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PACKINGHOUSE NEWSLETTER

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DRYER FUNDAMENTALS - ENERGY CONSERVATION

PART D. This article is the fourth in a 4-part series detailing considerations for packinghouse dryers. In this final segment, an overview of energy conservation measures is presented. The first three parts are found in Packinghouse Newsletters 144, 146 and 148.

Energy Conservation

Energy requirements for surface drying fruit are related to the amount of water to be vaporized and the dryer air conditions, specifically temperature, relative humidity, and airflow. In theory approximately 1000 BTU are required to vaporize 1 lb of water. However, actual requirements for a high efficiency dryer will be at least twice that amount, 2000-2500 BTU/lb-water range. To reduce energy usage, both optimal dryer performance and associated dryer operations should be considered.

Dryer Performance

Two major considerations of an efficient dryer are thermal insulation and an air recycling system. Adequate insulation is a logical energy conservation tool in light of current energy prices. Optimum thickness for any application can be calculated if certain parameters are known: design temperatures, thermal properties of the insulation, hours of operation, fuel costs, capital installation costs, and factors related to the cost of money such as interest and depreciation.

A generalized determination of optimum thickness is shown in Fig. 1. Expenses will vary linearly with insulation thickness after including the initial outlay for installation. Anticipated escalation of energy costs make it reasonable to overdesign. Note that additional costs to over-insulate are not very great. Insulation manufacturers and installers will normally provide optimum thickness value for a given application.

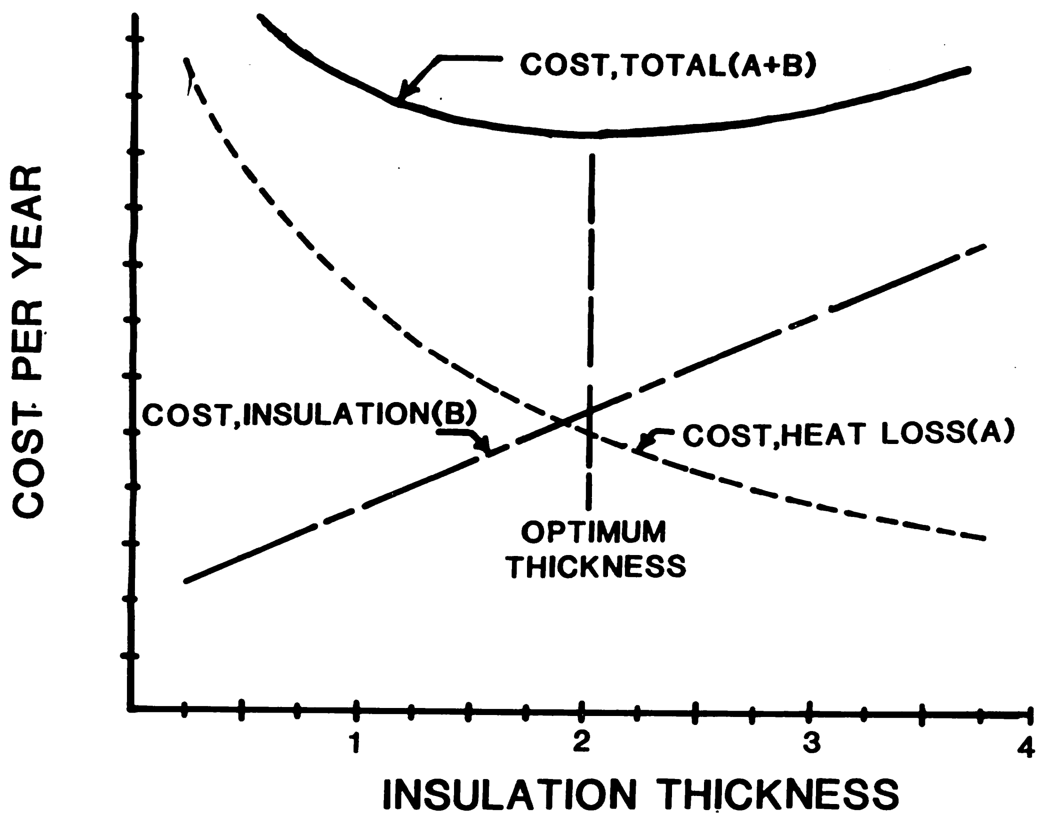

Fig. 1. Cost vs. thickness relationship for thermal insulation.

The most important thermal insulation property is the "R" value or thermal resistance. An R value of 10 provides one-half the thermal resistance as an R of 20. Some typical values are given in Table 1. Low moisture permeability and mechanical strength/durability are desirable. Fire and safety specifications for the insulation material are also important considerations.

Table 1. Thermal resistance values for typical insulating materials.

Material	Resistance, R (BTU/hr-ft^2-^{o}F) per inch of thickness[a,b]
Calcium silicate	2.70
Cellular glass	2.63
Mineral fiber (with binder)	3.45
Urethane	6.25

[a]For 75^{o}F (24^{o}C). In general, thermal resistance tends to decline with increased temperatures.

[b]For SI units: 1 BTU-in/hr-ft^2-^{o}F = 0.1443 W/m^{o}C.

Air recycling is another energy conservation feature in dryer design. In most cases, heated air is not saturated after passing through the fruit. The air can be further utilized in a multi-pass dryer, in an air-to-air heat exchanger, or by proportionally mixing with ambient air for recycling (Fig. 2). The latter is the most straightforward and requires the least capital investment. Additional costs are for ductwork and controls.

