HOW TO MEASURE AIR VELOCITY AND USE THAT INFORMATION TO IMPROVE DRYING

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The success and profitability of your drying operations depends just as much on the uniformity of conditions (temperature and humidity) throughout the kiln as it does on the schedule used to dry the lumber. If conditions aren't uniform throughout the kiln, all the lumber won't be dried the same. The result will be losses in quality and production.

In this article I'll talk about some procedures you can use to measure and diagram air velocities through all the loads of lumber in your kilns. The procedures are easy to do and the results will amaze you. You'll use those diagrams to detect nonuniformities that can cause loss of quality, nonuniform final MCs, and longer drying times than necessary. We'll talk about how you can use this information to eliminate those nonuniformities and improve the overall quality of your dried lumber, and shorten your drying times dramatically.

Why Measure Air Velocity?

1. Too much air velocity is expensive

Drying lumber can only pick up a certain amount of heat from the air. Air can only hold a certain amount of moisture coming off the surface of the lumber. Once those limits are met, any more air is wasted. As it's expensive to move air around inside a kiln, wasted air flow is wasted electrical energy.

Also, too much air velocity can result in too fast drying, especially over ends of boards and around ends of kiln. Too fast drying often results in splits, checks, collapse and other such defects. And too-fast drying can cause nonuniform final MCs because more air tends to be pushed through places where there's less resistance.

2. Too little air velocity is expensive

If you don't have enough air flow not enough heat will be transferred to the lumber and not enough moisture will be carried away. Drying will be too slow, schedules will be longer than necessary, and nonuniform final MCs may result.

Also, if you don't have enough air velocity you will get inaccurate wet-bulb readings so the kiln conditions created by the controller will be different from the desired and your lumber may dry too fast or too slow.

3. Nonuniform air velocity is expensive

As is often the case, if the ends of a kiln are 15° cooler than the center, or if the top of the kiln is 15° hotter than the floor, the lumber in those different places will dry at different rates and to different final MCs causing degrade and other problems.

The same is true for air flow. Air carries heat to the lumber and moisture away. If you have more or less air flow over the lumber in different parts of the kiln, you're going to have more or less heat carried to the lumber and more or less moisture carried away. All these conditions result in differences in final MCs and quality.

How Much Air Velocity is "Enough"?

1. To dry lumber

There are no general rules for what's adequate air velocity for drying. Each kiln is different. Each run in each kiln is different, if only slightly so, because of things like differences in stacking, baffling, and available steam supply.

The only way to determine what adequate air velocity is for each load of lumber is to measure the rate of MC loss continuously. That will tell you whether your lumber is drying at just the right rate -- not too fast or too slow -- to meet your goals.

2. To assure reliable wet-bulb readings

You need at least 500 feet per minute (fpm) air velocity over the wet-bulb for reliable and repeatable readings. Less than 500 fpm results in less evaporation from the sock and less cooling of the bulb. When the indicated wet-bulb temperature is higher than it should be, the controller thinks the air is wetter than it really is and may signal the vents to open.

How Do You Know if You Have Too Much, Too Little, or Nonuniform Air Velocity?

You probably have too much, too little, or nonuniform air velocity if you have to deal with one or more of the following issues on a regular basis.

- Problems with under-dried or over-dried lumber in parts or all of a kiln charge.
- Problems with wet areas within a kiln, often on a persistent basis.
- Problems with wet pockets within loads.
- Problems controlling the zones in a multizoned kiln.
- Problems controlling your wet-bulb temperature.

What Can Cause Low Air Velocities?

- Poor baffling, damaged baffles, or no baffles.
- Fan not turning due to slipping or broken belt.
- Damaged fan blades.
- Fan motor not working.
- Underpowered fans.
- Thick and thin lumber.
- Poor stickering.
- Poor stacking on carts.
- Stacks too wide.
- Plenums too narrow.

What's The Range of Air Velocities You Should Shoot For?

