IOA/PAG AGRI-FOOD TASK FORCE

USER SUCCESS REPORT

TITLE: **OZONE FOR TREATMENT AND STORAGE OF GRAIN – Harvest States Amber Milling, Huron, OH, USA**

ABSTRACT:

Mold and bacteria in grain traditionally are addressed by the use of chlorinated water. However, this technique frequently is inadequate for removing these harmful materials allowing tempering bins, holding containers, and processing lines to become contaminated and have to be cleaned. This requires complete shutdown of the plant and results in production and financial losses. Elevated bacterial and mold counts sometimes cause final products to fail to meet client microbial standards. Returned shipments can cost up to $5,000 per rail car plus reprocessing costs. Chlorine also causes corrosion in metal parts in the mixing and grain transfer equipment and is a hazardous chemical to store and handle. Furthermore, chlorine chemically reacts with some materials and organics, and the resulting chlorinated compounds sometimes remain in the final product as contaminants. A project sponsored by the Electric Power Research Institute (EPRI) at Harvest States Amber Milling demonstrated that ozone and ultraviolet radiation overcame the problems encountered with chlorine use, and resulted in significant cost savings to the plant as well.

A. DESCRIPTION OF THE PROBLEM

Grain is produced by plants growing in open fields and, as such, arrives at a processing mill carrying some foreign matter in addition to plant leaves, dust, and stalks. The milling process separates the grain from the other material and grinds it into flour. Chlorinated water normally is used to control bacteria and mold during the process.

Milling begins with the grain being mechanically separated from stalks and foreign matter. The next step is to increase the moisture content of the grain. This is necessary because hard wheat is too dry to grind into flour. Consequently, water is added to bring the grain's moisture content up from about 12 percent to approximately 15 percent (this latter number varies within the industry). Moisturizing is accomplished via automated temper systems, which are large augers that mix and move the grain while a carefully regulated stream of water is added. The test plant had three augured temper systems.

Chlorine is added to the water to control bacteria and mold which typically are present in the grain. At the test plant, chlorinated water (450 ppm) is applied at a flow rate of four gallons per minute in each temper system, or a total of 12 GPM for the three units together. The temper systems convey the moistened grain into large concrete tempering tanks or bins, which are approximately 45 feet high and 8 feet in diameter. The grain flows continuously, and residence time in the bins is approximately 18 to 24 hours, which allows the water to be absorbed. Next the grain is conveyed through tubes to the wheat rolling mill where the grain is abraded to loosen the bran, which then is separated by sifters and air purifiers. The grinding continues until the grain reaches the proper level of fineness, at which point it is packaged or shipped in bulk.

1. Problems With the Current Process

- ***Contamination of grain prior to and during processing***
  Wheat and other grains collect dust, insects and other foreign matter – such as insects, soil, and feces – in the fields where they are grown. When the wheat is harvested, inevitably some foreign matter accompanies the grain and plant material. The grain is exposed to additional contamination from bacteria and foreign material through transportation vehicles, storage containers, fertilizers, rain, and moisture in the air. The result is a potentially high level of bacteria and mold on the preprocessed grain surfaces. Further exacerbating the problem is the necessary addition of water to the grain to increase its moisture content, creating warm, moist tempering conditions prior to milling. This moist grain supports growth of mold and bacteria. It is to combat these inherent problems of contamination that grain processors treat the grain with chlorinated water during the tempering process when water is added to the grain to increase its moisture content.

- ***Effectiveness of chlorine treatment***
  Although problems of mold and bacteria in grain traditionally are addressed by the use of chlorinated water, this technique frequently is inadequate for removing these harmful materials. As a result, tempering bins, holding containers, and processing lines become contaminated and have to be cleaned. This requires complete shutdown of the plant and results in production and financial losses.

- ***Returned shipments***
  In addition, elevated bacterial and mold counts sometimes cause final products to fail to meet client microbial standards. Returned shipments can cost up to $5,000 per rail car plus reprocessing costs.

