IMPROVED MOISTURE CONTROL FOR THE PANEL INDUSTRY

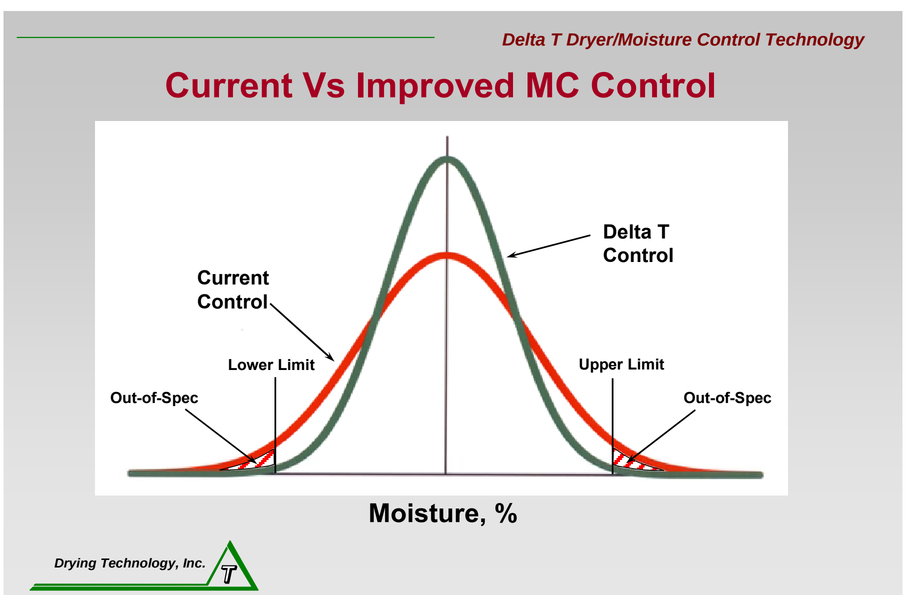
INTRODUCTION:

Drying is a costly unit operation in the panel industry; and if not properly controlled can be more costly in terms of lost production, poorer quality, increased unit energy consumption, and higher chemical consumption. The purpose of this paper is to point out problems with current moisture control methods, provide solutions for these problems, and estimate the potential savings resulting from improved moisture control. Application of the Delta T moisture control technology is described for controlling the moisture of: OSB strands using rotary and conveyor dryers; wood veneer using conveyor dryers; MDF fiber dried in flash dryers, and particleboard dried in rotary dryers. Other building products such as gypsum wallboard, ceiling tile, insulation board, etc., may also be controlled with this technology.

I. WHAT IS POOR MC CONTROL?

Slide (1) shows plots of moisture distribution curves (normal curves) derived from current (poor) and improved MC (Delta T) control that illustrate the difference in poor and improved MC control.

Slide 1



Normal curves shown in slide (1) describe how well the MC values are distributed around a mean value. Notice the red curve for current control is wider than the improved MC control (Delta T) curve. These curves may also be used to represent the percent of production within certain MC ranges if the standard deviation of the MC samples is known. The product upper and lower MC specification limits are drawn on each curve and show that the current control system has out of spec production on both ends of the curve; whereas, the improved curve has eliminated this out-of-spec production by improved control. Consequently, poor MC control may be characterized by:

Too much out of spec production
Having a wide normal curve

Much of the poor MC control experienced today is a result of the use of a control system that is ***unable to detect and react properly to water load changes*** entering the dryer with the feed.

II. WHAT IS IMPROVED MC CONTROL?

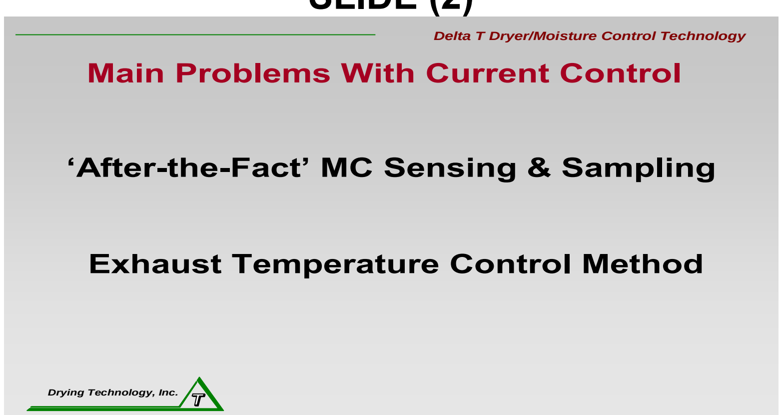
Improved MC control may be characterized by the green curve of slide (1) that:

Is Narrower than the curve for current control
Has more production within the upper and lower specification limits.
Out of spec production reduced or eliminated.

