Simulation of effective volume increasement inside oxidation ditch reactor

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Abstract. Oxidation ditch reactor is wastewater treatment unit that based on activated sludge process. Water flow characteristic inside reactor is either completely-mixed reactor or plug flow reactor. Water flow characterization plays important role in wastewater treatment process. To ensure the biological process going well, the water flow in reactor must be completely mixed type. Characterization study of water flow in reactor consume time thus financial, so the simulation using CFD (Computational Fluid Dynamics) becomes a good solution. Based on the calibrated model, the CFD simulation was generate to define the water flow characteristic of the oxidation ditch reactor in longitudinal section. The simulation was conducted using VoF (Volume of Fluid) scheme, an open surface model in unsteady flow with k- ϵ turbulence model. The simulation result shows that water flow inside the oxidation ditch reactor was plug flow. The role of aeration system is to increase water flow to be more homogen, indicated by higher effective volume inside the reactor. The simulation result shows that the aerator could increase effective volume inside the reactor from 32,94% into 55,5%. The higher effective volume means dead zone inside the reactor is reduced.

1 Introduction

Wastewater treatment unit as a chemical reactor which occurred chemical process inside it to change the substance of various chemical compounds. Reactor effectiveness are integral part of every wastewater and water treatment unit. Chemical reactor is categorized into two types, that are the completely mixed reactor and a plug flow reactor.

Hydrodynamics aspects on plug flow reactor had widely studied, usually using tracer study. Other method is profiling water velocity along the reactor. Both methods are experimental method, whilst other is computational method using computer simulation.

Computer simulation in hydrodynamics is computational fluid dynamic that has been widely used in wastewater treatment reactor [1-2]. It has concluded that water flow in wastewater treatment unit is defined as multi phase flow [3-6]. [7-8] had studied hydrodynamics on reactor using variation in aerator type. Based on [9], aerator is needed to increase the effective volume inside oxidation ditch reactor, since [10] already mention that the installation of aerator will reduce the dead zone. This research aims to observe the effect of aerator existence inside the oxidation ditch reviewed through hydrodynamic aspects.

2 Methods

There are two approaches to do the research, that are numerical approach and experimental approach. numerical approach is computational simulation, while experimental approach is tracer study in oxidation ditch reactor, as seen in Fig. 1.

Fig. 1. Oxidation Ditch Reactor.

To analyze the water flow, the oxidation ditch reactor is divided into 4 zone, that are inlet zone, outlet zone, aerator 1 zone and aerator 2 zone. In each zone, the water flow velocity is listed in every grid (dimension 20 cm x 20 cm x 20 cm). For water flow velocity below 10^{-5} m/sec, the area is define as dead zone. Otherwise, the area with water flow velocity higher or equal with 10^{-5} m/sec, define as effective area. By counting the amount of grid of effective area, the effective volume of the reactor could be obtained.

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3 Results and discussion

The simulation result of water flow in longitudinal section shows that the difference is occurs in both

aerator zone. The comparison between simulation without and with aerator is shown in these two aerator zones as seen in Fig. 2 and 3.

Fig. 2. Water flow in longitudinal section without aerator : (a) aerator 1 zone, (b) aerator 2 zone.

Fig. 3. Water flow in longitudinal section with aerator : (a) aerator 1 zone, (b) aerator 2 zone.

The calculation of effective volume is shown in Table 1.

Table 1. Calculation of effective volume.

Hydrodynamic Aspects	Effective volume
Without aerator	32,94%
With aerator	55,50%

From the calculation result, it can be concluded that in without aeration system, the volume that used effectively as reaction zone is only one third of total volume, while in with aeration system, it is increase about half of total volume. The higher effective volume, the lower dead zone exists, the more homogen the mixture between waste water and air from aeration.

The hydraulic retention time is time needed to maintain the hydrodynamic condition that consistently occurred along the reactor and chemical reaction. Using the simulation result, hydraulic retention time is calculated by divide the total volume with effective volume. In reactor without aerator, the hydraulic retention time is 100% divide with 32,94%, resulting 3 fold of design retention time. While in reactor with aerator, the hydraulic retention time is 1,8 fold of design retention time. This number must be take into account when evaluate the effectiveness of the reaction.

4 Conclusions

For design considerations, hydraulic retention times must take into account the presence of dead zones. Based on simulation result, hydraulic retention time of reactor design must be approximately 1,8 - 3 fold of design retention time.

To get more comprehensive result, more simulation study about variation in rotation speed of aerator is needed. Other simulation study should be conducted using other type of aerator as well.

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