- ***Other problems***
  Chlorine is a reactive chemical and causes corrosion in metal parts in the mixing and grain transfer equipment. In addition it is a hazardous chemical to store and handle. Furthermore, chlorine chemically reacts with some materials and organics, and the resulting chlorinated compounds sometimes remain in the final product as contaminants. Some of these compounds, trihalomethanes (THMs) have suspected carcinogenic properties.

This project, supported by the Electric Power Research Institute (EPRI), showed that the combination of ozone (generated by UV radiation) plus UV radiation is an economical replacement for chlorinated water currently used for bacteria and mold control in this wheat processing plant.

B. DESCRIPTION OF PLANT OR PROCESS

The project was installed at the Harvest States Amber Milling plant in Huron, OH, USA, and was designed to test the effectiveness of ozone (generated by corona discharge and by UV radiation at 185 nm and applied simultaneously with UV radiation at 254 nm) as an antimicrobial agent for flour milling. Ozone was used in three ways in the project:

- in steeping water applied to wheat during the flour milling process (CD-generated ozone)
- in gaseous phase in conjunction with UV light and hydroxyl radicals during tempering (Figure 1)
- in gaseous phase as a facility-cleaning agent for further bacteria and mold control.

A plant survey and evaluation of the existing process was made in 1999. The project began early in 2000 with process design, equipment specification, and installation performed by RGF Industries (West Palm Beach, FL, USA). Testing of the ozonation process began in May 2000 and was continuing at the time of this detailed report (Chester et al., 2000).

Figure 1. UV hood in grain plant in combination with UV/ozone system. Left side = closed; right side = open (courtesy of RGF Industries). Note the UV bulbs in the open cover (right side).

C. DETAILS OF OZONE SYSTEM AND APPLICATION

The treatment system used in the study consisted of ozone (generated by corona discharge, absent UV radiation) treatment supplemented by "photo-ionization" (a term coined by RGF Industries), delivering both ultraviolet light and ozone to create hydroxyl radicals for the control of microorganisms, mold, and yeast on the wheat grain and the processing equipment. The system has three major components:

- A skid-mounted corona-discharge ozonation system with a dry air feed to dissolve ozone in the water used to temper the grain.

  This system is placed adjacent to the existing water tank. It is sized to provide sufficient ozone for 12 to 15 GPM – 4 GPM for each of the three temper systems, even though it was used to supply only one tempering auger during this study. The major components of the system include a corona discharge ozone generator with pressure swing adsorption air drying system, venturi mixer, chlorine destruction filter, ozone destruction for ozone off-gas, recirculating stainless steel pump/motor assembly, and pressurized contact vessel. An integrated dual metering system is used to measure and control the levels of dissolved ozone in the water and to measure and control the levels of ozone present in the ambient air.

- A stainless steel photo-ionization chamber mounted over the grain-mixing auger to supply UV light and UV-generated ozone (Figure 1).

  The purpose of this combined system (as stated by RGF Industries) is to create hydroxyl radicals to attack the surface of the grain. The ionization hood consists of a series of UV/ozone emitters shrouded for protection in an FDA-approved plasticized shroud targeted on titanium dioxide (TiO_2). The hoods are hinge-mounted to the top of the existing temper augers and employ a safety system to automatically shut down the UV lamps if the hood is opened by plant personnel.

- An ozone generator to supply gaseous ozone in elevated concentrations to the grain storage tempering bin and the roll bin to suppress bacteria and mold growth.

  A dried air-fed corona discharge system generates the ozone gas and delivers it to the application points via Teflon tubing. It too is accompanied by a dual metering system to monitor ozone levels in the bin as well as in ambient air surrounding the bins.

Evaluation and Data Gathering

To determine the effectiveness of ozone treatment, more than 1,000 samples of flour ready for shipment were evaluated. These samples were tested for total plate count bacteria. To establish a base of comparison, 365 of the samples were taken from flour processed using traditional chlorinated water disinfection. The remaining 650 samples were taken from flour processed using ozone disinfection. Figure 2 summarizes the many data points obtained during this study.

