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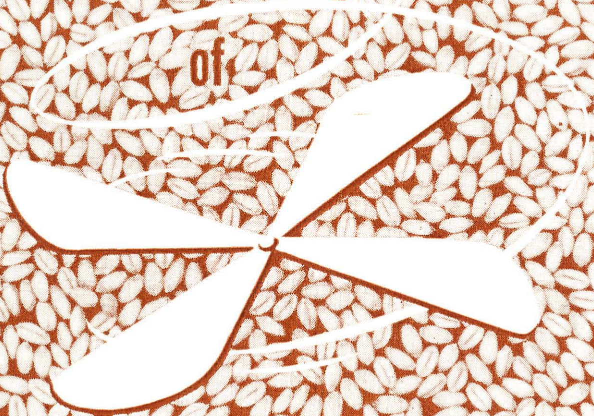

MICHIGAN STATE UNIVERSITY
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Mechanical Cooling of Grain

(Aeration - Cooling of Grain)

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About 5 percent of the total grain produced is lost each year during farm storage to mold, rodents, and birds. Another 1 to 10 percent is lost to insects. For cereal grains and corn, this loss in the United States comes to 250 million dollars each year.

A large part of that loss comes from storing grain which is no more than 1 percent above the moisture level normally considered safe for storage. Another part of the loss is damage from moisture that collects during storage, although the grain's moisture content is considered safe for storage when harvested in the field or after mechanical drying.

This accumulation of moisture can be prevented. It is possible to remove up to 1 percent of the moisture by forcing a very small small amount of air through the grain after it is placed in storage. This process of moving a small amount of air through the grain for cooling (or aeration) is called mechanical cooling.

Cooling has been done on the farm by natural ventilation in narrow cribs for ear corn. However, it is hard to move enough air by natural ventilation to cool wheat, shelled corn, and other small grains. The usual commercial method of mechanical cooling is to lift and drop the grain through the air three or four times a year. It is not practical for a farmer to use this method on the farm; however, he can use forced air cooling easily. Mechanical cooling system costs are low, and this method will effectively cool grain for farm and commercial storages.

WHAT IS MECHANICAL COOLING?

Several terms are generally used to describe the operation of forcing air through a grain crop with a fan and motor. These terms are defined as follows:

Mechanical Cooling — Moving a small amount of air, from 1/60 to 1/10 c.f.m. (cubic feet per minute) per bushel, through the grain mechanically to control temperature, usually using a small fan and motor. Equipment ranges from a 50-watt (1/20-h.p.) motor and fan on a farm bin to a 7½-h.p. motor and fan in a large commercial storage unit.

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Aeration — The process of using a low airflow to ventilate a stored crop.

Some equipment marketed as "aeration equipment" generally includes a duct system and fan and motor of a fixed size. If placed in a large bin, such a system will produce airflows per bushel in the mechanical cooling range. If the same system is placed in a small bin, airflows per bushel approach the minimum recommended for drying. Therefore, the term "aeration" only partly describes the operation; it should be coupled with either the term "cooling" or "drying" (as aeration-cooling or aeration-drying).

Drying — Forcing air through grain at a minimum rate of 3 c.f.m. per bushel to remove excessive moisture up to 15 percent above the desired level. Heated-air dryers have greater airflows. Size and cost of equipment increase with the quantity of grain or amount of moisture to be removed. Minimum equipment for drying with unheated air would probably be a 3-h.p. motor and a 24-inch fan for about 1,000 bushels.

USE OF MECHANICAL COOLING

Farmers can use mechanical cooling of grain for several purposes.

1. *Prevent moisture accumulation* — Daily and seasonal temperature changes produce rising air currents which cause moisture to collect in bins. The more grain, the greater the problem; bins with over 2,000 bushels accumulate much moisture in the top layer.

Grain and shelled corn go into storage with kernel temperatures about the same as air temperatures at the time of harvest (60° to 90° F.). As fall temperatures drop, the surface temperatures of the grain or shelled corn also drop, but internal bin temperatures remain comparatively warm; this causes rising air currents. The warmer air in the center of the grain carries moisture to the top or outer grain layers. As the warm air strikes the cooler grain, moisture condenses and builds up.

This buildup increases kernel moisture in the top 6 to 24 inches of grain. Crusting, molding, insect growth, and spoilage can then take place.

2. *Remove moisture, up to 1 percent* — When outside air temperatures are above 50° F., some moisture can be removed by forcing outside air through the grain. The amount of moisture removed can total about ½ percent a week with an airflow of 1/10 c.f.m. per bushel. To do this, the outside temperature must be 70° to 80° F. and relative humidity about 60 percent. Less moisture is removed at lower temperatures.

3. *Control temperature in storage* — Temperature control is important in maintaining grain quality. Ventilation will reduce grain kernel temperature from harvest level and prevent an increase in grain temperature after storage. Air temperature over the grain in storage bins has been measured as high as 130° F. with an outside temperature of 90° F.

