Excerpt from a Thesis project: Regulating the Nutrient dosage in an organic industrial water treatment system results in

Less Nitrogen Release and Greater Efficiency.

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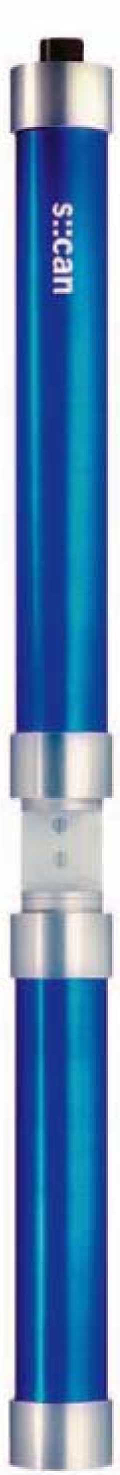
Working Model established in Norske Skog Bruck's 2 stage Organic Water Treatment facilities in Bruck/Mur.



To meet the ever-increasing specifications for water quality in effluent streams Industrial wastewater treatment facilities progressively turn to improving analysis and automation. That decision leads to further multiple choices in analysis/measurement techniques. Expensive, intermittent analysis / batch process methods are continually replaced with reliable and economical on-line probes. Of course any measurements from the on-line probes must be subject to stringent QA before approval, since measurement errors have a broad impact upon the process system, as well as the effluent stream. In this study; data from specialized on-line probes was compared to results from traditional analytical methods. This thesis finds "control protocol" solutions for problematic clearing of very difficult process streams, those with a reaction time of up to 14 hours. The process stream was analyzed with conventional methods, mathematically modeled and simulated. Simulation has become a necessary component of automation. With the help of simulation an operation protocol was formulated, which resulted in a 20% reduction in Nitrogen release while improving the process efficiency. A secondary goal of the thesis was to reduce the Chemical/ Additive costs. The new protocol reduced the requirement for Urea from 800 t (2002) to 600 t (2003).

<u>Installation of UV-Spectral probes.</u>

The UV-Spectral probes "s::can" to determine the chemical oxygen demand (COD) were positioned at the inlet and outlet process streams of a waste water treatment system. The online measurements were fed into the advanced process control system and calculated. The precise probe locations were determined working with "s::can" and the probe data justified/corrected to conventional (spectrophotometer test) methods. A regular calibration protocol is necessary to guarantee the accuracy of the data specified by the probes (hinges on alteration of electrical components and alteration of the waste-water stream composition. At steady state conditions a calibration interval of 6 months was approved after 3 years of working experience with the probes. Figure 3 shows the very good correlation between data determined conventionally (Lab) and "UV determined COD-filtered concentration" measured on-line. These ranges correspond with the data from the effluent from the pre-settling (900 mg/l), the effluent from the post-settling (300 mg/ l), and the mid range data corresponds to measurements of the effluent from mid-settling stages. It can be concluded that there is good agreement between s::can data and those data determined by conventional lab procedures especially within the <300 mg/l and >900mg/l range.

<u>Research of the Process Stream</u>

One of the most important points to determine while formulating an control protocol is which behavior(s) is(are) shown by the process stream(s) and what adjustment increment (control) has influence on the stream, that is to say when a variable is disturbed(changed) what behavior and adjustment does it impact. One well-known disturbance is the addition of calcium suspension. This is a necessary step in the composition of wastewater in the treatment process, and is followed by bacterial (rod, string type) growth/bloom. The bacterial bloom forms a net like topping,

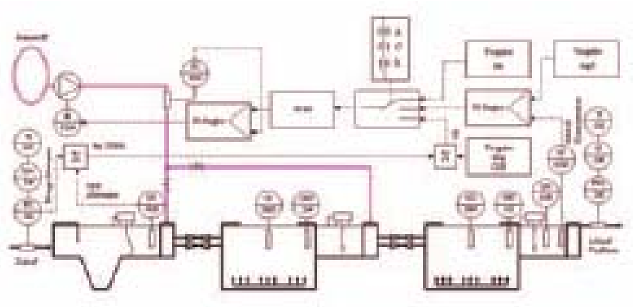


Figure 1. Block diagram of the urea regulation.

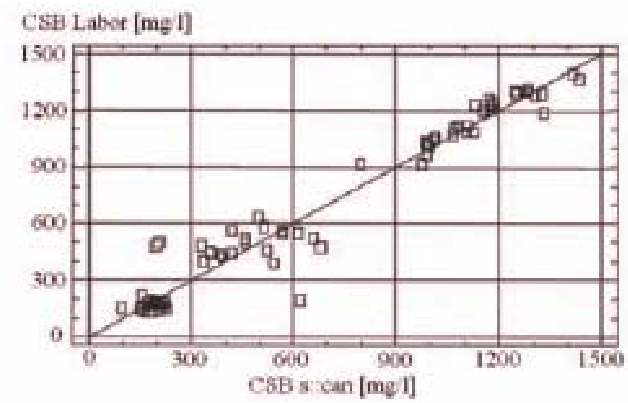


Figure 3. Correlation between laboratory and oin-line spectrally-determined COD.

