Control of polymer addition to maintain good clarifier performance

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Dynamic control of activated sludge plants should in the first place be oriented at a minimisation of the concentration of suspended solids in the effluent because these solids contain a lot of organic pollutants, nitrogen and phosphate which determine the effluent quality. Due to the inherently slow response of the system a feedforward (FF) component in the controller is advantageous. Such FF control can be based on measurements of the solid flux to the settler (flow to the clarifier times sludge concentration) or the sludge volume loading (flow to the clarifier times sludge volume). Instead of a feedback (FB) control of the effluent suspended solids, an alternative FB element can be built around the sludge blanket that should be kept below a certain critical height. Such strategies are sound as several authors (for an overview, see Vanderhasselt, 1999) learned from full-scale observations that the effluent suspended solids concentration only rose significantly when the sludge blanket exceeded a critical level.

At the studied industrial wastewater treatment plant the clarifier is overloaded during peak flows. At this site, the more traditional options for clarifier control strategies by manipulation of influent flow, recycle flow or step feed are limited. Consequently, polymer dosing was identified as the most interesting control action to prevent massive wash-out of sludge.
Different settler control strategies based on distinct measured variables and polymer dosing as manipulated variable, were formulated. Testing all these strategies in full-scale would be quite expensive as it entails not only installing all sensors involved, but also their implementation in a control loop and empirical controller tuning. Moreover, the good operation of the full-scale plant should not be jeopardised and, consequently, the experimental degrees of freedom remain limited. Further, objective evaluation of the control strategies would certainly be a hard task as it is difficult to subject the different strategies to identical disturbances. Therefore, evaluation of the performance of these control strategies in a simulation environment was considered as a good alternative.
In order to evaluate the polymer dosing control, it is obvious that the effect of the polymer must be modelled. Hence, within the chosen mechanic modelling approach, it was necessary to determine the settling velocity not only as function of the sludge concentration but also as function of the polymer concentration. Such models were not available in the literature and a new model was built and calibrated using data collected with an automated Settlometer.

Different control strategies were formulated to maintain the sludge blanket height below the critical level of 1.5 m. The sludge blanket height (SBH), the solids loading, the hydraulic loading or the sludge volume loading were taken as measured variables. Combinations of the SBH and one of the other measured variables were also considered. Each control strategy was tuned by an optimisation algorithm to achieve the lowest polymer cost while still preventing the sludge blanket to rise above a height of approximately 1.5 m during the whole evaluation period. For some strategies the algorithm didn’t give reasonable result and manual tuning by trial and error was then performed.
The polymer requirements for the different control loops are, with the exception of the FF control based on the hydraulic loading alone, in the same order of magnitude. Moreover, a sensitivity study revealed that the FB strategy based on SBH and especially the FF/FB strategies based on a combination of SBH and solids loading or sludge volume loading are more robust towards suboptimal tuning and model mismatch. The final selection of which control strategy to implement will also be based on the ease and cost at which this can be achieved.

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