Advances in Veneer Dryer Moisture Control

presented by

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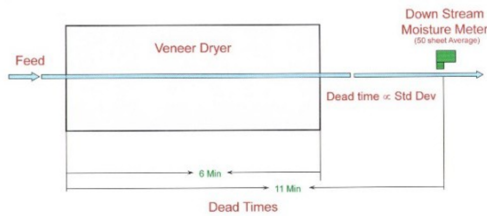
The Plywood Industry has made significant progress with such developments as green end moisture (mc) sorting, dry end grading, average dried veneer sheet mc sensing, sandwiching, use of high mc glues, improvements in dryer design, and use of the Delta T Veneer Dryer Moisture Sensing & Control System. However, most, if not all plywood plants continue to use % redry or mc sensor data with their long lag times (lag time is the time it takes for a mc disturbance entering the dryer to be detected) to control the dryer speed at the expense of causing veneer mc to vary widely. This is unfortunate and costly because veneer production rate, veneer quality, glue savings, unit thermal energy savings, and veneer recovery could all be significantly improved if the optimum target veneer mc were set and maintained with at least 30% less variation than that presently achieved using redry control. The objective of this paper is to recommend that the veneer dryer control paradigm be changed from the present redry-based control to a moisture-based control method. Since veneer production rate, veneer quality, glue usage, and veneer recovery are each improved by operating with higher and less variable veneer mc, continued use of % redry as the basis for controlling a veneer dryer is costly and makes little sense.

Major Obstacle to Improved Veneer Dryer Control:

Figure (1) illustrates the long lag time involved when using either % redry or an inline mc sensor located downstream of the dryer in a feedback control system.

Figure (1) – Lag Time Delay



Problem Solution:

Since long lag time significantly increases mc variation, the most effective way to reduce this variation is to move the mc sensor inside-the-dryer. This was made possible by the mathematical derivation of the Delta T model[1,2] specifically for a veneer dryer; however, in addition to wood veneer, the model has been validated for application on most dryer-types and products:

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

The model relates the average mc of the veneer exiting the dryer to the temperature drop (T) of hot after contacting the veneer in a selected control section inside-the-dryer, and (2) the dryer speed (S). This invented an *exclusive,* inside-the-dryer, mc sensor, consisting of two ordinary temperature sensors and software that is rugged, reliable, does not drift, needs no re-calibration, and reduces lag time delay by at least 30%. Figure (2) illustrates its location inside-the-dryer and its reduction in lag time. Since lag time is directly proportional to veneer mc variation exiting the dryer, at least a 30% reduction in mc variation (standard deviation) is achieved with this exclusive inside-the-dryer mc sensor.

Figure (2) - Delta T Inside-the-Dryer Moisture Sensor Reduces Lag Time

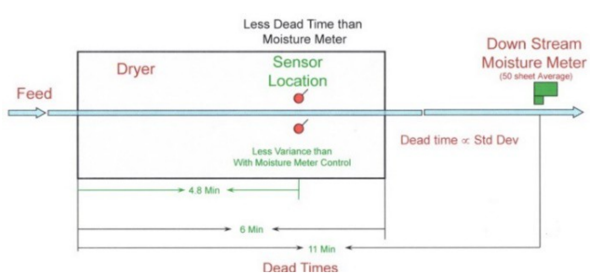
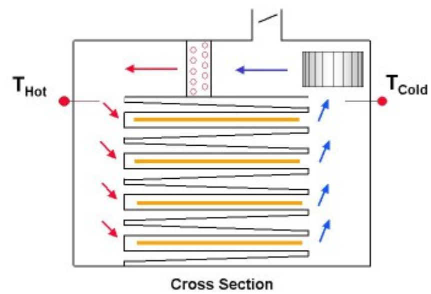


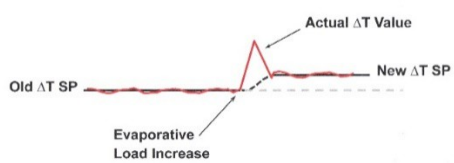
Figure (3) illustrates how the model, that relates veneer mc directly to (T), enables continuous sensing of the average veneer mc in a dryer section[3] by continuously sensing the temperature drop (Thot – Tcold) = delta t = (T) across a selected veneer section. Longitudinal dryers may be controlled by selecting a particular zone for the delta t measurement. Unlike most inline mc sensors, the Delta T uses 100% of the production rate as the mc sample size rather than a small sample on the surface of the veneer.