1. High

Boards blow off the tops of the stacks.
Baffles stand up off the tops of the loads or get pushed away from the ends.
Lumber drying too fast.
Lumber drying as fast as possible.

2. Low

Do NOT use fan speeds that produce less than 500 fpm over the wet bulb. If you do, the wet bulb readings will be wrong at those lower speeds. You won't be able to equalize and condition your lumber properly if you don't have correct wet-bulb readings.

When should you not slow your fans?

If your kiln doesn't meet the following guidelines you probably shouldn't slow your fans.

- If more than 10% of the air that can be reasonably baffled off bypasses the sticker openings.
- If air velocities vary by more than 20% above or below the average.
- If the temperatures along the length of the kiln do not vary more than 5° from end-to-end and top-to-bottom.
- If the controllers temperature sensors do not vary more than 3° from the device used to calibrate them.

What Causes Nonuniform Air Velocity and, Therefore, What Do You Need To Do Before Measuring Air Velocity?

All of the following factors can cause nonuniform air velocity. Therefore, make sure you minimize or eliminate at least these sources of nonuniformity before taking readings.

- Load lumber properly, which means with proper alignment along the sides and ends and with a proper chimney in the middle.
- Good stickers and stickering of all loads.
- Uniformly sized bolsters.
- Uniformly sized lumber.
- Place baffles all around the loads.
- Load lumber of uniform length so that large gaps are not formed within the stacks.
- Close the vents securely. No light should show around the lids.
- Close the doors securely. No light should show around the edges.
- All fans are turning in the proper direction.

Always follow all of these safety precautions and any others you have in force at your company.

- Never go in a hot and humid kiln, especially one over 130° F wet bulb.
- Make sure heat coils are cool enough so they won't burn you before working near them.
- Lock the heat valves closed manually and in the controller.
- Never go on the fan deck when the fans are running. Check out moving fans from a ladder against the load or the kiln wall. Lock out fan motors before going out on the deck.
- Post a helper outside the door, especially if the kiln is hot.
- Know how to get out of the kiln if the lights go out.
- Use spot lights to assure good lighting.
- Hang streamers from the thermometers so you won't run into them.
- Always wear a hard hat.
- Always wear ear plugs.
- Always wear eye protection, preferably goggles.
- And any others you can think of.

How Do You Measure Air Velocity?

TWO KEYS:

1. GET THE SENSING HEAD ALIGNED PROPERLY AND EXACTLY WHERE YOU WANT IT
2. GET OUT OF THE WAY.

Hold the sensing part of the meter where you want to measure velocity and note the reading. Especially when measuring velocities through sticker openings, move the sensor up and down, right and left, and twist it around one way and then the other. You're looking for the orientation of the sensor that gives the highest reading. Keep in mind that air velocities will vary up and down.

Take the time necessary (usually 5 to 15 seconds is enough) to assure that you have the highest reading on average for that location. This takes a bit of patience. How much time should you spend on each reading? What's the value of the lumber you'll push through that part of the kiln over the next year (or until you get around to measuring air velocities again)? What's it worth per 15 seconds?

This is one of the harder procedures to learn how to do well so consulting with an expert is often worth the time and money at the outset. It can easily take 3 hours to measure air flows on one side of a kiln the first time. After that, the same work can be done in 1-1/2 to 2 hours. If you spend any less time than that the first time you probably aren't doing a thorough enough job.

Where Do You Measure Air Velocity?

Everywhere it flows. Focus on measuring velocities and variations. Assume that if you can get your velocities uniform throughout the kiln you've done the most important work. Check out the diagrams in Figures 1 and 2 to see where you should be measuring. Here are some guidelines.

- Through each unit at several locations from top to bottom and end to end.
- At many places above, below, and on each end of the entire load.
- Through the bolster openings.
- Over the wet-bulb sensors.

Measure air velocity on the exiting air side of the loads with the fans blowing in each direction. In double-track kilns measure air velocity on the exiting air side of the loads on both tracks.

