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NEW MCA GENERATOR

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Abstract:

Monochloramine (MCA) has become a leading oxidant chemistry for biological control in the paper industry. It is formed in situ by mixing the monochloramine precursor (MCAP) with industrial grade sodium hypochlorite in water at a specific molar ratio and pH.

The new MCA generator is a breakthrough chemical-digital solution that uses artificial intelligence with actionable insights to stabilize the wet-end process, providing improved performance and reduced overall chemical costs. It combines superior MCA chemistry with modern sensing technology, cloud-based data analytics, 24/7 expert monitoring and analysis, and accurate predictive modeling to manage paper machine microbicide programs.

New features include patented reaction temperature technology, proprietary automated ratio control of the chemicals, PID (proportional–integral–derivative) flow control valves, and sensor-controlled dosing that can be tied to multiple inputs.

A 3-phase trial was initiated to demonstrate impact on key performance indicators (KPI) for a customer's microbial control program. Phase 1 compared the new MCA generator performance against an older unit, maintaining similar MCA headbox residual and machine runnability. Further program optimization in Phase 2 utilized chemical ratio control and PID flow control valves. The goal of Phase 3 was to reduce variability in the mill's biocide program KPIs by automating the flow rate of one application point via two of the mill's process variables. Trial results will be presented.

Key words: *Monochloramine (MCA), MCA program, Paper machine microbicide program, Biocide program, New MCA generator*

Introduction

Monochloramine (MCA) is formed in situ by mixing an industrial grade sodium hypochlorite (bleach) with an ammonia source (i.e., monochloramine precursor or MCAP) in water. Depending on the pH and molar ratio of the chlorine to ammonia source, three species of inorganic chloramines can be formed.

Monochloramine is formed at a pH ≥ 7 and at a 1:1 molar ratio of chlorine to ammonia. This equates to a weight ratio of ≤ 5:1 molecular chlorine : ammonia [1].

$NH_3 + NaOCl \rightarrow NH_2Cl$ (monochloramine) + NaOH

If additional bleach is added, either dichloramines or nitrogen trichloride will be formed. Dichloramine occurs at a pH range of 5-6 but can also occur at a pH 7-8 if the molar ratio of chlorine to ammonia is 2:1 (10:1 by weight).

$NaOCl + NH_2Cl \rightarrow NHCl_2$ (dichloramine) + NaOH

Nitrogen trichloride is formed if the pH of the process drops below 5. It can also be formed at pH 7-8 if the chlorine to ammonia molar ratio increases to ≥3:1 (20:1 by weight).

$NaOCl + NHCl_2 \rightarrow NCl_3$ (nitrogen trichloride) + NaOH

Because it is a "combined chlorine", monochloramine is considered to be a weaker oxidizer when compared with other oxidants such as hypochlorous acid, hypobromous acid, and chlorine dioxide. This offers several advantages over the traditional oxidants commonly used in the paper industry. These include: (1) little to no interaction with wet-end additives such as dyes, optical brighteners, starch, retention aids, and sizing agents; (2) excellent biofilm penetrator[2-4]; (3) lower potential of vapor corrosion at typical continuous dosing rates; and (4) the formation of disinfection by-products such as adsorbable organic compounds (AOX) and trihalomethane (THM) is minimal. Because of these advantages, MCA chemistry has become one of the major oxidant biocides

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used in the paper industry for neutral and alkaline processes.

Monochloramine is typically produced in an on-site MCA generator that mixes the MCAP with the industrial bleach and water under controlled conditions to ensure the proper molar ratios of MCAP to chlorine. Via timed or continuous dosing, the MCA solution is then delivered to various portions of the process. The flow of an application point may be controlled via feedback control, such as total chlorine or oxidative-reductive potential (ORP), to provide better control of a dosing scheme.

Material and Methods:

Paper mills are currently being challenged to reduce water usage, improve on-machine efficiency and product quality while minimizing additional costs. This may lead to the use of more chemistries in the influent/effluent treatment plants or the machine process. In response to these challenges, a new chemical-digital solution was developed combining MCA chemistry with a new sensing technology, cloud-based data analytics, 24/7 expert monitoring and analysis, and accurate predictive modeling. The new MCA generator can monitor data from multiple sensors and mill process to automatically adjust the biocide program, minimizing the overfeeding or underfeeding of the biocide. In addition to standard safety features found on previous MCA generators, such as separated chemical pumps, leak detection, emergency flush water for all application lines, it includes additional safety features including patented reaction temperature technology.

