ENCON2.3
December, 2012
Fact Sheet

Continuous Flow Dryers

Cross Flow Dryers

One of the more popular continuous flow dryers is the cross-flow dryer. They are available in horizontal designs (Figure 1) and vertical or tower designs (Figure 2). In this type of dryer, airflow is perpendicular to grain flow. Heated air blows across the grain as it flows by gravity down an 8- to 18-inch-wide column. quality and value.

Figure 1: Horizontal cross-flow dryer. Source: Scott Sanford

The energy efficiency is a function of the plenum air temperature and the airflow rate, with the highest efficiency occurring at high plenum temperatures and low airflow rates (Figure 3). In practice, energy efficiency needs to be balanced with grain quality. The lower the air flow rate, the higher the grain moisture content difference between the grain kernels on the inside versus the outside of the column and the larger the temperature gradient. Many manufacturers have developed methods to mix the grain as it flows down the column to lessen the moisture variation at the dryer discharge. Controllers can be used that sense kernel moisture and regulate unloading augers as grain meets moisture set points. The efficiency will vary depending on air flow rate, plenum temperatures and heat recovery options. The range is typically between about 2000 Btu per pound of water removed with energy efficiency features in place to about 3000 Btu per pound of water removed for a well-maintained dryer with no energy conservation measures.

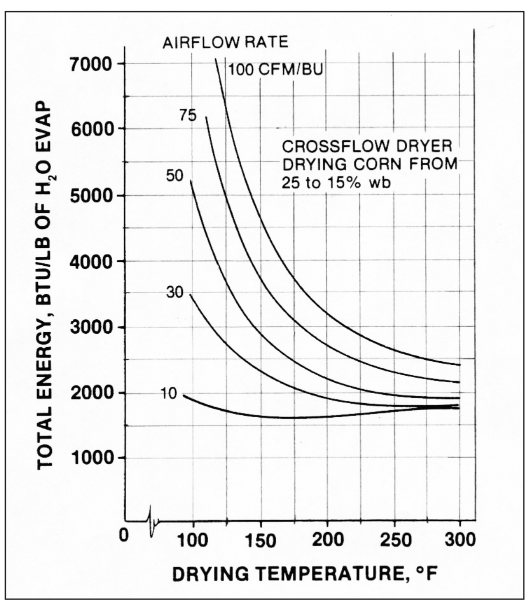

Figure 3: Cross-Flow Dryer Efficiency. Source: University of Nebraska

Figure 2: Tower cross-flow dryer. Source: Scott Sanford

Counter-flow Dryers

In a counter-flow dryer the grain flow and the airflow move in opposite directions. Typically this is an in-bin continuous flow dryer, which consists of a round bin with a full perforated floor and a sweep auger. Heated air is pushed up through the grain and the sweep auger removes grain when the control system indicates the grain has reached the desired moisture. Hot grain is moved to a cooling bin when it is discharged from the dryer (Figure 4).

One advantage of this dryer type is that wet grain can be piled on top of the drying grain, eliminating the need for a separate wet holding bin. However, increasing grain depth reduces drying rate and fan efficiency. Fine particles can hinder airflow through the perforated floor, so it is recommended that the grain be screened when filling the dryer. It is usually necessary to shut down the dryer every 3-4 days to remove fines that have accumulated on the floor to maintain proper airflow.

In-bin continuous-flow dryers are among the more efficient continuous-flow type dryers - about 2000 Btu per pound of water removed - which is about 20 to 30 percent more efficient than a traditional cross-flow dryer. This type of dryer can be retrofitted into an existing bin, and can be used to store grain at the end of the drying season. The last batch of grain would be dried with the dryer operating in a recirculation mode (Figure 5). The energy efficiency of this dryer can be increased by 10-15 percent using dryeration process for cooling the grain instead of in-bin cooling.

