HOT AIR KILNS

of

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Hot Air Kilns under discussion to be defined as direct-heated kilns, the heat being generated by gas or oil.

For several decades hot air kilns have been of the greatest interest to dry kiln users and designers alike, particularly in cases where the cost of installation and operation of a boiler plant seemed out of proportion to the cost of installing a hot air type of dry kiln.

Since about 1959, direct heated dry kilns have become of increasing importance in British Columbia, especially kilns heated by gas or oil without the employment of boilers or boiler crews. The reason for this increasing importance of direct heated kilns is their economic advantage, ease of operation and high efficiency in the utilization of BTU's employed.

Economic Advantage:

1. Capital Cost

The first cost of installing a gas unit will be far less than the cost of installing the same size of dry kiln complete with boiler and boiler house.

2. Labour

The average labour cost of operating a high pressure boiler plant in B. C. is around $25,000 per annum for a small plant. For larger installations requiring extra labour around the fuel bin, the yearly labour cost can be considerably more.

3. Fuel Cost

With woodwaste-fired boilers, the fuel cost is, of course, nil. The cost of drying is variable in accordance with the price of fuel obtained. We assume it requires about 1¼ million BTU's per/M Bd. Ft. to kiln dry 2" Spruce from green to 16% moisture content on a yearly average. These figures are empirical and have been estimated entirely for the Prince George area. Natural gas used to be available at 38 to 40 cents per million BTU and the average gas cost would amount to about 50 cents per/M Bd. Ft. on a yearly average. Obviously this figure is less in summer time and more in winter time when frozen lumber has to be thawed out. With natural gas now available at about 60 to 64 cents per million BTU's in the Interior, the cost will be about 80 cents per/M Bd. Ft.

Using Propane at, say, 90 cents per million BTU's, we would estimate drying costs of around $1.12½ per/M Bd. Ft.

Using diesel oil at 20 cents per gallon and a calorific value of approximately 164,000 BTU's per imperial gallon, you will require about 6 gallons of oil per million BTU's. The fuel cost on that basis would be $1.20 per million BTU's and the cost for drying 2" Spruce in northern areas would be as high as $1.60 per/M Bd. Ft.

Various types of bunker oil are available at much less cost but if they contain impurities such as sulphur, this is to the detriment of the kiln equipment.

Fuel cost for gas and oil kilns must then be compared with the labour cost arising at a boiler house.

Assuming a 100 ft. dry kiln will produce at least two million Bd. Ft. per month, then with natural gas at 80 cents per thousand Bd. Ft., the fuel bill per month would be $1,600; with a production of 2.5 million Bd. Ft. per month, the fuel cost would amount to $2,000 per month. Obviously with a fuel consumption of about $24,000 per annum, we are about level with the cost of an engineer's crew for a small high-pressure boiler installation. As we have pointed out before, if larger boiler installations are considered, some wages must also be allowed for the crew attending the fuel bin. In this event a somewhat greater production of hot-air kilns can be considered and consequently a substantially greater fuel bill can still be competitive with the cost of running a boiler plant. However, there is an economic limit as to the size and output of gas or oil-heated dry kilns. In accordance with present cost of fuel and cost of boiler-house attention and maintenance, the economic advantage will certainly be with one-100 foot hot-air kiln and probably with two such kilns, depending entirely on factors of economy. My feeling is that beyond two kilns; that is, beyond a kiln capacity of 300-350 M Bd. Ft., the fuel cost must run so high that for larger mills steam kilns with the proper boiler house installation, however costly, should be considered.

Kiln Installation

The physical size of a hot air dry kiln, (doors, rails and general building construction) is identical to a steam kiln installation of equal size. However, instead of steam coils, the hot air kiln must be supplied with hot air ducts. As hot air is thus added to the dry kiln, kiln air must be taken from the kiln, re-heated in the hot air furnace and returned to the kiln.

As with all kilns, the main principles are as follows:

Kiln air must be heated;
Kiln air must be circulated through the lumber pile;
Kiln air must be humidified or de-humidified.
The above features must be automatically controlled.
Heat humidity and circulation must be uniform throughout the whole dry kiln.

Circulation

Circulation is employed in my kilns with a series of fans located above each lumber pile. A single stack dry kiln air circulation is thus achieved. The kiln fans are reversible and thus supply warm air to alternate sides of the lumber pile. If the pile is about 9 ft. wide, the deepest point of air penetration is half-pile or 4'-6".

Heating

The furnace is placed outside the kiln, usually along one of the side walls. Air is discharged downwards, the hot air ducts leading into two longitudinal plenum chambers. From the plenum chamber the air is taken upwards and a separate adjustable outlet is provided for each kiln circulation fan. From here the kiln fans blow the heated air to the lumber pile.

