Nutrient dosing with TOC + RTC-CNP from Hach®

Load-based nutrient dosing in paper waste water saves 20% of chemicals with the same effluent quality

Challenge

The recirculating water treatment plant of the Smurfit Kappa Paper & Board branch in Diemelstadt had a difficult task: It had to treat the problematic waste water that is typical for the industry in a biologically safe manner and, before that, had to compensate for a nutrient composition that was extremely unfavourable for bacteria. But how do you continuously compensate for a high carbon load without losing sight of the costs and without exceeding the consent limits?

Solution

With the use of a Hach real-time control system for dosing nutrients (two-channel RTC-CNP), a two-channel online TOC analyser, an online ammonium analyser and an online ortho-phosphate analyser, the correction of the C:N:P ratio is now based solely on the actual measured load. The RTC-CNP module controls the urea and phosphoric acid dosing pumps based entirely on the contamination; these pumps are installed in the inlet to the flotation and in the inlet to the aeration.

Benefits

The Hach RTC-CNP real-time control system ensures compliance with regulatory limits. It continuously corrects the C:N:P ratio and results in more favourable sludge properties and better cleaning performance. One impressive feature is the 20% reduction in the use of chemicals with a consistently high or improved discharge quality. Safety relevant: Integrated backup stages take responsibility for the stable dosage of nutrients if the online measurement values fail, which leads to fewer standby calls.

Background

In the context of aerobic biological waste water treatment, a C:N:P nutrient ratio of between around 100:10:1 and 100:5:1 results in what is referred to as a balanced diet for the bacteria. This not only promotes health and well-being, but is particularly noticeable in the performance of our little helpers when they're breaking down substances. The right ratio also keeps filamentous bacteria away. In the waste water generated from paper production at SMURFIT KAPPA, which has a significant excess of C and a pronounced deficiency of N and P, the nutrient ratio can be shifted to approx. 100:0.6:0.1. Of course the ratio is not always shifted to the same extent but, depending on the production focus, these differences in the composition of waste water demand far more than just opening the valves for urea and phosphoric acid. If too little nitrogen is added, the bacteria are not able to sufficiently degrade the carbon load, which leads too much C-load in the effluent. If too much nitrogen is added, it will also be detectable in the effluent. The same is true of phosphorus. In the worst-case scenario, the growth of bulking and/or floating sludge even causes the system to shut down completely. In all scenarios, the Sword of Damocles hangs over the system as there is a risk of exceeding limits and incurring the consequences.

That's why the stated goals for optimisation had to be demanding: complying with the limits at all times, easing the burden on personnel (especially after work hours and at weekends) and integrating measurement and control technology during operation without a shutdown.

Smurfit Kappa in Diemelstadt

Success thanks to the right control and process measurement technology

Anyone who works around the clock to treat waste water that is difficult for bacteria to digest needs control and process measurement technology that adds nutrients continuously, reliably and in a load-controlled and contamination-dependent manner.

And anyone who needs to install the technology while business continues, like in a bypass operation, is best advised to order deliver everything pre-assembled and ready for use in an AnaShell analyser shelter from Hach.

An RTC-CNP control module then takes responsibility for adding urea and phosphoric acid to the TOC measurement value obtained online at the inlet to the treatment plant (see Fig. 1). In addition, a second TOC value is measured at the outlet of the flash aeration, the ammonium concentration is added at the aeration outlet and further addition of urea is actuated at the aeration inlet. Finally, an orthophosphate measurement at the aeration outlet will, in future, ensure that there is sufficient phosphorus saturation.

Only this new transparency with regard to the fluctuating waste water composition and the resulting real-time reaction can stabilise the performance of biological degradation.