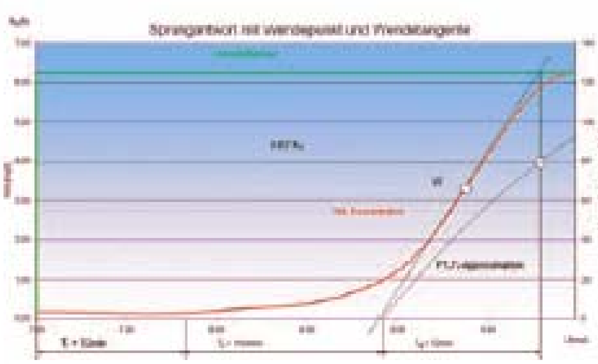


Figure 5. Step response of the main circuitry after an inducement to the system with a “step function”.

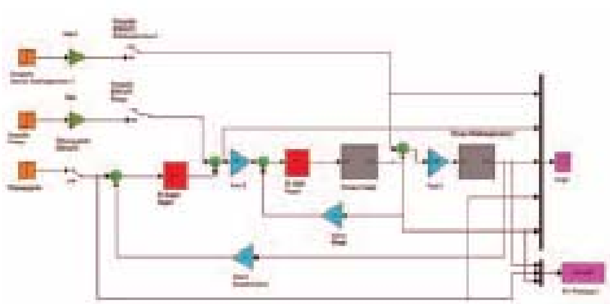


Figure 6. Reproduction of the urea regulation with "Simulink".

which advances to a worse “sludge deposit” condition (sludge volume index). Conventionally the calcium suspension (pH 11 to 11.5) is added in a minimum amount of time to counteract the impact of the bacterial bloom. Figure 4 provides an explanation of the behavior and the introduction of bacteria (bacterial growth cycle) with respect to the addition of calcium. An increase (bump) in pH follows the addition of calcium suspension, (compared with the system-time-constants this approaches an impulse function) and prompts a *weight function* (Impulse answer). *The system can call/follow a higher order phase shifting section/lag element behavior*. These graphics are used later to simulate the process stream, moreover to confirm the control parameters. Figure 5 shows the step response of the main circuitry after an inducement to the system with a “step function”. At time t=0 the Urea concentration is altered incrementally from 0 to 125l/h in settling pond 3 and the NH_4 concentration in the effluent was determined lot wise, in the Laboratory. Next; the control parameters were incrementally/”Intermediate function method” confirmed, according to Ziegler Nichols and Chien Hrones. Further the system was approximated on a PT_n-Range and simulated via a mathematical close approximation model.

<u>Modeling and Simulation of the Urea control with “Simulink”.</u>

Modeling with the software “Matlab” and the Toolbox “Simulink” were used to analyze the behavior of the systems urea under several conditions/variables. The PI(or I)-Help control with the process “pump” and the resetting (amount measure) builds the inner Control circuit (help control circuit), and the PI(or I)-Main control with its process “Settling pond 3” with its resetting features (concentration measures) completes the outer circuit, and builds the so called main control circuit. Both subsystems (gray boxes) are located within the system streams (figure 6) process pump and settling pond 3. The amplification (Gain 2, 3) had to be brought in line with the stream amplification (KS=0.05) of settling pond 3. The complete system was corrected to the same relative time frame. *Next the control settings were simulated on the basis of variable behaviors (verified by determined parameters) and through turning on the step functions (orange) with respect to reference input variables and the behavior of disturbance variables.* Chein Hrones allowed for, unlike Ziegler Nichols, in the lay out design of the control parameters as well as the ramp control time, as a <u>behavior</u> of the system. The before and after sections of both behaviors were analyzed

Figure 7 compares the modeled systems with respect to impacting behaviors. Where at t=0 min the theoretical value (green) changes from 0 mg/l to 1 mg/l and at

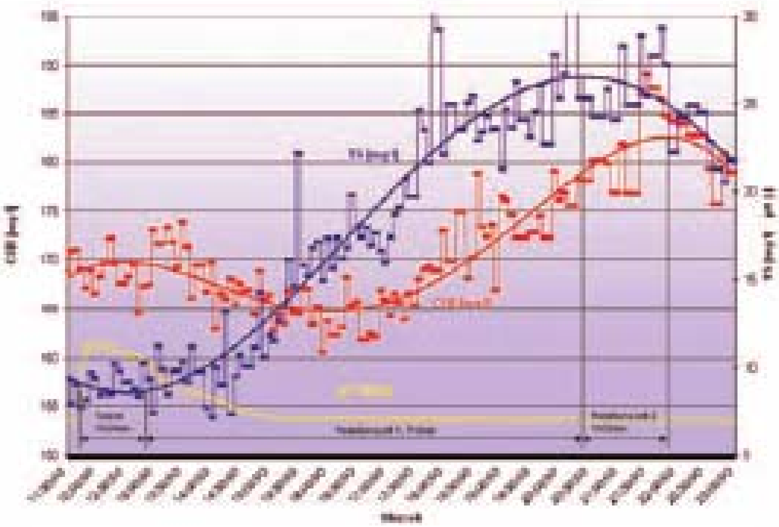


Figure 4. Behavior and introduction of bacteria (bacterial growth cycle) with respect to the addition of calcium.

