S3.5.2 Inferring In-situ Floc Size, Predicting Solids Recovery, and Scaling-up using the Leung Number in Separating Flocculated Suspension in Decanter Centrifuges

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Centrifugation accompanied by flocculation of fine biosolids is often utilized in wastewater treatment. Unfortunately, commonly used laboratory jar tests often over-estimate the size of the flocculated solids (flocs) that can be realized in-situ in the centrifuge as the fragile flocs can be easily broken by shear and turbulence during feed acceleration in the centrifuge. Currently, there is no satisfactory method to predict in-situ floc size in the centrifuge, despite the floc size is critical to separation and solids recovery. The difficulty in making predictions also leads to inaccuracy in predicting solids recovery by decanter centrifuge and scale-up between centrifuges of different sizes, designs, and operating conditions, which is an even more serious issue. This study attempts to address these hurdles.

First, the flow pattern in a decanter centrifuge in form of moving layer at the pool surface is demonstrated by two different experiments. Second, a model on separation of suspended flocs in the moving layer in a centrifuge is developed. Further, a two-parameter model is proposed to represent the floc size distribution wherein the first parameter represents the minimum floc size and the second parameter represents the median floc size. A closed form analytical solution for the model is obtained with results expressed by the ratio of minimum-to-median floc size and a dimensionless Leung number which measures feed rate to the clarification rate of the centrifuge. Third, a Buckingham-π analysis has been conducted on separation in a moving layer under centrifugal field confirming these two governing dimensionless parameters can also be derived independently from the more basic dimensionless π groups. Fourth, by matching the solids recovery obtained from field tests with the model prediction, the median floc size can be inferred. In this matching process, the minimum floc size is assumed to be equal to the size of the primary, unflocculated solids. Fifth, four sets of tests (over 20 runs) have been carried out using two decanter centrifuges of different sizes and designs operating, respectively, under different pool depths, feed rates, polymer dosages and rotation speeds in a wastewater treatment plant processing mixed sludge with 48% primary sludge and 52% waste activated sludge. The median floc size inferred from the present method is in the range of 4–9 mm from the three series of tests (14 tests). The improved feed acceleration design with speed matching closely that of the rotating pool results in less pool turbulence, larger flocs, and lower polymer dosage (7 kg polymer/ton sludge); while the poorer feed acceleration with more pool disturbance from the under-accelerated feed results in smaller flocs, and higher polymer dosage (9 kg/t). Sixth, an important application of the model is to predict solids recovery using an estimated median floc size and this approach has predicted the solids recovery reasonably well on the fourth set of tests (9 tests). Seventh, the scale-up for predicting solids recovery of flocculated suspension from decanter centrifuges of different sizes, designs, and operating

conditions has been demonstrated using the dimensionless Leung number and the minimum-to-median floc size ratio.