CONSIDERING THAT YOU MIGHT NOT MEASURE AIR VELOCITIES AGAIN FOR ANOTHER 6 TO 12 MONTHS, TAKE THE EXTRA TIME TO TAKE LOTS OF MEASUREMENTS.

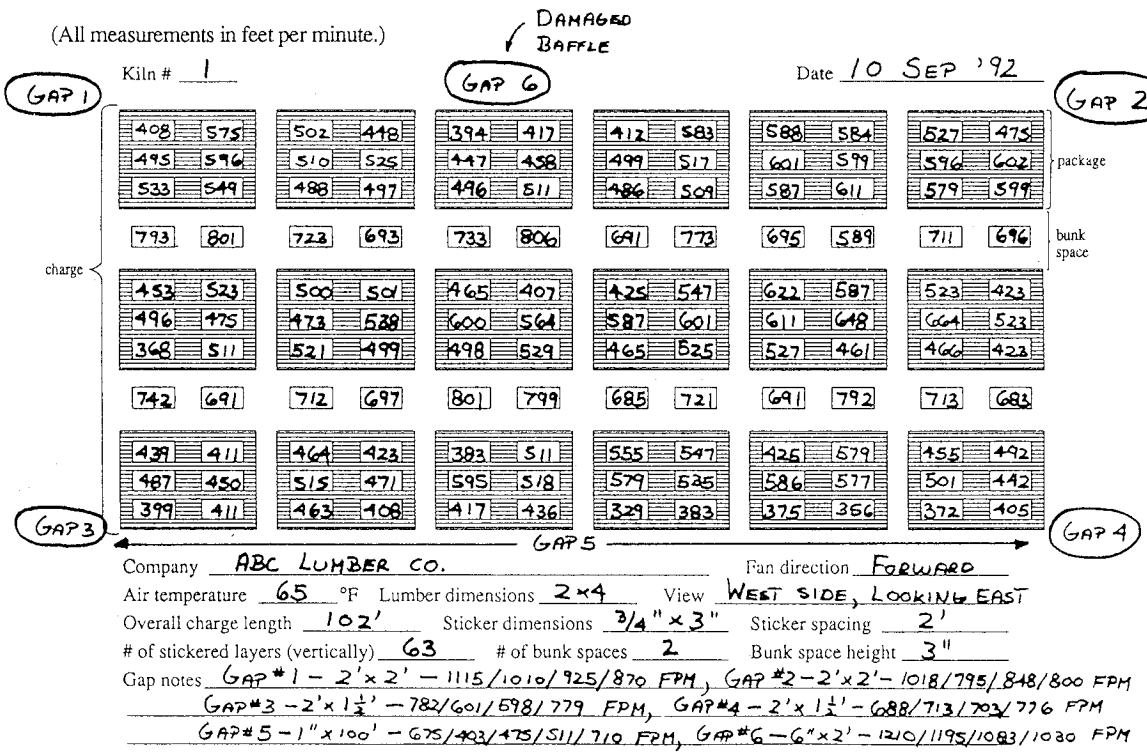

FIGURE 1. Sample form showing where to measure air velocity. The view is from the plenum of a kiln with six packages of lumber long and three high. Air velocities are in feet/min. Approximately 130 velocity readings were recorded on the exiting-air side of the package.

