# Effective Biomass Moisture Control

By

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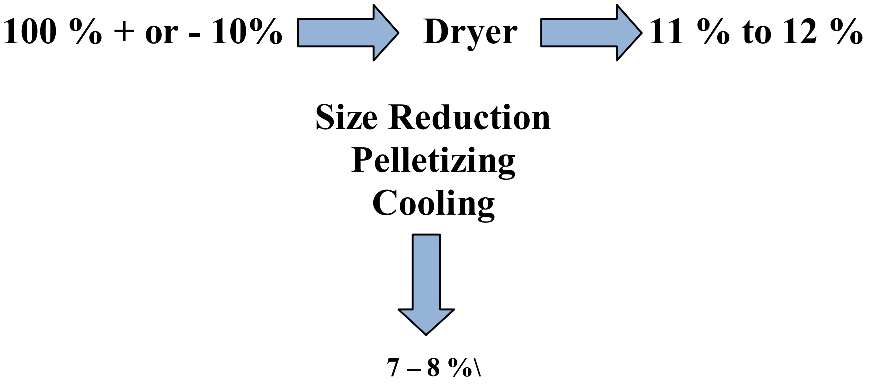
## Introduction:

Use of biomass waste such as wood bark and sawdust for steam and electrical power production has a relatively long history in forest product industries. This woody biomass, both green and dry, was and still is burned directly in power boilers for the production of steam and electrical energy. The author once managed a biomass fueled 7 MW power plant that supplied all the electrical power and steam required by a large lumber-plywood- particleboard complex. Today, wood pellets mills and biomass based power plants are multiplying with intensity in wood-rich North America. These pellets are replacing fossil fuels now used for domestic and commercial space-heating and as fuel for industrial power plants. Other biomass waste products may be converted into pellets; however, since wood-based pellets are the preferred product today, this paper will primarily cover moisture (MC) sensing and control of biomass used for producing pellets. However, this same sensing and control technology applies equally as well to all biomass materials.

## The Wood Pelletizing Process:

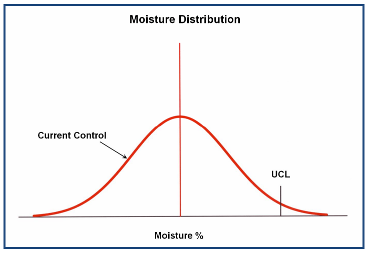
Wood chips for green pellet usually have a MC content of about 100% + or ï 10% variation (dry basis). Following reduction of the incoming biomass to the proper particle size, it is dried to a target of 11% to 12% MC prior to pelletizing. Further drying during pelletizing and cooling reduces the finished pellet to the desired range of, for example, 6% to 8% MC. Figure (1) below presents a simple diagram of the MC content reductions throughout the pellet fuel process.

**Figure (1) – Green Pellet Plant Biomass Moisture Balance Content (Dry Basis)**



The combined variability of the incoming wood biomass and the period of uncontrolled drying during pelletizing and cooling can present a challenge to currently used traditional MC sensing and control systems . Figure (2) shows a typical normal MC distribution curve produced by traditional MC sensing and control technology.

Figure (2) ï Typical MC Distribution Curve Produced by
Traditional MC Sensing and Control Technology



Notice that in figure (2) the MC is widely distributed. If the mean and standard deviation of the distribution are known, it is possible to predict the percent of total production above and below a given MC percent. For example, using traditional MC sensing and control, if biomass is dried to a target MC of 11.5% with a standard deviation of 1.0, the percent of total production above 12.5 % MC as shown in figure (3) is 8% and that produced below 12.5% is also 8%.

Figure (3) ï Normal MC Distribution for Traditional MC Sensing & Control

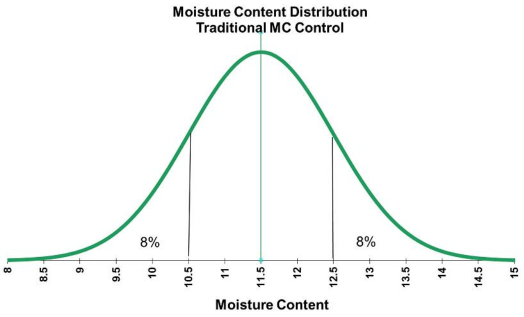
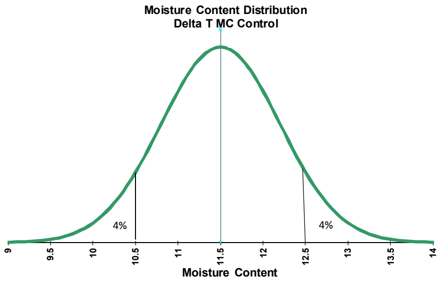


Figure (4) shows that if MC control could be improved by at least 30%, the percent production above 12.5% MC is 4% and that produced below 12.5% is also 4%. Thus, improved control reduces the total amount of production above and below + or ï 1.0% of the mean is reduced 50%.

