Energy considerations for low-temperature grain drying

Energy efficiency of low-temperature drying

Harvested corn often requires artificial drying to lower moisture content (m.c.) for safe storage into the following spring and summer. Although much artificial drying in Iowa is done with high-temperature LP or natural gas dryers, some corn is dried with natural-air or low-temperature systems.

Low-temperature systems take advantage of the natural drying potential in warm autumn air. Drying in the bin occurs as corn kernels come into moisture equilibrium with outside air blowing past. Air temperature and relative humidity fluctuate in autumn, but corn in Iowa will typically dry to 12 – 13% m.c. if adequate airflow and time are available to remove the moisture (PM 2089Q).

Low-temperature grain drying can be an energy efficient strategy for grain stored in shorter bins (e.g., 18 ft or less of grain depth). Due to airflow requirements, low-temperature drying is not well-suited to larger bin sizes. For example, consider a 40,000 bushel bin. At a diameter of 42 ft, the corn is 36 ft deep. To provide 1 to 1.25 cubic feet per minute (cfm) airflow per bushel (bu) for drying, more than 180 hp of fan capacity would be required to force the air up through 36 ft of grain. Compare this to two 42-ft diameter bins each filled 18 ft deep and requiring 28 hp of fan capacity each (56 hp total), or three 36-ft diameter bins filled 16 feet deep and requiring only 14 hp of fan capacity each (42 hp total). Each system stores 40,000 bu, but as grain depth increases with bin size, increasing horsepower and airflow requirements make low-temperature drying more inefficient and impractical.

If the farm operation can store grain in smaller bins, it can gain energy efficiency by using the drying potential of natural air for low-temperature drying. Assuming on-farm bin storage is already needed and a full perforated drying floor is used, low-temperature drying could be accomplished with a larger fan and additional electricity, without the need for gas, heaters or extra drying equipment. An advantage of low-temperature drying is that corn needs to be moved only once into the bin that will provide drying and storage, so there is no waiting for the dryer to catch up with the harvest rate.

Energy costs vary with cost per electrical kilowatt-hour (kWh) or gallon of LP and also efficiency of the systems, but energy used for low-temperature drying is generally about two-thirds that of conventional high-temperature systems, because much of the drying potential is contained in natural air. LP consumption for high-temperature drying ranges from 0.010 to 0.025 gal per bushel per point (average 0.018 gal) plus 0.01 kWh per bushel per point for fans. Natural air drying uses only electricity for fans ranging from 0.30 to 0.40 kWh per bushel per point (average 0.33 kWh).

Low-temperature or natural-air drying

Low-temperature drying spans weeks of time (sometimes requiring completion in the spring); therefore, management techniques are different from high-temperature systems and should be fully understood before implementation. This energy efficiency fact sheet provides a brief introduction to low-temperature drying.

Iowa State University
Extension and Outreach

PM 2089U May 2012




In low-temperature drying, a layer of corn about 1 – 2 ft deep (the drying zone) dries as the kernels come into equilibrium moisture content with the air blowing past them (Figure 1). The drying zone moves slowly upward through the bin: previously dried corn is below the drying zone and wet corn (yet to be dried) is above it.

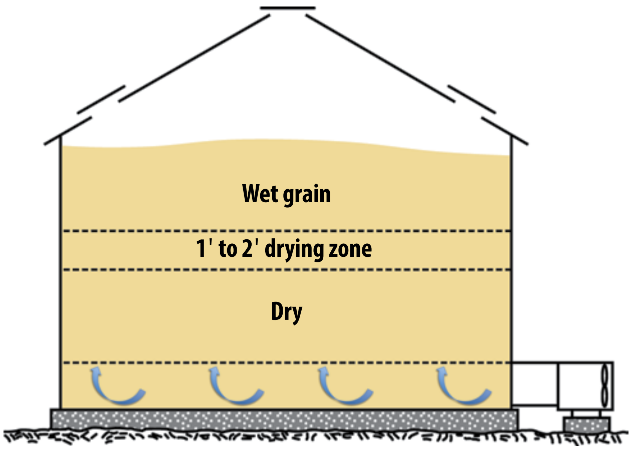

Figure 1. Low-temperature grain drying

Wet grain in the top of the bin is the last to dry and has a limited allowable storage time before it starts to degrade with mold or other biological activity. Adequate airflow is needed to push the drying front to the top of the grain mass and to complete drying before top grain spoils. Slower drying in a cold, wet autumn may delay finishing the top grain drying until spring. A greater risk of spoilage occurs, however, if unseasonably warm air temperatures during the autumn prematurely shorten the allowable storage life of wet corn in the top of the bin. Table 1 shows that greater airflow per bushel allows corn to dry successfully starting at slightly higher m.c., however greater fan horsepower (Table 2) is required to increase airflow through a given mass of grain (more cfm/bu) resulting in lower energy efficiency.

Table 1. Maximum corn moisture content for successful natural-air drying in Iowa

	Corn harvested on or after		
	Sept. 15	Oct. 1	Oct. 15
Airflow, cfm/bu	Maximum corn moisture content, %		
1.0	20	20	21
1.25	20	20.5	21.5
1.5	20.5	21	22.5

Table 2. Approximate fan power requirements (hp per 1000 bu) for natural-air drying[a]

Airflow, cfm/bu	Corn depth, ft			
	14	16	18	20
1.0	0.5	0.7	1.0	1.3
1.25	0.9	1.3	1.7	2.2
1.5	1.4	2.0	2.7	3.5

Most importantly, corn harvested above 21% m.c. is typically not suitable for low-temperature drying with commonly used airflow rates and normal Iowa weather. An alternative high-temperature drying strategy is required with wetter corn. Table 1 shows maximum corn m.c. that can be successfully dried in Iowa using natural-air based on drying start date, and airflow rate (cfm/bu.) Note lower allowable starting corn m.c. when grain is harvested earlier in the fall and air temperatures are warmer, which results in more microbiological activity (Table 1). Another strategy for starting harvest with wetter corn is partially filling bins early in the season, which allows greater airflow per bushel. After this corn has dried, the bin can be fully filled later when temperatures are more suitable for full bin airflow rates.

Summary

Low-temperature or natural-air grain drying can be an energy efficient option. Management techniques are different from high-temperature drying and should be fully understood. An alternate plan for high-temperature drying is necessary in years when corn must be harvested above 21% m.c. Successful low-temperature drying requires high fan horsepower for adequate airflow when grain depth is greater than 18 ft, which can limit application of this drying method for farms with large storage bins.

References

[a]Wilcke, W., and R. V. Morey. 2009. *Natural-air corn drying in the upper Midwest.* (WW-6577-GO) University of Minnesota Extension bulletin.

VanFossen, L. 1985. *Low-temperature drying systems in Iowa.* (PM1016) Iowa State University Extension bulletin.

Prepared by Shawn Shouse, extension ag engineer; Mark Hanna, extension ag engineer; and Dana Petersen, program coordinator, ISU Farm Energy Initiative; Iowa State University Extension and Outreach. Sponsored by the Iowa Energy Center.