GETTING THE MOST FROM YOUR DRY KILN FAN SYSTEM

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INTRODUCTION

Most cross shaft fan systems operating today are set up pretty much as the manufacturer left them following kiln construction. Kiln operators tend to take their fan and airflow systems for granted unless a motor failure or fan loss forces them to look closer. Even then the objective is a quick fix and to return the equipment to operation as soon as possible. At this point it is important to ask yourself. "Are you getting everything possible from your fan system?" This discussion is intended to help you answer that question for yourself.

GETTING THE MOST FROM EXISTING EQUIPMENT

Most kiln operators must be content with existing equipment with little prospect for wholesale replacement of their fan system. They have to make do with what they have. A close and objective examination of the equipment often points to areas of improvement. Before we begin, however, it is important that we think about the natural airflow tendency in a kiln.

In one sense, airflow reacts much as we do to an obstruction. Given the choice between a restriction and an open avenue we head or the wide open spaces every time.

Our ideal objective is to eliminate airloss around the lumber and achieve uniform airflow patterns through it. This effort actually begins at the sawmill and extends to the final loading of the kiln.

Sawmill practices which impact on airflow are mostly limited to trimming. At mills which have poor trimming practices, the lumber units do not butt tightly together and often large gaps result between units. The following data was taken from a new double track kiln which stacked two units per truck, 30 layers per unit, using 3/4" sticks and a single 4" crossout. Trimming in the sawmill was so poor that a 9 inch gap was left between adjacent units on the track. When the kiln was loaded with studs, eight openings resulted down the kiln length.

Opening	Average Velocity FPM	Area Sq. Ft.	Volume CFM	Percent of Total Volume
Sticker	764	290.0	221,560	61.9
X-Out/Bolster	1473	26.7	39,330	11.0
Gap Between Units	1273	76.2	97,000	27.1
TOTAL			357,890	100.0

Over 25% of the total air volume was needlessly lost through the gaps between the units which represents a significant expenditure of energy. Closing this gap results in a significant increase in effective airflow, although in practice it is never fully recovered. We usually anticipate recovering, at most, less than half of this flow depending on the performance curve for the fan and the change in static pressure. Still, this would be sufficient in this example to increase total air velocity through the lumber to 930 fpm. This reduces drying time and narrows moisture distributions.

Sorting can be a significant problem for those mills mixing multiple lengths in the same units. In many cases there are too few boards to restrict airflow through the mixed-length end. Aside from the air loss through these gaps, the reduced lumber volume results in overdried ends. Although this condition cannot be avoided, the impact of the openings on airflow uniformity can be reduced by stacking the longest lengths on the outside edges. This also improves the stability of the stacked units.

Kiln setups often result in large gaps when there are insufficient units of the desired length to fill a kiln. We want a continuous wall of lumber which is met by the baffles at the top, bottom, and on the sides. Large openings result in massive imbalances in the airflow patterns and must be avoided. If you stack two units side by side on a truck, place the shorter units to the inside next to the center coils, otherwise a large gap will open up beneath the overhead baffles.

Always fill kilns to capacity. Kilns are designed to hold an optimum amount of lumber. If the end baffles do not reach the lumber there is an open avenue for air loss which reduces the efficiency of our drying system. Shortloading a dry kiln also represents a lost drying opportunity. In the double track by 84' kiln in the above example, shortloading one track by 2 feet results in a 1.25% reduction in kiln capacity. That represents from 2 to over 4 extra charges per year that you really did not have to dry.

Baffles are installed in kilns for a distinct purpose: to direct airflow through the lumber. Are you certain they are doing the job they were intended to do? The next time you finish loading each kiln and close the doors, lock-out the heat and turn on the fans. Grab a flashlight and an airflow meter, if you have one, and enter the plenum area on the low pressure side. Look at your baffles closely.

The overhead baffles should contact the top edge of the lumber along the entire kiln length. There should not be variations in stacked lumber height which leave gaps for air loss under the baffle. The baffles must not sail or otherwise be held off the lumber. They must not be damaged. If so, repair or adjustment them.

The floor baffles must contact the bottom edge of the lumber along the entire length of the kiln. If you have concrete or stationary baffles, the resulting gap must be even down the length of the kiln. The baffles must remain in place and not fall over when the air gets behind them. Investigate and correct the cause for these baffles falling over. Repair or replace all which will not stay in position.

The end baffles must close the gap between the end of the lumber and the doors. If they blow back, find out if it is due to placement or inadequate restraint. Again, damaged baffles must be repaired or replaced.

While you are in the kiln, measure airflow through the sticker slots and compare this to the flow escaping around the lumber. Think about what you can do to capture this lost air volume and put it to work. After all, you paid for it. You may as well get the benefit.