Figure (3) – Cross-Sectional View of a Veneer Dryer Showing Temperature Locations



In addition to solving the lag problem, the Delta T is able to calculate a new (T) setpoint needed to maintain the target mc following evaporative load changes entering the dryer. Figure (4) illustrates this exclusive capability:

Figure (4) – Delta T Re-calculates New Setpoint

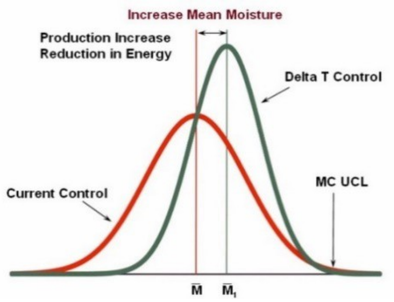


By using a moisture-based control without long lag times, it is now possible maintain the veneer target mc with at least 30% less mc variation in spite of evaporative load changes to the dryer.

Reduced MC Variation Allows Veneer Production Increase:

Figure (5) illustrates how a 30% reduction in MC standard deviation enables the average veneer mc to be shifted upward without exceeding the established upper control limit (UCL).

Figure (5) – Delta T Control Enables an Increase in the Mean Veneer Moisture Content



The value of increasing the target MC may be explained using the following example: Assume that traditional control has a veneer target MC of 10% with a standard deviation of 1.0. (This standard deviation value is probably much lower than the actual, but 1.0 is used for simplicity of calculations and illustration). Delta T control reduces the old standard deviation 30%; therefore, the target mc can be increased 0.90% to give a new mean of 10.9% without exceeding the established upper control limit (see difference in means of figure (5).

Figures (6) shows a typical veneer drying curve (mc vs drying time) with the target mc (10.0%) and the new target mc (10.9%) located on the dry end (lower) portion of the curve.

Figure (6) – Typical Veneer VS MC Drying Curve

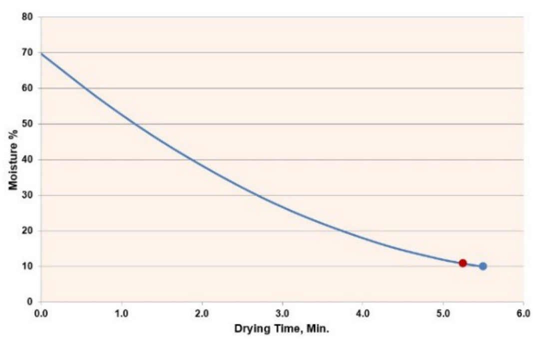
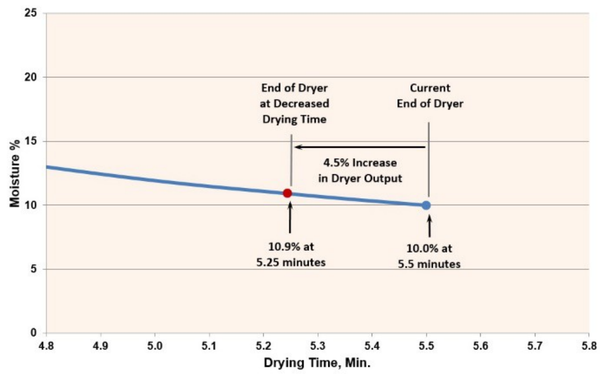


Figure (7) shows an enlarged view of the drying curve section (from figure 6) containing the two points. In shifting from 10.0% mc to 10.9% mc, the dryer speed is increased 0.25%. The % increase in dryer speed is (0.25/5.5 x 100) = 4.5%, thus the dryer production rate is increased 4.5%.

Figure (7) – Veneer Dryer MC Increase Produces Increase in Dryer Output

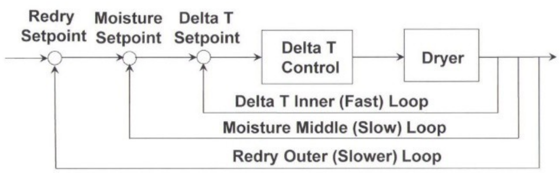


Therefore, it may be concluded that for every 1% increase in veneer mc from 10% mc, the veneer dryer speed (veneer production rate) can be increased approximately (4.5%/0.90) = 5.0%. If you are presently operating above 10% mc, the production rate would be less than 5%; if operating lower than 10%, the increase would be greater than 5.0%. ***This allows mills that are maxed out on steam availability to increase their production without use of additional steam.*** This Is only possible if you can reduce the moisture variation by at least 30% as is possible using the capabilities of the Delta T.

Improved Delta T MC Sensing & Control System Design:

Figure (8) depicts the three-loop, cascaded Delta T Veneer Dryer Control System that includes the two solutions explained above: an inside-the-dryer mc sensor and the capability for re-calculating a new process variable setpoint needed to maintain the target mc following evaporative loads changes to the dryer.