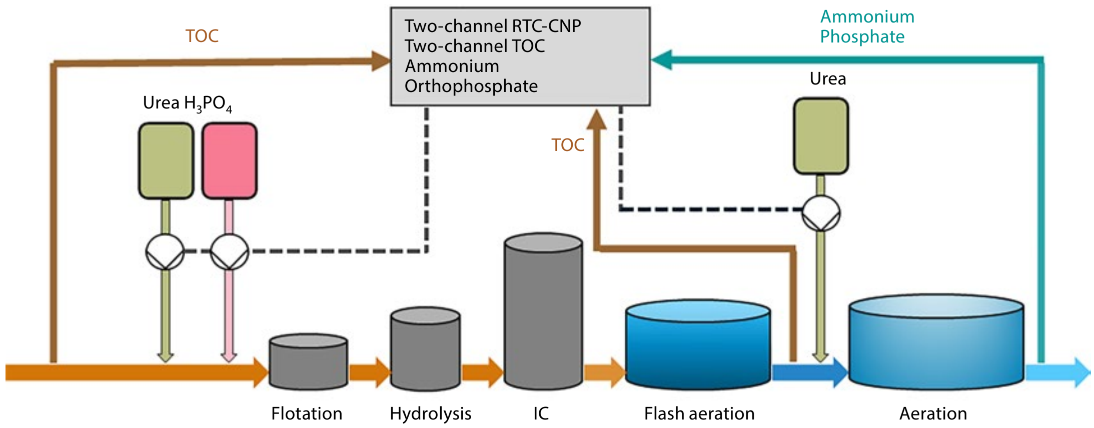

Fig. 1: Schematic diagram of the waste water treatment plant and integration of the new technology

The 2022 time curves show the success of these measures (see Fig. 2). In the course of the aeration process, an ammonium value as favourable as 1.0 mg/L NH_4-N was reliably maintained. However, an initially targeted value of 0.2 mg/L NH_4-N had to be sacrificed to the high lime content and the temporarily high nitrite values in the medium, because reliable conclusions could not be drawn about the N-load. Furthermore, the RTC-CNP control module was only able to work as a control unit, because a time delay of 14–15 h between dosing and measurement could not be compensated for with control technology.

Nevertheless, with the same and sometimes better effluent quality, 20% of chemicals can be saved and the stable treatment processes mean that significantly fewer personnel have to be deployed outside normal working hours.

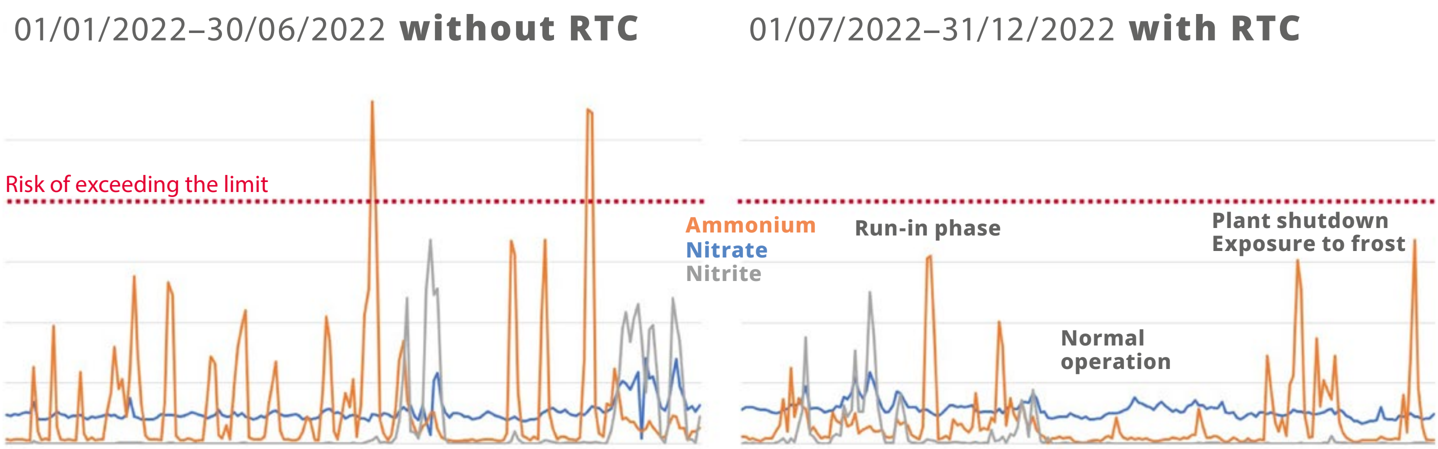

Fig. 2: Only after commissioning of the RTC-CNP control module does safe plant operation begin

