Using Ozone to Treat Grain

Methods being researched to help lead the way to larger scale treatments.

This article is based on information suppled by Dr. Carlos Campabadal, outreach specialist in feed manufacturing and grain storage and faculty member, International Grains Program, Kansas State University (KSU), Manhattan (785-532-3187) who has been researching ozone treatment of grain. This also is a companion article to the Ozone Status Report, *which appeared in the First Quarter 2012 issue of* Milling Journal.

The necessity of finding safer alternatives for grain protection has created a keen interest about research in using ozone to treat stored products.

Ozone is a gas slightly heavier than air which is composed of three oxygen atoms which can be generated artificially by circulating air through a high- voltage electric arc and introduced to the grain storage structure or handling equipment at a constant rate.

Ozone is a high-oxidizing agent that will react, when it is in contact with any organic molecule. Therefore, with its strong sterilizing properties, it can reduce contamination of fungal spores and toxins located in the outer surface of the grain kernel.

Carlos Campabadal

Also, it effectively can kill adult stored-product pests located in storage structures and reduce the volatile compounds present in grain that can cause rejections for off-odors.

Field research projects developed in commercial food-grade facilities and on-farm grain storage structures by Purdue and Kansas State University researchers have showed that an effective concentration-time product (CTP) of ozone can effectively eradicate 100% adult insects present in the grain mass, plus reduce fungal spores present on the grain surface, compared with a similar treatment using phosphine fumigation. ►

At left is a mobile unit that can generate ozone gas on site using electricity. Research has been conducted on treating grain with ozone in 10,000-bushel-capacity, on-farm bins to effectively control insects. Photo supplied by O3Co.

Potential of Ozone

Presently, a milling operation can use ozone as part of an Integrated Pest Management program to control pests in stored wheat by using modified grain handling equipment (e.g., screw conveyor or belt conveyor) or by treating it in layers when loading a grain bin.

Another option is to treat the grain in smaller 10,000-bushel-capacity grain bins using fixed-bed ozonation and a CTP of ozone.

Unfortunately, the size of grain storage bins at mills is too big for current ozone technology to treat large volumes of grain rapidly and all at once. Also, the size of the ozone generators available commercially need to be increased to handle and treat bigger grain bins.

However, ongoing research will help develop grain handling equipment that can be used in a continuous ozonation process to treat grain at faster rates.

These issues will be dealt with successfully in the very near future, which will provide millers with a very effective tool to treat grains quickly and economically.

What follows are some highlights of the research work being conducted at Purdue and Kansas State universities.

Ozone Treatment Methods

Among the big advantages of ozonation observed during treatment trials compared to traditional fumigation for pest control are that the ozone gas can be generated at the treatment site, and no residue is left on the treated product.

An initial treatment of fixed-bed ozonation was developed to treat grain in on-farm grain bins by introducing it through the grain mass using forced air at a minimum air velocity of 0.03 meters per second (m/s), until the right CTP is reached.

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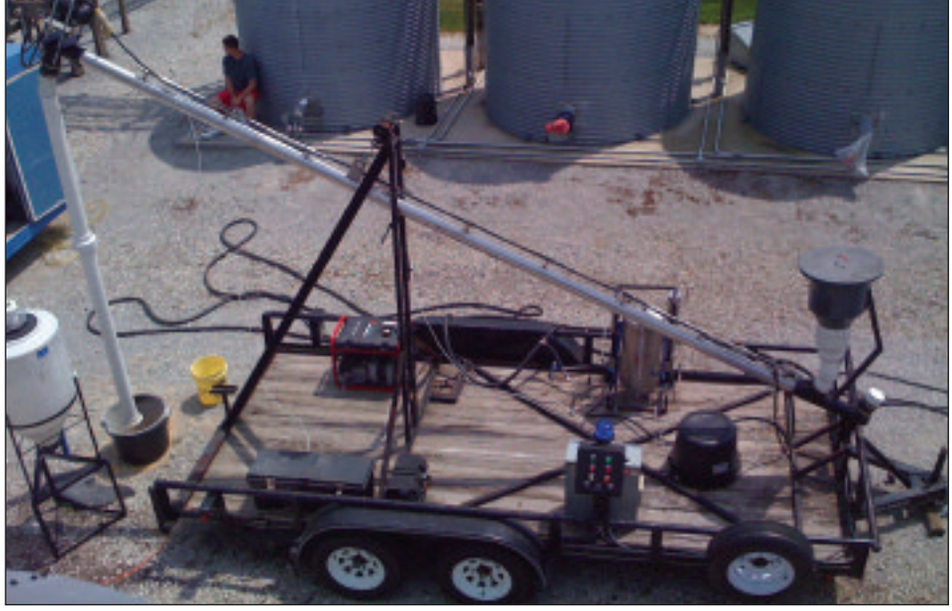
>
> - Carlos Campabadal, outreach specialist, Kansas State University

