Portable batch and continuous flow are two very popular high-speed grain drying techniques. Both dryer types are similar in appearance and operation and require wet grain storage ahead of the dryer. The basic principle in both dryer types is to force high quantities of air (50-125 cu ft/bu) through relatively thin grain columns (12-24 inches) to obtain relatively high drying rates. The portable batch units usually dry a fixed amount of grain, cool it and then unload to storage whereas the continuous flow units will meter cool-dry grain at a steady-adjustable flow rate from the drying chamber. While the drying units are movable or portable as the name implies, a permanent centralized location is generally desirable.

**Equipment Requirements**

**Portable Batch**

Figure 1 is a schematic drawing of a typical column batch dryer. The dryers are self-contained units with fan sizes generally ranging from 10 to 20 hp, drying temperatures of 160°F to 200°F and heater capacities of 2 to 5 million BTU/hr. Larger units than the one shown may have multiple fans and drying chambers which allow the grain to be dried in stages. Most portable batch units come with a complete set of controls to automatically load, dry, cool and unload the grain which eliminates the need for any manual operation of the dryer and allows extended drying periods after nightfall. Many portable batch units have an optional cooling cycle which can be eliminated when dry-eration is practiced. This option will increase the capacity of the dryer.

**Continuous Flow**

Figure 2 is a schematic drawing of a typical continuous flow dryer showing the configuration of the heating and cooling chambers. The basic difference between this type dryer and that of a portable batch unit is that the grain continually flows through this dryer and is regulated by the grain meters shown in Figure 2. Fan sizes for continuous flow dryers are comparable to those of the portable batch but the drying temperatures are higher (180°F-230°F) and the heater sizes are generally larger, ranging from 3-12 million BTU/hr depending on the individual dryer. Most continuous flow dryers are completely automated and do not require constant supervision.

**Handling**

While the name "portable" implies that these drying units are movable, they will function better in a central-
Figure 2. — Schematic drawing of a continuous flow dryer with a heat recirculation feature.

ized location with permanent handling equipment for the wet grain. The central handling unit may be either a bucket elevator or transport auger, with both requiring a minimum handling capacity of 1500 bu/hr. In systems where transport augers are used, a second auger unit should be available to unload the dry grain into storage. In systems using bucket elevators, a smaller dry leg may be installed just to handle dry grain. An important consideration for grain systems requiring high speed dryers is not to limit the drying capacity of these units with insufficient handling capability for movement of wet and dry grain.

Wet Holding

Both the portable-batch and continuous flow dryers require wet grain storage preceding the dryer itself. This storage may be a ground-level tank that feeds the dryer by means of a portable auger, or an elevated wet grain bin which provides faster gravity loading of the dryer. If the elevated tank is chosen, care should be taken to properly design the support structure to accommodate the heavy stresses that occur when the tank is filled with wet grain. A rule of thumb is that minimum wet storage requirement for these systems is generally 1½ to 2 times the batch size of the dryer or vehicle size, whichever is larger. A good estimate of the maximum size tank may be obtained by using the following relationship:

\[
\text{Tank capacity} = \text{Daily harvest} - \text{Drying time} \times \text{Effective drying rate}
\]

where: Tank capacity = the size of the wet grain tank in bushels.  
Daily harvest = the amount of grain harvested each day in bushels.  
Drying time = hours of dryer operation while harvest is still continuing.

Effective drying rate = the rate of the dryer in bu/hr, including the time for loading and unloading plus that of the cooling cycle, if any.

Remember that in most cases the dryer will not be started until after the first or second load reaches the grain facility.

