AIRFLOW COMPARISON BETWEEN CROSS SHAFT AND LINE SHAFT FAN DESIGN

Larry Lindberg
Roseburg Forest Products
Roseburg, Oregon

Perhaps a better title for this presentation would be, DURING A RETROFIT, A COMPARISON OF CROSS SHAFT AND LINE SHAFT FAN DESIGNS.

Recently, at Roseburg Forest Products we became faced with a situation which is probably similar to what many of you have had to face. With increased demands for kiln dried lumber we found that our kiln capacity was inadequate. With the construction of a new Small Log Mill to compliment the production of our Large Log Mill we felt that to handle the demand we would have to increase our ability to dry by 40%.

As we gave more thought to our upcoming situation we concluded that our actual kiln capacity was adequate, but inefficient. We operate thirty-five 104-foot tracks. The battery of kilns consists of two single track, thirteen double track, one 3 track, and one 4-track dry kiln, for a total of 17 dry kilns. With all tracks loaded and in operation the volume is 2.5 to 3 million bd. ft. Pretty impressive: it is probably one of the larger batteries of kilns on the West Coast.

Leaving the kilns for a moment let's take a look at the product line ahead of these kilns. We cut five species, ponderosa pine, sugar pine, Douglas-fir, white fir, and hemlock. We cut a wide variety of product lines. We saw shop, selects, moulding, commons, dimension, and studs for the domestic market, and we saw a large and varied product line for the export market.

We have over 300 sorts coming out of the two sawmills involving five species. Combining compatible items this still leaves over 40 items to be dried and controlled on individual schedules. It is not unusual to be sawing three species at the same time. This results in over 120 sorts coming into the green yard at one time. Now the need for such a large bank of kilns becomes apparent.

Now we will return to the kilns and look at the equipment we have to work with. The kilns were built in the late 1940s. They are all masonry kilns with poured concrete walls, flat top roof design. There were many similar kilns built during that period. The fan system is an overhead line shaft consisting of thirteen 72-inch steel disc fixed pitch fans on 8-foot centers, powered by a single speed 40 H.P. motor. Airflow is 340 F.P.M. to 400 F.P.M. depending on lumber thickness. The heating system consists of plain wall 1-inch pipe, no fins. The control system manages the heat in two ends. The kiln operates on 10.5 to 12 P.S.I.G saturated steam. Steam temperature around 257 degrees F.

During the winter months the kilns really struggle. Trying to run conventional schedules with normal wet bulb depressions, once we start to pull a load on the

vents it becomes hard, if not impossible to maintain dry bulb setpoint. We were out of control! Some of the kilns took over 3 days to reach 160 degrees. With such obvious limitations of our equipment, and the proposal of 40% more volume coming to the kilns, it was apparent that it was time to give some serious consideration to upgrading or adding capacity to our dry kiln operations. We felt that our three major areas for improvement would be upgrading our air delivery system, increasing our heating capacity, and control.

We contacted several vendors and met with them individually. We toured our kilns and looked at what we had and told them of the results we were looking for. We gave them some minimum requirements on the velocity we wanted and the heating requirements we needed. We also requested that they give us a proposal on a new high speed line shaft fan conversion as well as a cross shaft conversion.

While the engineering departments of the various vendors were calculating the amount of fin pipe, fan designs, and horsepower required to meet our demands, we obtained lists of similar retrofits and upgrade they had done for other customers. We picked a cross sampling of various sites which were similar to our operation in terms of species, product lines, and equipment design.

We toured these sites with several thoughts in mind. Had the manufacturers delivered the results they were looking for? Had they met demands on velocity and heat requirements? Was the delivery of equipment and installation on time? Did they have qualified people there during start up, to resolve any glitches that can and do occur? And most important, how was the support and service after the job was completed?

After our visits, and a random sampling of the various manufacturers' work, we walked away with the feeling that all of the customers were satisfied with the work done for them.

Now it was time to meet with each vendor and go over their proposal and bids. As can be expected there was quite a variation in equipment proposals to meet our demands. The size and amount of fin pipe, fan size and design, and the horsepower to drive the fans were the main areas where differences occurred. Another bone of contention was the number of zones required to obtain the uniformity we were after. The proposals ranged from 6 to 18 zones depending on the manufacturer.

We finally selected the manufacturer for the project. This vendor was the only one that would guarantee air velocity in cross shaft and line shaft upgrades. They were also willing to meet our demands in delivery, installation, and start up by a specified date. Also, their history of support and service on similar installations had been excellent.

