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# Corrugator Wastewater Reuse Results

The corrugating facility installed a DMP system in 1996 to treat the flexographic wastewater consisting of starch from the corrugating operations as well as rinse water from the ink applied to the corrugated boards. The waste treatment system consists of a 500 gallon Collection Tank, (2) 5,000 gallon Reactor Tanks with mixers, a filter press, and a 6,000 gallon Treated Water Tank.


The treatment process was designed to operate in 5,000-gallon batches. The wastewater was pumped from the facilities 3 sumps into the Collection Tank. The wastewater is pumped to either Reactor Tank alternating from one to the other in sequence. The DMP control system automatically operates the mixers and chemical addition for the Reactor Tanks. The batch treatment process involves the use of ferric chloride (coagulant), caustic (sodium hydroxide), and an anionic flocculant (polymer). The typical treatment required 35 gallons of ferric chloride, followed by 10-15 gallons of caustic and then 1 gallon of neat anionic polymer (added in 1% solution equates to 100 gallons).

The chemicals are added and the flocculated wastewater is allowed to settle and switches to the dewatering step. The dewatering step involves the addition of 1-1/2 bags of diatomaceous earth as a filter pre-coat (helps the sludge cake release from the plates as well as a filter enhancer) and then the treated batch is pumped to the Filter Press. The Filter Press acts as a filter, filtering the wastewater which then goes to the Treated Water Tank as well as dewaters the sludge.

The treated water in the Treated Water Tank is then reused in the plant as water makeup for the starch. The formulation of the starch varies with each plant, but the basic formulation is the addition of cornstarch with caustic forming gelatinous milky white glue. The starch is then pumped over to the corrugator and added to the bath under the glue rolls. As the glue rolls rotate, they pick up the glue and transfer the glue to the paper sheeting prior to the actual corrugator. The corrugation operation requires heat to quickly setup the glue, the faster the bond, the faster the speed the corrugator can be run. If the glue gel temp is high, the corrugator needs to run at a higher temperature or run slower to allow the glue to setup.

**Operations**

The reuse of the treated water caused problems for the corrugator operations. This was seen in the form of scale buildup on the glue rolls in the corrugator, uneven glue lines, delamination of the corrugated board, and unacceptable quality of the finished product. In addition, the average gel temperature of the starch was 152 degrees F. Even with the

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addition of up to 40 lbs of caustic, the gel temperature would remain at 152 degrees F. As the starch aged in the starch tank, the gel temperature would rise even higher.

To remove the scale, the glue rolls had to be hand cleaned to remove the buildup. The scale was sent out for analysis and it was determined that it contained 70.5% calcium carbonate. In addition, the reuse water had an orange appearance caused from the post precipitation of iron oxides from the coagulant, ferric chloride. The scale buildup caused the non-uniform glue lines and decreased the runtime for the corrugator as scale removal required periodic shutdowns.

**Reuse Water Quality**

The reuse water was inconsistent in water quality for pH and water clarity. The reuse water (after treatment) has these characteristics:

| Constituent | Concentration |
|---|---|
| Total Hardness | 1,075 ppm |
| Calcium Hardness | 326 ppm |
| Magnesium | 63.5 ppm |
| Total Alkalinity | 1,500 ppm as $CaCO_3$ |
| TDS | 8,000 uOhms |
| Sulfite | 1.0 ppm |
| Sulfate | 0.075 ppm |
| Silica | 2.1 ppm |
| Phosphate | 0.12 ppm |
| BOD | 81,000 ppm |
| Mold | 1,500 cfu |

**System Investigation**

After struggling with the system and trying varying ratios of reuse water and micro biocides to decrease the bacterial deposits on the glue rolls, the facility Manager requested the assistance of Integrated Engineers, Inc. to evaluate the system.

The initial investigation looked at the reuse water quality and how this could be improved with their existing wastewater treatment system. After a review of the water reuse water quality, it was determined that the high levels of conductivity (ions in the reuse water), calcium, and total hardness were the core of the glue roll scaling, high gel temperature of the starch, and variable finished water quality.

At the request of the plant manager, Integrated Engineers, Inc. interviewed the wastewater operator, the starch room operator, the corrugator supervisor, and other key staff to determine the depth of the problems due to the reuse water quality.

Simultaneously, a trial was started using Integrated Engineers, Inc. Floccin-D product, which has good success at other corrugating facilities, especially in reuse systems. The Floccin-D was fed with an automatic feeder at a dosage of 125-lbs/5,000 gallon batch.

**Source of Ions in Flexographic Wastewater**

Flexographic wastewater is a combination of water and ink. The inks contain sodium bicarbonate as filler as well as other components starch from corrugator process. The starch is comprised of starch, borax, caustic and preservatives.

**Water Stability**
The formation of scale on the glue rolls can be explained by looking at the water stability indices, similar to those used in boiler water treatment. This approach is supported by the fact that the scale on the glue rolls was 70.5% calcium carbonate.