For example suppose that the producer is harvesting 2200 bu in a 10 hr harvest period. The batch size of the dryer is 150 bu, dried in approximately 40 minutes; the cooling cycle requires 15 minutes and unloading involves another 5 minutes for a total cycle time of 1 hour; then the effective drying rate for this dryer is 150 bu/hr. Because of vehicle travel and loading time, the dryer does not begin drying until 1.5 hours after harvest has begun. Then:

\[
\text{Tank capacity} = 2200 - 8.5 \times 150 = 925 \text{ bu}
\]

Surge Bin

Another convenient item of equipment for handling the dry grain in these systems is the addition of a surge bin. This item of equipment is generally used in systems containing bucket elevators and allows the dryer to unload dry grain when ready, thus facilitating the drying process. In addition, the surge bin unloading auger or bucket elevator is required to operate only when the surge bin is unloading rather than for the entire dryer operation time. The surge bin should have a minimum capacity equal to the batch size of the dryer although it may be much larger if desired. Surge bins are generally equipped with sensing devices that allow automatic loading of the dry grain to storage.

Advantages and Disadvantages

The main advantage of a portable batch or continuous flow drying unit is drying speed. These units are designed to give the necessary drying capacity for grain harvesting situations that require fast harvest rates and large harvest volumes. Most dryer units of either type are completely automated, reducing labor requirements for loading and unloading, and are available in many different sizes to accommodate a wide range of drying needs. The drying units are generally small enough so that they may be moved if necessary but generally will operate better in a centralized location. Their portability allows for relatively easy replacement if they wear out or if expanded capacity is needed.

The main disadvantage of these drying units is their reduced drying efficiency in terms of energy when compared to other drying methods. This is the tradeoff that generally occurs with increased drying speed. The portable batch-continuous flow units are generally more expensive and require more associated handling equipment (wet holding, surge bins, dry legs, etc.) than do other drying methods. Grain must be handled at least
twice in systems using these dryers, but this is less of a problem than before with advances in automatic grain handling.

**Physical Performance**

Portable batch and continuous flow dryers are very similar in appearance and performance. Portable batch dryers are classified as stationary bed dryers. The grain mass does not move during the drying process and the drying air is blown across the grain column. These dryers operate with drying temperatures of 160° to 200°F and airflow rates of 50 to 100 cfm/bu. Their drying capacities for typical farm units will normally range from 100 to 400 bu for 10 points of moisture removal. Continuous flow dryers may be categorized by 3 types:
- **crossflow** — where the drying air is blown across the grain column the same as in a portable batch;
- **counterflow** — where the drying air and the grain move in opposite directions;
- **concurrent flow** — where the drying air and grain move in the same direction.

Continuous flow farm units typically operate with drying temperatures of 180° to 220°F, airflow rates of 75 to 125 cfm/bushel and at drying capacities of 125 to 600 bushels/hr for 10 points of moisture removal. Most continuous flow farm drying units used are of the crossflow type, so this publication will not provide further discussion of the other kinds.

An important consideration in the use of high speed grain dryers is the temperature at which the dryer is operated. The safe maximum temperature of the heated air for drying grain depends on the following factors: (1) the final use made of the grain, (2) the moisture content of the grain and (3) the type of grain.

Recommended safe maximum drying temperatures for shelled corn are presented in Table 1.

**Table 1. — Maximum Safe Drying Temperatures for Shelled Corn, Categorized by Use.**

<table>
<thead>
<tr>
<th>Grain Use</th>
<th>Drying Temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>180</td>
</tr>
<tr>
<td>Milling</td>
<td>140</td>
</tr>
<tr>
<td>Seed</td>
<td>110</td>
</tr>
</tbody>
</table>

Presented in Figure 3 are simulated performance curves for a crossflow dryer drying shelled corn in the typical operating ranges of 160° to 240°F for drying temperature, 50 to 125 cfm/bu for airflow rates and 10 points of moisture removal (25-15% wb). The top graph (Figure 3) shows heat energy use of the dryer (solid lines) and moisture spread (dashed lines) across the grain column for the operating ranges. Note that the drying energy will decrease and moisture spread across the grain column will increase for a given airflow rate as drying temperature increases. Conversely the drying energy will increase as the airflow rate is increased for a given drying temperature. This says that the hotter you can run the dryer for a given airflow rate, the more efficient it will be. The limiting factor here is the maximum safe grain temperature.