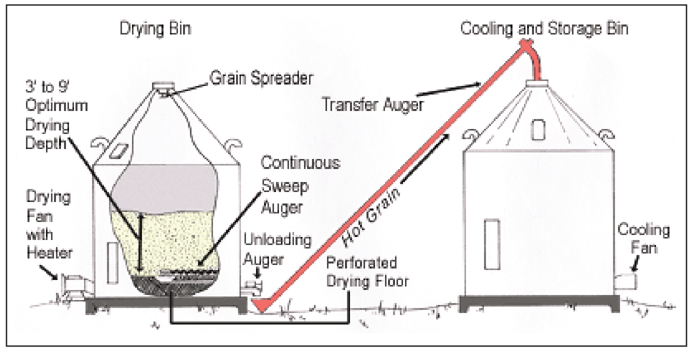

Figure 4: In-bin continuous-flow dryer and cooling/storage bin. Source: Scott Sanford

Figure 5: In-bin continuous-flow dryer with internal recirculation / discharge auger. Source: Shivvers

Mixed-flow Dryers

Mixed-flow dryers are column dryers that have airflow in both counter and concurrent directions (Figure 6). These dryers may have multiple zones (Figure 7) and, because the grain is not continuously exposed to high temperatures, they can use higher air temperatures than cross-flow dryers without damaging the grain. These dryers are usually self-cleaning and have energy efficiencies similar to a counter-flow dryer, using 20 to 30 percent less energy than a traditional cross-flow dryer without heat recovery. One major advantage of this dryer over one with a screen column (like a cross-flow dryer) is the ability to accommodate a wide variety of different grains from small rapeseed to corn. This type of dryer is popular outside of the U.S. but has not been accepted as readily in the U.S. corn growing regions, possibly due to slightly higher capital cost and lack of understanding of the advantage.

Cooling Options

Cooling grain in a dryer reduces drying capacity and rapid cooling in the dryer will cause kernels to stress crack, which may lead to lower value grain (more cracked kernels). Using the entire dryer for drying (full-heat dryer) and transferring the grain hot to a bin for cooling at a slower rate will save energy and improve grain quality. Grain can be transferred to a cooling bin at 1 to 3 percent moisture above the desired storage moisture level depending on the cooling method used.

For in-storage cooling (Figure 8), the grain is transferred to storage at 1 to 1.5 percent above the desired final storage moisture, which can save about 15 percent in drying costs and increase the dryer capacity by about 33 percent. For dryeration (Figure 9), the grain is transferred to a bin at 2 to 3 percent above the desired storage moisture, allowed to steep for 4 to 12 hours and then cooled with ambient air. This process can save about 25 percent in energy costs, reduce kernel stress cracks and increase dryer capacity by up to 70 percent. Condensation on the bin walls during dryeration is extensive, so it is imperative that the corn be moved to another bin for storage so the wet grain is mixed with dry grain. Condensation may also be a problem with in-storage cooling, particularly when outdoor temperatures are cool. This may lead to storage problems and corn adhering to the bin wall. Partial cooling in the dryer reduces the potential for condensation in the bin. See some of the resources below for more information on these processes.

Energy Efficiency Options

Some new dryers have energy-saving features such as grain turners, grain diverters, steeping sections, multiple metering rolls, heat recovery capabilities and computerized controls.

Grain turners move some of the grain from the inside of the column near the plenum to the outside and grain from the outside to the inside (Figure 10). The turner aids in reducing the moisture variation of the grain exiting the dryer. Without a turner, the grain near the plenum often gets over-dried while grain on the outside of the column is under-dried. A grain diverter works similarly, by allowing the grain on the inside of the column to move faster through the dryer than the grain on the outer side of the column (Figure 11). Some dryers use multiple metering rolls at the base of the grain column to remove the grain on the inside of the column near the plenum faster, providing results similar to diverters in reducing over drying.

A steeping section is an area where hot grain is allowed to pass down the grain column for a period of time without hot air being force through the grain.