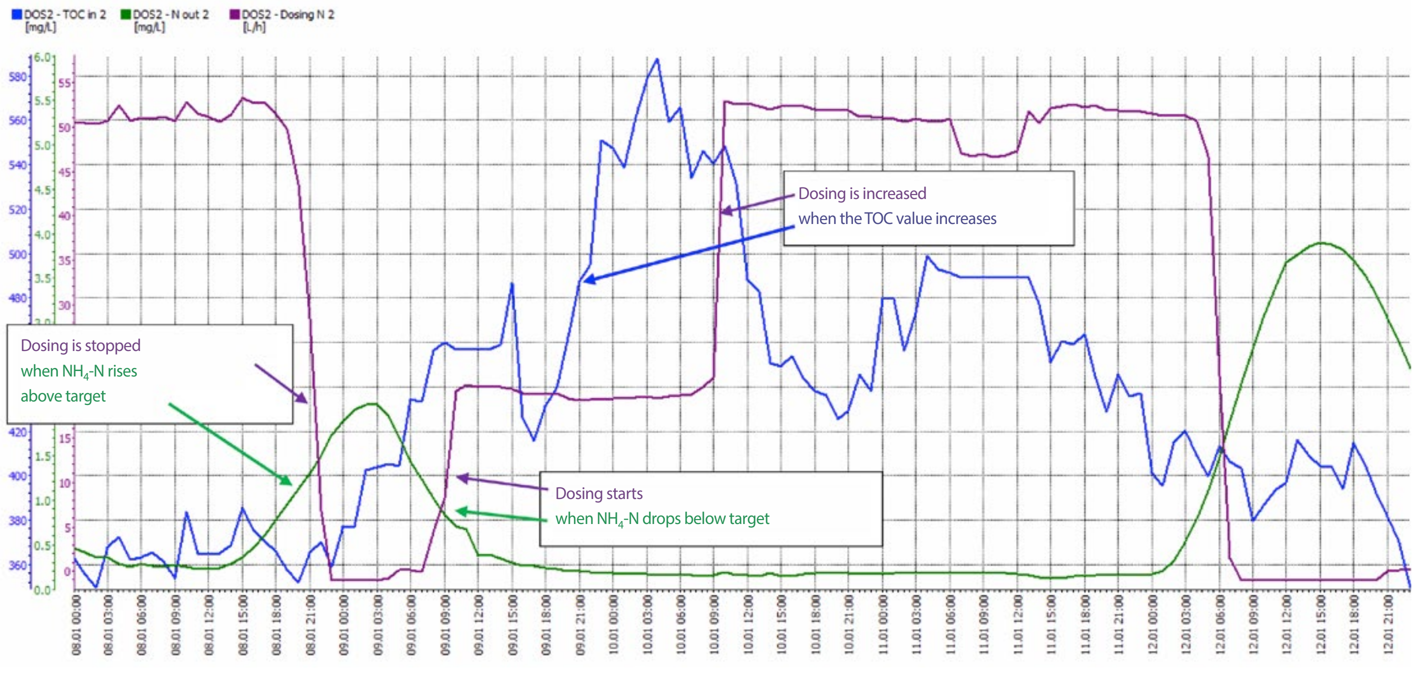

Fig. 3: The complete transparency of the treatment leads to load-based and contaminant-dependent nutrient dosing.

Fig. 3 illustrates the many options for intervention in the treatment process when the most important parameters (in this case ammonium and TOC) can be continuously recorded. The RTC control module can be configured so that the nutrient dosage (in this case urea) takes place within certain ammonium concentrations and simultaneously as a function of the TOC. Fig. 4 shows how closely the addition of urea tracks the TOC load, while taking into account the water quantity.

This is what the Smurfit Kappa team says:

The strongly fluctuating COD loads of the two paper machines repeatedly led to nutrients being over- or underdosed. In particular, the nitrogen saturation of the bacteria fluctuated so much that exceeding the in-house limits was sometimes unavoidable.
Since online TOC measurement and nutrient control have been set up, these outliers have been eliminated and costs for nutrients have been reduced. So the effort was definitely worth it. However, the work involved should not be underestimated either. In addition to a well-prepared analysis, it is extremely important to select the optimal location for the analysis container and to plan inlets, outlets, measuring points and dosing units precisely. Integration into the existing process control system requires resources too.