The bottom chart (Figure 3) presents the average grain temperature (solid lines) and drying rate (bu/hr/sq ft of dryer surface area — dashed lines) for the same ranges of temperature and airflow rate previously indicated. Note that both increase with drying temperature for constant airflow rates. For example, if the desired average grain temperature is limited to 180°F, the bottom chart (Figure 3) indicates that the drying temperature could range as high as 220°F depending on the airflow rate of the dryer. The expected moisture spread and drying energy then for 220°F is about 6.3% and 2300 BTU per pound of water removed, respectively. The tradeoff is that though the drying temperature can be raised to decrease the drying energy, the grain quality may be reduced significantly if temperatures are too high. The grain temperature should be monitored closely during drying and if the grain is brought out of the dryer "hot," it should not be cooled rapidly.
An easy way to measure the grain temperature is to place a grain sample in a large-mouth thermos bottle containing a thermometer that reads up to 200°F. After filling the thermos, read the temperature as soon as the reading stabilizes. Leave the hot grain in the thermos until the next sample is to be taken. This reduces the heat drawn from the new sample by keeping the container warm.

**Economic Considerations**

Portable drying units are expensive and may require a large capital outlay second only to that of the combine. Generally they are used where it is necessary to dry large volumes of grain rapidly. These systems can be completely automated and will require wet storage ahead of the dryer, which is also an added expense. When selecting or replacing these units the following factors should be considered.

**Drying Capacity**

A dryer should be selected that is capable of drying the daily harvest rate. The hours of dryer operation (generally around 16-18 hours) is an important factor in arriving at the necessary dryer capacity. However these units may be selected and designed to operate for 24 hours per day. This reduces the necessary dryer capacity and expense, but leaves few options if reserve capacity is needed to overcome breakdown, delays, etc. Future expansion of crop size or harvest rate must also be considered when selecting the appropriate dryer capacity.

**Drying Efficiency**

As LP gas and other fossil fuels increase in price, the efficiency of the dryer becomes even more important. The primary feature of portable dryers is drying speed, but generally the producer pays for the speed with reduced drying efficiency compared to other types of dryers. The more efficient the dryer, the less the cost of this speed. The continuous flow dryer shown in Figure 2 uses a heat recovery system. The drying air is pulled in through the cooling section and while cooling the grain, heat is recovered. Depending upon dryer design and operating circumstances, energy requirements of a crossflow dryer may be reduced by as much as 35% by using a heat recovery system.

**Dryeration**

Dryeration is a popular technique that increases both dryer efficiency and capacity. In this method the grain is removed "hot" (120°-140°F) from the dryer at a moisture content 1-3 points higher than the desired final value. This "hot" grain is transferred to a separate holding bin and held there for 4-10 hours. It is then cooled slowly taking out the excess moisture before being transferred into storage. The tempering and slow cooling of the grain reduces stress cracks and improves overall quality.

Dryeration benefits dryer capacity and efficiency in 3 ways. First, less moisture needs to be removed in the dryer, second, higher drying temperatures may be used, and third, the cooling cycle of the dryer is eliminated. Removing the cooling cycle reduces total batch time for a portable batch dryer and provides more drying area in a continuous flow dryer. For an existing system, dryeration is a viable alternative to purchasing a new unit. Depending upon the individual situation, significant gains in drying capacity and efficiency may be made for a minimal cost compared to that of a new dryer.

**Summary**

Portable batch-continuous flow drying is a good drying method for on-farm systems where drying speed is essential. Both dryer types require wet grain storage ahead of the dryer and each may be completely automated so that only little or moderate supervision is necessary. When selecting a dryer of either type, the unit should be chosen so that the drying capacity is equal to that of the daily harvest rate. These units are relatively expensive, but with proper selection and management they provide a viable high speed drying alternative where rapid harvest rates are necessary.

**References**