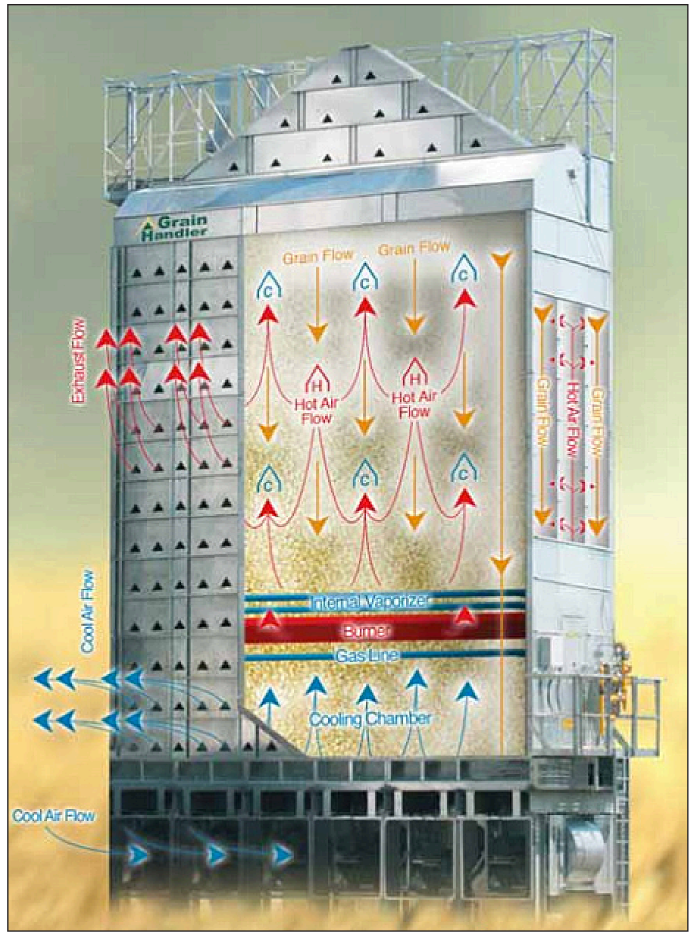

Figure 6: Mixed-flow dryer airflow pattern Source: Grain Handler

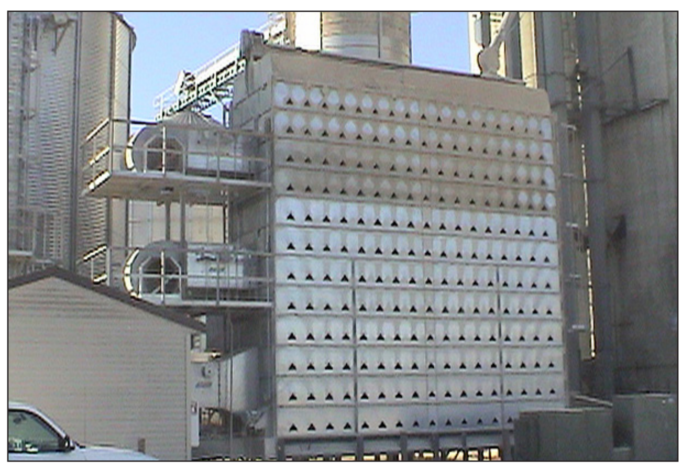

Figure 7: Three zone mixed-flow dryer. Source: NECO

This allows time for the moisture in the grain kernels to equalize before drying is continued. Steeping sections are typically offered as an option on tower dryers. Heat recovery on continuous flow column dryers can save 10 to 30 percent in energy costs. It is typically only done with dryers running in a heat-cool mode. Heat is recovered as the intake air for the heating section is drawn through the grain in the cooling section. This cools the grain while preheating the air entering the heating chamber. Air can also be recycled from the lower heat section to reclaim additional heat. Recycling air reduces dryer capacity slightly depending on the moisture content of the recycled air. Tower dryers and conventional cross-flow dryers can have heat recovery capabilities built into the dryer design.

Computerized control systems with temperature and grain moisture sensors can prevent over-drying and reduce energy use. The controller regulates the plenum temperature and controls the metering rolls or unloading augers based on the grain moisture. When the controller senses the grain has reached the set point for kernel moisture, the metering rolls or augers are activated to remove the grain. In some cases the speed of unloading can be regulated with variable speed drives as the detected grain moisture changes. If the grain exiting the dryer has a moisture content higher or lower than the set point, the speed of the unloading auger can be adjusted automatically as needed to run slower or faster, respectively.