MAXIMIZING AND BALANCING EXISTING FAN SYSTEMS

Not only is airflow affected by the way the kiln is loaded, each kiln design has its own peculiarities in airflow patterns. Designs which vary fan spacing impact the uniformity along the kiln length. Offsetting fans to one side or the other from the kiln centerline varies the patterns between fan directions. This is also a result of designs which place obstructions to one side of the fan. Fans mounted between the tracks rather than overhead also have variations unique to their design. However, unless we are considering the purchase of a new kiln or fan system these variations in design cannot be controlled. In existing systems we must live with what we have.

Obtaining the most from your fan system involves not only maximizing the output from the fans but balancing the output between fans. Although an easy procedure, it is often bypassed during startups because it is time consuming. Once the kiln is on line it is unlikely that further adjustments will be made.

The first part of this procedure determines the maximum output for the individual fan and motor combination. This involves finding the maximum blade pitch we can place on the fan without exceeding the amperage rating of the motor. Fan manufacturers have developed curves which predict fan performance at given static pressures, fan pitch, and motor horsepower. From these we can at least estimate the maximum blade pitch for our application. This is tricky. Finding the horsepower is easy but we can only guess what our static pressure is or will be. With so many variables, it is easier to simply set several fans to different pitch settings and then run them with the kiln fully loaded and baffled to determine full load amperage draw. Once we have this information all fans are set to the pitch which gives an amperage draw closest to the amperage rating stamped on the motor housing. It is often possible to set the pitch to 105% of rated amperage at cold startup for a little extra boost. However, be sure your motors have an adequate service factor before doing this. On belt driven systems be sure that the belts are properly tensioned to prevent slippage which affects amperage.

How do you measure fan pitch? Fan manufacturers stamp scribe marks into each blade base and angle graduations on the hubs for this purpose. For some reason, I have never found fans set, using these marks, which would result in uniform fan pitches throughout the kiln. Although it is possible that there are inaccuracies in the scribing method, it is also likely that the variation is due to the difficulty in reading and setting these marks in the often gloomy environment of a fan deck. Even under the best of working conditions the actual pitch, when measured directly on the blade, will vary up to 7 degrees or more. I prefer to set pitch using an inclinometer with the angle measured one third the radius in from the tip. Full instructions on this procedure may be found in my book, <u>High Temperature Drying</u> - <u>Enhancing the Operation of Your Kiln</u> available from Miller Freeman Publications.

On a recent kiln startup I used this method to measure the pitch of each blade as installed by the erector. On five 15 hp motors with six-blade fans the pitch varied from 62 to 69 degrees, measured from the horizontal. All kiln manufacturers measure fan pitch from the vertical which would correspond to 28 to 21 degrees in this example. I use horizontal readings because that is how the commonly available inclinometers read.

After repitching the fans to 66 degrees (24 degrees off the vertical) using the inclinometer, I checked fan amperage and found four of the fans drawing the same amperage, 20.5 amps. The remaining fan drew 21.0 amps. On systems which have run for some time, particularly where motors have been rewound and replaced, you can expect wider variations. In ten years of working with kilns, this is the closest I have seen. The variation usually ranges from 2 to 4 amps.

OTHER TECHNIQUES WHICH INCREASE OR REDISTRIBUTE AIRFLOW

So far we have discussed many ideas which serve to improve airflow within our kilns. In general they are simple things which require paying closer attention to the things we are doing anyway. These are the easiest and least expensive improvements we can gain. Beyond this, improvements come harder, requiring more effort and usually more money to accomplish. The following techniques fall into this category.

Covering Crossouts - While relatively inexpensive, recovering this airflow is definitely a hassle. In the earlier example where we looked at data comparing how airflow was distributed, our loss through the sticks amounted to 11%. This was through a single crossout opening. Recovering half of this air by blocking the crossout would raise the average air velocity by at most 70 fpm. This may be important to kilns with marginal airflow.

Another kiln with two crossouts lost 16.8%. A third with four crossouts lost 39.7%. In this latter example we ran a test covering the crossouts to see how much we recovered. Although we raised the total air velocity through the lumber from 975 fpm to 1118 fpm, we actually recovered only 22.3% of the volume we calculated we were loosing. Eliminating the crossouts increases the static pressure the fans must work against. Higher static pressures reduce the total volume of air a given fan can move at a given blade pitch and horsepower. How much will covering your crossouts benefit you? The only way to know for certain is to run a similar test.

Plenum Baffles - Another technique which helps redistribute airflow is the application of plenum baffles. These are simply fixed or adjustable panels which hang vertically within the kiln plenum chambers between the lumber and outside walls. Their purpose is to split and direct airflow between the top and bottom of the loads. Under certain circumstances they are effective. They should be used in situations where there is no control over the heat delivery top to bottom on the center coil. This occurs in kilns which have the center coils oriented vertically and are not multizoned. No changes will occur when plenum baffles are added to multizoned kilns.