START OF DRYING
FANS FORWARD

	Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6	
3 m	2.64	3.71	3.0	2.90	3.05	2.74	m/s
2 m	2.41	3.0	2.64	2.13	2.13	1.98	m/s
0.8 m	1.98	2.64	2.03	2.24	1.98	2.41	m/s

FANS REVERSE

3 m	3.35	3.05	2.90	3.40	2.39	2.74	m/s
2 m	3.05	2.90	2.90	2.18	3.05	1.47	m/s
0.8 m	3.25	3.30	2.39	3.0	3.15	3.0	m/s

END OF DRYING
FANS FORWARD

3 m	2.79	3.35	3.10	2.24	3.25	2.59	m/s
2 m	2.16	2.79	2.44	1.78	2.16	1.93	m/s
0.8 m	1.85	3.0	2.26	2.39	1.98	2.31	m/s

FANS REVERSE

3 m	3.0	2.77	2.87	2.95	2.59	3.0	m/s
2 m	3.1	3.56	3.35	3.15	2.79	2.69	m/s
0.8 m	3.4	3.56	3.25	3.10	2.79	3.56	m/s

START OF DRYING
FAN FORWARD

	Pos. 1	Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6	
3 m	0.46	0.25	0.31	0.20	0.25	0.76	m/s
2 m	0.30	0.15	0.13	0.25	0.36	0.30	m/s
0.8 m	0.15	0.31	0.36	0.41	0.41	0.56	m/s

FAN REVERSE

3 m	0.36	1.17	0.25	0.66	0.36	0.56	m/s
2 m	0.36	0.51	0.20	0.36	0.56	0.86	m/s
0.8 m	0.51	0.18	0.30	0.36	0.41	0.36	m/s

FIGURE 2. Simplified set of readings. This illustrates that measurements should be made with the airflow in each direction, before and after drying, and at different fan speeds. These readings were used to make the shaded plots in Figure 4.

What Do You Do With The Information?

You now know what air flows look like and how much there should be. What you need to do is look for discontinuities and big variations, and reduce or eliminate them. A spreadsheet program can easily be used to create plots such as those in Figure 3. With additional effort, shading can be used to create a picture of the airflow patterns (Figure 4).

Fix broken and missing baffles, put pieces of wood in the bolster openings, and make sure the end baffles connect with the load securely. Make sure the fans are all turning in the proper direction and that all their baffles and cowlings are in place.

Once you have fixed all the obvious things, go back and redo your measurements, though taking fewer measurements overall. Make enough measurements in the problems areas to make sure you've correctly dealt with the problems.

When Do You Measure Air Velocity?

At least every 12 months, and every 6 months in modern, high-production kilns where small changes in anything like a broken baffle or fan belt can cause big problems with MC variations.

Measure air velocity when the lumber is both green and cold, and dry and warm.

If you use variable-speed fans, measure air velocities at the entire range of fan speeds on loads of dry and warm lumber. For example, measure air velocities through loads of dry lumber at 100%, 90%, 80%, ... down to the lowest fan speed it's wise to use.

Who Should Measure Air Velocity?

The people who should measure air velocities are the people who's work directly affects air velocities. They are the people who load the kiln, place the baffles, and are responsible for the end product. They need to see the effects of doing good and not-so-good jobs. It doesn't do any good for a QC supervisor to do the work if s/he isn't going to be in there doing what's necessary to get the same amount of air to every stick of lumber, charge after charge after charge.

What do You Want to Look For in an Air Velocity Meter?

CONSIDER THAT YOU USUALLY GET WHAT YOU PAY FOR SO THINK FIRST ABOUT THE VALUE OF YOUR LUMBER AND THEN ABOUT THE COST OF A METER.

There are many types of meters on the market. Each has its advantages and disadvantages. When deciding which to buy, ask yourself, "What's the value

of the lumber I dry every year? How much am I willing to spend on a meter that will allow me to safeguard all my lumber year after year?" The following are features I recommend you not do without.

Digital readout. You want numbers (digits), not a moving needle, for accurate, reliable, and repeatable readings.

Detachable, telescoping extension probe. You want to be able to reach high up in the load without having to stand on a ladder. You want to be able to take as many readings as possible in the short period of time your kiln is going to be out of service. You don't want to have to worry about bumping your head on steam coils and baffles. Look for a probe two to three feet long at least.

