UPGRADING AN OLDER DRY KILN

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Improvements are made to dry kilns for one or more of the following reasons:

1. To extend the life of the kiln,
2. To increase productivity,
3. To improve the quality of drying,
4. To reduce energy consumed.

Generally speaking, all these reasons are legitimate reasons for spending money on an older dry kiln. You may be addressing one or all of these reasons. However, you should have a goal, and know what you want to achieve before you start.

The term "Lumber Dry Kiln" implies that the machine dries lumber. I prefer to think of it as a machine that evaporates water.

There are three mechanical systems within the kiln, all with a common goal, to evaporate and remove water uniformly from the dry kiln.

1. heat system,
2. fan system,
3. vent system.

All three of these systems are very much interrelated, and their capacities must be kept in the proper balance for the kiln to operate efficiently.

The heating system for the kiln supplies the heat energy to heat the wood and water and evaporate the water into the air. But, in order for the heat from the heat system to get to the wood and water it must be transferred through the air.

In a dry kiln we actually use the air as a conveyor. The air conveys the heat to the wood and water contained in the wood, and then conveys the water (in the form of vapor) from the wood, out the vents.

All the water removed in the conventional dry kiln leaves through the vents. In a 200,000 BF kiln drying hemlock from 100% down to 15%, 371,280 pounds of water are removed. That is 44,490 gallons of water. On a 60 hour drying schedule, that is an average of 742 gallons per hour, 12.3 gallons per minute.

If the average DB/WB temperature of the exhaust is 200/170, 24,700,000 cubic feet of air are required to contain it. This represents a cube 300 feet on each side. This is the amount of kiln exhaust if the kiln vent system is assumed to be 100% efficient, which it is not. One hundred percent efficiency assumes that all the air is exhausted at the proper wet bulb temperature, that no exhaust re-enters the kiln in place of dry dilution air, and that the outside air contains no moisture. By applying a 1.75 factor to our original figure, our cube enlarges to 350 feet on each side. If the dilution air has a temperature of 50 degrees, its volume would require a cube over 270 feet on each side (Figure 1).

As you can see, there is a fairly delicate balance between the design capacities of all these systems. There is no use increasing the heating capacity of the kiln, if the fan system can't move enough air through the system to convey the heat to the wood. There is no use increasing the capacity of the fan system if the
VENT AIR REQUIRED

DILUTION AIR
50°F

270' CUBE

EXHAUST AIR
200°F - D.B.
170°F - W.B.

350' CUBE

HEMLOCK D.T. x 104' KILN

Figure 1. Relative volumes of intake and exhaust air to dry hemlock.

Example:

Known:
DRY BULB = 180°F
WET BULB = 160°F

Find:
SPECIFIC HUMIDITY = .291
(# MOISTURE PER # OF DRY AIR)
SPECIFIC VOLUME = 23.6
(CUBIC FEET PER # OF DRY AIR)

Figure 2. Psychrometric chart for dry kiln temperatures.
vents can't exhaust the additional volume of air required of the higher evaporation rate. There is no use doing any of these things if your steam supply can't keep up.

We are not saying don't do any of these things. But rather, be aware of how changes to one of these systems may effect the other systems.

The requirements and capacities of all these systems can be calculated, analyzed and properly designed with the use of a Psychrometric Chart. The Psychrometric Chart is a graphical representation of air, water vapor mixtures at various temperatures. Everything that happens in the dry kiln can be analyzed and described on this chart. If you are making changes to your drying operation you should become familiar with the use of this chart.

Let's review what information we can find from a psychrometric chart such as the one in Figure 2.

