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CONTENTS

SEED DRYERS FOR EXPERIMENT STATIONS
DESIGN, CONSTRUCTION, & TESTING OF A PROTOTYPE

by

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INTRODUCTION

In order to maintain viability and superior seed quality it is essential that seeds be stored in properly conditioned and safe storage facilities after drying to required mositure content. In case of germplasm and breeders' seed in an experiment station, it becomes all the more essential that seed drying and storage be carried out with utmost care since the seed involved is valuable and if lost cannot be reproduced. The moisture content of seed at harvest is too high to permit safe storage. The seed, therefore, has to be dried to safer levels of moisture for storing. Similarly material from yield trials is required to be brought to a uniform level of moisture for comparative analysis. In addition to seed, there are a number of plant samples that the researchers need to dry for analysis.

SEED-DRYING REQUIREMENTS SPECIFIC TO EXPERIMENT STATION NEEDS

The basic needs are :

1. That the temperature in the drying bin not exceed 38 C throughout the drying period. In the case of bulk grain it could be much higher (Hall 1970, Harrington 1966).

2. The drying time should not be too long, otherwise fungus and mold will grow on the seed under high temperature and humidity conditions in the bin (Harrington 1970).

3. The size of the bin should be large enough to accommodate the samples from an experiment but at the same time not so big that a portion of the material gets over-dried; also sorting of samples while unloading becomes cumbersome if the bin is too large.

4. The bins should be so equipped that the dry seeds can be cooled by turning off the heat before the seeds are removed.

5. The drying system should have a fool-proof warning mechanism to avoid any damage to seed in case of failures.

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SEED-DRYING REQUIREMENTS AT ICRISAT

ICRISAT's mandate crops are sorghum, pearl millet, pigeonpea, chickpea, and groundnut. Therefore, our major requirement of seed drying is with respect to these crops only. However, we envisage drying of plant samples and seeds from other crops that form a component of our farming systems research. By virtue of location and climatic conditions at Hyderabad, the harvesting season for our monsoon crops falls during receding rains which makes artificial drying an essential requirement. Obviously, our drying needs at this time are much more than those in our postrainy season. The seed dryers at ICRISAT thus have to accommodate :

- Wide fluctuations in our drying requirements between rainy season (peak) and postrainy season (lean).

- Varying quantities of seed samples that range from a few grams to kilograms; the lot coming out of one experiment varies from 50 kg to 1000 kg.

- A variety of crops to be handled; often pods, earheads, and plant material are also to be dried before threshing.

Considering the above requirements, we needed seed dryers that would meet these requirements and still be efficient and economical. Basically, we needed a large seed drying system with individual drying bins which could be used for samples coming from different experiments. Each bin should have an individual control for temperature and air circulation so that it could be used for drying and cooling of seed after it is dried.

The system should be able to operate efficiently in peak and lean periods, and the heat source would have to be indirect, at the same time be centrally located with provisions for necessary modifications in case future requirements dictated. The drying time would have to be kept within a range that would suit groundnuts without spoilage; at the same time it should be efficient for seeds like pigeonpea and other crops. Lastly, it would have to be simple enough that locally available technicians could operate and maintain it. With these objectives in view, development of a prototype dryer was undertaken.

CONSTRUCTION OF A PROTOTYPE AND ITS FEATURES

The prototype has been designed and consturcted with four drying chambers, each with a unit heater system, permitting us to study the overall performance as well as the different components and incorporate any changes needed.

FEATURES OF THE SYSTEM

1. Each bin accommodates about 90 kg or more of material loosely packed in cloth bags to be loaded in sliding type wooden trays with wire mesh bottom. This not only facilitates easy loading and unloading, but also prevents the possible mixing and misplacing samples of different experiments.

2. The unit heater system is capable of delivering about $23 m^3$/min of air at 5 cm water guage (WG) at the required temperature. This quantity of air was arrived at taking into consideration the suggested air rates for groundnuts, i.e., about 15 m^3/min per m^2 of floor area for 1.5 m^2 of floor area of each bin (Woodruff 1973).

3. The unit heater system is capable of controlling the drying air temperature through a thermostat with the sensor placed in the plenum. Since each bin is independently operative for drying and cooling separately, the heat load on the central source, i.e. the boiler, would be reduced whenever any particular units are not working or are cooling.