III TWO MAIN CAUSES FOR POOR MC CONTROL:

The two main problems with current MC control are stated by slide (2):

SLIDE (2)

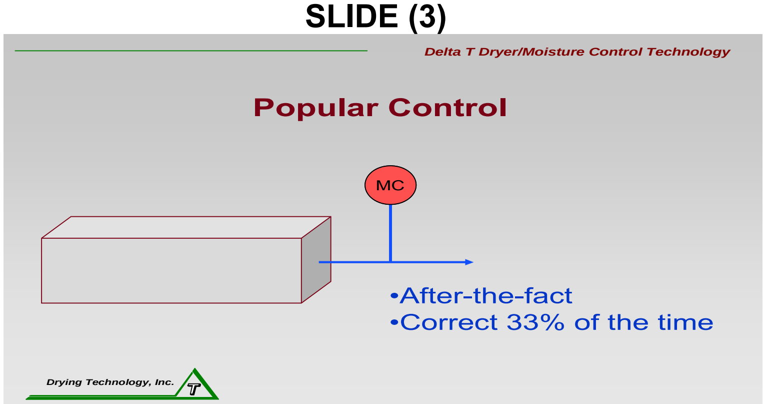


PROBLEM 1: AFTER-THE-FACT MC SENSING & SAMPLING.

As seen on slide (3), the popular but inefficient feedback control method **must** be used for those situations where the MC sensor cannot be installed inside the dryer. Since no conventional MC sensor can operate inside-the-dryer, they must be installed at the dryer exit or beyond, or the MC IS determined by a laboratory sample, thus adding more dead time (delay) in detecting a change that may enter with the feed. The variation in MC is directly proportional to the dead time (time a disturbance enters the dryer and is detected), i.e., the standard deviation of the product MC is proportional to the time it takes to detect a disturbance entering the dryer. If the MC sensor could be installed inside the dryer closer to the feed end, the dead time would be reduced by 30 to 45% and the standard deviation would be reduced the same percentage.

In addition to the problem with higher dead times caused by having to install conventional sensors at the dryer exit or beyond, slide (3) also shows that an "after-the-fact" MC control system makes ***only one correct control decision in three attempts.*** This is explained by realizing that an "after-the-fact" control system makes its control decision based on what the MC reading is at the moisture detector which can be either wet, dry or on target. Since it can be only one of these three conditions, its control decision is based on that one condition which must assume the product entering the dryer is at the same condition that produced that product under the MC sensor. However, the entering product can be only one of three conditions: wet, dry, or on target. Consequently, an "after-the-fact" control system can make, on the average, only one correct decision out of three attempts. These are not very good odds and result in poor MC control.

SLIDE (3)



In summary, an "after-the-fact" MC control system is characterized by:

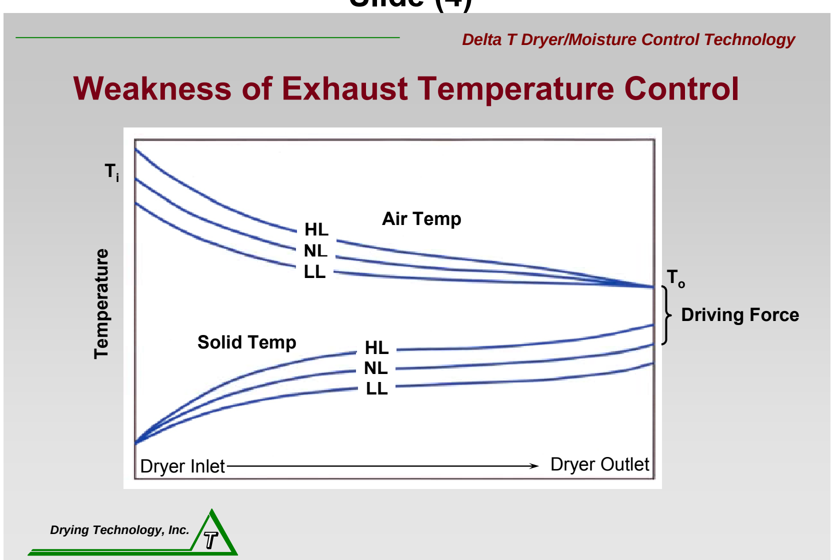
1. A MC sensor located at the dryer exit or beyond.
2. If laboratory MC samples are used, more delay is involved.
3. Too much time to detect a change entering the dryer.
4. Delay time directly proportional to product MC variation.
5. Makes correct control decision 33% of the time.

