LUMBER DRYING COMPARISONS RELATING TO KILN DESIGN AND BENEFITS OF FAN CONFIGURATIONS AND HEAT RECOVERY SYSTEMS

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I will make one point very clear at the beginning. I am not a kiln engineer or design specialist. I come with nothing to sell, no axe to grind, no products to plug. Only some common sense and a real life comparison of lumber drying in two different kiln designs. This presentation will probably raise more questions than it answers. Over the past two years, we at Willamette Industries and specifically the Bauman lumber facility, have undertaken the task of upgrading, mechanically and electronically, our kilns and controllers. Most recently, and in construction now, are an additional two double-track and one-single track kilns, giving us a total of eleven tracks. It was this most recent expansion that led us to our comparison that I now want to share with all of you.

After the decision was made to expand our lumber drying capacity, the question came up, "what shall we install?" Experience running kilns with the latest computer controls and recent innovations helped us make part of the decision. The other element was to do a controlled experiment with like charges of lumber and controlling as many of the variables as possible.

KILN DESIGNS

I will describe the equipment and kiln design so you will have an understanding of what we operate. Our double-track kiln is 104' long, all aluminum with 2" thick fiberglass insulation, 12 zones, and a vent loss minimizing system. The principle of temperature drop across the load is used to monitor and control the lumber drying process. 26 thermocouple stations are positioned on both sides of the load along the length of the kiln, about 35' apart. The cross-shaft fan system consists ten-72" cast aluminum, variable pitch, 6-blade fans, driven by 10 hp, 900 rpm motors. These are controlled through a variable speed drive. Air velocity is calculated at 800 ft/min, measured at load mid point with the fans running at 80%. There are 1400 linear feet of 2" finpipe overhead and an equal amount of center coil.

Nine modulating-type diaphragm valves control the steam flow. Venting is controlled by ten 28" square vents with a modulating-type, air-operated positioner. Two wet-bulb thermocouple sensors, one for each side of the kiln, measure humidity conditions for either air circulation direction. Steam pressure to the header is 90-110 psig.

The single-track kilns used for our drying comparison are 104' long, cinder block construction. The ceiling is insulated with 4" zonolite concrete. The kilns have two-zone control with six thermocouples mounted in two stations. These particular kilns were retro-fitted about two years ago with computerized

controllers, utilizing the existing computer and software that is on our new double-track. Our approach was to take 45-year-old kilns and equip them with some of the accouterments of state-of-the-art dry kilns.

The fan system is line-shaft configuration, 13-66" fans with 10 blades and a 30 hp, 1200 rpm motor. Air velocity was calculated at 585 ft/min. The sticker size is 3/4" x 2-1/2" x 52".

The overhead heating coils total 1728 lineal feet of 1" fin pipe. Three modulating-type diaphragm valves control steam flow, front and back (six total). All of the single tracks are equipped with a heat recovery system, which also eliminates the need for roof vents. There are two wet-bulb thermocouples for each kiln with water boxes and sight feeds.

Our test charges consisted of 2"x 5", vertical grain (VG), Douglas-fir, shop lumber for door stock. The rough green target size was 2.125"x 5.125". All lumber was cut during the first week of March, 1992 so that the mix of logs used for each test had been decked for similar times. All stock was marked and segregated to avoid mixing with previously-sawn lumber. Length separations were identical for each kiln.

The purpose of our test was to determine on a kiln-by-kiln basis; shrinkage, moisture consistency, drying consistency throughout each kiln, steam use, percent of over dry and wet lumber, grade recovery as degraded from drying characteristics, and total drying hours. Desired moisture content on all kiln charges was a maximum of 10%. All production of Douglas-fir VG shop goes out as door parts. Moisture content is critical. All samples were measured with dial calipers and marked accordingly. We took moisture samples and size samples from three locations in the kilns and from opposite sides from each kiln. The double-track had samples taken along either wall as well as along the center steam coils.

All lumber was planed within 24 hours after pulling. As I mentioned earlier in this presentation, all of our 2" x 5" VG Douglas-fir door shop is cut into 100% useable door parts. It is most critical to have all wet pockets identified and then sorted after cut up. Full length wets were re-dried and surfaced to 1-5/8" x 5" door shop. Those pieces with wet markings were then totalled at the conclusion of planing each kiln charge.

