Grain Drying Systems

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ABSTRACT

Grain drying begins in the field after the grain is fully mature. The primary objective of grain drying and storage is to manage the temperature and moisture of the air around the grain to minimize grain quality and market value losses while holding grain for better market opportunities. Maintaining grain quality requires drying the grain to safe moisture content levels after harvest followed by lowering and maintaining the grain temperature within a few degrees of ambient air temperatures. Natural drying exposes the wet grains to sun and wind. Artificial dryers employ high temperature directly or indirectly in both natural and forced convection systems. Mechanical dryers have been widely used in developed countries and new systems are developed with the increased demand in its application in farming and grain handling system.

Keywords: Grains, dryers, natural drying, mechanical drying

INTRODUCTION

Grains can be classified into the cereal grains (maize, rice, wheat, sorghum, barley, oats, millet), the oil seeds (soybeans, sunflower seed, canola), and the pulses (edible beans) [1]. Drying is one of the various methods to preserve crops. During drying moisture is removed to prevent the development of a favorable environment for the growth of molds and insects that normally cause spoilage [2]. Drying of grains can be divided into four broad categories: (1) low temperature drying, using unheated air, or air heated by up to 8 °C, (2) medium temperature drying with heated air that keeps grain temperatures below 43 °C for seed grains, and below 60 °C for grains to be milled and processed, (3) high temperature drying with heated air that keeps kernel temperatures below 82 °C for animal feed, and (4) combination drying, which uses both low and higher temperature air to reduce the grain moisture content to a safe storage level [1]. Grain drying is a simultaneous process of heat and moisture transfer. Airflow rate, air temperature and air relative humidity influence drying speed. A significant parameter in grain-dryer evaluation is the residence time of the grain in the dryer.

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The range of systems available for drying grains varies from thin-layer drying in the sun to expensive mechanized systems such as continuous flow dryers. The choice is governed by a number of factors, including rate of harvest, total volume to be dried, storage system, cost and flexibility [1].

Natural and Solar Drying

Sun Drying

The traditional practice of grain drying is to spread crop on the ground in order to expose it to the effects of sun, wind and rain. This is the most common drying method in tropical and sub-tropical regions. This method of drying is based upon absorption of heat by the grain from the sun’s rays. Evaporation and movement of moisture occur under the influence of the excess of the temperature and the partial pressure of water vapor in the grain over those of the surrounding air.

Although this method of drying is simple and does not require labor or other inputs, field drying may render the grain subject to insect infestation and mold growth, prevent the land being prepared for the next crop and is vulnerable to theft and damage from animals.
Solar Drying

An improved technology in utilizing solar energy for drying grain is the use of solar dryers where the air is heated in a solar collector and then passed through beds of grain. Two basic types of solar dryer are appropriate for use with grain: natural convection dryers where the air flow is induced by thermal gradients; and forced convection dryers wherein air is forced through a solar collector and the grain bed by a fan [4].

Mechanical Dryers

Batch Drying Systems

Different batch drying systems (Fig. 1.) [2] are described as follows:

1. Full-bin dryers: Drying of grains in full-bin in batch is a slow process as the grain bed is deep and a relatively low air flow rate is provided. Hence, full-bin drying has been restricted to small grains harvested during warmer months at moderate moisture contents (20% w.b. or less), and to corn harvested late enough in fall that air temperatures are relatively low and the corn has field-dried to 25% w.b. or less.

2. Layer dryers: In this process, the first layer placed in the bin usually have the highest initial moisture content and they receive the highest airflow rate because grain depth is shallow. The last grain added has the lowest moisture content of the grain in the bin, and because the depth is more, the airflow rate during this stage of the process is lowest. If grains with same initial moisture content is harvested, the drying period will be shorter than that with full-bin drying.

3. Batch-in-bin dryers: Here grains are dried in batches within a bin and then moved to storage. The principle behind this drying system is to force large quantities of heated air through relatively shallow thicknesses of grain to obtain rapid drying.

Continuous-flow Drying Systems

Continuous-flow dryers deliver predictable performance and dry all grain types (in all weather conditions) from any moisture content. Efficient handling equipment, before and after the dryer, is necessary in order to gain greatest benefit. Continuous flow dryers need minimal supervision and produce an evenly dried result. Economies of scale mean that they are best suited to high throughput applications.

There are four categories of continuous-flow dryers based on the way in which grain is exposed to the drying air (Fig. 2):

1. Cross-flow dryers, in which the wet grain flows by gravity from a wet holding bin through screened grain columns surrounding the plenum. A heater-fan assembly is located within the drying section of the heated air plenum and forces the hot air through the grain to the ambient in a direction perpendicular to the flow of the grain. Ambient air is drawn by cross-flow through the grain into the heater-fan assembly in the cooling section of the dryer. [1].

2. Concurrent-flow dryers, in which a tempering section separates the two adjoining drying stages. The wet grain flows from a garner bin through the two drying sections and the tempering section in the same direction as the drying air. There is no airflow in the tempering section. The function of the tempering process is to reduce the temperature and the moisture gradients in the kernels before grain is further dried, and thus improves the quality of the grain. In the cooler, the grain and air flow in opposite directions. The depth of the grain bed (or layer ) in a concurrent flow
drier and the static pressure and inlet-air temperature are substantially larger and higher than in cross-flow and mixed-flow dryers [1].

3. Counter-flow dryers, in which the drying zone exits only in the lower layers of the grain mass and is truncated at its lower edge so that the grain being removed is not over-dried. The warm, saturated or near-saturated air leaving the drying zone passes through the cool, incoming grain [2]. These dryers are relatively efficient since the air exhausts through the wettest grain [3].

4. Mixed-flow Dryers: In mixed-flow dryers, the wet grain flows from a garner bin over alternate horizontal rows of hot inlet-air ducts and cold outlet-air ducts. The spacing between the airducts determines the grain-layer depth through which the air is forced. Air from the inlet-air ducts flows upwards and downwards to the surrounding outlet-air ducts, in a combination of cross-flow, concurrent-flow, and counterflow with respect to the grain. In a mixed-flow dryer the bottom series of inlet-air and outlet-air ducts serves as the cooling section [1].

Other dryer types

Apart from the drying systems already mentioned, fluidized bed dryers, conduction dryers, rotary dryers, microwave and infra-red dryers are also being used in many countries [3].

Conclusion

In summary, production priorities and grain quality should be considered prior to selecting a grain drying system. When having economic consideration, the producer should rely on field or natural drying. If the main goal is to dry the large quantity of grains quickly, then continuous dryers types should be chosen. Batch dryers should be used when drying small quantity of grains.

References

Fig. 1. Schematics of batch grain drying systems

Fig. 2. Schematics of four major types of continuous-flow grain drying systems