IMPROVING AIR VELOCITY IN DRY KILNS

Lyle Carter
Lumber Systems, Inc.
Portland, Oregon

Over the past several years, I have been involved with field work relative to improving velocity in dry kilns. The information gained is not new or surprising. However, it does graphically display some points we all tend to forget. In this talk, I've tried to simplify the air delivery system of a kiln to a point we can think of it in very basic terms.

Air velocity is a lot like boiler capacity. When you have lots of it, you tend to get sloppy and waste it until the schedule which has been satisfactory has to be lengthened to get the lumber dry. It's only then you look for ways to improve the kiln efficiency.

Improved air velocity can be attained by making improvements in one or more of the following areas:

1. Improved stacking and stickering.
2. Improved baffling. This includes replacement or repair of baffles as well as improving their method of placement and operation.
3. Improved fan performance which includes increased horsepower, speed, or new, more efficient fan systems.

All of these items are valid means of improving air velocity and uniformity.

Before going on, let's take a few minutes to talk about fans.

There are two types of fans:

Centrifugal - Throws air off ends of blades.
Axial flow - Moves air parallel to the axis of rotation. Propeller fans are typically used in most kilns.

Any fan system will have an inherent resistance to the flow of air.

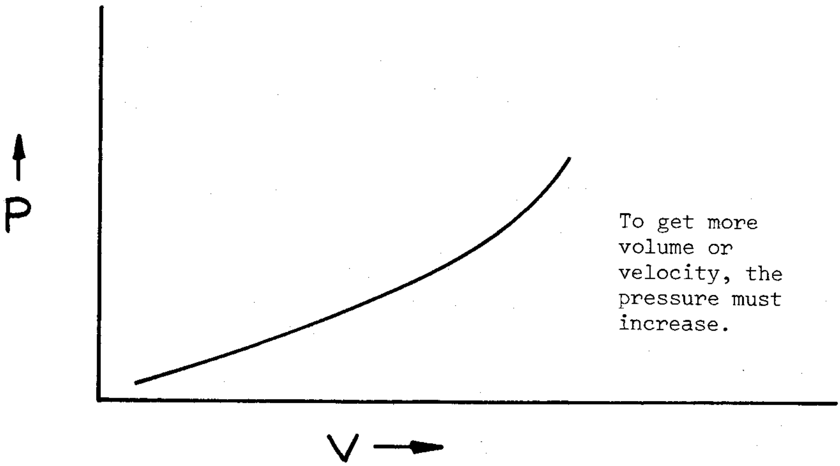
In the case of the dry kiln, the system resistance relates to:

1. Design of the fan chamber.
2. Amount and design of the heating coils.
3. Width of plenums.
4. Sticker thickness.

All of these items contribute to the overall system resistance.

The "System Resistance" can be plotted as a curve.

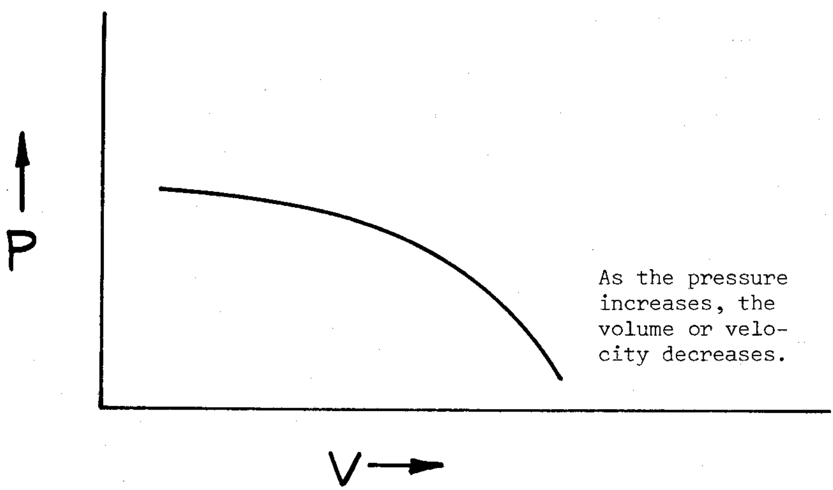
The static pressure is on the vertical axis, and the volume is on the horizontal axis.



To get more volume or velocity, the pressure must increase.

The curve will be parabolic having an exponent within the range of 1.5 to 2.