PROBLEM – 2: WEAKNESS OF THE EXHAUST TEMP. MC CTRL. METHOD:

Many dryers such as rotary (OSB and Particleboard) and flash (MDF) are controlled using the Exhaust Temperature Method (ETM). This method assumes a correlation between exhaust temperature and MC exists over a range of operating temperatures. This correlation exists only if no water load changes enter the dryer. Since water load changes are inevitable, the correlation breaks down immediately. There are no automatic methods for continuously producing the setpoint MC, therefore, the operator is always hunting for a setpoint. This problem may be further described by slide (4).

Slide (4) is a plot of the product and air temperature as they progress through the dryer (rotary or flash). Three conditions are given: HL = high load; NL = normal load; and LL = low load. The problem is that the outlet temperature is held constant which fixes the driving force for drying. Notice that for the HL condition, the driving force for drying is less at the end which means that the product will come out wet and a LL will come out over-dried because the driving force for drying (temperature drop between air and product surface) has increased. Using the ETM causes a wide moisture distribution and a relatively high product moisture standard deviation.

Slide (4)



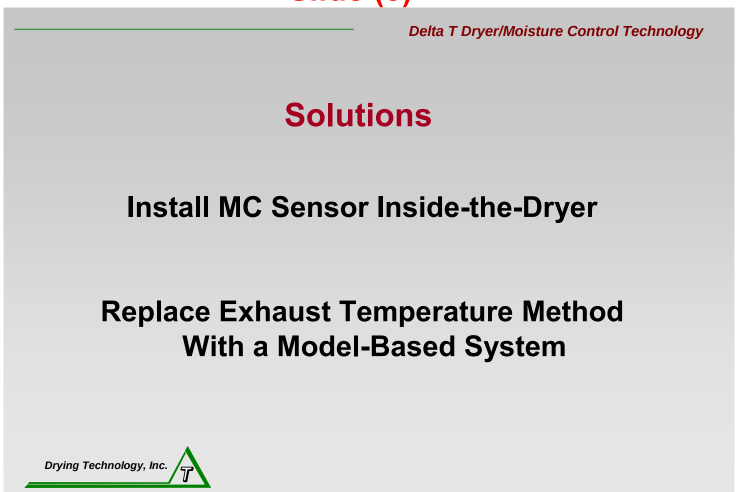
In summary, the Exhaust Temperature Method is characterized by:

1. The operator is always hunting for the setpoint.
2. No automatic method is available for adjusting for water load changes.
3. Driving Force for drying is always incorrect if water load varies because the outlet (dry bulb) temperature is held constant (see graph slide 4).
4. Setpoint to obtain target MC is only correct if there have been no changes in water load to the dryer.
5. Loss of 30 to 45% in MC control efficiency compared to use of Delta T.

IV. SOLUTIONS FOR THE TWO MAIN CONTROL PROBLEMS

Solution to the two main MC control problems is summarized in slide (5):

Slide (5)

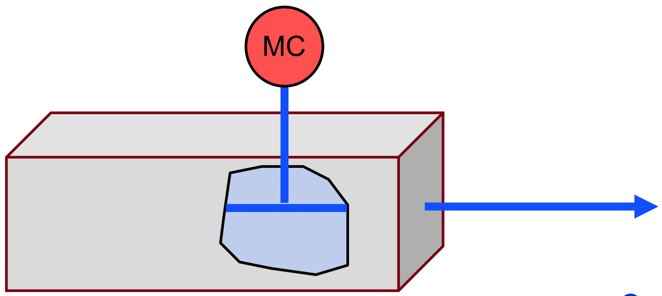


Solution to Problem 1 – Install the MC Sensor inside-the-dryer:

Installing the MC sensor inside the dryer to reduce the dead time would appear to be the logical solution; however, conventional moisture sensors will not operate inside the hot, dirty, space-limited environment of a dryer. Fortunately, the Delta T MC Control system is based on a unique MC sensor that can be installed inside the dryer. The Delta T sensor uses a minimum of two temperature sensors and a math model to sense moisture. Therefore, it can be installed inside a dryer, thereby, reducing the dead time by 30 to 45% which reduces the moisture variation the same percentage. Slide (6) provides an example of an “inside-the-dryer” sensor installation for a conveyor dryer (veneer, OSB):

Slide (6)

ΔT - Improved Control



- Inside-the-dryer
- Earlier response

Advantages of an inside-the-dryer MC sensor are summarized:

1. MC variation reduced by 30 to 45%
2. No calibration required.
3. Cruise-control startup.

Solution to Problem 2 – Use the model-predictive Delta T MC Control System.