4. The temperature of this volume of air, 23 m^3 /min has to be raised from the ambient to a maximum of 38°C for seed and about 65° to 70°C for plant samples. The temperature is initially raised by about -6.67°C (20°F) requiring about 4000 kilocalories per hour, and then the return air — the air leaving the material — is exhausted or recycled depending upon the relative humidity (RH) of the air leaving the material, with fresh make-up air added whenever necesarry as the drying process progresses. Since the moisture content of the material is high initially, it does not need a drying temperature of 38 C immediately when the drying process starts. The return air can be recycled, depending on its RH, with a little of make-up air. The temperature of air is gradually increased to a maximum of 38 C for seed and 65 to 70 C for plant samples as the drying process progresses. The amout of heat needed also will reduce gradually as more and more warm air becomes available to be recycled and as the temperature drop through the material reduces.

OTHER FEATURES

The prototype consists of four individual drying cabins with hollow concrete block walla, a wooden top and twin doors; each cabin is capable of drying seed 30% to 10% moisture content in a 24-hour cycle, including loading and unloading of material. The drying medium is hot air. Each cabin is provided with its own unit heater system mounted on the top of the cabin, consisting of a centrifugal blower (23 m^3/min) at 5-cm WG forcing air over hot water coils carrying about 4.5 L/rain of water, down through the supply air duct into the plenum to rise through the material being dried and be either exhausted or recycled. Hot water is provided to the coils by a central boiler (in this case a SEARS steam cleaner with heat input of 57,500 K.cal/hr was used), water being pumped by a 1.5 HP pump @ 18 L/min.

TESTING METHODOLOGY

Fresh harvested samples of seed (90 kg each) and straw with high initial moisture content were loaded into separate bins, with the plenum thermostats set at 38 C for seed and 70°C for straw samples, so that these temperatures are not exceeded. Similarly, the humidistat placed inside the bin, sensing the RH of the air leaving the material, was set at 50% RH so that air above that level was exhausted or got proportionately recycled with a little fresh make-up air whenever the RH of the air leaving the material dropped below 50%. Thermometers and hygrometers were fixed to record the temperature and RH of the ambient air, plenum air, and the air leaving the material, as well as the temperature of hot water and return water. An anemo-thermometer was used to measure the air quantities delivered by the blower and the static pressures. The weight of representative samples was recorded for every 6 hours during the drying process. The termostat of the boiler was set at 93°C so that water temperature was maintained around 93°C. Initially, only the pump and boiler were started for about 10 to 15 min so that the temperature of the water raised to 93°C and then the blowers started. Water was cooled by the air passing over the coils and was reheated by the same amount by the boiler every time water was recycled through the boiler. Hot air was cooled as it passed through the material picking up moisture above 50% RH either to be exhausted or proportionately recycled with a little of fresh make-up air as the EH dropped below 50%. The temperature of the hot air was controlled by the thermostat with the sensor placed in the plenum sensing the temperature of the air, actuating a modulating motor proportionately controlling the amount of water to the coils through a three way valve.

Similarly, the return air was exhausted or proportionately recycled with fresh make-up air, the operation being controlled by the humidistat in the cabin sensing the RH of the air leaving the material and actuating the modulating motor controlling the dampers through linkages. The temperature of the hot water was maintained at 98°C by the thermostat sensing the temperature of the water leaving the boiler. The fuel consumed was measured by noting the quantity of the fuel in the tank before and after the test.

RESULTS & DISCUSSION.

These units have been used for drying seed samples of all the crops and also plant samples. It was observed that seed samples could be dried in about 24 hours, whereas the green plant samples took more time -- even up to 40 to 48 hours — especially when the stems were of more than 2.5 cm dia. The temperature of the ambient air was observed to rise by about -6.67°C (20°F) in one pass, i.e. from 23 to 25°*C* at 75 to 80% RH to 35°C, 40% RH initially, and then drop by about -9.44°C (15°F) through the fresh material being dried and the air exhausted. The return water temperature dropped at this stage by about -1.11°C (30°F),. from 93 to 76°C. As the drying process progressed, with the material getting drier, the temperature drop of the air through the material reduced; the drop varied from -15 to -12.20°C (5 to 10°F), and as the air leaving the material was dry enough, less than 50 to *55%* RH was recycled gradually increasing the temperature of the hot air to 65 to 70°C. The return water temperature dropped by -6.67°C (20°F) from 93-86°C gt this stage. The hot water temperature through the boiler was maintained at 93°C with the boiler consuming about 2.5 liters of kerosene oil per hour.