The kiln is also equipped with a return air plenum chamber which collects kiln air uniformly throughout the whole length of the dry kiln. By means of a duct. this air is returned to the furnace where the air is again heated and returned to the kiln.

Humidification and Ventilation

Ventilation of a kiln is achieved by means of the above return air duct. By fully or partially opening a damper in the return duct kiln air is vented to the outside and fresh air admitted. The hot air kiln is, of course, a "cold water kiln". Cold water is injected into the kiln in two ways:

1. By atomizing nozzles inside the dry kiln with one nozzle located opposite each kiln fan.

2. By atomizing nozzles injecting water into the kiln hot air duct. This hot air duct runs at temperatures well above the boiling point of water, thus steam at atmospheric pressure is produced. However, there is a limitation in the amount of water vapour which will be formed within the kiln by injecting, however finely atomized, streams of water opposite the kiln fans. There is also a limitation in the amount of water vapour the heated air can absorb and we cannot, therefore, obtain the extremely high humidities which can be produced with a steam kiln. Of much importance also is the quality of building material which should not be permeable by water to any great degree.

As opposed to this, it is a complete fallacy to assume that a hot air kiln needs no water injection. I believe it has been argued that water is produced as part of the products of combustion and that therefore a gas (oil) heated kiln requires no additional humidification. Usually these kilns require no humidification in the heating-up stage -- in fact, the injection of cold water is detrimental to the heating-up process. Gas kilns undoubtedly need humidification facilities in the later stages of the drying process. Particularly, if at the end of the kiln run an equalization period is required, you have a period where the maximum addition of humidity is needed with perhaps the minimum input of heat. Should you have relied on the humidity produced by the products of combustion, you would then be in the unhappy predicament of needing the most amount of humidity when, in fact, the furnace will produce the least amount of heat energy and therefore, the least amount of additional water vapour.

Controls

The dry kiln is controlled by means of the usual wet and dry bulb thermometer with the usual "split" dry bulb system where two dry bulbs of a vapour tension system feed into one bourdon tube. Thus the bulb at the air inlet side of the lumber pile will be the controlling one. This instrument will indicate kiln temperature; it will record kiln temperature and it also will control kiln temperature. If required, it will fulfill all these functions with a preset cam schedule for temperature and humidity. All instruments on slides shown are by Taylor Instrument Co. of Canada.

This primary temperature and humidity demand will be expressed in a pneumatic signal varying from 0 to 20 PSI.

For the control of humidity, the pneumatic signal will open or close the pneumatic water regulator and open or close the kiln vent damper.

For the control of temperature, the pneumatic signal is fed into a second controller situated at the furnace outlet.

This controller is set for a maximum temperature of 325 degrees and the pneumatic signal has to pass through this second controller to reach a modulating gas valve. As the safe temperature limit at the fan outlet is reached, the primary pneumatic signal of 20 PSI will be reduced in magnitude to permit modulation of the pneumatic gas valve and thus effect modulation of the gas flame. With oil furnaces, the same effect is achieved by using one-two-and three stage burners.

Safety

Safety is all important in all kilns and even more so with a plant heated with a bare flame. I have just explained the heat control and built in safety features with regard to the hot air fan. When talking of 325 degrees Fahrenheit I mean the maximum temperature of hot air fed to the dry kiln fans. The kiln temperature would be as per kiln schedule temperature required, usually from 150 degrees Fahrenheit anywhere up to 200 degrees Fahrenheit. The reason for a maximum of 325 degrees Fahrenheit at the fan outlet is that the ignition temperature of wood is about 375 degrees Fahrenheit to 400 degrees Fahrenheit. By admitting your medium of heating, namely, the air fed to the kiln fans at some 50 degrees Fahrenheit below the ignition temperature of wood, we add immensely to the safety of the whole dry kiln.

The Final Product

The main area of employment of hot air kilns has been in the center of the province and thus the main products dried have been Spruce and Jack Pine. Douglas Fir, Balsam, Hemlock, Cedar, Idaho White Pine and others have also been dried very satisfactorily. For an average of 2 x 6 Western White Spruce, an average drying time is approximately two days with temperatures at about 175 degrees Fahrenheit dry bulb, wet bulb at 140 degrees Fahrenheit reduced to 135 degrees on the second day. Moisture content has been an average of 40 to 50 per cent green reduced to 16% dry. Considerably less drying time can be estimated when the green lumber has a lower moisture content or where higher temperatures are employed.