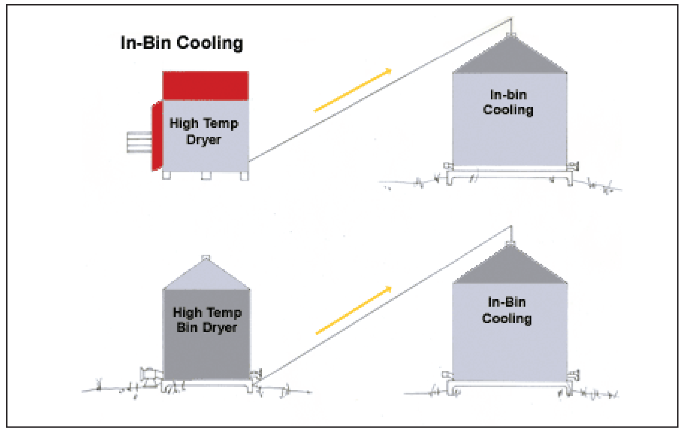

Figure 8: In-store cooling. Source: Scott Sanford

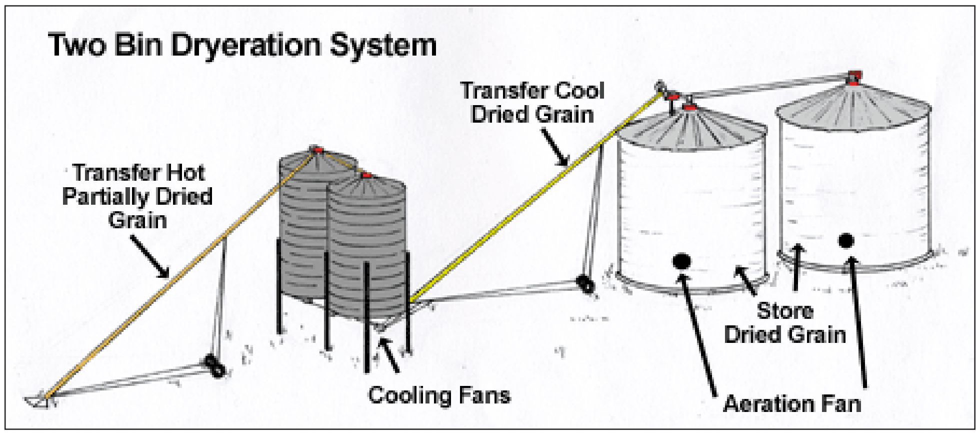

Figure 9: Dryeration. Source: Scott Sanford

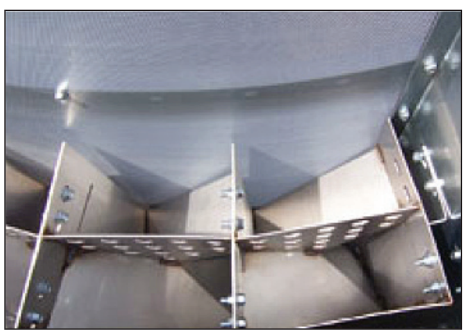

Figure 10: Grain turner - top view. Source: K. Hellevang

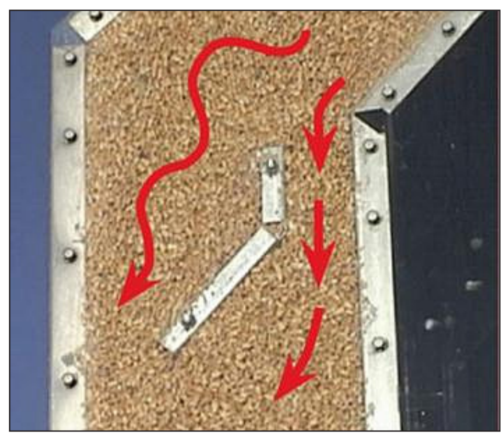

Figure 11: Grain diverter varies grain flow rate across the drying column. Source: K. Hellevang

References

K.J. Hellevang. 1983. Crop Dryeration and In-storage Cooling, AE-808, North Dakota State University Extension. Available at: http://www.ag.ndsu.edu/extension-aben/documents/ae808.pdf verified 12/2012

H.A. Cloud, Morey, R.V. 1998. Dryeration and In-storage Cooling for Corn Drying, University of Minnesota Extension. Available at: http://www.extension.umn.edu/distribution/cropsystems/DC7356.html verified 12/2012

B.A. Mckenzie, Foster, G.H. 1980. Dryeration & bin cooling Systems for Grain, AE-107, Purdue University Extension. Available at: http://www.extension.purdue.edu/extmedia/AE/AE-107.html verified 12/2012

S. Shouse, Hanna, M., Petersen, D. 2010. Managing High-temperature Grain Dryers for Energy Efficiency, Iowa State University Extension, PM2089f. Available at:
http://www.extension.iastate.edu/Publications/PM2089F.pdf verified 12/2012

This publication is available online at:
http://blogs.extension.org/encon1/files/2012/12/FS_FlowDryers.pdf

On-line training programs on bioenergy and sustainability, on-farm energy conservation and efficiency, and anaerobic digestion are available online at:
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