Washable sensor tip. The inside of a kiln is a dusty place. Your meter has to work flawlessly during the entire measuring process in all of your kilns. Hot-wire meters that use thin wires (cross hairs) easily get gunked up and are difficult or impossible to clean. Propeller-type meters can get fine dust in their bearings.

"Averaging" mode. This feature shows the average of a bunch of readings. Without it you're faced with wildly oscillating numbers. You're forced to guess what the average is. A must where air velocities are variable, like inside your kilns.

Automatic temperature correction. As you'll want to take readings when your kilns are both hot and cold, you need this feature to assure that all the readings will be corrected to the same temperature. You don't want to have to hunt around later in tables to make the corrections.

Built-in temperature sensor. Check out your dry and wet bulbs at the same time as when you're making air velocity measurements. This allows getting a rough measure of temperature uniformity throughout the kiln.

Memory and averaging capability. This allows taking dozens of readings quickly to get a much better measure of the average air velocities through single units.

Interface to your computer or a serial printer. Send data from the meter right into your computer where you can use a spreadsheet program to create graphs.

Conclusion

The value of your kiln-dried lumber depends very much on the conditions under which it was dried. Kiln conditions are some of the only things that can be regulated carefully during the entire production process. Of all the conditions -- temperature, humidity, rate and direction of air flow -- uniform air flow is perhaps the most important because it's the one that's most easily made good or bad. Every lumber drier needs a high quality air flow meter and needs to use it to balance air flows in his kilns at least once or twice a year.

Reverse Airflow Audit (FPM) Track #18 April 14, 1995

1490	1510	1510	1540	1520	1520	1550	1580	1560	1590	1710	1660	1650	1570	1640	1730	1540	1550	1060	1290
630	790	850	730	750	780	800	820	910	720	780	750	730	740	860	820	790	710	890	880
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790	900	900	970	1050	950	1190	990	1010	980	1020	1090	960	1030	930	950	930	960	1000	560
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560	660	610	630	570	580	670	700	670	670	700	650	560	780	690	650	660	660	680	580
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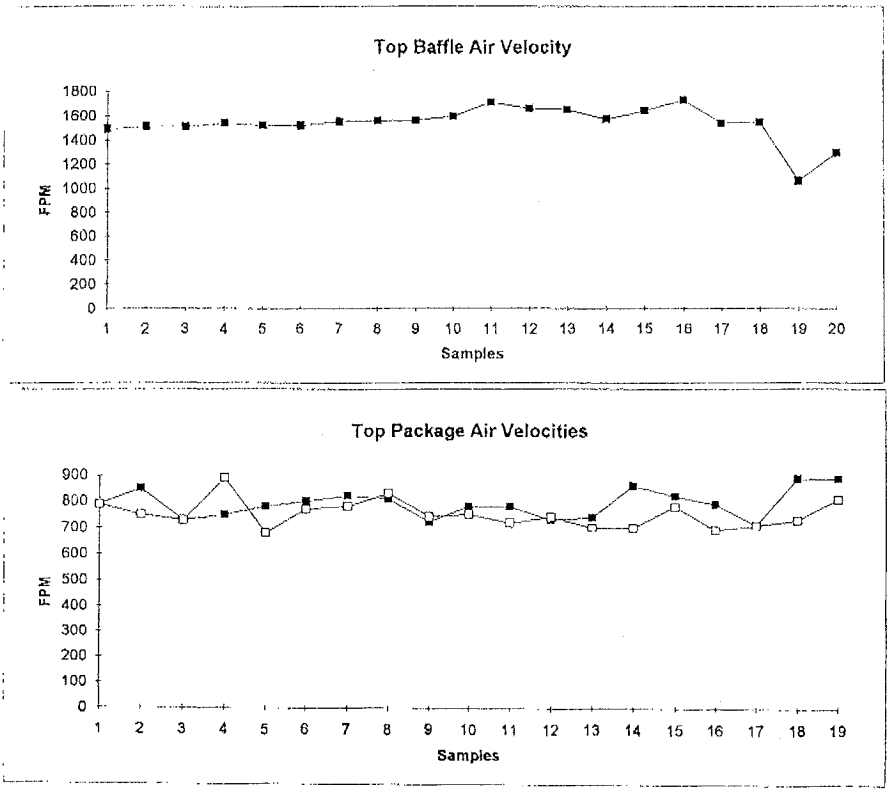


FIGURE 3. A spreadsheet program can be used to change the data from a table format (top) to a graphical format. The graphical format is easier to interpret.