As the ozone reacts with the grain mass during the treatment, a recirculation system is needed to help capture the gas and to keep it from exhausting into the environment.

As mentioned earlier, due to the production limitations of current ozone-producing generators, there is a limit to the size of grain bins that can be ozonated.

Consequently, more efficient ozonation treatment systems were ▶



The continuous-ozonation flow system consists of applying high concentrations of ozone through a modified screw conveyor in the same flow direction of the grain going into a bin. Photo supplied by Carlos Campabadal and Lynntech, College Station, TX.

developed such as a semi-continuous counterflow ozonation system and a continuous-ozonation flow system, in order to treat grain at a continuous rate and sterilize any fungal spores and eradicate insects. These systems offer a faster treatment time compared to the current fixed-bed treatment method.

Semi-continuous Counterflow System

The semi-continuous counterflow ozonation system's design was based on an in-bin, continuous-flow dryeration system used for on-farm grain drying.

These drying systems included tapered unloading augers in the grain silo floor. The auger is capable of unloading a 6- to 12-inch layer of grain after it completes one full revolution inside the bin.

For a semi-continuous counterflow ozonation treatment, the procedure involves removing the bottom grain layer after it reaches the desired ozone concentration to achieve insect mortality, mold reduction, and/or removal of off-odors.

The treated grain is subsequently transported to a semi-truck trailer, grain wagon, or second storage silo. At the same time, an equal amount of untreated grain from another silo is added on top of the grain surface in the bin receiving ozone treatments. This is done so that a constant grain depth can be maintained during the treatment process.

During a treatment, the system's control variables include: air flow, ozone mass flow, and exposure time.

• **Air flow**: This is controlled by a variable-speed fan equipped to deliver at least the minimum air velocity of 0.03 m/s to move ozone through a grain mass but without causing the ozone to become too diluted in the bottom grain layer.

• **Ozone mass flow**: This is controlled by the ozone-producing generator. Presently, the only safe method to control this variable is by shutting down one or more of the four chambers of the ozone generator. The newer generators now have a built-in device to control ozone production and flow more efficiently.

• **Exposure time**: The exposure time of the grain to ozone is controlled by determining the CTP, as a function of the ozone concentration, at each grain layer depth needed for the desired treatment effect (e.g., odor removal, fungi sterilization, and insect mortality).

Once the desired CTP is achieved and maintained, the tapered unloading auger is programmed to remove the bottom treated grain layer.

Continuous-ozonation Flow System

The continuous-ozonation flow system consists of applying high concentrations of ozone through a modified screw conveyor in the same flow direction of the grain going into a bin. This method is necessary to achieve the desired CTP for insect eradication.

The treated grain at the end of the modified grain-loading screw conveyor flows into a pipe that leads to a receiving chamber for storage.

At the same time, untreated grain is moved continuously into the modified screw conveyor at a constant rate.

The control variables of this type of system include grain residence time and ozone mass flow.

• **Grain residence time**: The grain residence time is controlled by the rotational speed of the modified screw conveyor auger. This measurement is defined as the time it takes the first kernel introduced into the modified screw conveyor to come out at the other end, after it has been treated with ozone.

• **Ozone mass flow**: The ozone mass flow is controlled in the same way as in the semi-continuous counterflow ozonation system.

Overall, the uses of the different ozone treatment systems are alternative tools and proven technologies that can be incorporated into any grain quality management program to control stored-product pests and fungal spores in grain effectively.

Karl Ohm, editor