1981

Fan Selection for Grain Drying and Aeration

Cooperative Extension South Dakota State University

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FAN SELECTION FOR GRAIN DRYING AND AERATION

Cooperative Extension Service
South Dakota State University
U.S. Department of Agriculture
Energy requirements for grain drying fans represent a substantial investment because they may run for several weeks or months at a time. Aeration fans are smaller but also run for extended periods. Studying fan selection alternatives enables the operator to choose equipment that will deliver the amount of air needed at the lowest possible cost. As you will see, proper sizing of fan and bin combinations can save as much as 60% of the energy needed to dry a given amount of grain.

There are two basic criteria for fan selection: 1) How much air is needed, and 2) How much pressure is required to move air through the grain.

How much air is needed?
The volume of air a fan must move depends on the number of bushels in the bin and on the type of drying or aeration system.

Aeration fans generally move from 1/20 to 1 cubic foot of air per minute (cfm) for each bushel (bu) in storage. The air is used to cool the grain and to prevent moisture migration rather than to remove moisture (see FS 774, Aeration of grain in storage, for more details on aeration needs).

Drying requires more air than cooling because the air has the dual function of delivering heat to the grain and removing moisture from it. Low temperature drying requires from 1 to 3 cfm per bushel (depending on the moisture content) in order to dry the grain before it goes out of condition (see FS 772, Natural air/low temperature grain drying). Batch dryers need 10 cfm per bushel or more to accomplish drying in the time available (see FS 771, Saving energy in high temperature grain drying).

The total airflow rate that a fan must deliver depends on airflow per bushel and on total bushels in the dryer or in storage. Bin capacities for each foot of depth for various size bins are given in Table 1.

<table>
<thead>
<tr>
<th>Bin diameter</th>
<th>By per foot of depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>14'</td>
<td>123</td>
</tr>
<tr>
<td>15'</td>
<td>141</td>
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<tr>
<td>16'</td>
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<tr>
<td>18'</td>
<td>204</td>
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<td>21'</td>
<td>277</td>
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<td>24'</td>
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<tr>
<td>30'</td>
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<tr>
<td>33'</td>
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<tr>
<td>36'</td>
<td>814</td>
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<td>60'</td>
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</tbody>
</table>

(Flat storage: 0.80 bu per cubic foot of space.)

Example:
A farmer wants to dry corn with natural air at the rate of 1.25 cfm/bu. It is stored in a 21-foot diameter round bin 17 feet deep. What is the total fan capacity he needs?

Solution:
A 21-foot bin contains 277 bu per foot of depth. His total storage volume is about 4700 bu (277 x 17 = 4709). At 1.25 cfm/bu his fan capacity must be nearly 5900 cfm (4700 x 1.25 = 5875).

How much pressure will be developed?
Pressure is required to force air through ducts or through grain. The pressure is not over 1/2 pound per square inch so it is measured in inches of water pressure. A U-tube containing water is used to measure the pressure in the plenum under an aerated bin of grain. One end is placed in the plenum under the perforated floor and the other in outside air (Fig 1). The pressure developed by the fan is the difference in water level (measured in inches) in the two columns of the U-tube. The same U-tube placed through the bin wall at the top of the bin shows no difference in water level when the bin roof contains an adequate open area for air escape.

The pressure developed depends on airflow rate, type and depth of grain, amount of fine material in the grain, how tightly it is packed, and on the air handling equipment in the system. Grain type and depth are the two most important factors which determine pressure requirements. Tables 2-5 give static pressure values for various depths and airflow rates per bushel for four types of clean grain. As seed size gets smaller the space between the kernels also decreases; since air moves through those spaces, air pressure must be increased.

Air follows the path of least resistance. Fine material such as dirt and weed seeds mixed with the grain will partially fill the space between kernels. If fine material accumulates directly below the filling spout it creates a zone of low airflow in the center of the bin.

Grain distributor equipment will increase pressure requirements in two ways. It spreads fine material throughout the grain mass and also causes the grain to pack more tightly. The effect is almost like having a vibrator on the bin.

Packed grain may require pressures
up to 50% higher than loose fill grain. Fine material will increase pressure requirements, but the exact amount is difficult to determine.

Air moving through duct work can increase pressure requirements on the fan. However if air velocities are kept below 1500 feet per minute and transitions in duct size and configuration are kept gradual, such losses are usually negligible for the ducts used in most drying installations.

Perforated surfaces without enough open area also cause increased pressure for the fan. A perforated surface that has about 2% open area causes as much pressure increase for the fan as 2½ feet of grain. Four percent open area is equivalent to 1 foot of grain, and the grain equivalent decreases linearly to zero at 20% open area.

Types of fans available
Two types of fans commonly used in grain drying are the axial flow or propeller type and the centrifugal or squirrel cage type.

The axial flow fan and motor are directly connected and mounted in a cylinder that serves as the fan and motor housing (Fig 2). Air moves parallel to the fan axis. Some axial flow fans contain vanes that straighten air flow and reduce energy loss due to turbulence.