A three-phase trial of this new technology was conducted at a North American paper mill. The objective of Phase 1 was to compare the new MCA generator with an older MCA generator by maintaining the mill's key performance indicators, such as MCA headbox residuals and microbial activity, without changing the application points or dosing strategies. Results are shown in Figures 1-3 and summarized in Table 1. Headbox MCA residuals were maintained with the new MCA generator unit (Figure 1) while a reduction in the MCAP usage (12.0%) was achieved (Figure 2). With regards to controlling microbial activity, headbox adenosine triphosphate (ATP) remained well below the mill's established upper limit of 500 relative light units (rlu) (Figure 3). The outliers (above 100 rlu) occurred after an unscheduled down and correlate to lower headbox MCA residuals (Figure 1) during the same time period.

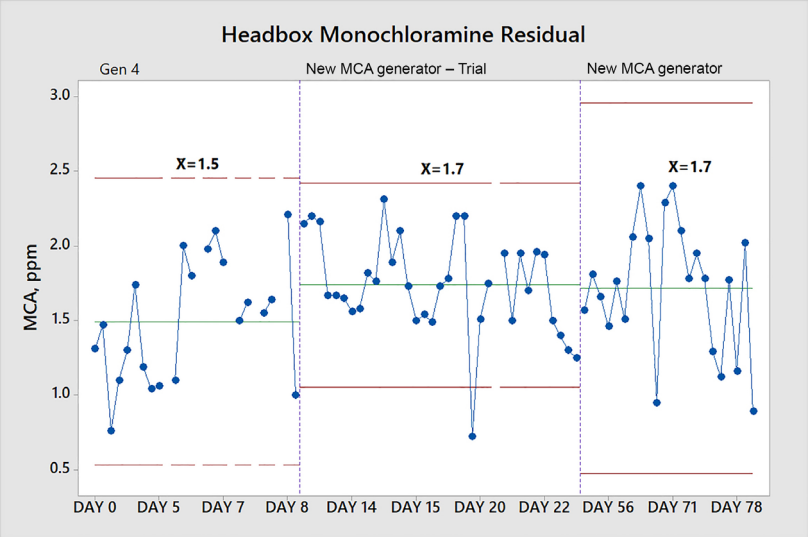

Figure 1. Phase 1 Trial Evaluation Headbox MCA Residual. Similar MCA residuals were achieved during both periods when the performance of the new MCA generator was compared with the older generator.

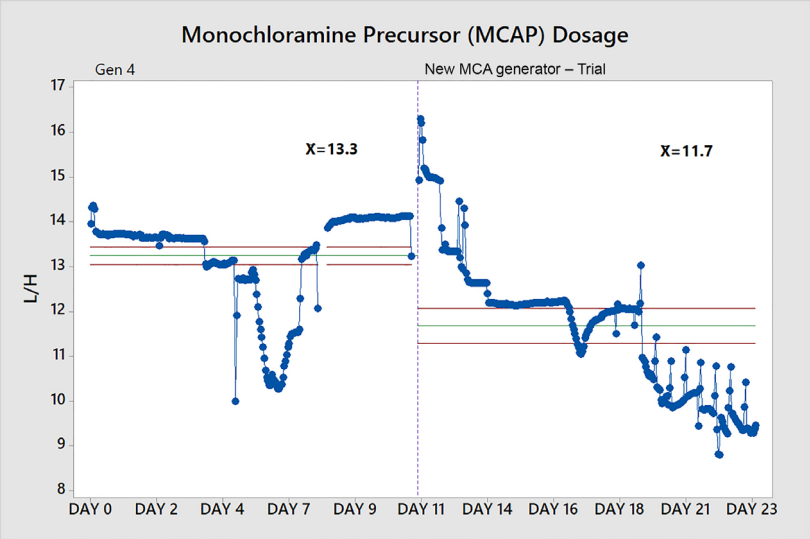

Figure 2. Phase 1 Trial Evaluation of MCAP Dosage Rate. The MCAP chemical flow rate was reduced while maintaining a similar headbox MCA residual (Figure 1) when the new MCA generator was compared with the older generator.

