Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2019.23378

143 (2019) 29–37
March

Computational fluid dynamics (CFD) modeling of hydrocyclone for the recovery of ballasts and removal of sludge floc in ballasted flocculation process

Ki-Yeon Kim†, Seongjun Park†, Won-Hee Lee, Jong-Oh Kim*

Department of Civil and Environmental Engineering, Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, South Korea, Tel. +82 2 2220 0325; Fax: +82 2 2220 1945; email: jk120@hanyang.ac.kr (J.-Oh Kim), Tel. +82 2 2220 4512; emails: kimyeon072@naver.com (K.-Y. Kim), jayenv93@hanyang.ac.kr (S. Park), wheelwh@naver.com (W.-H. Lee)

Received 31 August 2018; Accepted 15 October 2018

ABSTRACT

The ballasted flocculation (BF) process is widely used in the water treatment process to cope with climate change. Microsand and magnetite are commonly used, which act as a seed in ballasted floc. The recovery of the ballast in BF process can affect the operating cost. In this study, we evaluate various sizes of magnetite particle with a specific gravity of above 5 in order to apply the hydrocyclone as a ballast recovery system in the BF process. The conventional purpose of the hydrocyclone is to separate solids and liquids, while the ideal recovery system in BF process should separate the ballast from the sludge and liquid. Computational fluid dynamics modeling was prepared to estimate the optimal conditions for the ballast recovery and the sludge removal ratio. The average ballast recovery ratio shows up to 99.9% varying with the inlet flow velocity. As the inlet flow velocity increases, the average sludge removal ratio decreases until 2 m/s, but it changes to increase after 2 m/s. The highest ratio is approximately 91% at 3.5 m/s of inlet flow velocity. This difference is due to the Reynolds number, which are summarized as the change of the particle size, the inlet flow velocity, and the specific gravity. In addition, the separation efficiency of each particle shows a fish-hook shape related with the Reynolds number. In BF process, the ballast recovery ratio should be maintained high, while the sludge recovery ratio should be maintained low. Criteria for the ballast and sludge recovery can be reached by maintaining the range of particle size, simultaneously satisfying this requirement at a certain inlet flow velocity. In other respects, for optimal ballast recovery and sludge removal, above a certain size of ballast should be used, and the sludge needs to be pulverized to a certain size as the pretreatment of the hydrocyclone.

Keywords: Ballasted flocculation; Hydrocyclone; Recovery of ballast; Sludge removal; Fish-hook phenomenon

* Corresponding author.
† Joint first authorship.

1944-3994/1944-3986 © 2019 Desalination Publications. All rights reserved.