A "Fan Performance" curve generally looks like this:



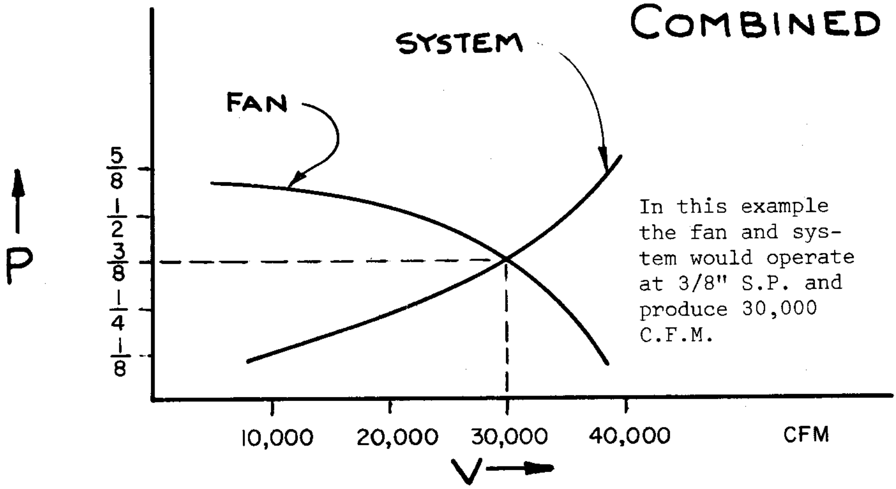
As the pressure increases, the volume or velocity decreases.

The top of the curve is normally flat. The top of the curve represents conditions which should be avoided.

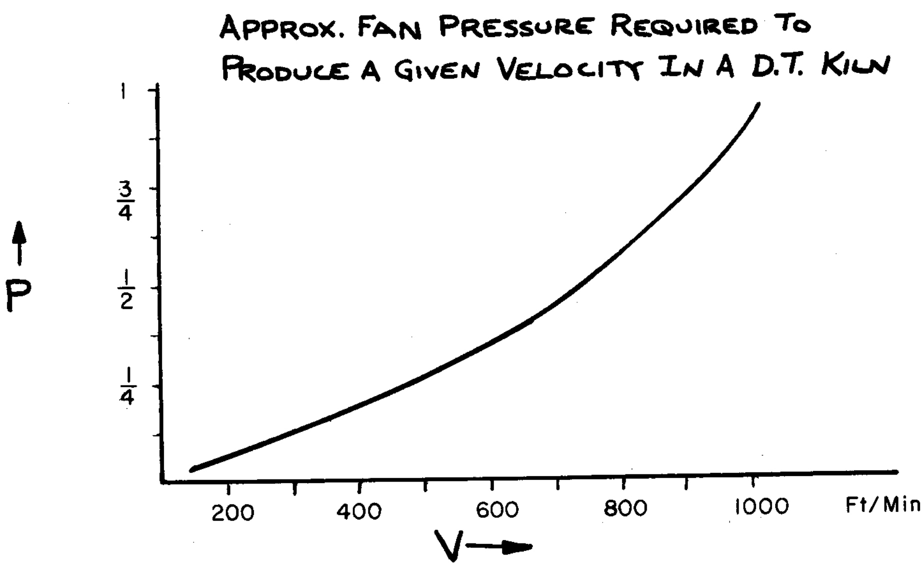
As you will note, small changes in static pressure account for large changes in volume.

This is a very unstable area and you can expect pulsing, motor overload, excessive vibration, and fan failure.

If both curves are drawn on the same scale, the point where they cross is the operating condition of the system.



In the case of the D.T. kiln, the system resistance looks like the following curve.



In this curve, the pressure is plotted against velocity. From this curve we can determine the static pressure the fan must operate under to provide the required air velocity.

The work we have done points out the fact that substantial improvements can be gained from improved stacking, stickering and baffling.

The first case in point is of a double track by 54-foot kiln with line shaft fan system and steam heated.

A full set of air velocity readings were taken. The sticker openings were marked with chalk where the readings were taken, so accurate comparisons could be made. (The average velocity was found to be 314 FPM).

The fans were changed to new Hi-Performance line shaft fans. With the original cribs of lumber in the kiln, a new set of velocity readings were taken. The readings were taken in the same marked sticker openings and found to average 487 FPM. This is an improvement in air velocity of 55%.