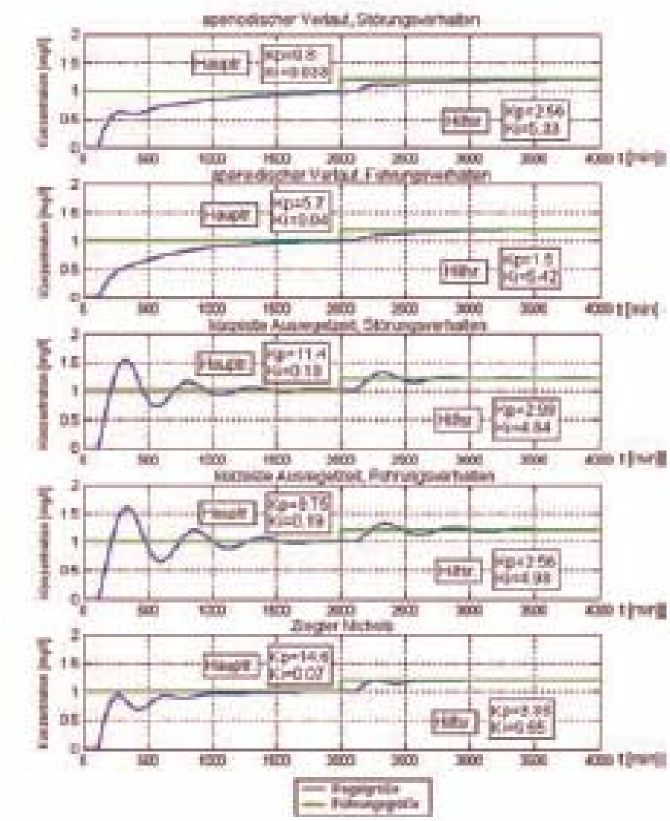


Figure 7. Simulation of the urea regulation with "Simulink" change of the reference with t=0 of 0 to 1 mg/L and with t=2.000 from 1 mg/L to 1.2 mg/L.

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t=2.000 min it increases again by 0.2 mg/l. Through the lag time (t=116 min) the system controls the actual value (blue) by delayed anticipated measure. After control interpretation/layout the single systems differentiate themselves within their characteristic ramp, control condition, and magnitude of overshoot. An overshoot of magnitude ~6 mg/. (60%) occurs within the behavior with the shortest lag time, the theoretical value is achieved through steady “irregular/sinusoidal” controls. The behavior of Ziegler Nichols shows the best possible characteristics, where the theoretical value is reached in t=250 min, doesn’t overshoot, and reaches the steady state at the optimal range/limit within t=900 min. Both control systems with the design features that reach the theoretical value in the shortest transient time after t_{an}=200 min are not eligible due to the very high maximum overshoot e_{max}=0.6 mg/l. The two irregular control/sinusoidal systems which do not overshoot are inferior to the behavior of Ziegler Nichols due to the very long ramp/rise time of t_{an}=1.5 to 2.000 min. One can conclude by saying the behavior of Ziegler Nichols shows the best reference reaction and is therefore chosen for this task.

Results

Figure 8 shows the Urea amount used in relation to the supply stream. The graphic clearly shows a drop in the amount needed in 2003. A 32% reduction was realized after the data was adjusted to the supply stream. This translates to an annual saving of over 200 t of Urea. Another principle goal, to reduce the nitrogen release from the entire settling pond system was also reached. The nitrogen release per year was, on average reduced by more than 20%.

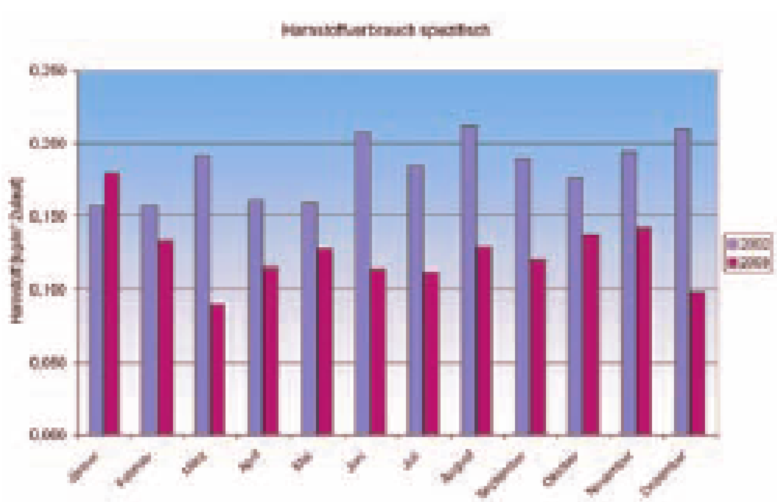

Figure 8. Urea consumption specifically.