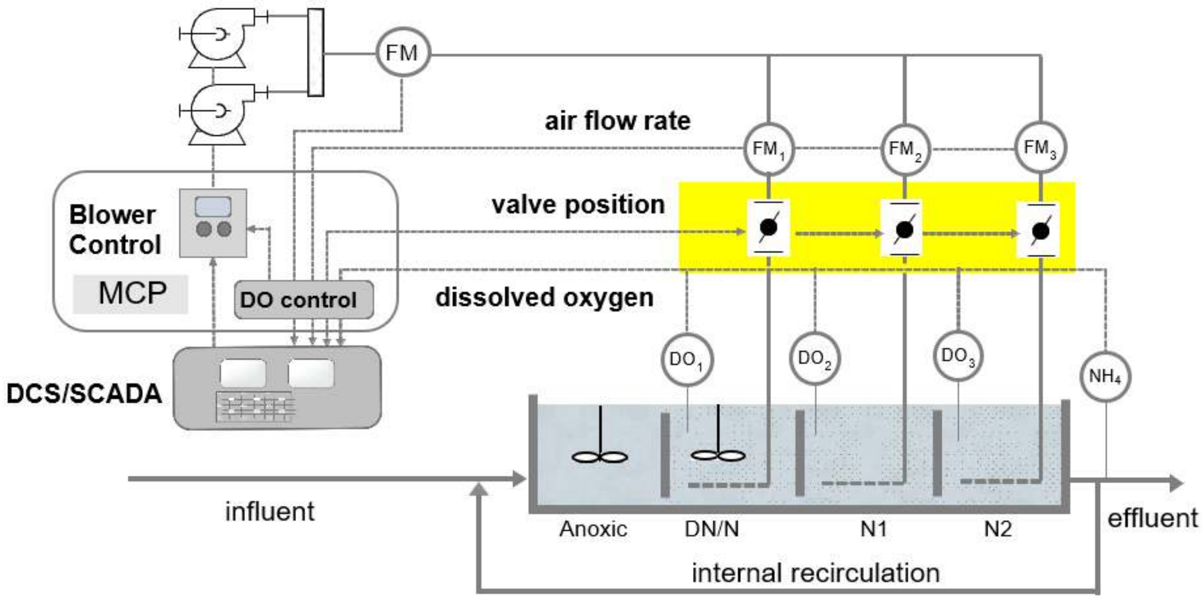
Energy Efficiency in aeration control
Part 1: Interactions and System Integration

Sewage treatment plants are the biggest municipal consumer of energy. $^2/_3$ typically of the energy consumption of a sewage treatment plant are related to the aeration system in the biological stage. This part is the heart of the plant, where nitrogen and phosphorus removal take place.

Nitrogen and phosphorus removal must be secured to protect the environment, especially the water resources. Ground water and river water mainly used for the production of drinking water today. Pollution of these resources by not sufficient treated waste water must be prevented in any case.

Fine bubble aeration diffuser (FBDA) systems consist of a group of 5 main components:

1. a certain number of blower, each one with a local control unit (LCP) and a superordinated master control unit (MCP) which ensures a safe and cost-efficient operation of several blowers at the same time
2. a piping system with ON/OFF valves and control valves to distribute the air to the various aeration tanks
3. a fine bubble diffuser system for efficient oxygen supply to the aeration tanks
4. sensors to measure process data must be placed on the right place in the tanks (DO, NH_4-N, NO_3-N, pH, Redox … SS, P, conductivity, BOD, COD)
5. a hard- and software for the calculation of required air flow rates and control of the valves (considering suited control strategies as described in [1])



The design of the system is done for the whole operation range, from minimum load in night hours to high load phases during day. Number and size of blower as well as number of aerators and valve size must be designed well to get best performance in typical load situation but meet also full range of load situations.

Aeration control system typically based on PI- or PID-controller must be able to calculate the required valve strokes stable but not too sensitive or too slow.

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If one of the components is not designed well, the whole system cannot run with best performance. Typical design errors are:

- too small number of blowers of same size, so one blower at lowest possible operation point will feed too much air in low load phases
- not sufficient pressure discharge of the blower, during years of operation the counter-pressure of the system can increase due to ageing of the diffuser, the blower cannot increase the pressure to a sufficient level (blower start to surge)
- blower management system (MCP) not available or doesn´t run well, supply gaps will lead to jumping DO-level and high switching frequencies (maintenance issue)
- valves are designed too small – always operated with high pressure drop
- valves designed too big – valves are operated at low strokes, which will create a high pressure drop
- BFV or "water valves" are used with poor control performance
- repeatability / accuracy of control of air flow rate by the valve too poor (too big mechanical slag of the valve, too fast-moving actuator, too poor operational characteristic of the valve)
- number of aerators is designed too low, system is operated with poor oxygen transfer efficiency, a high air flow rate is required
- number of aerators is designed too high, non-equal bubble pattern can occur, can cause formation of deposits on membrane surface and in the slits, danger of clogging is increasing, special measures must be taken during operation
- aeration controller must use a flexible controller, considering actual control deviation, permanent off-sets, process parameter e.g. actual load, water temperature and must overcome non-linear characteristics of control valves to calculate under all circumstances very precise control results; typical standard PI or PID-controller are used, not considering different control responses from the "dynamic" load systems, operator must adjust manually configuration settings summer/ winter, DO is running up and down = over- and under-aeration takes place, process safety regarding nitrogen removal is not always secured

Best design, highest quality and efficiency of used equipment, best control performance of the aeration controller and system integration are the main objectives to achieve high level of purification at lowest consumption of energy.

Literature:

[1] DWA-A 268: Automatisierung von einstufigen Belebungsanlagen (EN: Automation of one-stage activated sludge plants). Beuth Verlag, August 2016

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