MIKE BY DHI CASE STORY

LOWER CHEMICAL USE IN WASTEWATER TREATMENT

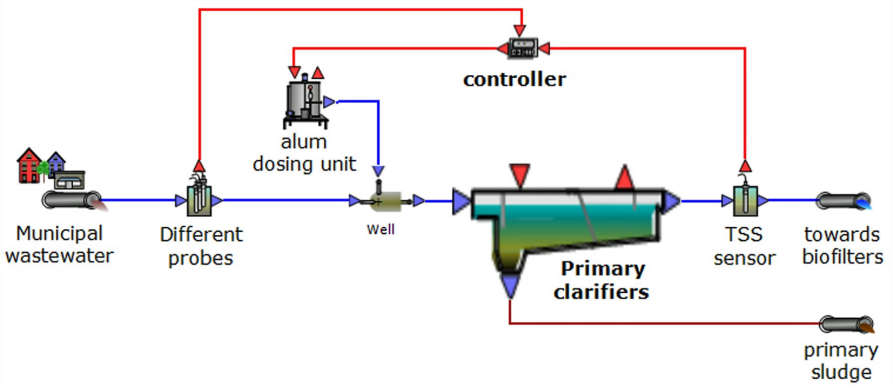
Model-based development of a control strategy for chemically enhanced primary treatment (CEPT)

Québec City in Canada invested in chemical enhancement of its wastewater treatment plant (WWTP) by installing alum addition in its existing primary clarification process. Despite promising results in preliminary tests, the designed chemical dosage seemed to over-perform, causing chemical supply costs to be unsustainably high. In order to reduce chemical use while keeping good effluent quality, the city set up a project to gain a better understanding of the dynamic effects of alum addition in primary treatment. The aim was to design an appropriate automatic controller able to maintain performance at reduced resources. The city chose a model-based approach using WEST, which allowed it to test different control strategies and settings in a cost-effective way without jeopardising operational stability and performance.

The city installed alum addition in its existing primary clarification process in order to ensure compliance with the total suspended solids (TSS) discharge limits and to safeguard the good operation of its biofilters, performing secondary treatment. They initiated the study to reduce chemical supply costs and to evaluate the feasibility of developing a controller in collaboration with the modelEAU research group at Université Laval.

CHEMICALLY ENHANCED PRIMARY CLARIFICATION MODEL

Québec City chose a model-based approach using our wastewater modelling software, WEST and browsed the WEST model library for the most suitable primary clarification model available. The 'Takács multi-layer primary clarifier model with solubles propagation' was chosen, as it allowed reproduction of the experimental results of tracer tests, which were performed at the full-scale WWTP.



A chemically enhanced primary clarification process with control. © DHI / modelEAU

SUMMARY

CLIENT

- Québec City

CHALLENGE

- Insufficient information about recently installed chemical enhancement of primary clarification process
- Unsustainably high and cost-inefficient chemical dosage

SOLUTION

- Model-based design of a controller in the existent chemically enhanced primary treatment process

VALUE

- Cost reduction of approximately 30% on chemicals supply
- Development and evaluation of model-based control strategies
- Compliance with target values
- WWTP performance improvements
- Reduced environmental burden by diminished chemical resource use

LOCATION/COUNTRY

Québec, Canada

SOFTWARE USED

- WEST

MARKET AREA

Cities

The alum distribution delay is indeed an important factor to take into account when properly describing the enhanced coagulation and flocculation processes occurring in chemically enhanced primary treatment (CEPT).