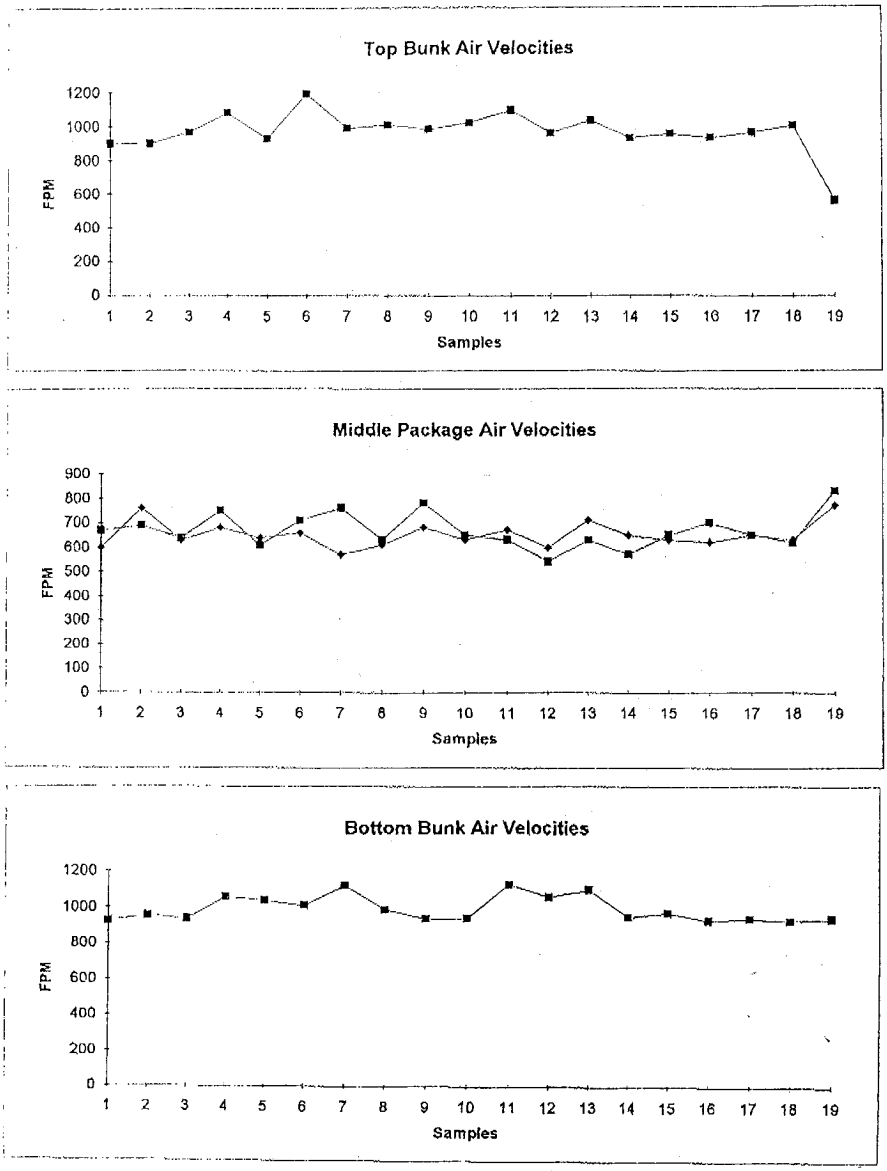
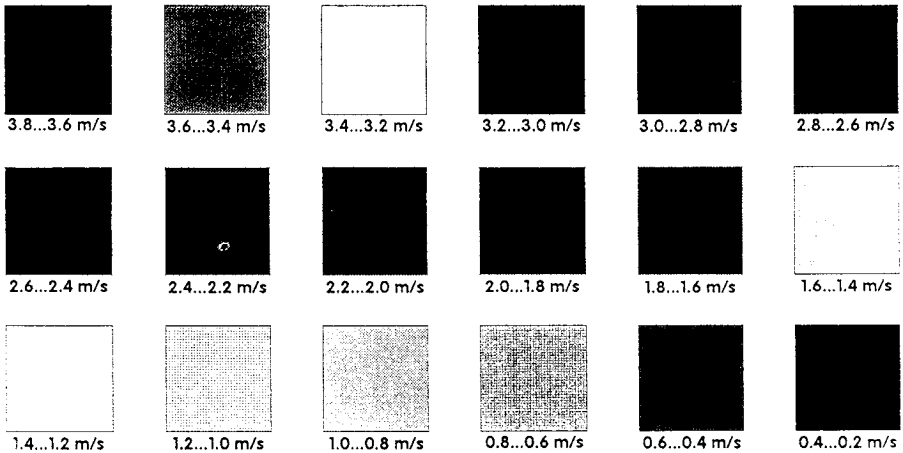
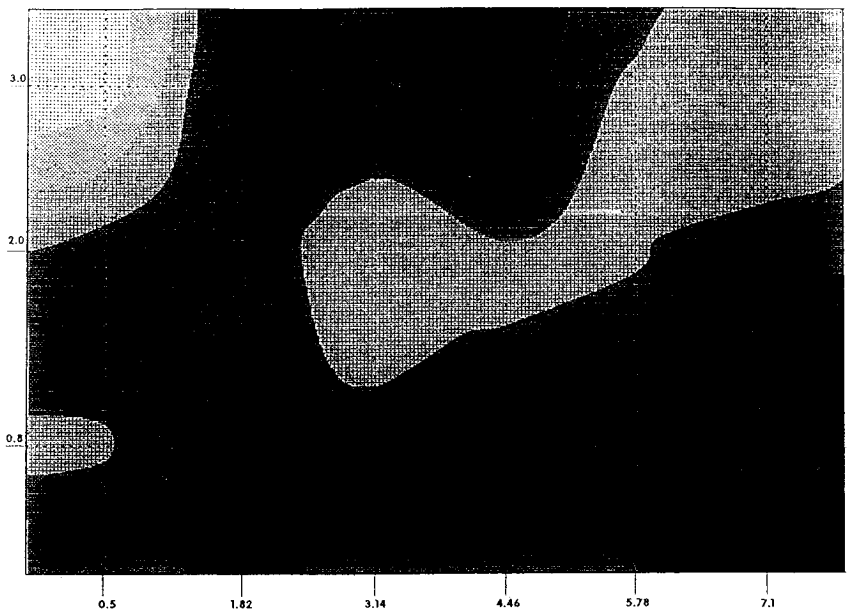


