AN INTERNAL-FAN KILN FOR DRYING SEED CONES

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Although the drying of seed cones with artificial heat to quicken the opening of the cones has been a practice in North America and in Europe for some time, the results obtained point to a need for improved apparatus. The purpose of this paper is to describe a cone kiln that will do the job in less time than most existing seed cone drying methods and at the same time will yield more viable seeds per bushel of cones at a lower cost per pound of seed produced.

Before describing the new cone kiln it is perhaps best to review briefly previous work on the drying of seed cones.

Previous Methods of Seed Extraction

Toume (5) has carefully studied the air drying, solar drying, and kiln drying of seed cones. He describes the outstanding kiln types used in the United States, Canada, Germany, and Sweden. The type of dry kiln that has met with greatest favor in the United States is the so-called tray type, designed as a simple natural circulation kiln. This kiln has an oven or compartment in which the seed cones are spread on wire mesh trays or perforated drawers of various sizes and spacings. The seed cones are usually heated in the trays by convection of heat from a hot-air furnace commonly located beneath the oven or compartment. With this type of kiln, the seeds are extracted by shaking after the cones have been dried and opened. One of the objections to the natural circulation tray-type kiln is the lack of uniform drying of the cones due to the low rate of circulation and the long upward air travel through the trays of cones.

The other outstanding kiln types employed for drying seed cones, particularly in Europe, are the drum and tunnel types. In these kilns the drying and shaking of the seed cones are combined in one process, the drum or cylinders being rotated in a heated room. The drum-type kilns are designed to stir the cones in order that they may be more uniformly dried, and at the same time utilize the stirring movement to shake out the seeds.
The Annaburg plant described by Recknagel (3) is a German installation of the drum-type kiln. This plant employs natural circulation in that the heat from the furnace reaches the seed cones to be dried in the revolving drums by convection only. Another cone kiln of this general type has been installed at Angus, Ontario, by the Ontario Forestry Branch, and is described by Richardson (4). Whereas the Annaburg plant is solely a natural circulation kiln, the Ontario plant utilizes two 12-inch fans to force the movement of air in the room in which the drums are located. Both of these drum-type installations are heated with hot air, the Annaburg plant heating the air with an open fire in the kiln room and the Ontario plant with a hot-air furnace.

The tray and the drum types of dry kilns are generally termed "compartment kilns" and are "batch" dryers. A "continuous" dryer is one in which a continuous flow of material to be dried is carried through the kiln. A cone kiln used in Sweden and described by Baldwin (1) is of this continuous type. It also combines the drying and shaking of the seed cones, as does the drum dryer, but the heated air is carried to the seed cones by forced circulation, utilizing a blower. This latter kiln can be considered as a typical tunnel dryer in that the cones being dried gradually descend from the top to the bottom of a vertical cylindrical kiln.

Recknagel (3) indicates that the natural circulation tray-type cone kiln has proved unsatisfactory in Germany because the unequal temperatures throughout the kiln result in more rapid drying in certain trays than in others, thus necessitating changing and sorting of trays, which requires extra hand labor. The Annaburg cone kiln tends to overcome some of the objections to the older type of natural circulation tray-type kilns, but still lacks adequate temperature control. Moreover, if the cones are agitated sufficiently in the drum to give good uniformity of drying they are badly broken, and the cost of cleaning the seeds is thereby increased.

In order to decrease the time required to open the cones in the natural circulation tray-type kilns, the temperatures are often increased to the point where the viability of the seeds is endangered. The fire hazard in these installations also increased with the use of higher temperatures, and often the nurseryman has found his extractory in flames. On the other hand, the use of higher temperatures increases the rate of natural circulation, which results in more uniform drying.