Figure (8) – Delta T - Three Loop, Cascaded Veneer Dryer Control System



Following is a description of each of the three loops:

Loop 1 – Delta T Inner (fast) Loop: This loop uses the Delta T inside-the-dryer mc sensor to continuously sense the delta t value and compares it to the target delta t setpoint. The difference in the two values is used to adjust the dryer speed appropriately to maintain the target mc at, for example, 10 %.

Loop 2 – Middle (slow) Loop: This loop uses an existing mc sensor (if available and sufficiently accurate) as a verification loop. If the veneer drying characteristics changes significantly, e.g., as a result of beetle-killed veneer being fed to the dryer, it will detect the change and appropriately adjust the delta t setpoint. If there is no downstream mc sensor, or it is not reliable, this middle loop can be omitted.

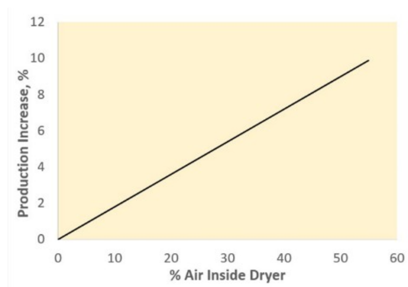
Loop 3 – Outer Slower Loop: Normally operated in manual mode to find best % redry rate.

The Effect of Air Content on Veneer Production Rate:

Research [4] has shown that the driving force for drying veneer is greater when using a drying medium consisting of air plus superheated steam than when using 100% superheated steam. Both heating mediums, when used separately, have a heat transfer driving force equal to the difference between the medium temperature and the surface temperature of the product being dried (Tmedium – Tsurface). Up to a temperature of 400 degrees F., the presence of air in the heating medium adds a mass transfer driving force consisting of the difference in the partial pressure of water vapor pressure of the water being dried from the surface and the partial pressure of water vapor in the mixture of superheated steam and air. Therefore, the driving force for drying is greater the higher the air content in the air-superheated steam heating medium when operating up to 400 degrees F. This phenomenon reverses itself somewhere between 400 degrees F and 600 degrees F.

The increase in driving force for drying when changing from 100% superheated steam at 350 - 400 degrees F to 100% air at 350 - 400 degrees F., is 18%. Consequently, for each 5% of air content inside a veneer dryer, the driving force for drying is increased 0.9%. For example, if the current air content in the heating medium is 25% and is reduced to 5% for energy conservation purposes, there should be (4 x 0.9) = 3.6% reduction in mass transfer driving force, which normally would cause a 3.6% reduction in veneer production rate. Figure (9) shows a plot of the effect on veneer production rate increase vs percent air content in the dryer.

Figure (9) –Production Rate Increase Vs Percent Air Inside Dryer



Therefore, the total cost calculation for installing a control system that reduces the air content inside a dryer for energy conservation purposes must take into consideration the value of the veneer production loss as air content is reduced. Based on the above analysis, it seems reasonable to assume that production losses, when balanced against energy savings resulting from reducing air content, would suggest caution in reducing the air content for energy savings purposes. The Improved Delta T Control System continuously senses air content in the dryer and sets the existing dampers to maintain the optimum air percent that maximizes total savings.

Summary of Economics Advantage from Improved Veneer Dryer Control:

Use of the Delta T three-loop, cascaded control system should increase the veneer production rate by about 11.5 %. This value includes 7.0% (normal increase based on 130 Delta T installations (while burdened by % redry feedback) and 4.5% for each mill that can increase their target mean mc by 0.9%. If the shift from % redry-based to moisture-based control is made, the saving should be significantly higher. For those mills that control the air content inside the dryer, there may be additional savings as a result of controlling to the optimum air content, an option offered by the Delta T.

Therefore, use of the improved Delta T Veneer Dryer Control System enables the dryer to be optimized in terms of operating at: (1) a higher average veneer mc with less mc variation, (2) a lower glue usage due to operating at a higher veneer mc, (3) an optimal dryer air content, (4) a lower unit energy consumption rate, (5) less veneer breakage due to higher veneer mc, and (6) less redry due to less dryer speed cycling previously caused by % redry feedback.

References:

1. Robinson, J.W., ‘a New Drying Model,” Proc. North American Drying Symposium, Forest Products Utilization Lab, Mississippi State University, P. 78 – 84, (Nov. 27 – 28), 1984.

2. Robinson, J.W., “Improve Moisture Control,” CEP, (Dec. 1092), pp. 25 – 33.

3, Robinson, J.W., “Delta T Completes Ten Years,” Panel World, (May 1997), pp. 56 – 59.

4. Laity, Walter W. et. al., Comparisons of Air and Steam as Veneer Drying Media, FPJ, Vol. 24, No. 6, pp. 21 – 29.