It can be seen that the temperature drop of hot air through the fresh material initially was only about -9.44°C (15°F) and further reduced to, say, -15 to -12.22°C (5 to 10°F), as the drying process progressed, affecting the overall efficiency. The rate of picking up of moisture from the material was reduced because of the fact that the material was packed in cloth bags; also it was mostly either earheads or pods and not loose grain, thus restricting the direct air contact to some extent, especially on material sandwiched inside the bags. The overall efficiency thus was affected,though the efficiency of the two main heat-transferring units of the system — from boiler to water and from water to air — was quite good.

The heat input of burning — about 2.5 L/hr of kerosene with 10,000 K.cal/kg calorific value is 20,000 K.cal/hr (Perry 1976) was utilized to raise the temperature of 18 L/min water by -6.67°C (20°F), about 12,000 K.cal/hr, i.e., an efficiency of 60%. Similarly the heat lost by water — 3,000 K.cal/hr for each bin — was utilized to raise the temperature of 23 m^3/min air by about -12.22°C (10°F) as the drying process progressed and the system stabilized,using about 2,000 K.cal/hr with an efficiency of 66%.

The overall thermal efficiency was 13.5%; this was with a heat input of 20,000 K.cal/hr from the boiler consuming kerosene @ 2.5 L/hr to remove about 73 kg water from all the four bins drying seed of 30% to 10% moisture in about 22 hr, equivalent to 2700 K.cal/hr heat capacity (825 K.cal are needed to vaporize 1 Kg water).

The functioning of the various components of the unit heater system such as blower, heating coils, and different controls, has been found to be good except that the blower is a little noisy. The SEARS steam cleaner used in place of a boiler also worked well operating on kerosene instead of light diesel oil (LDO) to be used in the boilers of the permanent complex. The descaling of the unit was to be done about once in a season to remove the scales.