The many years' experience of the Forest Products Laboratory in the kiln drying of lumber has shown that both decreased drying time and increased rate of circulation can be obtained with minimum fire hazard by means of mechanically operated fans. It was therefore suggested that the natural circulation tray-type kiln be modified to a forced-draft type kiln by installing a simple disk fan. This was done in the extractory at the Cass Lake Nursery, Cass Lake, Minn., and with other minor modifications
jack pine seed cones that previously required 12 to 14 hours to open were opened in 5 to 6 hours, and Norway pine seed cones that formerly required 8 hours to open were ready in from 4 to 5 hours. The temperature at which these increased efficiencies were obtained was less than that formerly used to dry these species of seed cones.

As forced-draft circulation indicated marked drying efficiencies, temperature and relative humidity control with the use of steam rather than with the use of a hot-air furnace were suggested as further necessary modifications where increased extraction programs were involved. So far as the author is aware, the first forced-draft, steam-heated, controlled seed-cone kiln used in the United States was designed and installed by the Southern Region of the Forest Service. It was built and installed in the fall of 1934 at the Stuart Nursery, on the Kisatchie National Forest, near Alexandria, La. This kiln replaced a natural circulation tray-type kiln that, in order to supply the longleaf pine seeds needed for an expanded nursery program, had been pushed to the point where the whole extractory building was burned down.

The rebuilt extractory is equipped with a tray-type, batch-operated compartment kiln, using steam for heating and humidification and a nozzle system for recirculating the air. The kiln is equipped with an external blower for building up air pressure at the nozzles. In the older natural-circulation cone kiln it required from 45 to 66 hours to open the longleaf pine cones, and a yield of 0.76 pound of seed was obtained per bushel. With the new forced-draft kiln the drying time has been reduced to from 8 to 12 hours, and the yield has increased to 1.20 pounds per bushel of cones. The increased production of this new kiln and the lowered drying costs compared with the old type of equipment are reported to be sufficient to pay for the installation of the new extractory in two extraction seasons.

In drying a material so susceptible to temperature as is tree seed, forced-draft drying equipment that is controllable as to temperature and relative humidity seems necessary, especially where a volume of 3,000 or more bushels of cones are to be dried and extracted each year. The costs of collection or purchase of seed cones and the invested transportation charges by the time these cones reach the extractory are usually very high, and therefore few agencies can afford to kiln dry seed cones under conditions conducive to greatly reduced viability. This implies high-grade drying equipment manufactured and installed by reputable engineers and companies qualified to design and install such equipment.

Forest Products Laboratory Internal-Fan Kiln

The cone kiln designed at the Forest Products Laboratory and described here is of the forced-draft tray type. It is adaptable to the
drying of small or large cones at whatever drying conditions the particular species of cones being dried requires. The kiln provides for the control of the temperature and the relative humidity of the drying atmosphere, and permits large volumes of air to be circulated at uniform velocities throughout the seed cones in order that viable seeds suitable for immediate planting or for storage can be obtained with low extraction costs.

The design is based on the principle that, where uniform and fast drying is desired, it is more economical to move mechanically the air carrying the heat for evaporation than to attempt to move the material to be dried. With a forced-draft design a short and unrestricted air travel can be had by directing the flow of air horizontally across the trays rather than vertically, thereby obtaining uniform drying of the cones.

The schematic sketches of Figures 1 and 2 indicate the general layout of the kiln. It is an overhead, short transverse-shaft, internal-fan kiln in which steam is used for heating and humidification. The kiln walls and ceiling, in the form of panels, are attached to a steel frame. This frame also supports the overhead fan equipment and heating coils. Two 24-inch disk fans are used, operating at 550 r. p. m. and driven through "V" belts by two 1/4 horsepower reversible electric motors. The heating coils are located to give efficient heat transfer as well as to break up any velocity heads produced by the fans. The heating coils are subdivided in order that the radiation can be varied to suit the heating demands, and thus provide better temperature control.

The temperature and relative humidity of the kiln are controlled with either an electric or an air-operated recorder-controller. The same instrument automatically controls the amount of air vented by the vent blower when dehumidification is required. This system conserves heat in that only the air necessary to remove the moisture evaporated from the cones is vented. Humidification is provided in order that air-dried casehardened cones can be treated, to facilitate their opening.

