Secondary settling tank modelling and design Part 2: Linking sludge settleability measures

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Abstract

In order to bring theoretical and practical developments in secondary settling tank (SST) design closer together, a number of tasks have been identified by the authors in Part 1 of this series. The first of these tasks is to establish relationships that link conventional sludge settleability measures to the flux theory constants, V_o and n, and is presented in this paper. Previous work in establishing relationships between various sludge settleability parameters (SSPs) is reviewed. General forms for the V_d-SSP and n-SSP relationships are proposed and two different approaches to fining the data to the selected functions are evaluated: firstly, a one-step direct correlation of zone settling velocity (ZSV, V_s) on SSP and sludge concentration (X_t) and secondly, a two-step correlation in which first V is correlated with X to get V and n and then V and n are correlated to the SSP, Statistical tests were conducted to check which of the different data sets obtained from the literature could be pooled and treated as one set. One- and two-step linear least squares regression analyses were conducted on the largest family of data for each of the three SSPs to determine the constants in the selected relationships. It was concluded that the relationships based on the stirred specific volume index at 3.5 gTSS/l($SSVI_{3.5}$) are the most reliable. The relationships must be applied with caution because the pooling statistical analysis indicates that the results appear to be influenced by activated sludge plant type.

Introduction

In order to accomplish the objective of bringing the theoretical and practical developments in secondary settling tank (SST) modelling and design closer together (see Ozinsky and Ekama (1995), Part 1 of this series), two tasks were identified:

1. To collect, evaluate and analyse as much information on sludge settleability parameters and relationships between them as available in the literature and examine, refine or establish relationships between the sludge volume index (SV1), $SSV1_{,;}$ diluted SVI (DSV1) and the flux constants V_o and n.
2. To verify the flux theory as a model tor the simulation of dynamic behaviour of the settling tank, with varying influent flow rates, reactor concentrations and feed solids concentrations.

Task(l) was identified as necessary in order to use the Dutch full-scale secondary settling tank data set collected by STORA (1981a; b; c; 1983) in order to accomplish Task (2). In the STORA investigation, in which 47 solids loading tests were conducted on 27 full-scale settling tanks in Holland, the sludge settleability was measured in terms of DSVI, SSVL, and the V and n values. Unfortunately, the zone settling velocity (ZSV) - concentration (X) column tests from which the V_o and n values were obtained were conducted over too narrow a concentration range (1 to 6 *g-l-*'). The V_o and n values obtained were therefore not reliable and led to the erroneous conclusion that the flux theory was fundamentally deficient as a design procedure. As a result, STORA (1981 b) (see also Stofkoper and Trentelman, 1982) pursued the DSVI-based ATV design approach and developed the STORA design procedure based on it (Epskamp and Van Hernen, 1984). To use the STORA data set, which is the only comprehensive data set available with the necessary detail for the verification of the flux theory to accomplish Task (2), it was necessary to determine the required V_D and n values by some other indirect method. The only viable indirect method that appeared to be available was to establish relationships between the $SSV1_{35}$ and DSVI and the V_o and n settleability parameters. These relationships would then serve as a basis to determine the V_o and n values from the DSVI and/or the $SSVI_{35}$ measured by STORA. The establishment of relationships between the sludge settleability parameters (SSP) and the flux theory constants V_o and n is presented in this paper. In Ozinsky et al. (in prep.) Part 3, accomplishment of Task (2) above is presented. In Ozinsky and Ekama (In prep.) Part 4, the calibrated dynamic flux theory model is checked to see if it is capable of reproducing important design information included in the ATV and STORA design procedures (ATV, 1973; 1976; 1991; Epskamp and Van Hernen, 1984)

Review of previous work

The general acceptance of a single simple sludge settleability parameter that defines the settleability of a sludge is a source of much controversy in the field. It is recognised that the flux theory ZSV-X, or its associated V_o and n, is the best sludge settleability description in so far as settling tank design and operation is concerned, but the tediousness of its measurement and the lack of proven reliability of the associated flux theory has led to other simpler sludge settleability parameters (SSPs) being developed in practice. As many as three different SSPs are in current use (SVI, $SSVI_{3.5}$ and DSVI) and there is disagreement as to their relative merits. Nevertheless, despite the obstacles, the desire to use the flux theory for settling tank design and operation has been great in English-speaking countries because many relationships have been proposed by means of which the flux V_o and n values can be calculated from one of the simpler SSPs (inter *alia* Pitman, 1984; Daigger and Roper, 1985; Ekama and Marais, 1986; Koopman and Cadee, 1983 and Wahlberg and Keinath, 1988). However, there appear to be no generally accepted functional relationships linking one SSP to the flux ZSV-X (or associated V_o and n) or even to another SSP. This means that, at present, if data are available in

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