OPTIMIZING THE USE OF STEAM IN DRY KILNS

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The purpose of this presentation is to review the basic principals of steam generation and use to insure that we are maximizing the quantity and quality of dry lumber production from a facilities existing boiler and dry kilns.

What is limiting current dry lumber production?

- ☐ Boiler Capacity?
- ☐ Boiler Steam Pressure
- ☐ Dry Kiln Steam Pressure?
- ☐ Dry Kiln Heating Surface?
- ☐ Dry Kiln Air Flow?
- ☐ Dry Kiln Drying Schedule?

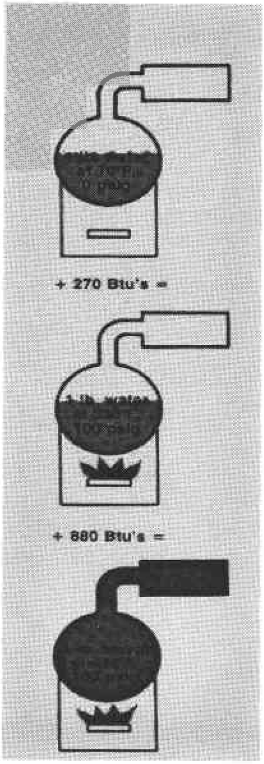
Steam Engineering has an experienced team of people that can evaluate all of these questions and this paper is limited to the first three. We hope that a better understanding of the basic principals of steam generation and use will enable the Western Dry Kiln Association Members to identify opportunities to improve their drying operations.

Generating Steam

Listed below is an excerpt from the steam tables.

Gauge Pressure	Temperature	Heat, Btu/lb			Specific Volume
PSIG	*^0F*	*Sensible*	*Latent*	*Total*	*Cu ft/lb*
0	212	180	970	1150	26.8
20	259	227	939	1166	11.9
50	298	267	912	1179	6.68
100	338	309	880	1189	3.89
150	366	339	857	1196	2.74
250	406	382	820	1202	1.75

The steam tables provide the physical properties of water and steam that we will need to analyze the performance of a boiler and dry kiln system.



From the steam tables we learn that it takes 270 Btu's of heat to the raise the temperature of one pound of water from 70°F to 338°F at a pressure of 100 psig.

If we add an additional 880 Btu's of heat to the pound of water we will convert the hot water to one pound of saturated steam at a temperature of 338°F and a pressure of 100 psig.

From the steam tables we learn that the total heat in steam at a pressure of 100 psig is 1189 Btu's

The steam tables demonstrate that it takes little to no extra heat to generate steam at 250 psig as it does to generate steam at 100 psig. At higher pressures the steam occupies a smaller space because the specific volume of the steam is decreased. This means that if we generate steam at high pressure we can use smaller diameter piping to transmit the steam to the dry kilns.

Using Steam

When steam is used in a dry kiln, the generating process is reversed. If 100 psig steam is used in the dry kiln coil, 880 Btu's of heat are removed from the steam to dry the lumber at a constant temperature of 338°F. The pound of steam is converted to a pound of hot water at 338°F and the water must be removed from the kiln coil to keep from flooding the coils. If the condensate is left in the coil and additional heat is removed the water temperature will drop.

The reason that we use steam in a dry kiln instead of hot water or hot oil is that the steam gives up all of its useful heat at constant temperature.

In this example the hot water exits the kiln coil at 338°F and it is discharged into a vented condensate receiver. The maximum temperature in the vented condensate receiver is 212°F. Some of the hot condensate is converted to flash steam and the energy and water is vented to atmosphere.

This is a picture of the vent on a condensate receiver with dry kilns operating at 100 psig. This is a significant amount of energy and water loss. Tabulated below is the potential energy loss from dry kilns operating at various pressures.

Dry Kiln Pressure	% Energy Loss
20 psig	4.7%
50 psig	8.6%
100 psig	12.6%
150 psig	15.4%

If we use low pressure steam in the dry kilns we will convert more of the total heat in the steam to useful heat, the steam in kiln coils will be dryer, and the loss from the condensate receiver will be reduced.

Steam Engineering's Axioms for Steam Use

From the steam table, it can be seen that the specific volume decreases as the steam pressure increases. This suggests our first axiom.