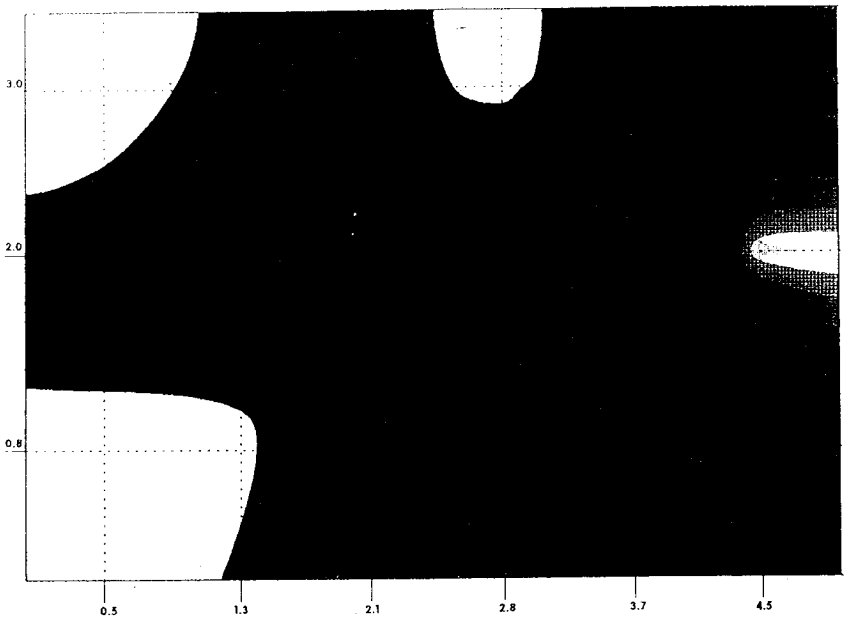
FIGURE 3 (continued). A spreadsheet program can be used to change the data from a table format (top) to a graphical format. The graphical format is easier to interpret.