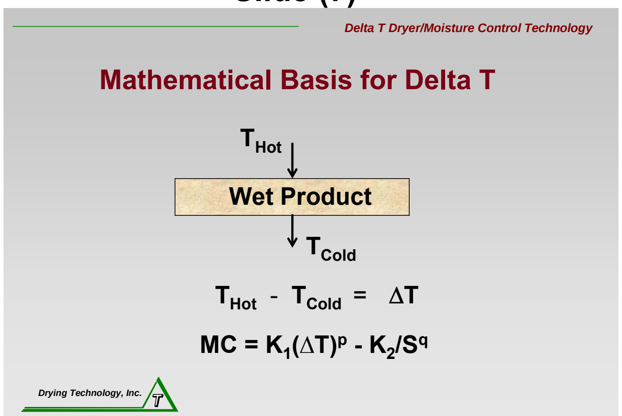
The Delta T moisture control system is based on the mathematically derived model (slide 7),

$$\mathbf{MC = K_1\,(\Delta T)^{\,p} - K_2/S^q}$$

that relates the moisture content (MC) of the product exiting a dryer to the temperature drop (ΔT) of hot air after contact with a wet product and the production rate or dryer speed (S). Ks are constants and p & q are exponents**.** The model is not a regression equation or a correlation of empirical data, but was derived from first principles, therefore, it is robust and applies exceedingly well to most dryer-types and products. That is why it needs no calibration, applies to most dryer-types and products, and can be started up by cruise-control.

It has proven to apply quite well to rotary and flash dryers that are not being controlled well using the Exhaust Temperature Method or a MC sensor downstream of the dryer. Additionally, it is capable of automatically and continuously adjusting for water load changes entering the dryer with the feed, thus solving problem 2 outlined above.

Slide (7)

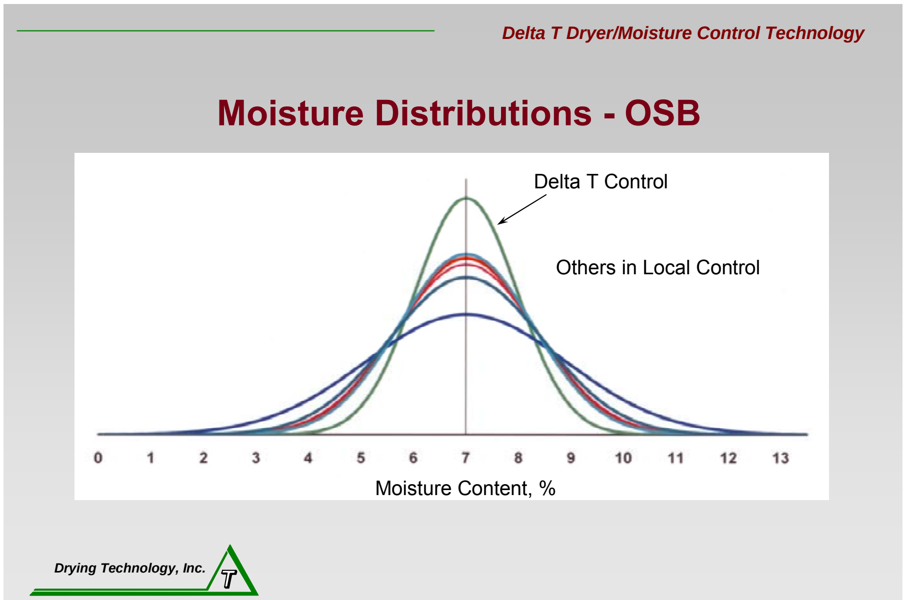


IV.   APPLICATIONS & RESULTS OF IMPROVED MC CONTROL:

A.   OSB MC CONTROL:

The Delta t has been quite successful on OSB dryers having been applied to rotary and conveyor dryers. Results of operation on five triple-pass rotary dryers are shown by slides (8) and (9)

SLIDE 8 – CURRENT VS IMPROVED CONTROL FOR 5 ROTARY DRYERS:



Slide (9)
Results of Trial of Delta T Vs Five Rotary Dryers from 2/16 to 3/9/2004

	Control Method	Standard Deviation	% Reduction	Samples Outside 6% - 8%	Samples Outside 5% - 9%
Dryer 1	**Delta T**	**0.97**	**-**	**29%**	**3%**
Dryer 1	Local	1.46	33.6	42%	11%
Dryer 2	Local	1.91	49.2	56%	17%
Dryer 3	Local	1.35	28.1	43%	13%
Dryer 4	Local	1.30	25.4	41%	9%
Dryer 5	Local	1.29	24.8	43%	12%

CHEMICAL ADDITIVE REDUCTIONS:

Slides (10) and (11) show the potential reduction in chemical additives to OSB as a result of improved MC control made possible with the Delta T.

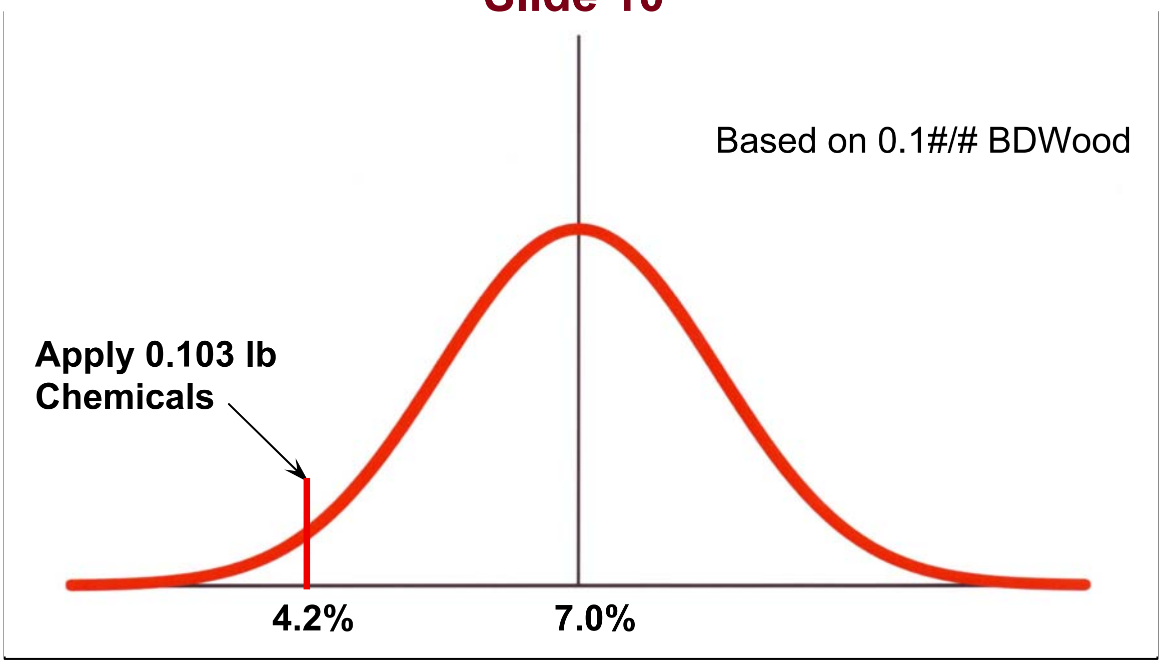
Comparison of Chemical usage for Current Vs Delta T Control:

Chemical usage based on 0.1#/# of bone dry wood.

<u>For Current Control Method (slide 10)</u>:
Selecting the lower limit as two standard deviations from the mean gives 4.3% MC lower limit. The chemical additive rate to cover this possible low MC is equal to 0.1030 #/# of strands as dried.