Turn the fan on for a short time as soon as the grain is placed in the bin. Run it periodically during warm weather to prevent heating of the grain and also whenever outside air temperature is 10° to 15° F. below that of the average grain temperature. Find the average grain temperature by placing a thermometer in the airstream at the fan discharge. Operate the fan until the average temperature is within 5° F. of outside temperatures. During late fall — with outside air temperatures between 15° to 20° F. — the fan can cool grain from an average temperature of 55° F. down to 30° F. in 7 to 15 days.

4. *Fumigation* — The fumigant can be placed in the bin and recirculated as long as needed, then flushed out according to recommendations for the fumigant being used. A vertical duct extending to the floor will give uniform and complete fumigation coverage (Figs. 1 and 2). A system with horizontal ducts also works very well. Follow the instructions of the fumigant manufacturer.

5. *Insect Control* — Insect infestation results from a combination of temperature, moisture, and contamination. Although mechanical cooling is primarily for temperature control, reducing both temperature and moisture in grain greatly helps to control insect infestations. Once insects have become active in stored grain, though, they can create their own favorable moisture and temperature conditions. Therefore, regardless of the condition when grain is stored, check it at least once a month, especially in the fall.

6. *Other* — During periods of high temperature, mechanical cooling equipment can be used to warm sensitive products before handling. For instance, beans might crack badly if they were handled while cold. The operator should be warned, however, of the possibility of spoilage by moisture from warm air condensing on cold stored products.

By running the fan during periods of high humidity, moisture can be added to grain. (Commercial operators sometmes buy grain at a certain moisture level, dry it out for safer storage, then add moisture before selling.)

EQUIPMENT REQUIRED

A fan and an air distribution system (ducts) are needed for mechanical cooling. This equipment is similar to that for drying, except that the fan and motor used for cooling are much smaller and the cross-sectional area of the duct system is much less. Drying equipment can be used for cooling.

Airflow recommendations for mechanical cooling vary with geographical area, moisture content of the grain, and size of storage. An airflow of 1/30 c.f.m. per bushel for continuous operation and 1/10 c.f.m. per bushel for intermittent operation have proved satisfactory. If you plan to run the fan at more than one location, use an airflow of 1/10 c.f.m. per bushel.

Fan and motor — The fan can be either a propeller or centrifugal type. To find the quantity of air output needed for intermittent operation, multiply the number of bushels of grain by 1/10 c.f.m. Thus, for each 1,000 bushels capacity, the fan must move 100 c.f.m. of air. The pressure against which the fan must work (called static pressure) varies with the depth of grain.

The static pressure for an air flow of 1/10 cfm. bu. for various depths is as follows: 10 ft. depth—.05 in.; 20 ft.—0.2 in.; 30 ft.—0.4 in.; 50 ft.—1.2 in.; 100 ft.—5 inches. To figure the total air flow needed, multiply the number of bushels times 1/10 cfm. bu.

Typical horsepower requirements for shelled corn storages are as follows:

1/16 to 1/8 horsepower for 1,000-bushel bin.
1/8 to 1/4 horsepower for 3,200-bushel circular bin.
1/3 to 1/2 horsepower for 10,000-bushel circular storage.
1/2 to 1 horsepower for 20,000-bushel flat storage.
1 to 1-1/2 horsepower for 35,000- to 40,000-bushel flat storage.
5 to 7-1/2 horsepower for 30,000 bushel silo type vertical storage, 60 feet high.

Static pressure and power requirements for small grain such as wheat are about three times that of shelled corn.

Vertical Ducts — A very simple system for mechanical cooling of grain consists of installing a duct *vertically* in the bin, with the fan on the duct exhausting air from the bin (Fig. 1). The length of the vertical duct can vary according to the depth of the bin. The duct needs to extend only two-thirds of the depth of the bin for mechanical cooling, but it should extend to the bottom of the bin for fumigation.

A 4- to 12-inch diameter stovepipe will do for the upper half of the duct, with a screen-covered, perforated, or slotted metal opening on the bottom half for air passage. The bottom of the duct can be 3 to 4 feet from the bottom of the floor, but quicker, more uniform cooling of the grain results with a full-length duct. Several manufacturers make exhaust fans for these installations. The cost is low, usually about $25 to $50 for an installation.

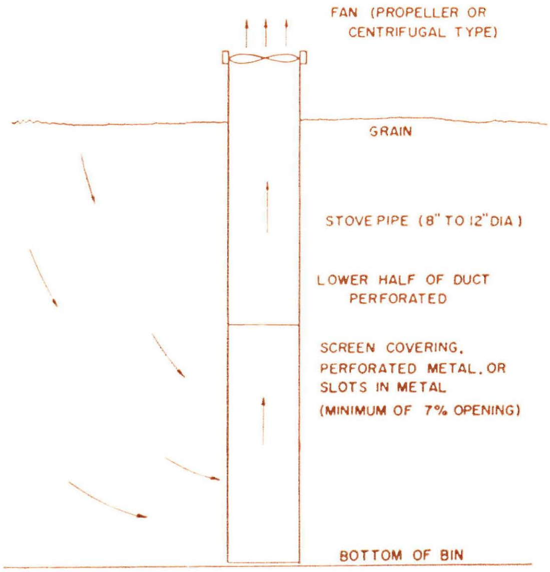

Fig. 1. Installation of vertical duct in bin with fan exhausting air may be used for cooling and fumigating in round or rectangular bin.