Axial flow fans are:
- Mounted in a tube.
- Easily attached to round ducts or to matched heater tubes.
- Lowest cost type of fan.
- Noisy (although they can be muffled).
- Restricted to low pressure applications.
- Most centrifugal fans on grain drying systems are of the backward curved type (Fig 3). The rotor blades curve back away from the direction of rotation. Air enters near the fan hub and exits along the fan circumference.

Sometimes belt driven and need adjustment.
Best suited for high pressures.

How are fans selected?
Unless you match the fan to the grain drying system it will not operate as you expect. Use fan "curves" to make your selection. They are graphic or tabular relationships between the fan discharge rate (cfm) and the pressure the fan will develop at that rate (Fig 4).

As the system changes, more or less air will be delivered by the fan.

Example:
A farmer wants to dry 4700 bu with 5900 cfm of natural air. He has 17 feet of corn in the bin. The bin has a perforated floor with 4% open area. What kind of fan does he need?
Table 4. Static pressure against grain drying/aeration fans produced by soybeans in storage.

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<thead>
<tr>
<th>cfm/bu</th>
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<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
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<td>08</td>
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<td>12</td>
<td>14</td>
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Table 5. Static pressure against grain drying/aeration fans produced by wheat in storage.

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</table>

Solution:
The perforated floor with 4% open area adds the equivalent of 1 foot of grain. Eighteen feet of grain with 1.25 cfm/bu of air gives a static pressure of about 4.5 inches (Table 2). He must obtain a fan that will deliver 5900 cfm with a static pressure of 4.5 inches. The fan curve of the fan he selected is Fig 4.

Example:
The next fall he harvests at a higher moisture content due to weather conditions and wants to dry at 3 cfm/bu airflow rate. How much corn can he place in the bin?

Solution:
This example must be worked by a trial and error method using Fig 4. First, guess a depth of grain he

With 3 cfm/bu, that gives a static pressure of 11.8 inches (Table 2) and is well off the fan curve (Point 1 on Fig 4).

Since this fan will not produce 12,500 cfm against a pressure of 11.8 inches a smaller grain depth must be tried and the solution repeated. Continue trying alternative depths until the static pressure determined for the airflow rate falls on the fan curve. In this case he can place about 9 feet of corn in the bin (Table 6).

Not all fans of the same horsepower rating have the same fan characteristic curve. Fig 5 shows the fan characteristic curves for some of the 10 hp centrifugal fans on the AGNET computer system. Fig 6 gives the same for the axial flow fans. No two fans on AGNET have the same curve. Only two axial flow fans operate at above 5 inches of water pressure. Centrifugal fans are designed for higher pressure use than axial flow fans, but only two of these work at pressures above 9 inches of water.

Figures 5 and 6 show that horsepower ratings are not a good way to compare fans. If possible, compare fans for cfm/watt as well as airflow delivery. Drying costs are directly related to cfm/watt. Although cfm/watt ratings are seldom published, the manufacturer or his sales representative should have them.

Matching bin and fan will save you money
Proper sizing of fan and bin combinations can save money in several ways. The same storage
Table 6. Trial-and-error/solution for Example 2.

<table>
<thead>
<tr>
<th>Trial number</th>
<th>Corn depth (ft)</th>
<th>Bushels (bu)</th>
<th>Total cfm (3 cfm bu)</th>
<th>Equivalent depth* (ft)</th>
<th>Static pressure (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>4150</td>
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*Add 1 foot to grain depth to compensate for pressure loss through perforated floor.

Fig 6. Fan characteristic curves for 10 hp axial flow fans on AGNET.

Table 7. Larger diameter bins with smaller fans save energy.

<table>
<thead>
<tr>
<th>Bin diameter</th>
<th>Depth of grain</th>
<th>Pressure</th>
<th>Date when:</th>
<th>Ave. moisture content at 15.5%</th>
<th>Top moisture content at 15.5%</th>
<th>Top moisture content at 15%</th>
<th>Hours of fan operation</th>
<th>btu/lb water evaporated</th>
<th>kwh/bu for fan</th>
<th>Total kwh for 5000 bu</th>
<th>Drying cost at 4¢/kwh</th>
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<tbody>
<tr>
<td>21'</td>
<td>18'</td>
<td>7.2 hp</td>
<td>11/17</td>
<td>11/17</td>
<td>11/17</td>
<td>11/17</td>
<td>1512</td>
<td>1452</td>
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<td>$450</td>
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<td>19.8'</td>
<td>5.0 hp</td>
<td>11/15</td>
<td>11/15</td>
<td>11/15</td>
<td>11/15</td>
<td>1512</td>
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<td>5950</td>
<td>$238</td>
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<td>11/17</td>
<td>11/17</td>
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<td>$160</td>
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<tr>
<td>30'</td>
<td>23'</td>
<td>3.0 hp</td>
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<td>11/17</td>
<td>11/17</td>
<td>11/17</td>
<td>1512</td>
<td>511</td>
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27 to 30 feet in this case. The fans given in Table 7 are moving about 90,000 volumes of air to dry one volume of grain.