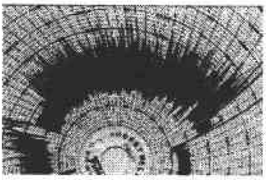
1. Always generate and transmit steam at the highest practical pressure. At higher pressures, equal volumes of steam occupy smaller spaces. The physical size of the boiler, valves, and piping can be reduced. In this axiom, the word "practical" is important, because as pressure exceeds 150 psig and 300 psig, the cost of piping and valves will increase, and analysis must be done to determine the most practical (economic) pressure for generation.

   This table also indicates that the latent heat of vaporization in the steam decreases with increased pressure, which provides reasons for our second and third axioms.

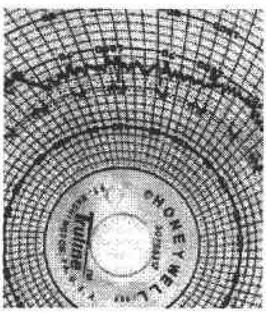
2. Always utilize steam for process work at the lowest practical pressure. Process work is accomplished by condensing the latent heat contained in the steam. The lower the pressure, the greater the available latent heat in the steam and the more efficient is the steam conversion to useful process work. Therefore, if the process does not require an extremely high temperature, the steam should be used at a low pressure.

3. Once energy has been sent to the process plant as steam, extract every useful Btu possible before it is returned to the boiler for reheat. If a high pressure process is utilized, the steam table shows that much of the total heat in the steam remains as useless sensible heat in the condensate. If the high pressure condensate can be flashed to a lower pressure, then the sensible heat will be converted to latent heat at the lower pressure and will be available to do more useful work.

Steam Load Management



Using what we have learned in the previous sections of this paper many dry kiln operations could be improved by operating the boiler at its highest practical pressure, transmitting the steam to the dry kilns at high pressure and then installing a pressure reducing station at the dry kilns to operate the dry kilns at the lowest practical pressure. We have used a simple electronic single loop controller with an output rate feature to operate the recommended pressure reducing station. The effect is that we are able to dampen the spikes and oscillations often associated with dry kiln operation.



This chart shows the advantage of steam load management.

- The quality of steam is improved, the steam leaving the boiler is dryer.
- There is a reduced condensate vent loss, saving energy and water.
- Boiler makeup water and chemical treatment is reduced.
- The boiler firing rate changes are much smoother.

The feedwater balance is better, there is less air pollution, the boiler is easier to fire, and the supply of steam to the dry kilns is steadier. The key to the success of this improvement is the device used as the pressure reducing valve controller.

Cost of Wasted Steam and Condensate

Few dry kiln systems condense all of the boiler-generated steam, there is almost always some vent loss from the condensate receiver, or from live steam use for conditioning lumber. The loss of a pound of steam or a pound of condensate requires replacement with a pound of makeup water and the associated chemicals to treat the makeup water. The loss of a pound of steam requires much more fuel than the loss of a pound of condensate.

The following table estimates the cost per pound of wasted steam and cost per pound of wasted condensate using two fuels, natural gas and wood waste. Caution must be exercised when using this table because it assumes a value of wood waste fuel and the price of natural gas. These kinds of tables are often out of date even before they are printed.

Cost of Wasted Condensate or Steam		
Description	Gas Fuel	Wood Fuel
Chemical cost per 1000 lbs of wasted steam or condensate	0.25	$0.25
Fuel Cost per 1000 lbs of wasted condensate	0.55	0.40
Total Cost per 1000 lbs of wasted condensate	**$0.80**	**$0.65**
Fuel Cost per 1000 lbs of wasted steam	3.96	2.63
Total Cost per 1000 lbs of wasted steam	**$4.21**	**$2.88**
Assumes a wood fuel value of $25.00/BDT and a natural gas price of $0.25/therm. All costs are tabulated per 1000 lbs of steam or condensate.		

Summary

Many dry kiln operations are challenged to produce sufficient quantities of quality dried lumber. The first priority should be to evaluate the steam and dry kiln system to be sure that the facility is maximizing the performance of the existing equipment.

Generate and transmit steam at high pressure, use steam at low pressure, take advantage of all of the heat recovery opportunities that are available, and manage the dry kiln steam load.