Because the Harvest States plant does not perform mold counts, visual inspections were used to determine the effectiveness of ozone for mold control in comparison to chlorinated water. In addition to microbial analysis and mold estimation, the study evaluated operation of the plant using ozone water *versus* chlorinated water.

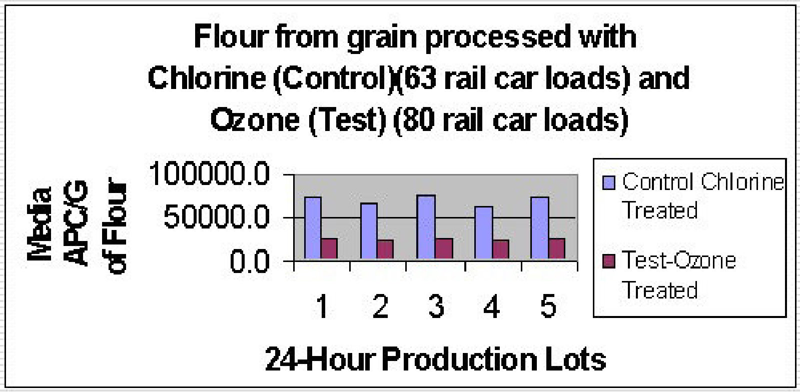

Figure 2. Summary of test data from grain mill study (Chester et al., 2000).

D. CASE STUDY INFORMATION

1. RESULTS -- ANTIMICROBIAL ACTION

Data gathered during the project indicate a potential 75 to 80 percent reduction in total plate count bacteria in comparison to conventional treatment with chlorinated water. The anaerobic plate count (APC) of one group of flour samples from grain treated with chlorinated water averages 181,675 cfu/g. In comparison, the average APC for flour from ozone-treated grain was 42,627 cfu/g, a reduction of 77 percent. Later data on 195 samples of flour processed during late July and August had 75 lots (38%) with APC of less than 10,000 cfu per gram.

Although, the project did not include mold counts to quantify the effectiveness of ozone over chlorine in mold abatement, visual inspection of equipment and lines by plant staff indicated a similar reduction of mold growth in the equipment.

2. COST SAVINGS / ROI

According to RGF, the company supplying ozonation and UV equipment for the project, there is a cost savings of about $40,000 per year by using ozonation and UV in place of chlorination. (Electrical costs to operate the ozone system are $0.18 per hour or approximately $1,600 per year.) ***This rate of savings would pay out the capital investment in the ozonation and UV equipment in 30 months***. This analysis does not include potential additional savings from some reduction in maintenance and plant downtime previously needed to remove mold from lines and equipment, and costs for reprocessing grain failing to meet microbial standards.

E. EMPLOYEE HEALTH & SAFETY ISSUES

The hoods are hinge-mounted to the top of the existing temper augers and employ a safety system to automatically shut down the UV lamps if the hood is opened by plant personnel, thus avoiding inadvertent exposure of plant personnel to ultraviolet radiation.

The levels of ozone in the work place at the points of application are monitored by ambient ozone monitors designed to effect complete system shutdown if excess levels of ozone are sensed.

F. ADDITIONAL COMMENTS

Equipment Compatibility

The ozone system is located on the top floor of the flour mill near the existing chlorine tank. The ozone gas and water plumbing go to the floor below where the grain processing and storage equipment are located. The ozonation system is completely independent of the plant chlorine system so the plant still has access to this method of sanitation.

G. SUBMITTER – JOB TITLE – CONTACT DETAILS

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H. REFERENCE(S) – ARTICLE(S) – AS APPROPRIATE

Chester, T., Graham, D., Schwartz, C., and Sopher, C., “Ozone and UV for Grain Milling Systems”, EPRI, Palo Alto, CA, 2000. EPRI Report No. 1000591 (2000).

Rice, R.G., “Recent Studies on Ozone and UV Combinations for Food Processing Plants in the USA”, paper presented at IOA/Pan American Group Annual Conference on "Advances in Ozone Technology", Newport Beach CA., May 5-9, 2001, Session 7 – Food Applications of Ozone.

I. DISCLAIMER

R.G. Rice – 1 Sept. 2006