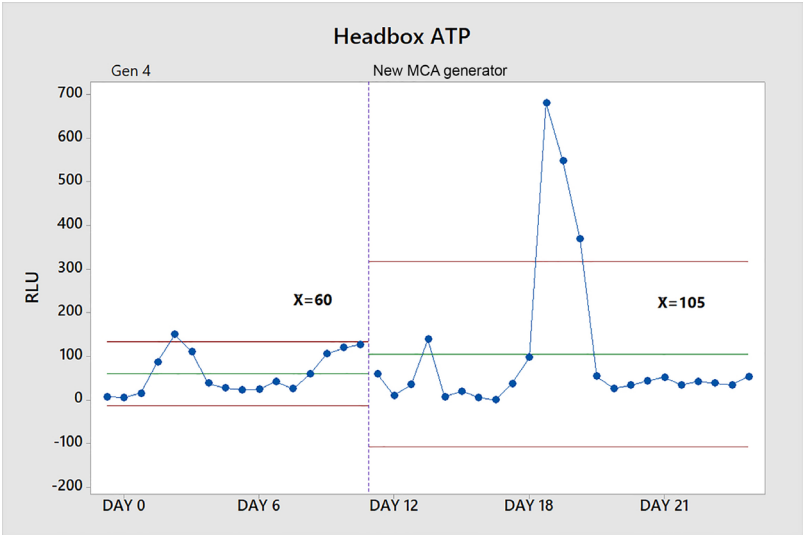

Figure 3. Phase 1 Trial Evaluation of Microbial Control via Adenosine triphosphate (ATP) Analysis. The original MCA program using the older generator achieved headbox ATP numbers well below the mill's established upper limit of 500 rlu. The new MCA generator produced similar results. The three outliers occurred after an unplanned down and correlate to slightly lower MCA headbox residuals during the same time period (Figure 1).

	Older MCA Generator	New MCA Generator	Difference	% Change
Headbox MCA Residual, ppm	1.5	1.7	+0.20	13.3
MCAP Flow Rate, LPH	13.3	11.7	-1.6	-12.0

Table 1. Summary of key findings from Phase 1 Trial Evaluation

The goal for Phase 2 was to utilize two of the MCA generator's key features, a proprietary automated ratio control of the chemicals and PID (proportional–integral–derivative) flow control valves, for continued optimization of the biocide program. Results are summarized in Table 2. During Phase 2, MCA headbox residuals were maintained at 1.7 ppm (Figure 4) while the flow rate of the MCAP was further reduced (Figure 5). Through the use of the automated ratio control, the new MCA generator adjusted the MCAP : sodium hypochlorite ratio in real time. This maintained the proper 1:1 molar ratio of both chemicals to produce a very stable MCA molecule. The addition of PID flow control valves eliminated drifts which can occur with the use of manual flow valves. A comparison of the water booster pump variation over a 12-hour period between the new MCA generator and the older generator is shown in Figure 6. The PID flow control valves in the new unit reduced flow variation by 75%. This translates to having the right amount of MCA chemistry in the process at the right time.

	Older MCA Generator	Optimized new MCA Generator	Difference	% Change
Headbox MCA Residual, ppm	1.5	1.7	+0.20	13.3
MCAP Flow Rate, LPH	13.3	10.7	-2.6	-19.5