For 1" boards in Prince George, we used a 30-hour drying cycle. More time should be allowed for very wet Spruce or Spruce required for re-sawing into 3/8 inch boards when extra time will be needed for conditioning and probably the Spruce be dried at a lower temperature schedule.

Buildings have been made in lumber, cement block with lumber roof and all-aluminum construction. Undoubtedly aluminum is the best and should have the longest life with the least maintenance. Wood buildings undoubtedly are the cheapest with maximum maintenance over a short lifetime. Concrete block construction occupies a position between these two extremes and they certainly have a maximum resistance to mechanical damage.

Conclusions

1. Hot air kilns are very competitive with steam kilns provided fuel cost does not out-distance labour cost in the boiler house and fuel bin.

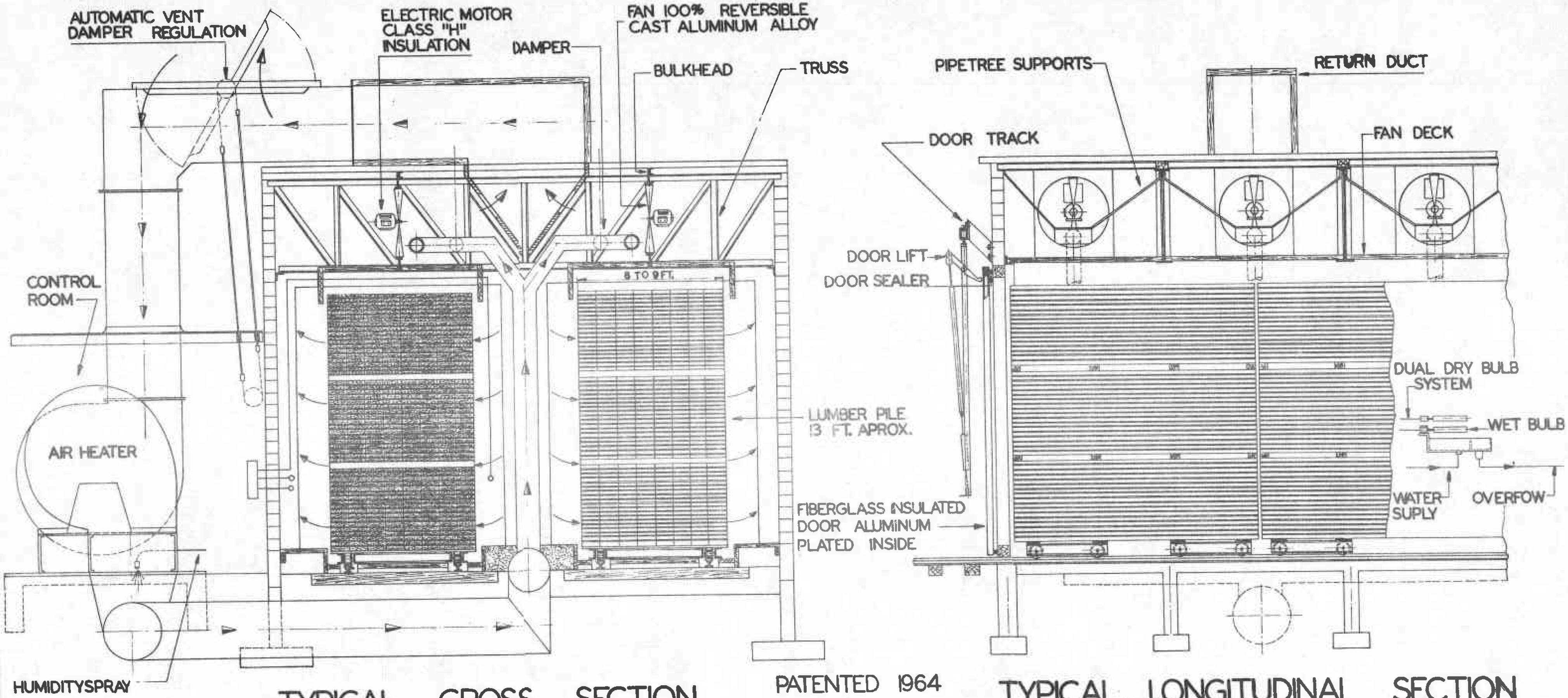
2. Kiln circulation, heat, humidity and ventilation can be closely and uniformly controlled. There is a limitation with regard to very high humidity as explained.

3. Safety features of direct heated kilns are excellent provided all due precautions are taken and no short-cut is permitted in the design stage.

4. Drying results in the Interior have been equal to steam kilns using wood from similar timber stands.

5. Limitations are very large kiln installations where the cost of fuel will out-pace the cost of boilerhouse and fuel bin personnel.

FURNACE HEATED DRY KILN



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