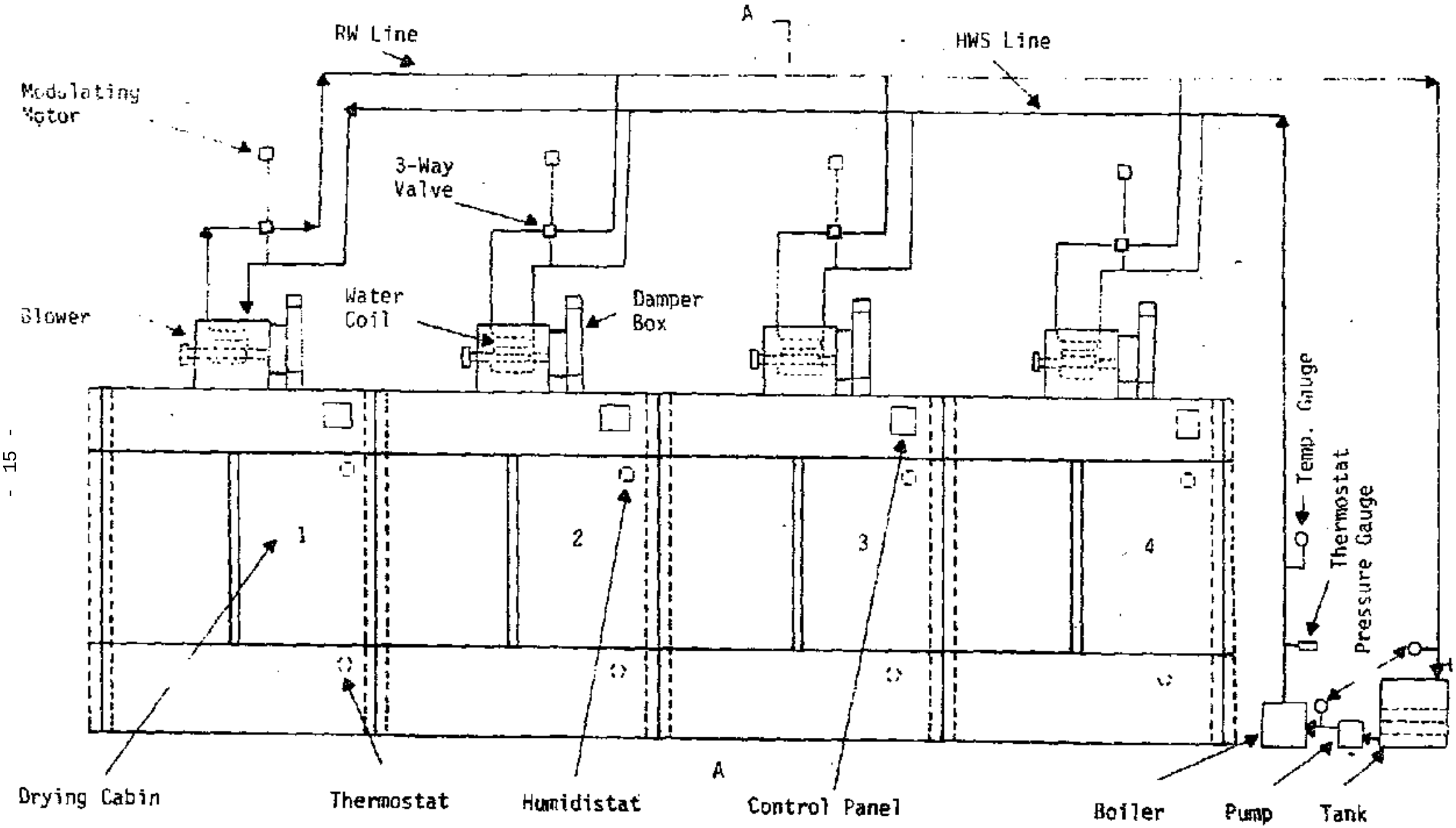
WHY UNIT HEATERS WITH LDO ARE CONSIDERED MORE SUITABLE OVER OTHER HEAT SOURCES

As an alternative to the unit of heaters drawing heat from a central boiler, the use of electric ovens would have been quite expensive, in view of their initial cost as well as the high operating cost. They also would require more drying time since in the ovens, the air is generally circulated around the material and not forced through. Similarly, the use of electricity as a source, though clean, necessitates increased wire and equipment size to take care of the increased electrical loads and also causes high-peak, short-duration loads that are sometimes not desirable. Also, the cost of operation would be high, since the cost per unit amount of heat output through an electric heater is substantially more than through a boiler for an equal amount of heat output. For instance, the calorific value of 1 liter of kerosene or diesel would be approximately equal to 9 KWH or 9 electric units.

Our experience with the ovens indicates that one of the ovens with a 1.4m^3 capacity consuming 12 KWH takes about 48 hours for drying plant samples, nearly the same time that the prototype takes for drying material of about 3.6 m capacity in all the four bins with two tiers of trays in each bin consuming about 2.5 L/hr of kerosene. This gives a ratio of coat of operation of Rs.4.8 for the ovens to Rs.1.4 for the prototype for drying an equal amount of material.