Here I should note that the stacking and baffling of this kiln was not at its best. There were missing baffles and voids through the loads caused by multiple length sorts. The velocity readings were taken as the kiln was being used. No changes were made prior to taking the velocity readings.

The increase in air velocity brought about by the fan change has two points that should be noted: (1) due to the shape of the blades and design of fans, it was more efficient; (2) the adjustable pitch blades made it possible to fully load the motor.

At a later date, we returned to the kiln and attempted to simulate good baffling by tacking strips of veneer over areas where baffles were missing. The stacking was pretty good and there were no abnormal areas between cribs.

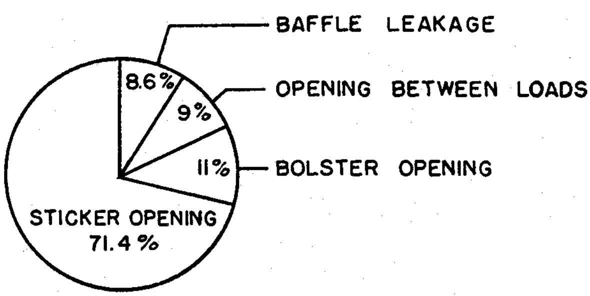
Velocity readings were taken and the average had increased to 716 FPM. Comparing these new air velocities with the previous readings, we found an improvement of 56%.

These are actual velocity readings from an actual kiln.

It's interesting to note that a 55% increase was experienced when the fans were changed, and a 56% increase was experienced when stacking and baffling was improved.

The only improvements to the baffle system were the temporary strips of veneer used to replace the missing or damaged baffles.

The information which follows is general in nature and it's presented to give a magnitude to the importance of the various points of good baffling, stacking and stickering.



TOTAL OPEN AREA
WITH GOOD STACKING & BAFFLING

This circular chart represents the total area open for air passage through a 54-foot charge of lumber with reasonably good stacking, stickering and baffling. For this chart, all areas were based on 8' studs with 3/4" stickers, 4" bolsters.

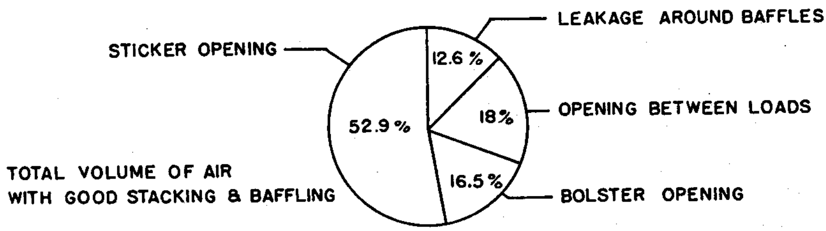
Note that the sticker area represents 71.4% of the area available for air passage. In other words, 28.6% of the available air passages by-passes the lumber.

For the purpose of this comparison, we have assigned realistic velocities through these open areas:

Velocity through sticker openings	=	500 FPM
Velocity through bolster openings	=	1000 FPM
Velocity between loads	=	1350 FPM
Velocity through baffle leakage	=	1000 FPM

Applying these velocities to the areas outlined on the first chart, we can get a good idea of the relative volume of air passing through the respective areas.

The volume actually passing through the sticker openings is probably less than shown here due to the boundary layer effect.



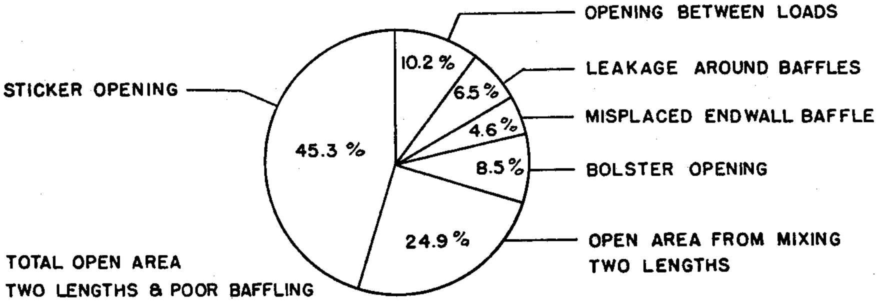
Note that because of the greater velocity through the larger openings, only 52% of the air flow produced by the fans passes through the sticker openings.

This is a simplified approach, but it should help you analyze the efficiency of your kiln air system.

The next two charts graphically represent a situation which happens every day.