The wall and ceiling panels can be made of almost any material. The material should preferably be moisture-proof and fireproof and should possess a fair amount of insulation. With the fan and heating coils located overhead the kiln is easily cleaned, thus reducing the hazard of dust explosion.

The cone kiln can be located on the ground floor or on the second floor of an extractory building, depending on how the cone trays are loaded and how the extractory building is arranged. If steam is not available, it is necessary to provide a small boiler capable of generating low-pressure steam. An ordinary house heating boiler is sufficiently large.

If electrical power is not available, either a small gas-engine generator can be installed or the fans can be operated directly by a gas
engine, the same engine operating a small compressor supplying air for an air-operated recorder-controller.

The cones to be dried are spread on wire mesh trays that are nested on top of one another and all piled on a skid that is moved in and out of the kiln with a lift truck. The spacings between the trays can be varied to suit the size of the cones, 2-, 3-, and 4-inch spacing lugs being provided in the cone tray design. The cone trays are 3 by 4 feet in size, and the kilns long enough so that two skid loads can be put in the kiln. Capacity of the kiln is about 33 to 35 bushels of seed cones.

A single row of skid loads of trays in a kiln, as illustrated, is the preferred arrangement. However, it would be quite possible to develop a good double-row design.

Tray sizes may be determined by local conditions; in general, trays larger than 3 by 4 feet are likely to be difficult to handle. The variable-spacing feature can be omitted when cones of one size only are to be extracted.

It should be pointed out that this particular design is presented simply as one of a number of possible effective arrangements. The one most important requirement is that the kiln, of whatever design, be capable of maintaining the proper temperature and humidity conditions throughout its entire volume and be provided with ample circulation.

The design here presented is not limited as to length; in fact it can be easily shortened to accommodate a single skid-load of trays, or extended to hold as many units as may be desired. Two kilns can conveniently be placed side by side, or end to end. The fan arrangement shown does not lend itself to the installation of more than two kilns side by side, but it is not difficult to modify the design to permit such installation.

A single kiln unit of this design has been installed by the U. S. Forest Service at the Ozark Nursery, on the Ozark National Forest, Russellville, Ark. A 2-unit installation is being considered for installation at the Chittenden Nursery, on the Manistee Purchase Unit in Michigan.

Drying Schedules

With the advent of fast-drying equipment under complete and automatic control, drying conditions or schedules for the various species of seed cones may possibly be revised. Controlled cone kilns with high rates of uniform circulation of air can operate at lower temperatures, yet produce more seeds at a lower cost under conditions of lowered fire and explosion hazard. On the other hand, the rate of drying and the time in the cone kiln may have a material effect on the temperatures usable for drying,
possibly increasing the maximum temperatures that may be used. Tourney (5) indicates that the cones must be properly cured before drying, that they must be subjected to a uniform temperature just long enough to effect their opening, and that the kiln air must be kept as dry as possible. Baldwin (1) suggests that the rational extraction procedure is one of increasing temperature and gradually lowering relative humidity.

Bates (2) has found that 4 to 6 months of moderate air drying gives the best yield and quality of seed when lodgepole seed cones are subsequently kiln dried. He also finds that temperatures up to 200°F can be used in kiln drying lodgepole seed cones if they have been given a prolonged period of air drying. Bates further suggests that preliminary air drying of lodgepole is necessary so that the kiln drying period can be limited to 6 to 8 hours at the elevated kiln temperature; longer heating periods reducing the quality of the seed.

At the present stage, in which optimum drying schedules, conducive to the maximum production in a minimum time of seeds having the highest viability, are being worked out, the need is for a kiln in which a highly flexible drying schedule may be had. The internal-fan cone kiln described here appears to fulfill this need, since it is designed to meet the drying requirements whether the schedule be a constant temperature and relative humidity or a changing temperature and relative humidity.

Literature Cited


(3) Recknagel, A. B. 1912. The equipment and operation of a Prussian seed extracting establishment. For. Quar. 10:229-234.