FAN SYSTEM DESIGN DETAILS WHICH IMPROVE FAN PERFORMANCE

How well your fan system is designed has a significant impact on how well it performs. It pays to give close attention to construction details when considering a new purchase or remodel.

Fan Tip Clearance - This is the distance between the end of the fan tip and the inside of the fan shroud. Since the tendency of air is to be forced outward from the end of the blade, we should minimize this distance as much as possible. The practical limit on this distance is .375" to .500". Thermal expansion of the blade will reduce this distance from .055" (low temperature kilns) to occur from thermal expansion of the dry kiln structure and adjacent components causing the blade to rub the shroud. Allowances must be made for this keeping in mind that unnecessary tip clearance reduces fan performance significantly.

Shroud Design - How smoothly the airflow enters the fan has an impact on its efficiency. There are several fan shroud designs on the market which are essentially flat plates around the fan circumference as illustrated in Figure 1. A rolled shroud design allows air to flow smoothly into the fan and increases its efficiency 5 to 10 percent. See Figure 2. It is amazing how small details can have a significant impact on fan performance.

Aerodynamic Design - Anything placed next to the fan and within the airflow must be aerodynamic in design or it detracts from fan efficiency. This includes, not only shrouding, but fan supports and struts. Everything must encourage smooth airflow into and away from the fan. Overhead coils also fall into this category. These should be placed as far away from the fans as possible for peak fan performance and must be equally balanced on both sides of the fan. Placing coils only on one side of the fans imparts an airflow imbalance from one fan direction to the other. In high velocity kilns I have measured differences in average air velocity approaching 200 fpm between fan directions. This impacts on drying uniformity and moisture distributions across the unit widths.

Fan Position - Fans must always be in alignment with the centerline of the kiln for balanced air delivery between fan direction. Fans which are mounted eccentric to one side of the kiln have different airflow patterns between fan directions.

CONCLUDING REMARKS

Our goal in this discussion has been an appreciation of the importance of the fan system and all the factors which have an impact on performance and airflow uniformity. On a practical basis, there is usually a great deal we can do to improve the efficiency of our airflow within the limits of existing equipment. Realizing these benefits requires effort and vigilance on our part to recognize areas for improvement and correct problems.

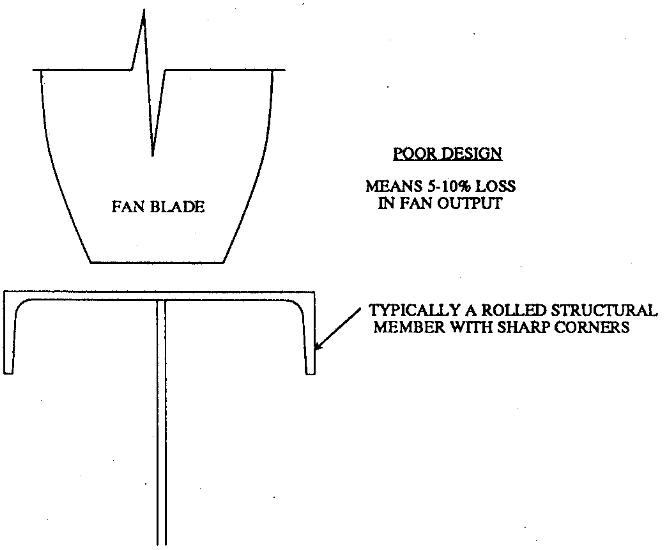

Figure 1. Fan shroud design with square inlet.

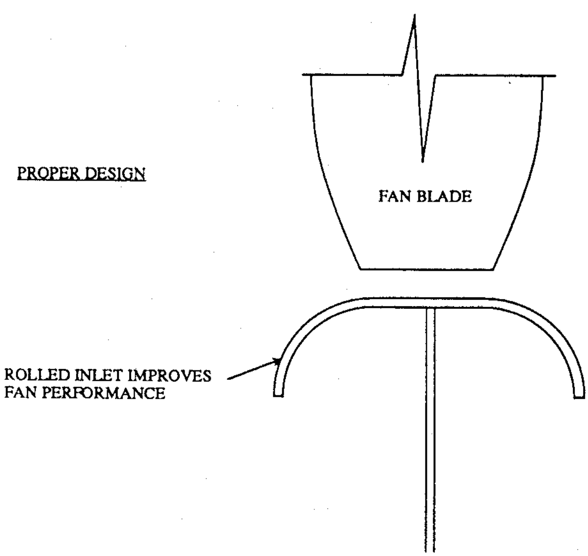

Figure 2. Fan stroud design with rolled inlet.