Our moisture detection system is an in-line sensor on the planer outfeed. A green ink is applied to the wet areas and the stock is sorted for full length wet boards or partial wet areas within a board.

RESULTS

The results of the study are presented in the following table:

		Single-track kilns #1	Single-track kilns #2	Double-track kiln
Test pieces average thickness, inches	Green	2.135	2.147	2.125
	Dry	2.023	2.032	2.019
	Shrinkage, %	5.25	5.12	4.96
Test pieces average width, inches	Green	5.143	5.123	5.145
	Dry	4.947	4.920	4.956
	Shrinkage, %	3.84	3.97	3.67
Total footage, bf		82,381	84,885	164,637
Average moisture content, %		8.5	8.3	9.3
Total drying hours:min		261:46	261:42	254:55
Fan reversal, hours		6	6	4
Steam usage, lbs		72,916	83,022	342,161
Steam usage, lbs/mbf		885	995	2,078
Wet pockets, lineal feet		315	162	438
Total wet, lineal feet		2,015	1,763	
Grade recovery prior to cut up, bf				
Clear		1,793	1,737	3,659
Select		4,875	3,728	8,945
#1		8,763	7,618	18,650
#2		23,437	20,380	42,885
#3		30,048	35,582	62,355
outs		4,010	4,102	9,046
scants		7,655	10,137	15,432
wets		1,800	1,601	3,665
Drying defects, lineal feet		975	581	1,981
Recovery after cut up, %		78	79	76

SUMMARY

From this comparison it appears that there are no appreciable differences in uniformity of moisture distribution in the multi-zone kiln as compared to the two-zone kilns. Both were within 1% MC. We did notice that lumber closer to the center coils was about 2% dryer than that on the outside of the kiln. As we moved towards the center of the charge this difference evened out. During the last 40% of the schedule, the bottom center coils did most of the work.

Shrinkage was within .020" for either kiln design, radially as well as tangentially. This was probably due to identical schedules being implemented and is more a characteristic of the wood than the kiln.

Drying time required was 2.68% Longer with the single-track than the double-track kiln, 254 Hours as opposed to 261 hours.

Steam consumption was remarkably different between the test kilns. On a per mbf basis, there was 108% more steam required for the double-track multi-zone kiln than the two-zone single-track kilns, 2,078 lbs/mbf as opposed to 995 lbs/mbf dried. This is probably due to the heat recovery systems and lack of venting heated air.

Amount of wets per kiln was negligibly different. The double-track multi-zone kiln was 3,665 board feet or 2.22%. Total for the two single-track kilns was 3,401 board feet or 2.01%.

Drying defects, or those characteristics that could be directly attributed to the drying process were consistent between kilns, 1,981 bf or 1.2% for the double-track kiln and 1,556 bf or 0.9% for the single-tack kilns. Remember, that this is 2"x 5" VG shop lumber, all to be remanufactured and cross cut. We were looking for checking, abnormal warp or twist that would have resulted in a clear cross-cut or rip having been discarded.

Machinability, color, and texture do appear to be improved in the single-track kilns with the heat recovery systems when compared to the kilns without the system.

Recovery after cut up, this is a percentage of inbound lumber to outbound cut stock. At the cut up process only the B&btr clear part are included in the total footage. For lumber from the single-track kilns, the recovery was 79.1% or 130,833 bf. For lumber from the double-track kiln it was 76.3%, or 125,618 bf. Our annual shop production of 2"x5" fir is about 11 million board feet. A 3% improvement amounts to 330,000 bf. I will let you draw your own conclusions to the dollar value.

We are firm believers in the modulating steam valves and being able to ramp up the heat and depressions, only made possible with the new computer controls.

A heat recovery system, as we have found, is an integral component in the dry kiln machinery, both from energy savings and lumber grade recovery improvements. A side point to our system is the reduction in kiln internal maintenance, such as coatings and the elimination of roof vents.

From our tests, fan and air flow configurations seemed to make no difference on the outcome of the kiln charge.