We decided to split the kilns into 6 zones of control. Basically we stayed with two end control but, we split the center coils top to bottom. As lumber tends to dry faster towards the top, the top coils throttle back to maintain set point while the bottom coils still pull a higher demand. This results in a better uniformity of moisture content with a lower deviation. We were still undecided about which fan system would best suit our requirements: line shaft or cross shaft. The manufacturer

guaranteed 800 to 850 F.P.M. if we choose to stay with line shafts, and, 1000 F.P.M. if we chose cross shaft. The line shaft would consist of thirteen 72-inch fans driven by a single 100 H.P. motor. The cross shaft system consisted of twelve 72-inch fans driven by 12 individual 10 H.P. motors. The fans themselves were 72-inch 6 bladed variable pitch fans. A variable speed drive was requested with each design. In order to fully utilize the potential of variable pitch fans this is a necessity.

Without the drives when you pitch your fans for full load amps at cold start up that's the best your going to get. As the air warms up and becomes less dense you cannot increase fan speed in order to increase air velocity. The drives allow you to do this. At start up when the air is cold and dense the fans might only run at 70%. But, as the air warms up and becomes less dense the fans will ramp towards 100% giving you the ability to maintain the highest velocity possible until you choose to reduce it. This might be done either at fiber saturation to save energy, or for conditioning, when lower velocities give better reabsorption of moisture for relief of stress incurred during drying. Another reason we felt we needed the drives was due to the fact of our varied product line. Some of our high grade export items are very prone to surface check in the early stages of drying. By being able to control the velocity we can slow down the drying rate early in the schedule to prevent this from occurring.

Still not sure which system to install we decided to retrofit two kilns: one with an upgraded line shaft, and one with a cross shaft design. Then we could compare them and decide for ourselves which design would best suit our needs. The line shaft was cheaper to install, both in terms of energy required and reconstruction cost. We could utilize our existing fan housings and vents. With the cross shaft system we would have to remove the existing fan housings, construct a new fan wall, and reposition the vents.

After several weeks of work the 2 kilns were completed and ready for start up. At start up we conducted air velocity test to confirm the manufacturer's guarantee. The grand average of the line shaft kiln was 950 F.P.M. the guarantee was 800 F.P.M. The grand average of the cross shaft kiln was 1208 F.P.M. the guarantee was 1000 F.P.M. Now we were ready to compare the kilns and determine if one design had an advantage. The first item we tested was 6/4 ponderosa pine Shop & Btr. Identical drying schedules were used. The schedule created for these runs was very conservative. The initial results of the line shaft showed a reduction in drying time of 29%. The moisture content within our target range was 99%. The initial results of the cross shaft showed a reduction in drying time of 34.5%. Again the moisture content within our target range was 99%. Tracking the lumber through the planer we were pleased to discover that our grade recovery was higher. The line shaft showed an increase in sales average of over 2%. The cross shaft enjoyed an increase of 5%. Subsequent runs of this same item have produced similar results. The cross shaft continues to dry 8% faster than the line shaft.

The next item chosen for comparison was 4/4 Ponderosa Pine Sap. The line shaft showed a reduction in drying time of 25%. The moisture content within our target range was 94.5%. The cross shaft showed a reduction in drying time of 31%. The moisture content within our target range was 98%. Again, identical conservative schedules were used. Tracking grade recoveries we again saw

improvement. Our sales average increased 9.5% in the line shaft. And 11.5% in the cross shaft. Again after subsequent runs the cross shaft continues to dry 8% faster.

Since the initial test runs we have run just about our full product line through these two kilns. Both kilns are showing better than 30% reduced drying times. The cross shaft still drys 8% faster than the line shaft. Uniformity of moisture content appears to be 3.5% better in the cross shaft design.

Our conclusions from these comparisons are that 250 F.P.M. higher velocity contributes to the 8% decrease in drying time. We feel that there are two contributing factors to uniformity of moisture content. First, the higher velocity itself, in that it delivers the heat to the lumber, and carries the moisture away in a more uniform manner. And second, the design of the line shaft. With the serpentine design of the fan housings you have an open and closed housing every 8 feet. We feel, and it is our opinion that this can create a slight effect on the uniformity of air flow. The cross shaft design enjoys some other advantages over the line shaft. In terms of maintenance or repair. In the cross shaft design if a fan or motor were to fail you can remove or tie down the fan and block the housing and continue to run the kiln, either until the charge is dry or replacement parts have arrived. It won't be quite as efficient as with all fans running but you can continue to operate. The line shaft on the other hand is another story. Generally, if you throw a fan in a high speed line shaft the damage can be extensive. At this point the kiln is down until repairs can be made and replacement parts can be secured. Because of the design of the fan housings you can't just remove the damaged fan and operate until you get a replacement. You will have no air flow in that area of the kiln and the lumber will not dry. Serious degrade can result from this.

Having had the chance to run these two systems side by side, we feel that for our particular needs and operation that the cross shaft fan system is superior to the line shaft.