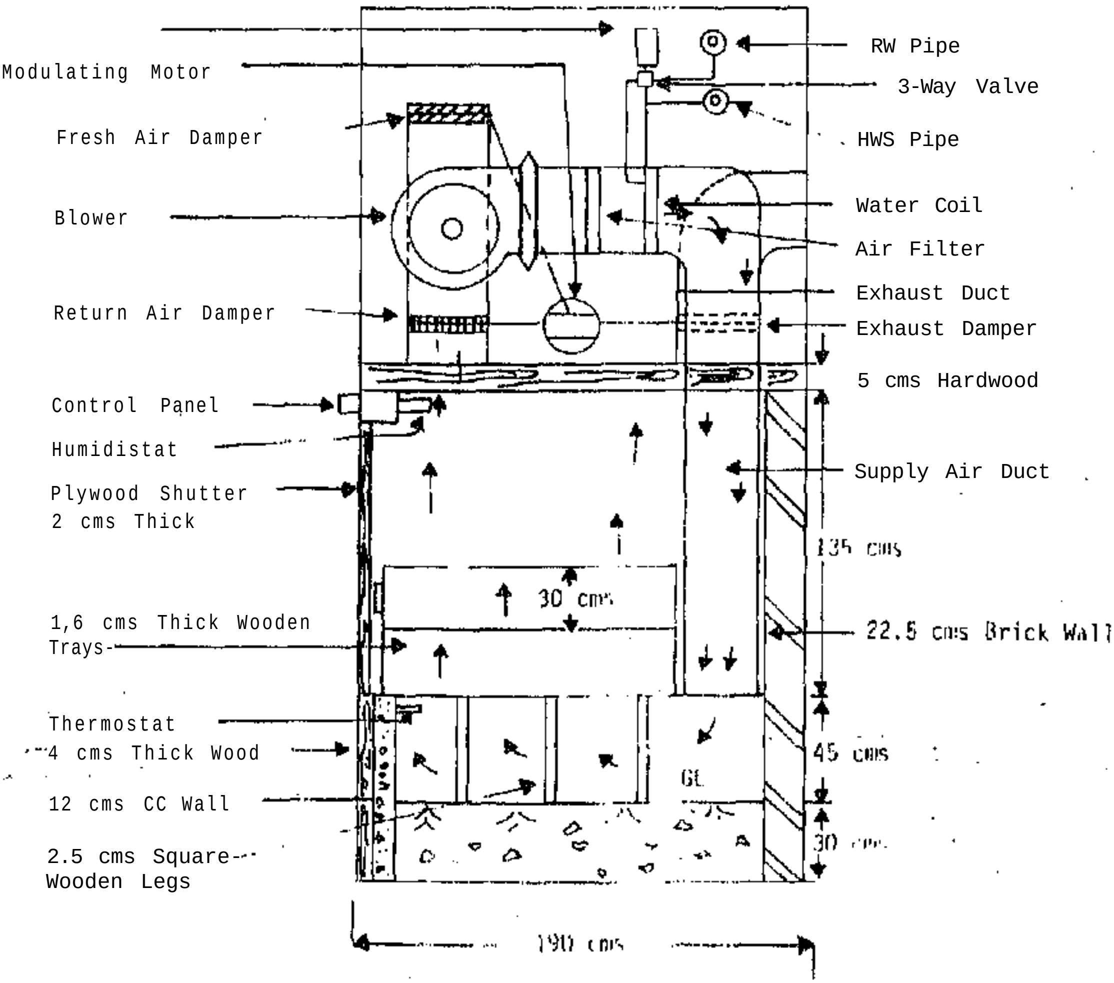
CONCLUSIONS

Unit heaters with all the controlu — dampers, modulating motors etc., delivering 23 m^3 /min of air at 5 cm WG would be adequate for drying 90 kg of seed samples from 25 to 30% moisture content to about 10% moisture content in a 24-hour drying cycle. A three-row water coil of 60 cm x 21 cm x 4 fins/cm 1 cm outer dia copper tube, carrying about 4.5 L/min of water was found to be suitable for gradually heating 23 m^3/min of air, to the desired temperatures (up to 38 C for seed and 70 C for plant samples), with the exhaust air below 50% RH getting recycled proportionately with a little fresh make-up air through the dampers. The use of a six-row coil instead of a three-row coil carrying up to 9 L/min of water would be more suitable for plant samples for a faster rate of drying. These unit heaters can operate independently for drying as well as cooling, thus reducing the load on the central boiler, whenever some of the units are not operating or only cooling the material.



SCHEMATIC SHOWING FRONT VIEW OF PROTOTYPE SEED DRYING UNIT

ICRISAT



DRG: NO1 10 SCALE

SECTION A-A SHOWING UNIT HEATER DETAILS

SPECIFICATIONS OF VARIOUS COMPONENTS/CAPACITIES

Drying capacity of each cabin	:	90 kg of seed from 25 to 30% initial moisture content to 10% final moisture content.
Air quantity/each cabin	:	23 m^3/min at 5 cm WG centrifugal type blower, 1 HP Motor (Model CF 122B, SWST-ARR9).
Boiler capacity	:	57,500 K.cal/hr Sears Steam Cleaner Model 765.44 5011 was used.
Water pump	:	18 L/min (hot water up to 98°C) 1.5 HP Motor, make BEACON, Model IDM5.
Heat Exchanger (Hot water coils)	:	Copper tube type 1 cm outer dia. Three-row deep (60 cm x 31 cm x 4 fins/cm).
Modulating Motor (for controlling damper)	:	Model M944A, 90° Stroke, Honeywell make.
Thermostat (PLENUM)	:	Honeywell. T 99 1 A -17.78 to 38°C (0 to 100°F).
Thermostat (Hot water)	:	PENN, 0 to 100°C .
Humidistat	:	Honeywell, Model H 93 A, 30 to 80% RH.
Temperature Gauge	:	Weksler Instruments (0 to 115°C).
Pressure Gauge	:	Marsh Instruments (0 to 4 kg/cm^2)
Modulating motor (for controlling water to coils)	:	Model: M 944 A. 160° Stroke, Honeywell make, with three-way valves and linkages.

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