

Full-scale evaluation of activated sludge thickening by dissolved air flotation

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Abstract

This paper presents an overview of waste activated sludge thickening with dissolved air flotation (DAF). The most pertinent parameters that could influence DAF thickening performance are first identified, followed by a thorough review of the design models of Bratby and Marais (1975) and Bratby and Ambrose (1994) - the only rational theories available at this point. These theories are then tested against a comprehensive data set collected over a period of eight months during 22 site visits at five full-scale operating plants. The design models are poorly supported by the operational data. Black-box regression analyses are next performed on the data set to obtain estimates for sludge concentration, float-layer depth and clarity of the underflow. The regression analyses do not show strong correlation, but do demonstrate that, in three of the five plants visited, the float layers are too thin to withstand the disruptive action of the float scrapers. Without these disruptions, the existing models may very well be supported. Despite these data limitations, it can be concluded that float-layer depths of at least 150 mm should be maintained to prevent disruption by the scrapers, and that the design models in general do include the most pertinent variables controlling DAF thickening.

Nomenclature

a_s	dimensionless air-to-solids mass ratio	(-)
C_F	float-layer concentration	%
COD_{in}	chemical oxygen demand of incoming sludge	$g \cdot m^{-3}$
COD_{out}	chemical oxygen demand of underflow	$g \cdot m^{-3}$
d_b	float-layer depth below the water level	m
d_w	float-layer depth above the water level (from lower edge of scraper blade)	m
L	effective length or periphery over which scraper travels	m
P	saturator pressure	kPa
Q	flow rate	
Q_s	solids loading rate on separation zone	$kg \cdot m^{-2} \cdot h^{-1}$
SS	suspended solids	
SS_{in}	suspended solids in the incoming sludge	$g \cdot m^{-3}$
SS_{out}	suspended solids in the underflow	$g \cdot m^{-3}$
SVI	sludge volume index	$ml \cdot g^{-1}$
t_c	hydraulic residence time in contact zone	s
t_e	effective drainage time in float layer	min
t_{on}	time during which scraper is scraping	min
t_{off}	time during which scraper is not scraping	min
v	scraper speed	$m \cdot min^{-1}$
v_c	hydraulic loading on contact zone	$m \cdot h^{-1}$
v_d	cross-flow velocity between contact and separation zone	$m \cdot h^{-1}$
v_L	hydraulic loading on separation zone	$m \cdot h^{-1}$
VSS_{in}	volatile suspended solids of incoming sludge	$g \cdot m^{-3}$
θ	sludge age	day

Introduction

This paper deals with our present ability to predict the efficiency of sludge thickening by dissolved air flotation (DAF). If the

crucial design variables cannot be isolated, and mathematically related to the performance of DAF thickening, then these systems also cannot be rationally designed with an adequate degree of confidence.

The work reported here followed from a design guide commissioned by the South African Water Research Commission (WRC) (Haarhoff and Van Vuuren, 1993). In this publication, design and operational data from a survey of South African DAF plants were used in conjunction with published literature and theory to suggest a number of empirical guideline values for practical design. In this process, it was noted that there seemed to be a wide discrepancy between values actually measured on site, and the values predicted by the design model of Bratby and Marais developed more than 20 years ago, also under the direction of the WRC (summarised in Bratby and Marais, 1976). This prompted a third WRC project, with the specific objective to systematically measure the performance of a number of thickening plants, and to compare it with available design models (Bezuidenhout, 1995). This paper summarises the main findings from the latter project.

The specific objectives of this paper are to:

- review the variables which are usually used in DAF thickening models,
- summarise the principal design guidelines for waste activated sludge thickening,
- present the results of a detailed, extended survey of five South African DAF systems where waste activated sludge is thickened,
- compare the predicted with the actual performance, and
- offer possible explanations for the discrepancies found.

This study is confined to the thickening of waste activated sludge by DAF, without the use of any chemical conditioning.

Selection of experimental variables

A number of potentially important variables were identified by previous reports. They can be broadly classified into a number of categories:

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