The equipment for exhausting the air can be installed after the bin is filled with grain, although it is easier to install before. The duct can be installed when the grain is placed in each bin, and the fan can be moved from duct to duct for intermittent cooling. Installation can be made so the air above the grain in the bin is partially recirculated through the grain, or it can be placed so the air is exhausted to the outside (Figs. 2a and 2b).

The installation shown in Fig. 2a is recommended for cooling; it has been found that the surface moisture will stay from 1 to 2 percent lower than the installation shown in Fig. 2b. If, however, the installation is being made in warm weather to remove a limited amount of moisture, the air should be exhausted to the outside as shown in Fig. 2b. This unit is not recommended for drying or removing over 1 percent excess moisture.

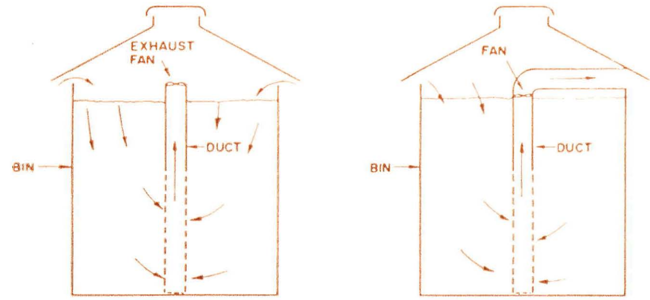

Fig. 2a. Vertical duct for exhausting air above grain will give more uniform temperature and moisture of grain than 2b.

Fig. 2b. Vertical duct for exhausting air outside of bin is used where slight moisture removal is desirable.

The vertical tube duct is ideal for small circular or rectangular grain bins. It can also be installed in a flat storage by placing vertical cooling ducts every 15 to 20 feet in the bin.

Horizontal ducts — These can be placed in the bottom of the grain bin and used with or without the laterals or branches shown in Fig. 3. The ducts are made of perforated or slotted metal 6 to 12 inches in diameter; and the fan size depends on previous recommendations. (See page 5.) The unit is usually used as an exhaust system.

If the fan provides 1/10 c.f.m. per bushel, it can be moved from bin to bin for cooling. Temperature reduction is faster and more uniform with the horizontal ducts; and they can be adapted to any shape or size of bin. Commercial units of this type are available.

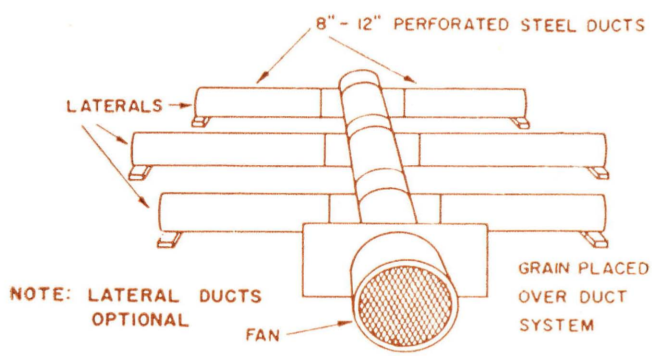

Fig. 3. Horizontal ducts placed in bottom of bin. Usually 8 to 12 inch diameter when laterals are used. When used without laterals, the center duct may be 12 to 20 inches or more in diameter, depending on size of installation.

OPERATION OF COOLING SYSTEM

With a small airflow of 1/20 to 1/30 c.f.m. per bushel, the fan should operate continuously until the grain is cooled. Although the fan can be turned off during periods of high humidity, rain, heavy fog, etc., the electricity saved usually does not justify the labor and time required.

Fans which put out an airflow of 1/10 c.f.m. per bushel are usually moved around to all the bins to cool grain down close to freezing temperatures in the winter. For intermittent operation, you can use a timeclock to operate the fan during periods of low humidity – from 10 a.m. to 4 p.m. Humidistats – instruments which respond to humidity as a thermostat does to temperature –are more expensive and generally less reliable.

For uniform cooling, it is important that clean grain be placed in the bin. Clean grain will stay cooler longer in the spring, and the possibility of damage from mold and insects is less.

COSTS

Installation costs for large storages (10,000-bushel) are about 1 to 2 cents per bushel for the equipment; for storages under 3,000 bushels, costs run about 5 cents per bushel.

Electrical costs for mechanical cooling of grain range from 1/10 to 1/2 cent per bushel a year.

SUMMARY

- Mechanical cooling will maintain the quality of shelled corn or small grains by preventing moisture accumulation and controlling grain temperature.

- Mechanical cooling may remove about 1 percent excess moisture from stored grain and shelled corn.

- An airflow of 1/30 to 1/10 c.f.m. per bushel is recommended for mechanical cooling.

- Fractional horsepower motors and small fans are used in mechanical cooling for flat storages under 20,000 bushels.

- Annual costs for installation and operation will run from about 1 to 5 cents a bushel, depending on storage size.

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