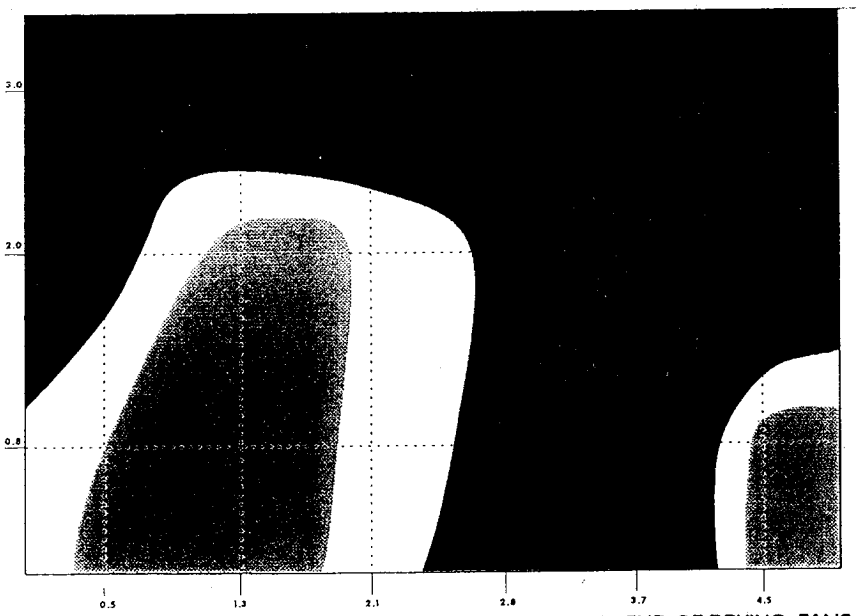


KILN 3, AIRFLOW MEASUREMENT 3.0., FANS FORWARD.
KILN NORMAL LOADED.
THIS FIGURE SHOWS THE ACTUAL AIR DISTRIBUTION, WITHOUT ANY CHANGES INSIDE THE KILN !!

FIGURE 4. Each value in Figure 2 has been assigned a color (top - only copied here in black and white). These colors have been placed on a two-dimensional graph to show the air velocity distribution. Note how it changes with fan direction and speed.



KILN 3, AIRFLOW MEASUREMENT 3.2B. (TEST 2B, REDRY), START OF DRYING, FANS REVERSE.



KILN 3, AIRFLOW MEASUREMENT 3.2B. (TEST 2B, REDRY) , END OF DRYING, FANS REVERSE.

FIGURE 4 (continued). Each value in Figure 2 has been assigned a color (top - only copied here in black and white). These colors have been placed on a two-dimensional graph to show the air velocity distribution. Note how it changes with fan direction and speed.