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A Study on Analysis of Clearwell in Water works by Computational Fluid Dynamics

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Abstract. This study aims at analysis of residence time distribution and vector in water works clearwell. Stagnation was generated in the region of retention time more than 400 sec. Vector is analyzed normal under average flow rate. Water level and velocity was decreased in case of the influx decreased as shown in the contour line. Water level and velocity was increased under maximum influx as shown in the contour line. The occurrence of vortex and reverse flow was simulated in average influx in the flow residence time of 1.0 m in height. In particular, in the last section of clearwell outlet was analyzed by static until about 80 minutes.

Keywords: CFD, clearwell, water works, retention time.

1 Introduction

The objectives of technical diagnosis of clearwell can be summed up in three main points: first, meet the requirements of the Waterworks Law for technical diagnosis, and promote economic viability to fulfill obligations for water service providers under the Waterworks Law and increase the efficiency of diagnosis cost; second, provide professional technologies and secure technical competitiveness for each water works to secure technical competitiveness by improving and providing diagnostic technique, a collective integrated technique of waterworks design and operation; third, improve the quality of tap water and pursue rational management by presenting optimum conditions for purification facilities, contributing to securing the safety and quality of tap water, presenting optimum methods to improve and replace facilities, and presenting reasons to establish a basic plan for short- and long-term waterworks facilities. The ultimate goal of the technical diagnosis of water works is to contribute

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to the health hygiene of citizens and increase public trust in drinking water by presenting the direction of construction of a supply system for sufficient supply of delicious and safe water, diagnosing functions for the problematic factors of deteriorated water works facilities and presenting improvement methods. [1][2]

Most of the water works in Korea use computational fluid dynamics (CFD) to provide agent addition and mixing in processing tanks for mixing basins, distribution channels, sedimentation basins, filter basins and clearwell, and an efficiency evaluation for flow distribution and flow pattern, including natural convection due to density difference and forced mixing.[3-6]

This study discusses on evaluation methods for the functions of a clearwell using CFD, focusing on the case of technical diagnosis of water works Y in city A, Gyeonggi-do. [7]

2 Experimental Apparatus and Methods

2.1 Status of Clearwell in the water works

The clearwell of a water works in city A, Gyeonggi-do consists of two chambers, as shown in Table 1. Their effective depth of water is 6.0 m, and their top freeboard 0.5 m

Table 1. Specification of clearwell in water works.

Heading level	Exam	Criteria	Status
Frame	Chamber No.	more than 2 chambers	2 chambers
	Demission	-	26.5mW×40mL×6.0mH
	Depth	3-6 m	6.0 m
	Upper margin	More than 30 cm	30 cm
Spec.	Available capacity	more than 1 hr	11.12 hr

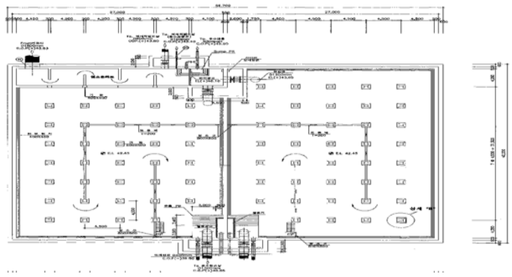

Fig. 1. Plane figure of clearwell

2.2 Computational Fluid Dynamics (CFD)

This study used program ANSYS CFX 10.0 and FLUENT 6.2.16, and used an unstructured hexahedral grid system for the finite volume method. The condition of the residual of the discretization equation being below 10-6 was selected as convergent and discriminant validity to produce the approximate solution.

Table 2. Condition of CFD

No.	General condition of CFD
1	Setting result of steady flow as initial condition
2	Injection tracer by pulse input

The clearwell had initial conditions entered, as shown in Table 3, to identity and interpret flow patterns and the presence of stagnation for maximum, minimum and average flow using three-year operation data for the target water works.

Table 3. Initial condition of water quantity in clearwell.

	Flow(kg/s)	Ave. Velocity(m/s)	Retention time(sec)
Ave. Flow	1,504.89	0.02862	7,674.63
Max. Flow	1,863.54	0.03280	6,830.37
Min. Flow	897.69	0.02561	8,775.60

2.3 Tracer Experiment Method

To verify the reliability of computational fluid dynamics (CFD), a comparative analysis of tracer experiment values for the clearwell was made. Tracer materials were subject to a pulse input tracer test, in which fluorosilicic acid (H_2SiF_6, 25%) is instantaneously injected. After sample injection, samples were collected at the outlet every five minutes over a total of two hours, and fluorine ion was analyzed using a Dionex DX-500 Ion Chromatography.

3 Findings

3.1 Computational Fluid Dynamics (CFD) for Inlet of Clearwell

Modelling for the analysis of mixing after chlorine injection in the clearwell is shown as Fig. 2. After the filtration process, the flow comes through the inlet of the clearwell, and chlorine is injected through the chlorine inlet. Treated water comes from the outlets of Clearwell No. 1 and Clearwell No. 2. Flow analysis was limited to average flow. Liquid chlorine is usually injected after evaporation, but in this study, on the assumption that liquid chlorine is injected for the convenience of CFD modelling, an analysis was conducted.