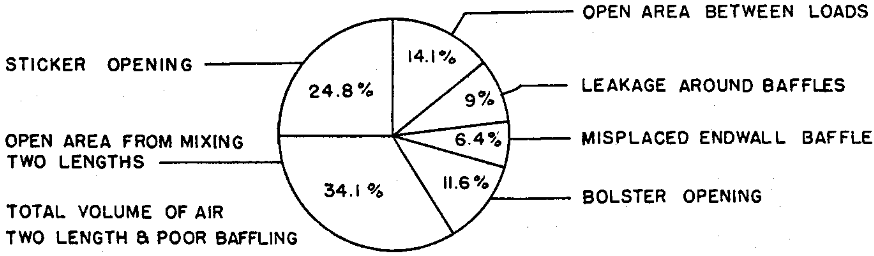
1st. Assume 8 feet and 10 feet material has been evenly mixed in each crib. (2" x 4" with 3/4 sticks).

2nd. We have assumed a very common mistake in placement of the end wall baffles. That is, so that the last section of wall baffle meets the edge of the load at 90 degrees rather than being parallel with the lumber. Baffles placed in this way leave an additional open area of approximately 2 square feet top and bottom at each end of the kiln.



This chart shows that under these conditions 54.7% of the available air passages by-passes the lumber.

By applying similar velocities to these areas, we arrive at the next chart, which shows relative volumes of air passing through the respective openings.



Note that only 24.8% of the air flow produced by the fans passes through the stickered openings.

In this situation, over 75% of the power consumed by the fans is used doing unnecessary work...that is, moving large volumes of air through voids in the lumber and around the lumber through misplaced or missing baffles.

In the kiln we are discussing here, that means that 30 H.P. is wasted. At $ .04/KWH, this could amount to $7,300 per year.

It is often stated that increasing velocity requires great increases in horsepower. This is true providing the volume delivered is increased.

However, I believe that by improving the efficiency of the baffling system so that more of the available air is directed through the sticker opening, the volume the fan must produce need not be substantially increased.

Reduction of drying time is possible. The reduction in drying time possible depends on many factors; some are: species, cut, kiln, schedule, steam available.

Some authorities on the subject believe that for 20% increase in velocity, a 10% reduction in drying time is possible. Our tests have not been extensive enough for us to determine if this relationship holds true. However, our preliminary data indicates a significant reduction in drying time is possible through easily attainable increases in velocity.

The first step in improving air velocity in any kiln is to take special care in the stacking, stickering and baffling.

The next slide shows the desired way of baffling a kiln charge. Items to take special note of are:

1. Place loads on bunks so that they are in line and will provide a consistent uniform edge for the floor baffles to lie against. You can see that if the loads are not placed square or that the loads are not somewhat even edged on the bunks, an opening is created which will contribute to the overall losses. Also, in cribs made up of packages, it's particularly important to align the packages vertically.
2. Keep loads of consistent height. Any difference in heights of loads will cause the ceiling baffles to leave a gap, again contributing to the overall losses.
3. Keep ends of loads uniform. Don't leave long ends sticking out of loads. These ends most likely will be lost to degrade and the space they create between loads contributes substantially to the overall losses. Just as lack of air may retard the drying process, excess will accelerate the process.
4. Place the end wall baffles as shown on this drawing. This reduces the openings around baffles to a minimum.
5. Avoid multi-length sorts in the same crib. When it's necessary, alternate the ragged end so you don't leave a void all the way through a crib.

A baffle system which has been properly designed will have the following features:

1. The ceiling baffles will extend to a point near the outer edge of the load.
2. The floor and ceiling baffles will extend the length of the kiln.
3. The top of the floor baffle will be close to the bottom of the wall baffle.
4. The ceiling and wall baffles should be able to tolerate up to 10" in height variation. This will account for some variation in crib height as well as shrinkage during drying.

These are the most important points in correctly stacking and baffling a kiln charge. There is much more to stacking, stickering and baffling to attain uniform air delivery than mentioned here. I have tried to bring out ways to generally improve the efficiency of the baffle system. That is, to direct more of air volume produced by the fans through the sticker openings.

Unless the heated air passes through the sticker openings, it cannot give up its heat or absorb moisture directly from the wood being dried.

The value of increasing baffle efficiency can be measured in shorter drying times, better uniformity of moisture content, higher quality lumber and decreased power costs.

By following these points you will be on your way to improving the efficiency of your kiln.