1. **Dry Bulb Temperature** is read on the scale across the bottom.
2. **Specific Humidity** is the actual moisture content of the air in pounds of water vapor per pound of dry air.
3. **Saturation Line** represents all the points representing a saturated air water vapor mixture.
4. **Relative Humidity** equals the percent of saturation, or the ratio of the specific humidity to the specific humidity at saturation. We have not shown relativity on this chart, in order to make the other data easier to read.
5. **Wet Bulb Temperature** - The wet bulb line meets the saturation line at the same dry bulb temperature. Another way of saying this is; if you add moisture to air of a given temperature until it becomes saturated, at the point if becomes saturated the dry bulb and wet bulb temperatures will be equal.
6. **Dew Point Temperature** is the temperature to which air must be cooled before condensing will begin.
7. **Specific Volume** is the reciprocal of density and is expressed in cubic feet of air-water-vapor mixture per pound of dry air.
8. **Enthalpy** represents the total heat content of the mixture, and is expressed in BTU's per pound of dry air. Enthalpy lines, not shown, are parallel to the wet bulb lines.

If any two of the properties are known, all the other properties can be found on the chart. The example in Figure 2 shows a dry bulb of 180 and a wet bulb of 160, from this data the specific humidity and specific volume can be found.

We said a few minutes ago there were three mechanical systems in the kiln, heat fans and vents. I'd like to talk primarily about the heat system and the fan system, limitations, problems and solutions.

Often the kiln in question is many years old and the job it is presently doing is far different from the job for which it was designed. No wonder productivity may be suffering from a heat system that will not respond in the desired time, or a fan system that will not provide the needed velocity.

Sometimes, changes to the fan system will help increase productivity. However, as air velocity is increased, drying time is reduced, and the same pounds of steam are required from the boiler in a shorter period of time, heat demand goes up. This may require changes or additions to the heating system in order to keep the "systems" of the dry kiln in balance. The "systems" I refer to are the Heat system, Fan system and Vent system.

Many of the older kilns have return bend coils (Figure 3) which were adequate for the early drying schedules. But, as increases in production dictate
shorter and shorter drying times, the return bend coil has difficulty supplying the increased heating requirements, uniformly down the length of the kiln. The return bend coil system is not the most efficient use of fin pipe.

The basic arrangement of the return bend coil system allows air to by-pass the lines of pipe. On milder schedules, with small temperature drops across the load, this may be fine. However, as you accelerate the drying schedules, and the drop across the load increases, the coils must provide a larger temperature rise to re-establish the set conditions. This means you must get better air-to-pipe contact by forcing the air through the coils. Coil units of equally spaced fin pipe across the air path provide better air to pipe contact, and provide a more efficient use of the fin pipe, and a more uniform distribution of the heat (Figure 4).

Baffles at the coils are a very good idea. Baffles at the coils reduce the by-pass air, providing better air to coil contact, actually allowing the coils to transfer more heat to the air. Remember - first you have to transfer the heat into the air before the air can transfer it to the wood.

The increased steam load will also require a close look at the control valves and traps. I'd prefer not to get deeply into valves and traps today as there are many competent people in the industry to provide this assistance. But instead I'd like to begin a discussion of potential improvements to the fan system.

We are often asked the question, "How much air velocity through the sticker courses in enough?" The way I like to address this question is as follows:

As the heated air passes through the sticker openings the dry bulb temperature is used up evaporating the water from the surface of the lumber. The larger the temperature drop across the load, the more water is absorbed into the air. However, the drop across the load is limited by the amount of entering wet bulb depression. The dry bulb temperature can not "drop" below the wet bulb temperature.

If the air becomes saturated or even near saturated before leaving the sticker opening, there is no wet bulb depression. Without wet bulb depression, drying will be slowed or stopped. If you compare your leaving air temperature with the wet bulb temperature, you can find how close to saturation you are getting. Generally speaking, after the heat-up period, and not too far into the drying period, you should have some "leaving" wet bulb depression in order to dry uniformly across the course.

Note, that the leaving air temperature must be measured just as the air leaves the sticker opening, before it is blended with other by-pass air.

