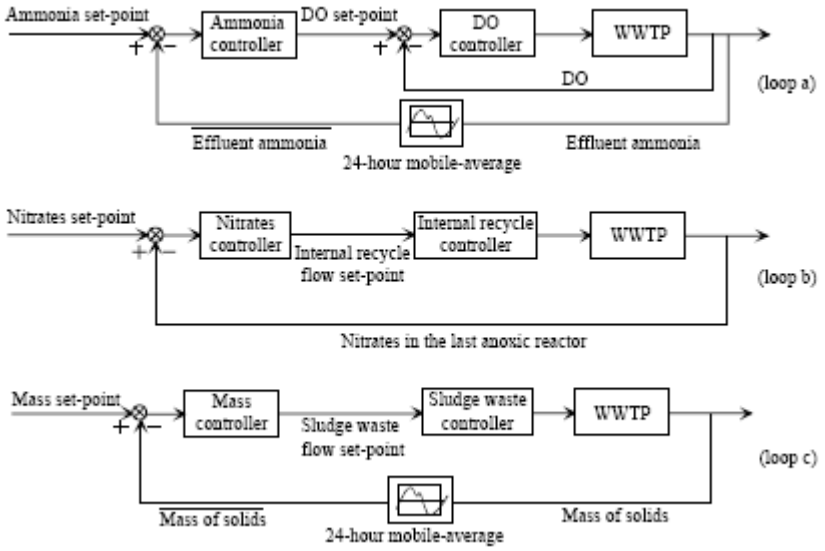
5.- Control systems for activated sludge processes

Title and name of product or technology
Control Systems for Activated Sludge Processes
Abstract
New supervisory control strategy designed for wastewater treatment plant (WWTP) with nitrogen removal. The control strategy combines three complementary control loops to optimise the nitrogen removal in pre-denitrifying activated sludge plants. The first controller is designed to maintain the average concentration of the ammonia in the effluent via the automatic selection of the most appropriate DO set point in the aerobic reactors. The second control loop optimises the use of the denitrification potential and finally, the third control loop maintains the selected amount of biomass in the biological reactors by automatic manipulation of the wastage rate. Mobile-averaged windows have been implemented to incorporate commonly used averaged values in the control objectives.
Description including main features/advantages
The main objective of the supervisory control strategy designed for Activated Sludge treatment plants with nutrient removal is the optimisation of the existing plant capacity, improving process stability and effluent quality with minimum cost. Therefore, the automatic supervision was conceived as a way to select, at any moment, the most appropriate set-point for the lower-level controllers, leaving the human decision for the top of the hierarchical plant control structure. It is well known that in a conventional or 'rigid' operational strategy of a predenitrificatrion activated sludge plant, the process operator has to select (based on their knowledge and experience) several parameters such as the DO concentration in the aerated volumes, the recirculation flow of nitrates to the anoxic zone and the wasting of the excess of sludge. The concentration of DO in the aerated zones should be maintained at a sufficiently high level to support the growth of the adequate organisms, to guarantee the required nitrification rate and to maintain the required level of mixing, but sufficiently low to save energy, avoid the excess mixing and to reduce, as much as possible, the oxygenation in the anoxic volumes induced by the nitrate recirculation. Nitrification is improved by high DO values; however, lowering the DO set-point not only favours the denitrification in the anoxic zone but also some simultaneous nitrification–denitrification in the aerated zone. It is important to point out that for a conventional WWTP, this DO set-point is not able to eliminate completely the fluctuations in the effluent ammonia. Therefore, it is suggested that a variable DO set-point should be selected to only reach the required (not the minimum) averaged value of the ammonia concentration at the end of the aerated volume. The first controller designed for the AS plants (Figure 1 loop a) has the aim of maintaining the selected 24 h-averaged concentration of the ammonia in the effluent by automatically selecting the most appropriate DO set point in the aerobic reactors. Logically, the measurement of effluent ammonia concentration should be made at the outflow of the biological reactors, in order to eliminate the delay and the equalisation effects produced by the volume of the clarifiers. The 24 h mobile averaged window is a simple mathematical concept that filters the typical variation in the effluent concentration generated by the daily load profile. The width of the mobile average window can also be used to 'distribute' these cyclical perturbations between the effluent ammonia and the DO set-point. Therefore, the plant operator can select the most appropriate size of the mobile average window for each particular plant. The second control strategy aims at the optimum use of the denitrification potential of the plant, selecting the most appropriate recycle flow of nitrates from the exit of the aerated volume to the anoxic zone. This means that there is maximum nitrates removal, maximum carbon consumption without oxygen and maximum recovery of the water alkalinity. For this purpose, the second control loop (loop b) designed is continuously selecting the required recycle flow to maintain a low and stable

concentration of nitrates at the end of the anoxic zone. A low nitrates set-point ensures the complete denitrification using the minimum recycle flow, with a minimum amount of recirculated oxygen and a maximum hydraulic retention time in the anoxic volume.
the third control loop (loop c) has the aim of maintaining a selected averaged value of the total mass of suspended solids in the biological reactors via the automatic manipulation of the wastage rate. The use of the total mass of solids (instead of the direct MLSS measurement), makes the generalisation of this strategy to step-feed or contact-stabilisation plants possible. However, for selecting an appropriate value for the mass set-point, the operator should take into account the maximum solid flux that can be accepted by the settler (associated with the MLSS in the final reactor). A 24-h mobile average filter has been also introduced to reduce the disturbances produced by the daily influent load profile.



The application of supervisory control strategies for the automatic selection of the main operational parameters in WWTPs can be a very useful tool for optimising the exploitation
of the process. The synergetic combination of three supervisory control loops facilitates a stable operation of the biological process, improves the effluent quality and lowers simultaneously the air flow needed.

Innovative aspects

The control system here presented is based on measurements of real sensors and the full-scale implementation of the control algorithms is based on experimental data combined with simulation programs and requires many additional improvement to the computing code so as to guarantee a safe operation of the process (upper and lower limits for all the manipulated variables, digital filtering and sampling of the signals, detection and elimination of outliers, automatic procedures for the initialisation and commutation of the control loops, etc.).

Current and potential industrial users/domains of application

WWTP operators and technology suppliers.

Current state of development

Tested at lab, pilot and full scale urban WWTP (Galindo, Bilbao, Spain)

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