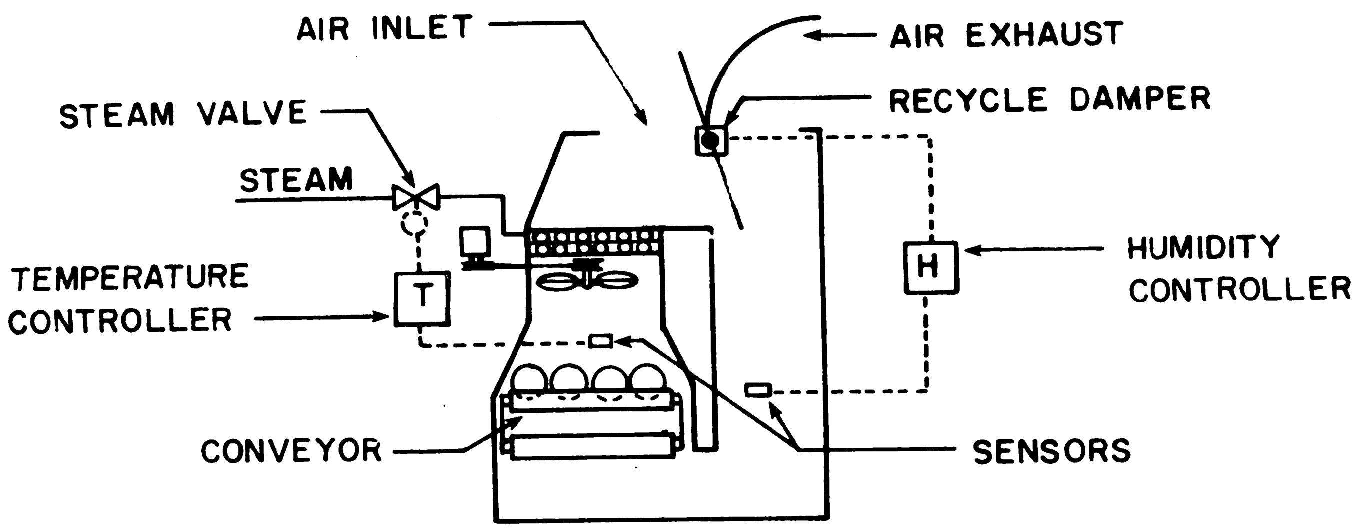

Fig. 2. Schematic of dryer with air recycle and appropriate controls.

Drying is an inherently stable process, so automatic controls compensate for environmental fluctuations and changes such as temperature or amount of surface moisture of the fruit being treated.

Sensors for measuring exhaust humidity include a psychrometer (dry and wet-bulb), dew point cells (lithium chloride or optical) and hygrometer (impedance or capacitive). Temperature sensors are typically either thermocouples, thermistors, or capillary bulb thermometers. Controllers can either be two-position (off-on) or proportioning. Proportional controllers provide an output signal directly related to the deviation from the desired humidity or temperature. The final control element would normally be a modulating valve or air damper. A high temperature safety cutoff can be incorporated to prevent excessive temperatures. For example, exceeding a set threshold would close a solenoid valve on a steam line and trigger a light and/or horn.

Associated Operations

The most straightforward technique to reduce dryer energy consumption is through dewatering either by brushes, sponge rollers, or high velocity air. As pointed out in Part A of this series (Packinghouse Newsletter #144), these techniques require significantly less energy than thermal drying and can remove 50 to 85% of the surface moisture. Again, maintenance is a key element in dewatering effectiveness especially in adjusting wringer rolls, flick bars, etc. Thorough pregrading will also reduce dryer energy needs as well as reduce fungicide and wax use.

Airflow is very important for efficient drying. Therefore, it is essential that air moving devices be serviced on a regular basis and that airflow is directed over the entire surface of the fruit.

Boiler and/or unit heater maintenance should be undertaken on a yearly basis. Proper air/fuel ratios are required to obtain most efficient use of fuel. The most economical and reliable method of determining the combustion ratio of an industrial dryer or boiler is to analyze the flue products. This technique involves quantitative measurement of one or more of the products of combustion (e.g., oxygen or carbon dioxide). This measurement can then be used to determine the air/fuel ratio of the entire combustion process. Effects of air infiltration or improper burner performance are taken into account. The drawback is that the exact cause of off-ratio combustion, e.g., air leakage, bad burner, or improper air/fuel supplies, can not be identified.

Properly adjusted burner equipment should operate with a slight amount of excess air in the flue gases. This amount should be preferably between 2.5 and 5% and should normally not exceed 10%. Since air is about 20% oxygen, the flue gases will contain between 0.5 and 1% oxygen and should not exceed 2%.

Remember, drying is an expensive unit operation for packinghouses. Careful maintenance is a sound financial investment.

W. M. Miller
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FRESH CITRUS QUALITY SHORT COURSE

By popular demand this short course taught at Lake Alfred in September 1987 will be repeated at Fort Pierce in January. The meeting room has limited space so that attendance may be limited. See the enclosed page for information on this meeting.

Will Wardowski, Editor

AVAILABLE PUBLICATIONS

Available from Dr. W. Wardowski, CREC, 700 Experiment Station Road, Lake Alfred, FL 33850

26th Annual Citrus Packinghouse Day Program and Abstracts. 1987.

Physical Properties Data for Postharvest Handling of Florida Citrus. Applied Engineering in Agriculture. 3(1):123-128. 1987.

Mechanical and Physical Properties for Postharvest Handling of Florida Citrus. Proc. Fla. State Hort. Soc. 99:122-127. 1986.

Diplodia Stem-End Rot, A Decay of Citrus Fruit Increased by Ethylene Degreening Treatment and its Control. Proc. Fla. State Hort. Soc. 99:105-108. 1986.

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