Evaluation of the dual digestion system
Part 4: Simulation of the temperature profile in the batch fed aerobic reactor

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Abstract

An algorithm is presented which enables the profile of the reactor sludge temperature vs. time in the batch fed aerobic reactor of the dual digestion system to be simulated by solving the unsteady state heat balance. From the algorithm a computer model is developed which calculates and plots the sludge temperature vs. time profile in a reactor which is oxygenated either by air, oxygen enriched air or by pure oxygen. The model is shown to accurately predict the temperature/time profiles in the pure oxygen aerobic reactor of the Milnerton dual digestion system for a wide range of different operating conditions.

Nomenclature and abbreviations

(For symbols not in this list see **Parts 2** (Messenger et al., 1993) and 3 (Messenger and Ekama, 1993a)

ATASIM = Autothermal thermophilic aerobic reactor simulation computer program.

f_b = batch fraction, i.e. fraction of the full operating volume transferred per batch cycle (= V_b/V_p).

H_s = enthalpy (heat content) of the reactor sludge (MJ). Subscripts t and t+At denote H_s at times t and t+At respectively.

T_{se} = reactor sludge temperature (°C). Subscripts 1, 2 and 3 denote T_{se} at the end of phases 1, 2 and 3 of the batch cycle respectively (Fig. 1). Subscripts t and t+At denote T_{se} at times t and t+At respectively

T_{ref} = reference temperature for reactor sludge enthalpy (°C).

t = batch phase time (h). Subscripts tpr, fpr, D and c denote transfer, feeding, heating and total cycle times respectively.

V_p = reactor volume (m^3). Subscripts t and t+At denote V_p at times t and t+At respectively.

AH_S = change in H over time interval At.

At = integration step length time interval (h).

Introduction

In **Part 3** of this series (Messenger and Ekama, 1993), considerations in, and a procedure for, the design of the aerobic reactor in the dual digestion system were presented. These were developed from principles observed in the results of the research on the Milnerton pure oxygen and Athlone air oxygenated aerobic reactors (Messenger et al., 1990;1992;1993; Pitt, 1990; Pitt and Ekama, 1993). In the interests of simplicity, the design procedure was based on the steady state heat balance which in effect accepts that the sludge flow through the digester is continuous. This approach allowed a constant temperature for the aerobic reactor to be calculated by balancing the heat sources and heat sinks. However, the aerobic reactor is required to be operated under batch draw-and-fill conditions so that the pasteurised effluent sludge is not contaminated by raw feed sludge. This causes a moment-by-moment imbalance between the heat sources and heat sinks and results in a continually changing reactor sludge temperature with time which takes the form of a distinctive saw-tooth profile (Fig. 1). In this paper, an algorithm is presented capable of simulating this reactor sludge temperature vs. time profile.

The algorithm presented is completely general and may be

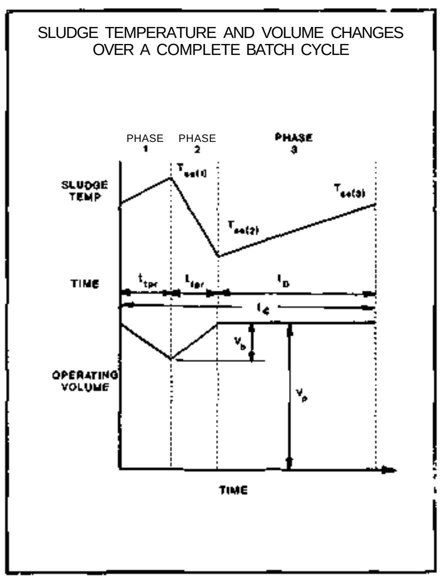

Figure 1
Reactor sludge temperature (top) and operating volume (bottom) versus time profile of the batch fed aerobic reactor in dual digestion showing the 3 phases over the batch cycle: (I) transfer (of duration t_{lpr}), (2) feeding (of duration tp_r) and (3) heating (of duration t_D). The volume of sludge transferred i.e. the batch volume Vb, as a ratio of the full operating volume V_p, is called the batch fraction (fj

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