LUMBER DRYING KILN ENERGY AUDIT WORKBOOK

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BC Hydro produced the Kiln Audit Workbook & Video because during energy audits of 90 or so (out of the 400) kilns in BC, we found that less than 50% of the kilns were not addressing the two basic requirements of efficient quality lumber drying - even air flow distribution and even heat distribution.

A 1975 Forintek study found -

- deficiencies were found in almost all kilns.
- a lack of baffles allowed volumes of air to bypass load contribute to uneven airflows.
- almost all kilns had significant imbalances of heat.

A 1992 Council of Forest Industries study determined that

- most noted deficiency in kiln drying is poor control over air circulation.
- industry is doing a poor job of baffling and monitoring airflows regularly.
- recommended that air circulation be the top priority when looking for ways to improve the profitability in a lumber drying kiln.

Resource material was nonexistent. We could not find single resource that detailed how to perform airflow and temperature audits.

BC Hydro Workbook guides the mill personnel through airflow and temperature audits of their kilns.

With the right equipment, it allows the kiln operator to do a mini-engineering study of his kiln.

Energy audits show how improvements to airflow and temperature distribution can be made to maximize energy efficiency of kilns.

Audits will determine whether the use of an adjustable speed drive (ASD) is appropriate for their facility.

A few lumber drying facts:

Uniform lumber drying needs uniform heat and airflow.
A 5 to 10°F difference can be significant.
Most kilns have significant heat imbalances.
Few kiln operators know their airflow distribution.
An airflow audit can reduce drying times.
Reducing fan speed 20% cuts power consumption 50%.

Uniform lumber drying needs uniform heat and airflow.

Airflow + Wet Bulb Depression = Drying Force.
Drying force should be as uniform as practically possible.
To dry final wood to a specified final moisture content with minimal drying degrade - heat and airflows need to be uniform.

A 5 to 10°F difference can be significant.

A number of kilns had temperatures recorded during the temperature audit that did not correspond to the temperatures recorded (and controlled) by the kiln controller.

Unbalance heat systems, door seal leaks, etc. can lead to one end of the kiln running 10 degrees higher than the control point (usually located in center of kiln) while the other end is running 10°F cooler.

The overall result, uneven drying. The smaller the depression, the more critical is the heat balance.

Many kilns have significant heat imbalances. From our kiln energy audits, we found the following:

Heat Imbalance	% of Kilns
< 5°F	20%
5 to 10°F	45%
10°F	35%

Large differences in temperature on the sides of the charge from one end to the other can lead to checking & problems with stress on one end of the kiln while the other end will lead to wet claims.

Few kiln operators know their airflow distribution.

From our audits, - about 50% of kiln operators know their average airflow level, and - less than 20% have ever checked the airflow distribution.

Poor airflow can be caused by poor load alignment, lack of chimney spaces between packages and kiln overloading.

Not only does bypass airflow waste energy used by fan system; it also increases both drying times and potential for drying degrade.

An airflow audit can reduce drying times.

The following was found in a specific kiln during an audit:
- average package airflows ranged from 100 to 475 FPM
- drying times varied from 8 to 9 days.

The following problems noted during the audit:
- damaged and missing baffles
- poor kiln loading practices left large gaps.

After correcting above problems, following was noted:
- average package airflows ranged from 340 to 390 FPM
- consistent drying time of 7 days

The drying rate depends less on airflow at low moisture contents than at high moisture contents. This is shown in Figure 1.

Reducing Fan Speed 20% Cuts Power Consumption 50%.

Only with good airflow & heat distribution, you may be able to reduce electrical energy even further of the circulation fan system by reducing airflow during the latter stages of lumber drying.

Fan Affinity Laws:

$$LAW\ I \qquad \frac{RPM\ 1}{RPM\ 2} = \frac{CFM\ 1}{CFM\ 2}$$

$$LAW\ II \qquad \left(\frac{RPM\ 1}{RPM\ 2}\right)^2 = \frac{SPEED\ 1}{SPEED\ 2}$$

$$LAW\ III \qquad \left(\frac{RPM\ 1}{RPM\ 2}\right)^3 = \frac{BHP\ 1}{BHP\ 2}$$

Example:

RPM1 = 1,000 rpm.
RPM2 = 800 rpm.
CFM1 = 2,000 cfm.
CFM2 = To be determined.
BHP1 = 100 bhp.
BHP2 = To be determined.

Using Law I, $\frac{1{,}000 \text{ rpm}}{800 \text{ rpm}} = \frac{2{,}000 \text{ cfm}}{CFM2}$

CFM2 = 1,600 cfm.

Note: Reduce fan speed 20%, air flow drops 20%.

Using Law III, $(1{,}000 \text{ rpm}/800 \text{ rpm})^3 = 100 \text{ bhp}/BHP2$

BHP2 = 51 bhp.

Note: Reduce fan speed 20%, fan power drops 50%.

Actual Case Study Using BC Hydro Kiln Workbook

Problems:

Airflow audit found some air going over the top of the charge - resolved by adding a new baffle.

Temperature audit discovered one side of kiln to be 10°F hotter than the other side - resolved by balancing the heating system.

Results from correcting the above problems:

Drying times were not noticeably reduced but the number of wets at the end of the run were substantially reduced.

Final quality improved resulting in a 4% reduction in drying degrade and trim loss.

What is in the BC Hydro Kiln Audit Workbook?

- Flow chart that goes through the sequence to achieving optimal kiln performance.
- How to perform & evaluate an airflow audit.
- How to perform & evaluate a temperature audit.
- Sample audit calculations.
- A method of estimating the savings that may be available using an adjustable speed drive.
- A subtle warning about the use of adjustable speed drives.
- References - recommended reading for those wanting to know more about improving the efficiency of their kilns.
- Suppliers of temperature dataloggers, anemometers and kiln services.

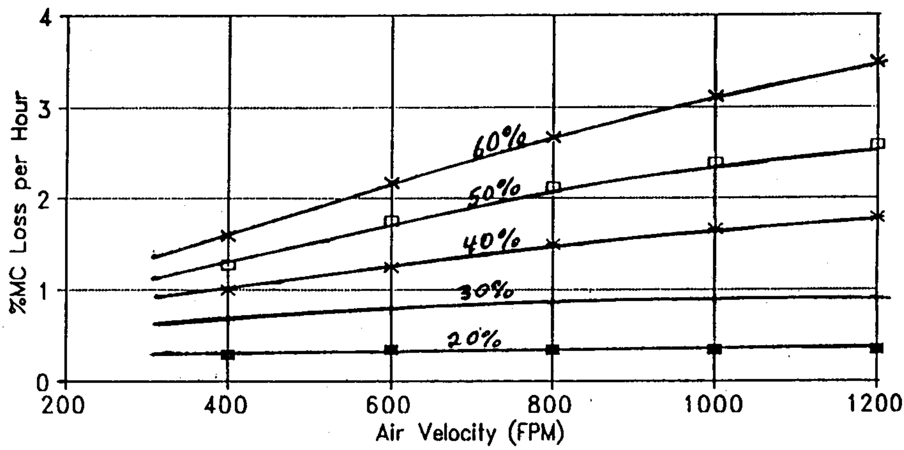

Figure 1. Effect of air velocity on drying rate at various moisture contents.