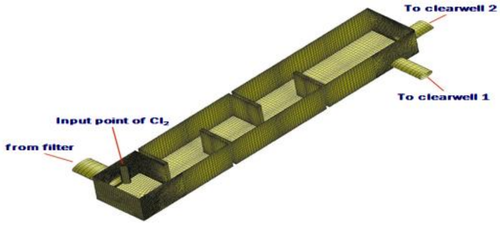

Fig. 2. Model of influx in clearwell

The speed vector marked to find flow patterns is as shown in Fig. 3. The scale on the left had vector marked in color to indicate speed (m/s). The flow is not smooth on the whole, but arises only on one side, and a great circulation current occurs behind each partition wall. The main flow downstream is fast in speed because the surface is not entirely used, and the circulating current was found to be very slow in speed.

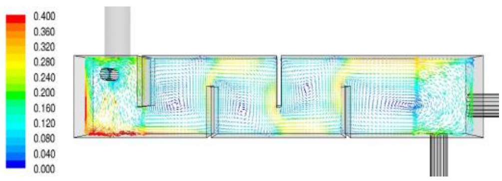

Fig. 3. Plane figure of vector in clearwell influx

3.2 CFD for the Whole of Clearwell

Speaking in terms of average flow, the analysis of the flow pattern of the whole of clearwell showed flow speed contour line at a height of 1.0 m, as shown in Fig. 4. The scale on the left had the speed expressed in m/s. The analysis showed that the flow was slow in speed overall compared with that of the mixture, and the flow behind columns was very slow, causing stagnation.

In a simulation of the whole of clearwell, the flow turned out to be normal downstream. However, some sections of the L-shaped rear section at the left bottom of Clearwell No. 1 partially had the vortex that could cause stagnation. As the flow speed contour line, a row of dividers in clearwell partially serve as partitions. Thus, flow patterns are different between the right and left of clearwell dividers, and only one side of the row has flow, while the other side locally has a reverse flow.

A low influx led to reduced water level and reduced flow speed. However, a significant chance in flow patterns due to a low influx was not found.

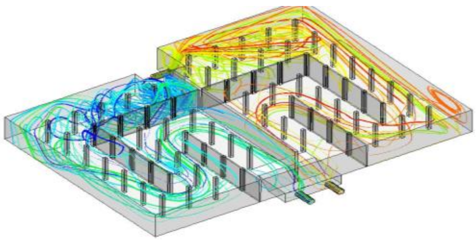

Fig. 4. Solid figure of contour line in clearwell

4 Conclusion

With the finite volume method using the computational fluid dynamics (CFD), a technical diagnosis of clearwell in the water purification process was performed using an unstructured hexahedral grid system.

To identify flow patterns and the presence of stagnated flow in clearwell, average, maximum and minimum influxes were simulated. Due to the characteristics of CFD, the simulation was performed on the assumption that chlorine is injected in a liquid form.

The simulation showed that the flow at the inlet of clearwell did not move smoothly on the whole, but moved along only one side of walls, a great circulation occurred behind each partition, and the main flow moved very quickly downstream because it did not use the whole surface, while the circulation moved very slowly. A vector simulation showed stagnation for over 400 seconds at the circulation areas.

Where clearwell have an average flow rate, a vector analysis at a height of 1.0 m showed a normal flow downstream. However, some sections of the L-shaped rear section at the left bottom of Clearwell No. 1 partially had the vortex that could cause stagnation. An analysis of flow speed contour line showed that a row of dividers in clearwell partially served as partitions.

An analysis of the flow speed contour line on the assumption of a minimum influx showed that a reduced influx led to a low water level and a low flow velocity.

However, a significant chance in flow patterns due to a low influx was not found. A simulation of the contour line for a maximum influx showed that the flow increased overall, leading to increases in water level and flow speed.

A simulation of an average flow rate in clearwell showed that there occurred a stagnation in the sections of residence time distribution, reverse flow and vortex at a height of 1.0 m from the floor. In particular, it turned out that the last section of clearwell outlets had a stagnation for around 80 minutes.

As above, this study used the computational fluid dynamics (CFD) to diagnose residence time distribution and flow patterns for clearwell, the last part of the water purification process. The results of the analysis can be used as basic data for the creation of alternatives such as the installation of supplementary training walls within clearwell.

In the future, a series of process will be necessary to increase the accuracy of CFD with some calibration based on the results of tracer experiments.

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References

1. Waterworks Law (2014)
2. Ministry of Environment, Criteria of Waterworks (2007)
3. Youngman Cho, Jaesoon Roh, Jaehoon Bin, Taekyun Kim, Youngjune Choi: Evaluation of Economic L/W Ratio and the Best Shape of Baffle in Clearwell by Using CFD. Korean Society of Environmental Engineers, Vol. 33, No. 6, pp. 432-438 (2011)
4. Liu Zhao, Jun-Kyu Yoon: A Study on Heat Transfer and Pressure Drop Characteristics of Staggered Tube Banks using CFD Analysis. Journal of the Korea Academia-Industrial cooperation Society, Vol. 16, No. 5, pp. 2985-2992 (2015)
5. Sungho Lim, Chulsoo Kim, Leesoo Yoon, Eonsang Park, Youngjae Lee: L/W Ratio Evaluation of Expansion Reservoir through Tracer Test and CFD. 2012 Korean Water Congress, Vol. 2012, pp. 732-733 (2012)
6. Yunho Kim, Junjung Park, Gwanghoon Rhee: Numerical Analysis for Optimization with Variation of Guide Wall and Porosity in Clearwell. Journal of the Institute of Industrial Tehcnology, Vol. 12, pp. 59-64 (2004)
7. Taemun Hwang, Hyunje Oh, Jin-hong Jung, Juweon Kim: Technical Assessment of Prechlorination and Postchlorination basin using CFD (CFD:Computational Fluid Dynamics). 2007 Korean Water Congress, Vol. 2007, pp 283-284 (2007)