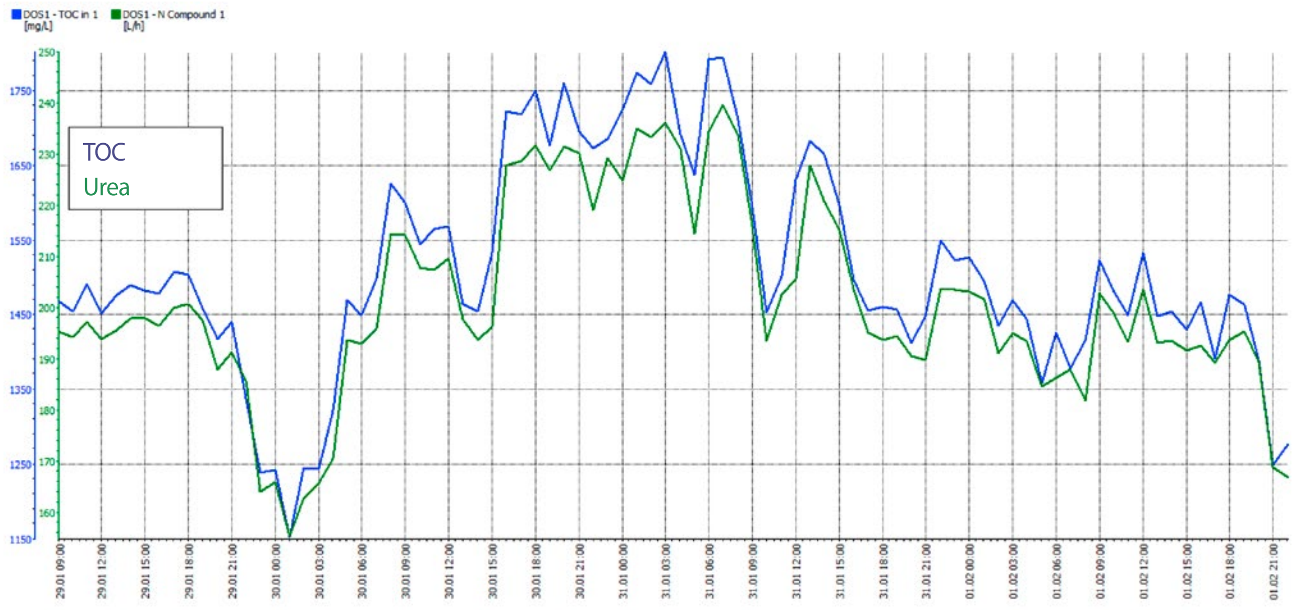

Fig. 4: Urea addition tracks the TOC load precisely according to the set dosing rate

Analyser shelter

A complete, ready-to-use solution in a weather- and corrosion-resistant AnaShell analyser shelter has proven to be very practical and convenient: All the necessary equipment including the RTC-CNP control module and sample preparation for the ammonium and phosphate analysers are professionally installed at the factory and arranged in a readily accessible manner – incl. thermal insulation, air conditioning and lightning protection. The entire analysis container was subjected to a functional and acceptance test (FAT) prior to shipment.

Conclusion

The SMURFIT KAPPA recirculating water treatment plant must be able to subject paper waste water with a high and fluctuating carbon load to reliable biological treatment. Without knowledge of the current waste water composition and without targeted addition of urea and phosphoric acid, the risk of exceeding the limit always remains. It was only with the help of process measurement technology that the requirements could be met for continuously recording the TOC load in the inflow and the ammonium and phosphate values in the effluent after biological treatment. The technology allows the RTC-CNP control module used to reliably meet regulatory limits even while making chemical savings of 20%. In addition a more stable treatment process results in fewer staff deployments outside normal working hours.

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About the customer

Smurfit Kappa Paper & Board currently employs 300 people at its Diemelstadt site, producing around 240,000 tonnes of paper and 80,000 tonnes of graphic cardboard per year on two paper machines. The corrugated base paper products are mainly sold in Germany and Europe, while the bookbinding board is sold worldwide.

Excerpt from website: „Our commitment to the environment is to protect it and continually improve our ecological record by reducing emissions, reducing our environmental footprint and minimising the company's environmental impact. In the countries where we operate, we set ourselves ambitious goals and offer local regions and communities the opportunity to benefit from our presence."

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