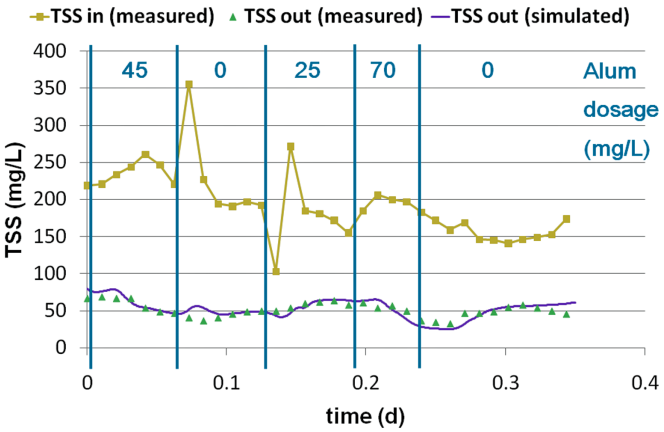
The user-friendly model specification language (MSL) model editor was employed to model chemical enhancement. It was used to extend the model library with a simple addition to the source code of the Takács model. More specifically, a sigmoid dependency of the settling properties to the alum concentration was added showing that:

- the maximum settling velocity increases with alum concentration
- the non-settleable TSS fraction decreases with alum concentration

CALIBRATION AND LABORATORY TESTS

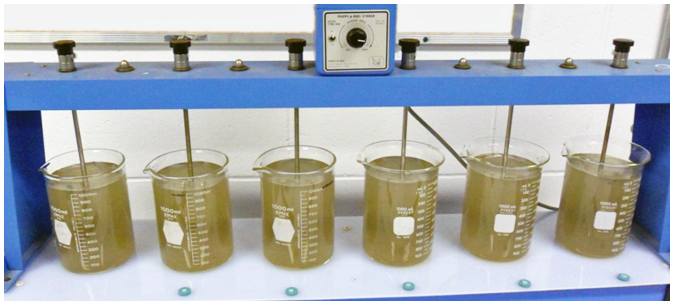
Subsequently, the following two types of model calibration were performed:

- calibration using experimental data by carrying out laboratory experiments using a jar test protocol to characterise the coagulation and flocculation processes. The results were complemented with several full-scale measurement campaigns, which were subjected to different alum additions
- calibration using the parameter estimation tool that comes with WEST in order to minimise the sum of squared errors between measured and simulated data



Total suspended solids (TSS) results of a full-scale experiment. Different alum concentrations were tested and TSS was measured at the inlet and outlet of the primary clarifiers. The solid purple line represents the simulated results. © DHI / modelEAU

Once a model was obtained that was able to reproduce observed behaviour of the process under chemical addition, the design of a controller became feasible.



Laboratory experiments using jar test to optimise chemicals dosage. © DHI / modelEAU

ACHIEVING 30% REDUCTION IN CHEMICAL USE

Online data of interest was evaluated based on the fact that it can be recorded easily, reliably and at acceptable costs and maintenance efforts. Based on the evaluation, turbidity measurements at the outlet of the clarifier were selected as control variable.

A feedback control loop using a standard PI algorithm was tested with promising results. With this simple, well-tuned controller, approximately 30% savings on chemical use can be achieved. This represents both an important operational cost saving as well as a reduced environmental burden through diminished resource use. Also, by using WEST, the controller was tuned to achieve effluent TSS concentrations that will also ensure good performance of the subsequent biofilters.

FURTHER ANALYSIS AND FULL-SCALE IMPLEMENTATION

In order to implement the designed controller at full-scale, further analysis needs to be carried out of chemical addition under snow melt conditions and lower temperatures, as these seem to have an impact on the effectiveness of the alum addition. Thus, before full-scale implementation can occur, Québec City anticipates correcting the settings of the control algorithm to also include wastewater temperature and to incorporate safety nets to ensure proper operation of the system in case of sensor or actuator failure.

BENEFITS OF MODEL-BASED CONTROLLER DESIGN

The main benefit of the conducted model-based approach was that it provided the possibility to try out different control strategies with different settings. This would not have been possible through actual experimental work, as it could jeopardise operational stability and performance and would have led to prohibitive experimental costs.

For more information about this project, please refer to the following Scientific Publication:

Tik S., Langlois S. and Vanrolleghem P.A. (2013) Establishment of control strategies for chemically enhanced primary treatment based on online turbidity data. In: Proceedings 11th IWA Conference on Instrumentation, Control and Automation (ICA2013). Narbonne, France, September 18-20 2013.

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