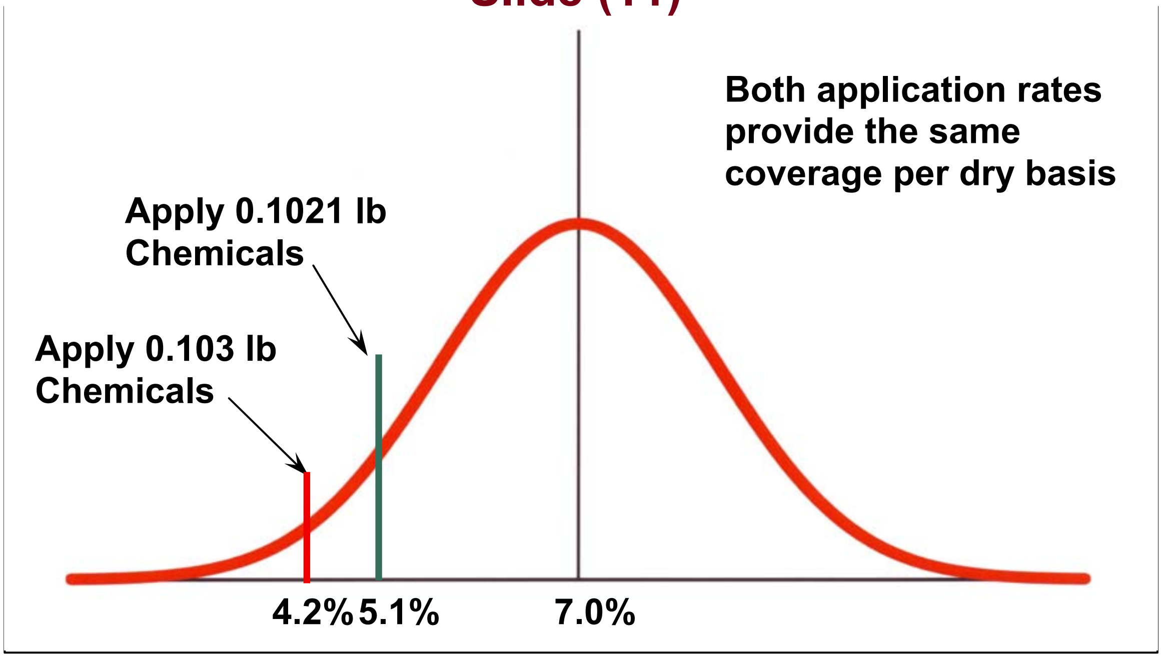
<u>For Delta T Control Method (slide 11):</u>
Due to improved control, the lower two standard deviation point would be increased to 5.1% MC.
The chemical additive rate to cover this possible low MC is equal to 0.1021 #/# of strands as dried.
% chemical additives reduction = [0.1030 – 0.1021]/0.1030 =<u>0 .874%</u>
$28 Million/yr x 0.00874 = <u>$244,720/yr</u> for 1.2 million #/day strands produced. Probably more savings could be realized if more confidence in the reduction of the MC variation is produced by the Delta T.