Table 2. Summary of key findings from Phase 2 Trial Evaluation

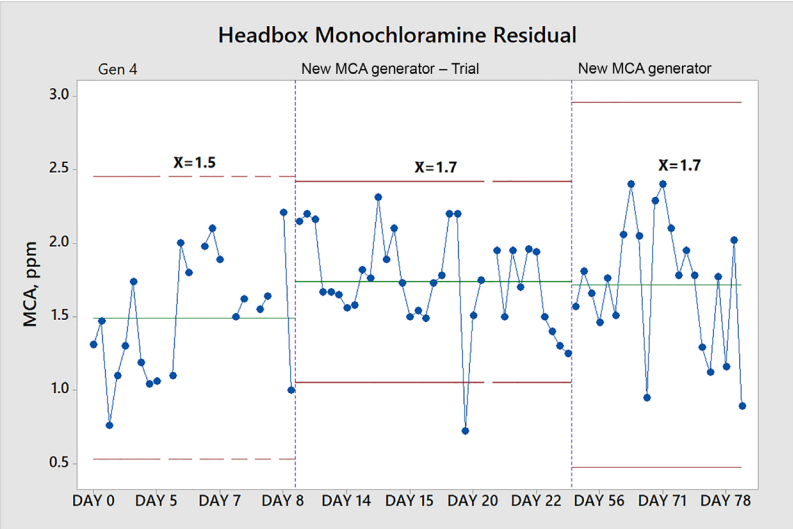

Figure 4. Phase 2 Evaluation of Headbox MCA Residual. The headbox residuals were maintained during this optimization phase while the MCAP flow rate was further reduced (Figure 6).

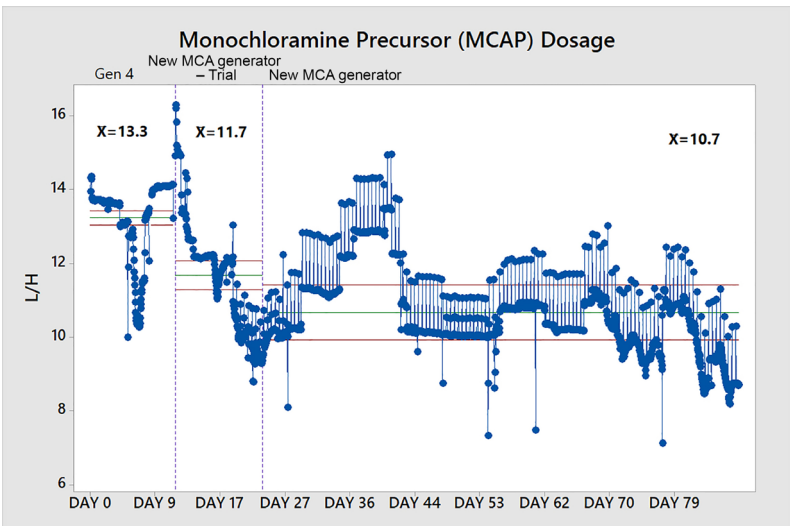

Figure 5. Phase 2 Evaluation of MCAP Dosage Rate. Further reduction in the MCAP chemical dosage rate was achieved while the MCA headbox residuals were maintained (Figure 4).

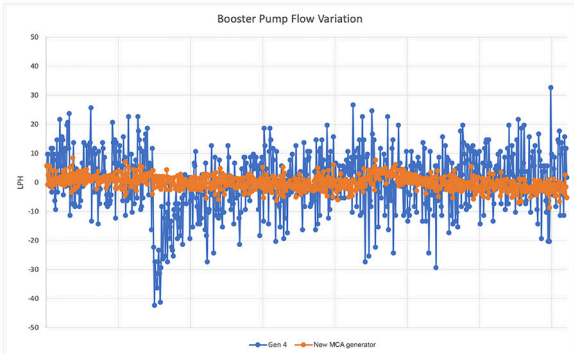

Figure 6. Phase 2 Evaluation of the PID Flow Control Valves. The water booster pump variation over a 12-hour period was compared between the new MCA generator and older generator. The use of PID flow-controlled valves on the new unit reduced flow variation by 75%.

Phase 3's goal was to reduce variability in the established KPIs for the biocide program by using advanced control modes on the new MCA generator. This was accomplished by using two of the mill's process variables to continuously adjust the MCA flow rate. Thus, the MCA dosage would constantly adapt in real-time to the changing mill process conditions. Paper machine production rate and machine grade process signals were sent via 4-20mA analog signals to the unit. Biocide program performance for the new control mode was defined as variability of headbox MCA residual and headbox ATP. To accurately compare the impact of this advanced control mode on the KPIs, the MCAP chemical usage was kept the same for both the baseline and advanced controls. Results of the advanced control dosing mode compared with baseline dosing mode (used in Phases 1 and 2) are shown below in Table 3 and Figures 7-8.