Calcium carbonate scaling and deposition rates increase as the temperature increases. At room temperature, the scale formation required 4 hours to show buildup. Over on the corrugator, the higher temperature allowed the scale to buildup faster, causing the glue rolls to not transfer the glue uniformly to the paper.

The use of the ferric chloride as the coagulant dropped the pH down 2-3, which was raised with caustic. The fluctuations in the pH and alkalinity produce unstable reuse water that has even higher scaling tendencies. To compound this problem, the use of the ferric chloride with caustic (sodium hydroxide) created finished water with high levels of sodium chloride (brine water). The high level of ions adds to the instability of the starch and the result of additional caustic not affecting the gel temperature.

**The Trial using Floccin-D**
Flexographic wastewater is a combination of ink and residual starch from the starch room as well as from the corrugator. The inks tend to be an emulsion that 'breaks' at a pH of 5.8. Starch is easily treated at a pH of 10.3. There is usually a combination of the 2 types of wastewater (ink/starch) so it was determined that the treatment worked best at a pH of 6.8-7.0.

The addition of the Floccin-D required some small changes in the system operations. It was determined that the Floccin-D worked best at a dosage of 125 lbs. The addition of caustic was only used to raise the pH to 6.8 just prior to the addition of Floccin-D. After mixing for 15 minutes with the Floccin-D, the dewatering step was started. The Filter Press was not pre-coated with DE since the Floccin-D had good dewatering characteristics. The resultant water quality was far superior in both clarity and consistency for treatment. In addition, the sludge cake was much drier than the previous chemistry (without using DE as a pre-coat), allowing the operator to clean the press in 45 minutes versus 3 hours.

**Trial Results**
The goal for the trial was to achieve reuse water with a lower conductivity, hardness, and alkalinity. This would decrease the gel temperature of the starch allowing the starch to setup faster and thereby allowing the corrugator to run at a faster speed increasing the output of the facility.

Within 1 week, the conductivity dropped from 8,500 uOhms to 3,000 uOhms, 62.5% decease in the ions. (Test results are pending)

| Constituent | Before | After Floccin-D | % Change |
|---|---|---|---|
| Total Hardness, ppm | 1,075 | pending | |
| Calcium Hardness, ppm | 326 | pending | |
| Magnesium, ppm | 63.5 | pending | |
| Total Alkalinity, ppm as $CaCO_3$ | 1,500 | pending | |
| TDS, uOhms | 8,000 | 3,000 | 62.5% |
| Sulfite, ppm | 1.0 | pending | |
| Sulfate, ppm | 0.075 | pending | |

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| | | | |
|---|---|---|---|
| Silica, ppm | 2.1 | pending | |
| Phosphate, ppm | 0.12 | pending | |
| BOD, ppm | 81,000 | pending | |
| Mold, cfu's | 1,500 | pending | |

**Reducing the Number of Chemicals**
The use of the Floccin-D reduced the chemicals used down to 2 (caustic and Floccin-D) as compared to 4 chemicals (ferric chloride, caustic, anionic flocculant, and diatomaceous earth). In addition to simplifying the treatment steps, the reduction of chemicals minimizes the exposure of the facility staff.

**Starch Gel Temperature**
The gel temperature dropped from 153 degrees F to 145 degrees F within the first week of using the Floccin-D. The viscosity was easier to control and stabilized over several hours requiring less, if any caustic addition in the starch makeup operation. Traditionally, the older chemistry required the addition of 40 lbs. of caustic to keep the gel temperature at 153 degrees F and the viscosity stable until it could be used in the glue rolls. The reduced gel temperature resulted in a more uniform finished product, no de-lamination, and increased corrugator output.

**Cost Comparison**
The traditional chemistry and diatomaceous earth (filter press aid) cost $0.035/gallon to treat. The Floccin-D treatment cost an average of $0.025/gallon and did not require the DE as a pretreatment to the sludge. The savings in labor was also significant with reduced time spent cleaning the filter press and elimination of the DE and the water premix and pre-coat step.

**Conclusion**
The result of using the Floccin-D product over the past 4 months has allowed the staff to maintain a low gel point and improved starch control. They are now able to operate the corrugator at a lower temperature, thereby saving energy costs in the boiler with reduced steam demand. The improved starch quality has decreased the de-lamination problems and has directly increased the monthly output from the operations. The reduced scale on the corrugator glue rolls has improved the production time by minimizing down time to de-scale the rollers or lost board due to poor lamination characteristics.

In the recent heat wave this summer, the facility normally had to run the corrugator at a much higher temperature with poor glue lamination and board quality. With the Floccin-D reuse water and the reduced gel temperatures, the summer heat wave (summer of 2001) did not cause any production upsets or finished corrugated board problems and they maintained good quality and strong corrugator board production rates.

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