If you find that you have "little or no" leaving wet bulb depression well into the drying phase of the schedule, there are two ways to increase the "leaving depression":

1. Increase the entering wet bulb depression,
2. Increase the velocity through the load.

If, due to the sensitive nature of the product being dried, a wider entering depression would cause loss of quality or uniformity, a higher air velocity should help. The higher velocity provides more volume of air across the course. The increased volume delivers more heat to the wood, but also increases the capacity to carry moisture away from the wood, and this reduces the temperature drop across the load. As the temperature drop is reduced, leaving wet bulb depression is increased.

Sometimes it is possible to attain significant improvements in drying times and uniformity by changes to the fan system. On many occasions, it is not that easy. Sometimes, due to the design of the kiln, space limitations do not allow for larger fans to increase air flow, or fin pipe to increase heating capacity.
Figure 3. Return bend coils often allow considerable air to by-pass the heating surface.

Figure 4. Coils placed in a plane perpendicular to the airflow provide better air-to-coil contact. Note the baffles which force all the air through the coil.
The most common structural limitation is the plenum width (Figure 5). For example, in many of the early "fans below" kilns there may only be an 18" space between the wall and the load. To maintain uniformity the plenum space should be equal to or greater than the sum of the sticker openings, plus the bolsters spaces, plus any space at the floor or ceiling baffles. Since the kiln uses air to convey the heat, if one area receives more heat. If this "area" is exposed to a higher air velocity, more heat, and more air volume available to carry the water away, it is not surprising that lumber in one area may be severely over dried in the same period of time that lumber in another area with less velocity is reaching the desired moisture content.

One word can describe what upgrading an older kiln is all about, that word is UNIFORMITY. The kiln must have uniform air velocity, and uniform temperature distribution in order to provide uniform drying.

The vents are also important. The older kilns were typically designed for milder schedules and therefore had smaller vents. As the kiln schedule is accelerated you may find the vents unable to maintain the depression required for the drying schedule, and the drying time is extended.

As you can see, several avenues are open to improve productivity. However, the relationship between heat, air volume, and venting must be kept in balance for the kiln to do the job effectively, and efficiently.

Figure 5. Plenum width may be the limiting factor in air circulation.
In my opinion, improvement in quality is the same thing as improvement in uniformity of the drying conditions. Assuming no changes are made to the drying schedule, anything done to improve quality will relate to an improvement in uniformity of the drying conditions.

When it comes to QUALITY, UNIFORMITY IS EVERYTHING. Anything you can do to improve uniformity, will have a positive effect on quality. Typical ways to improve uniformity are:

1. Better stacking and stickering.
2. Better positioning of the loads on the kiln trucks, locate the sticker line over the bunks, locate the loads to the end of the bunks so the floor baffles can do a better job.
3. Better use of the existing baffle system.
4. Improvements, changes or additions to the existing baffle system.
5. Improvements to the kiln controls.

This does not mean you have to install a new computer system. What I am referring to is modulated control valves, modulated vent control, positioning the temperature sensors in the central portion of each control zone, and calibration of the controller.

IN SUMMARY

There are many different ways and many different reasons for spending money on a dry kiln. Before you start, determine your objective. Since there are different objectives and many different kilns, there is not "one best" path to follow in all cases. One kiln may have a narrow plenum which will limit how much the fan system can be improved. Another kiln may have wider plenums, but have a restricted height in the fan chamber which limits the size of fan that could be used. Yet another kiln may have adequate air delivery but, be limited by the available steam generating system.

DON'T OVERLOOK THE BASICS

The greatest return on investment is still in the area of improved stacking stickering, and baffling. Yes, there are several new technologies on the market today, ranging from heat recovery to computer control. But before you spend your money on any of them, be sure you have gone as far as you can with stacking, stickering and baffling. Improvements to these areas will cost almost nothing in comparison to other improvements, and will reap very significant rewards.

If you have uniformity problems now which could be helped with improved stacking, stickering, and baffling, correct these points first. Anything you do to improve the kiln, such as increase the heating capacity, increase air velocity, or try to reduce drying times, will only make your uniformity problems worse.

Lastly, any kiln improvement project should have some economic justification and the realistic projected benefits should be worth the investment.