3 hours 25 minutes and 59 seconds. In the second and third stages, the concentration field is simulated with respect to the immediate release of tracer in unsteady state conditions for calculating the residence time in the form of pulses and steps release. Simulation time is 4 hours and 48 minutes and 34 seconds for a pulse release, and is 3 hours 45 minutes and 19 seconds for the system CPU 3 GHz and 8 GB of memory respectively.

The reaction speed equation is obtained by using equation 1:

$$\frac{\partial Cl}{\partial x} = -k.Cl \qquad (1)$$

Where Cl is the concentration of chlorine, k is the decay rate of disinfectants that is generally dependent on the quality of water and also the conditions of disinfection .In this study, the concentration of chlorine at the inlet and equal to 1.2 mg/l and the amount of k used is equal to $2.77*10^{-4}$ S^{-1} (Angeloudis et al., 2014).

The calculation of the concentration in the pulse is obtained by equation 2:

$$E(t) = \frac{C(t)}{\int_0^\infty C(t)d(t)} \qquad (2)$$

Where $C(t)$ is the concentration of the tracer at the outlet of the tank and $E(t)$ is a function, which represents a different time of the presence of fluid in the tank (Amini and Taghipour, 1388).

The calculation of the concentration in the output from Equation 3:

$$F(t) = \frac{C(t)}{\sum_{i=1}^{n} C0} \qquad (3)$$

Where C_0 is the initial concentration of the tracer at the injection moment to the tank input, and $F(t)$ indicates the cumulative distribution function.

Usually, a dimensionless time (θ) is defined which is the ratio between time t and time T, theoretically restraint. Equation 4 is used to calculate hydraulic performance indicators and compare them (Amini and Taghipour, 1388).

$$\theta = \frac{t}{T} \qquad (4)$$

3. Results and discussion

Table 1 shows the calculated hydraulic performance indicators for the CT-1 and MS4-C contact tanks using distribution curves of the residence time and the flow curve in the output of the contact tank. These indices are t_{10}/T, t_{90}/T, and MI, which are compared in two EXP (experimental study), Comsol (numerical simulation performed in this study by finite element method.

Table 1. Results of hydraulic performance indicators for CT-1 and MS4-C contact tanks

CT-1 Tank	t_{10}/T	t_{90}/T	MI
EXP	0.70	1.48	2.12
Comsol	0.76	1.3	1.71
MS4-C Tank	t_{10}/T	t_{90}/T	MI
EXP	0.78	1.32	1.69
Comsol	0.86	1.301	1.511

Table 2. Analysis of the results of hydraulic efficiency indicators

number of baffles	t_{10}/T	t_{90}/T	MI	V_{in}(m/s)	TDT(s)
3	0.61	2.240	3.67	0.02123	1283.89
5	0.69	1.94	2.81	0.03179	1275.42
7	0.76	1.3	1.71	0.0431	1265
9	0.85	1.217	1.43	0.05322	1258.47
11	0.904	1.206	1.33	0.06403	1249.78

Also, in order to investigate the effect of the number of baffles on tank performance, the geometry of the CT-1 contact tank was simulated in five modes: 1, 3, 5, 9 and 11 buffers. Table 2 describes the hydraulic performance indicators calculated from simulating the number of different baffles.

As can be seen, increasing the number of baffles in a fixed geometry of the contact tank increases the input speed. As the number of buffaloes increases, the t_{10}/T index (baffle factor) increases and the Morrill index decreases. In other words, increasing the number of baffles has had a positive effect on the hydraulic efficiency of the contact tank. The simulation of the 13-baffles tank concluded that by increasing the number of baffles from 11 to 13 to the value of t_{10}/T (baffle factor) decreased from 0.904 to 0.894 and the Morrill (MI) index from 1.33 to 1.38 has increased; as a result, it has a negative effect on the efficiency of the tank. Therefore, in general, it can be said that the benefits of adding the number of baffles are in the range of 9 to 11 and beyond this amount, it has a negative effect and the tank will have little efficiency.

4. Conclusions

In this study, the numerical simulation of chlorine disinfection contact tanks using Comsol software and the processes of purification and performance of tanks have been studied. The performance of the tank was determined using hydraulic performance indicators. Using the hydraulic performance indicators, the performance of the tank is determined. The best performance is when the amount of Baffle Factor (t_{10}/T) is maximum and the Morrill index (MI) is minimum. The initial simulation results showed that numerical results have good agreement with laboratory model results. Further simulations were then performed to investigate the effect of the number of baffles on the hydraulic performance of the contact tanks. In general, the configuration and arrangement of the baffles had a great impact on the hydrodynamics and efficiency of the contact tank; it was observed that the MS4-C tank with the new arrangement of the baffles had a positive effect on the hydraulic efficiency. The simulation of the effect of the number of baffles on the efficiency of the tank was concluded; with the increase in the number of baffles, the flow conditions become closer to the plug flow and the hydraulic efficiency increases. However, this positive trend is an increase in baffles on hydraulic efficiency in the range of 9 to 11 baffles, and a study of more baffles resulted in a tank with 13 baffles, which had a negative impact on the hydraulic efficiency of the tank.

5. References

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