Although the average headbox MCA residual was approximately identical for both evaluation periods (Figure 7), the standard deviation for the advanced control (0.3 ppm) was significantly lower than the baseline period (0.4 ppm). This represents a 31% reduction in variability. As measured by headbox ATP, both the basic and advanced control

modes provided microbial control; ATP levels were well below the mill's requirement of <500 rlu (Figure 8). However, the advanced control mode greatly reduced both the variability and level of headbox ATP. The ATP during the advanced control mode was 66% lower compared to the baseline period.

Key Performance Indicator, KPI	Control Method	Mean	St. Dev.
Headbox MCA, ppm	Baseline	1.6	0.4
	Advanced	1.5	0.3
Headbox ATP, rlu	Baseline	139	111
	Advanced	47	35

Table 3. Summary of key findings from Phase 3 Trial Evaluation

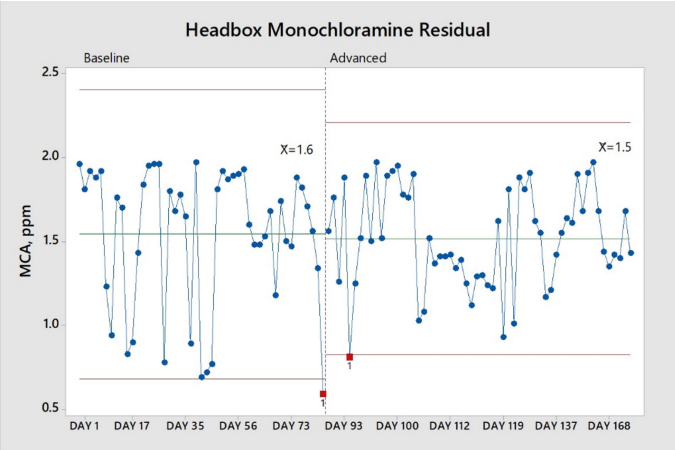

Figure 7. Phase 3 Evaluation of Headbox MCA Residual. Headbox residuals were comparable for both the baseline and advanced control dosing modes; the standard deviation for the baseline was 0.4 ppm compared to 0.3 ppm for the advanced control period.

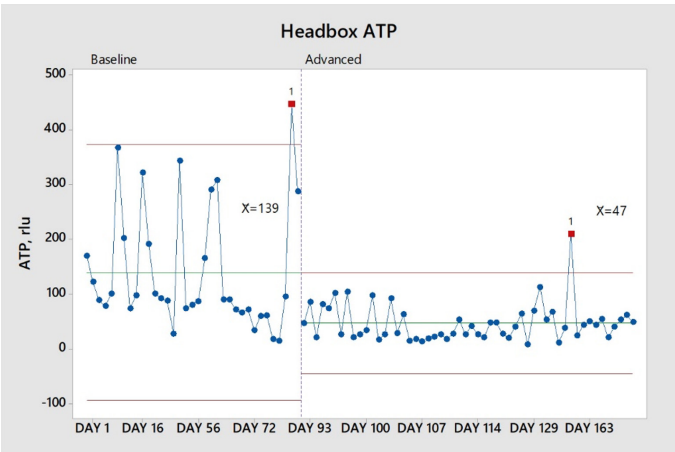

Figure 8. Phase 3 Evaluation of Headbox ATP. Although both control modes resulted in headbox ATPs below the mill's requirement, reduced variability was achieved with the advanced control dosing mode.

Conclusion:

If an MCA program does not use some form of feedback control, manual adjustments to application flow rates must be made to maintain target MCA residuals and other microbial KPIs. Process responses to these changes may take hours or longer. Large variations in MCA residuals may occur, allowing opportunities for microbial growth on the paper machine and thus quality and runnability issues. Biocide usage is then increased to bring KPIs back to target levels. This type of control is reactive rather than proactive. By adapting to changing process conditions, the advanced dosing controls on the new MCA generator reduced the variation in both the headbox MCA residual and ATP values. This eliminated periods of elevated microbial activity (as measured by ATP) and low MCA residuals which allowed fewer opportunities for microbial-related deposition on the paper machine and thus reduced sheet defects and other runnability issues. For this case history, machine production rate and machine grade process signals were used for advanced dosing control to one application point. The new MCA generator allows for the use of multiple inputs to any application point, customizing the MCA program to fit the mill's process. without additional programing from the mill.

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