Chemical Application
Slide 10

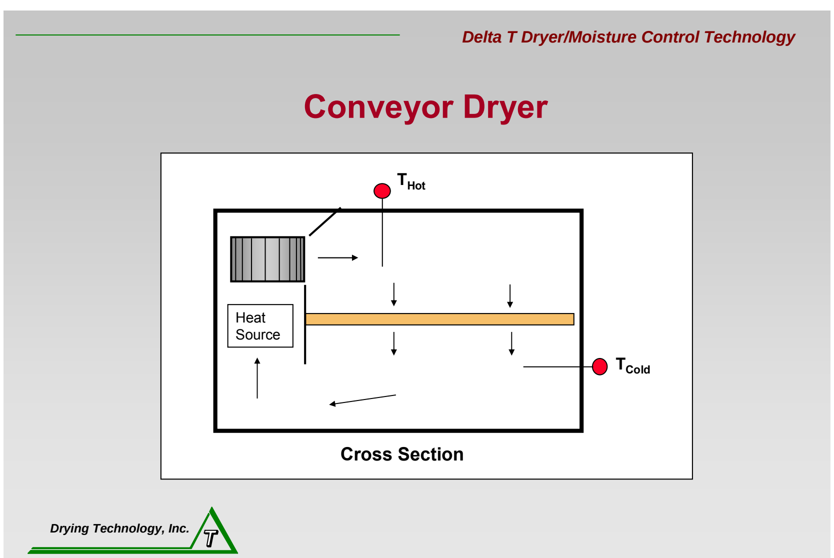


Potential Chemical Savings

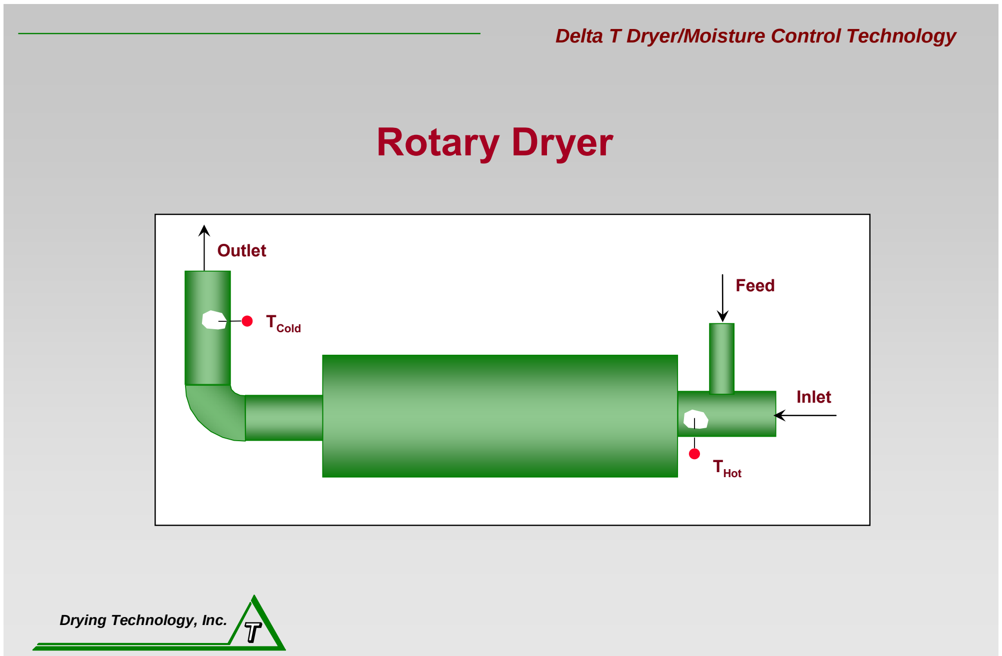
Slide (11)



SLIDE 12 – DELTA T MC SENSOR LOCATION ON A CONVEYOR DRYER.

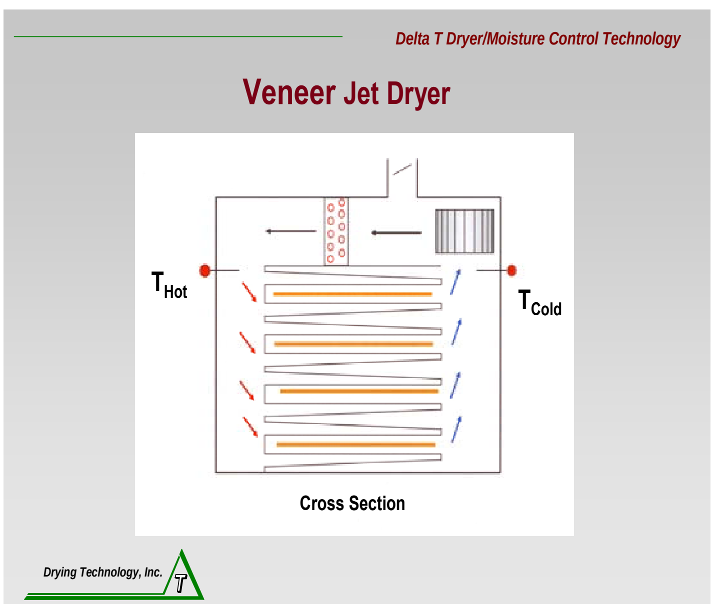


SLIDE 13 – DELTA T MC SENSOR LOCATION ON A ROTARY DRYER.

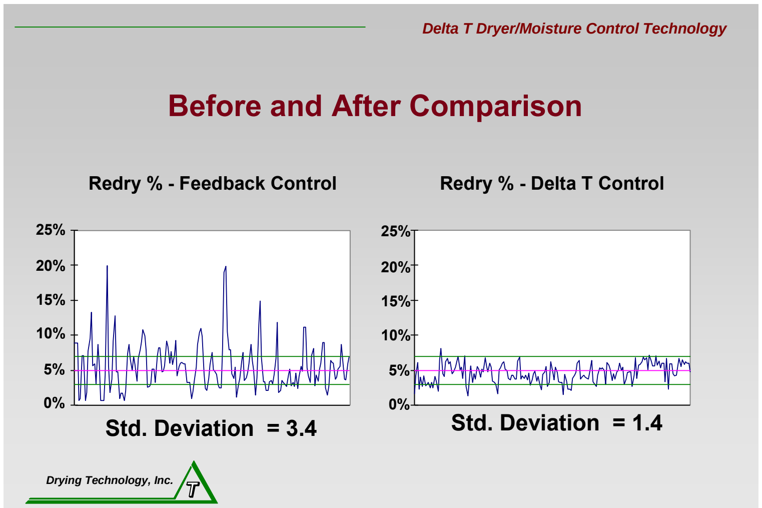


V. VENEER DRYER CONTROL:

SLIDE 14 – CROSS SECTION OF A VENEER DRYER W/MC SENSORS



SLIDE 15 – PLOT OF %RD BEFORE AND AFTER DELTA T CONTROL



Slide 16 CURRENT ACTIVITIES/RESULTS IN VENEER MC CONTROL:

Delta T Dryer/Moisture Control Technology

ACTIVITIES IN VENEER MC CONTROL

CURRENTLY INSTALLING NEW SYSTEMS

FOR PLYWOOD PLANTS AND ENGINEERED LUMBER

UPDATING OLDER SYSTEMS

VENEER IS FLATTER AND HAS A BETTER COLOR

CYCLING IS ELIMINATED

MORE UNIFORM MC IMPROVES GLUING

PRODUCTION GAINS OF 3 – 7%

OVER-DRIED VENEER ELIMINATED

Drying Technology, Inc.

For additional information describing the benefits of the Delta T to the plywood industry, go to www.moisturecontrols.com and select literature, then select technical articles, then select the article, "Delta T Dryer/Moisture Completes 10 years," published in the May 1997 issue of *Panel World*.

<u>VI. MDF:</u>

<u>Results when current MC methods are replaced by the Delta T:</u>

1, MC Variation reduced at least by 30% and sometimes more.

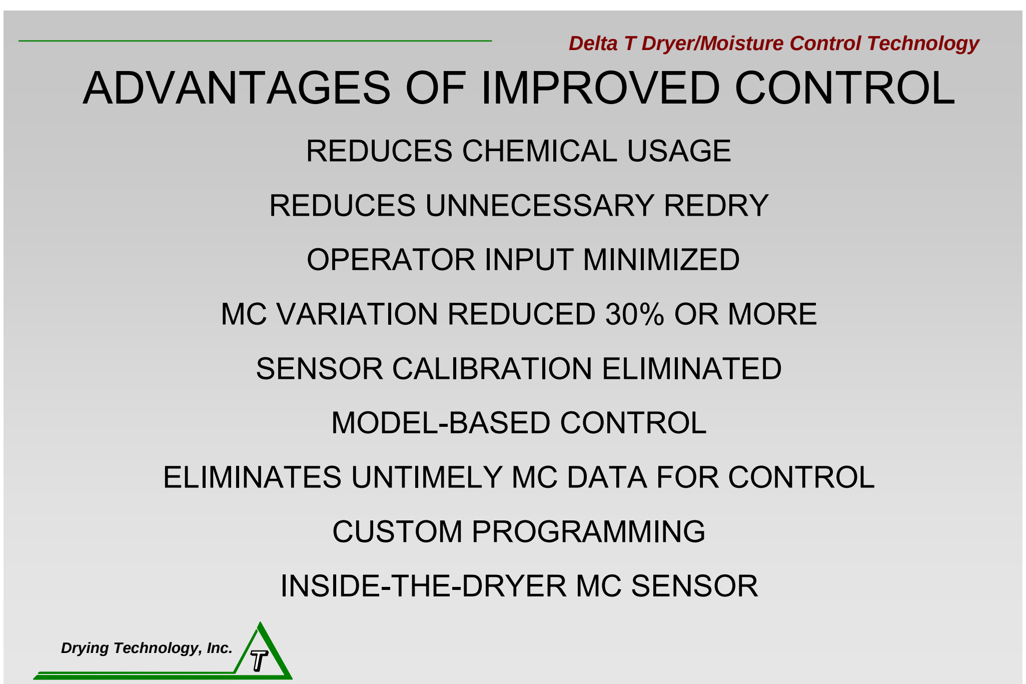
2. Some plants using the improved MC can go a shift or more without operator input.

3. Use of forming line MC feedback corrects for further drying following the dryer.

4. Replaces the flawed Exhaust Temperature Method for MC control.

<u>VII. ADVANTAGES OF IMPROVED MC CONTROL:</u>

<u>SLIDE 17</u> – ADVANTAGES OF IMPROVED MC CONTROL:



VIII. ADDITIONAL CONTROL SYSTEMS FOR PLYWOOD MANUFACTURE:

A. BLOCK CONDITIONING CONTROL SYSTEM.
B. MULTI-SPRAY BOOTH LAYUP LINE CONTROL SYSTEM.