Figure (4) ï Moisture Distribution Delta T MC Sensing & Control



## The General MC Control Problem:

Two main problems significantly reduce the effectiveness of commonly used traditional MC sensing and control technology:

(1) Lack of a reliable, inline MC sensor that supplies timely and accurate MC data upon which to base the control action.

(2) Lack of a control algorithm that correctly adjusts for evaporative load changes entering with the feed such that the target MC is maintained with minimum variation.

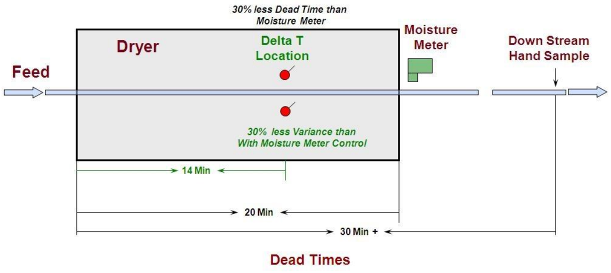
Further discussion of the two problems listed above illustrate the weaknesses in traditional MC sensing and control systems that limit the effectiveness of currently used MC sensing and control technology

### A. Moisture Sensing Problem:

Because of the harsh environment inside a dryer, traditional inline MC meters must be installed downstream of the dryer. This results in a dead time (time it takes to detect a disturbance entering with the feed and to start a control change) of 20 to 30 minutes. Figure (3) shows the minimum dead time for a dryer (20 min at the dryer exit) is the total drying time inside the dryer. If online lab samples are used, the dead time may increase to 30 minutes or more depending upon the sampling frequency. Inline moisture meters may be used if they are sufficiently reliable; however, the dead time will never be less than the total drying time through the dryer.

Use of the exhaust temperature to infer the product MC is sometimes used, and although it controls in the correct direction, its tenuous correlation with MC breaks down as soon as the evaporative load changes and usually is relegated to a manual system where the operator is continually searching for the correct setpoint.

Figure (5) ï Dead Time Increases
As Distance Between Sensor and Dryer Inlet Increases



This MC problem is further explained by assuming the dryer is operating at steady-state conditions and an evaporative load increase enters the dryer. If the dead time is 30 minutes, the disturbance will be detected in 30 minutes and the control action will increase the heat rate to the dryer; however, thirty minutes of production is produced at a higher MC. If the disturbance only lasts for 30 minutes and returns to the previous condition, the heat increase will continue for 30 minutes and produce dry product for 30 minutes.

What is needed is a MC sensor that can be moved closer to the feed end of the dryer, which would require that it be installed inside-the-dryer; however, traditional inline MC meters are incapable of operating inside the harsh environment of a dryer; therefore, MC traditional MC sensing and control suffers as a result.

B. Control Algorithm Problem:

Few MC control systems are operated in closed-loop control, especially in the biomass industry where few variables are possible of measurement, and highly trained control engineers are rarely on staff. Consequently, control is usually manual using lab MC samples with long dead times. Sometimes, inline MC meters have been installed downstream initially for use in closed-loop control; however, they usually have been relegated for use as a trending device.

Attempts have been made to use exhaust temperature as a surrogate for MC in either open or closed-loop control. Although the exhaust temperature control method controls well in steady-state operation, as soon as there is an evaporative load change, the old setpoint will not produce the target MC. Most operators have abandoned closed-loop control with this method and continually hunt for a setpoint that produces the target MC following disturbances to the system. Use of this method also causes wider MC variations.

There are more sophisticated control systems available such as model-predictive, multi-variable control system, and feedforward/feedbqack control; however, these are neither economically feasible nor practicable because of the lack of an ñinside-the-dryerò MC sensor coupled with a simple, robust, reliable and precise control algorithm

## MC Sensing & Control Solution:

Fortunately, one solution solves the above-listed two main problems with traditional MC sensing and control systems. It is based on the exclusive, first-principles-derived, Delta T general dryer/moisture control model:

$$MC = K_1(\Delta T)^p \text{ ï } K_2/S^q \qquad (1)$$

This model relates the product MC exiting a dryer to the temperature drop ($\Delta T$) of hot air after contact with the wet product and the production rate or evaporative load (S). The model solves the two main problems with traditional feedback MC sensing and control by providing the following **exclusive** technology:

1. An accurate, precise ñinside-the-dryerò MC sensor that reduces dead time, and thus the standard deviation by at least 30%. It is explained below.

2. A new and powerful control algorithm that maintains the target MC with a low s.d. in spite of changes in evaporative load.

## 1. A New MC Sensor :

The model relates MC to the temperature drop of hot air after contacting the wet product being dried. This invented a new method for sensing MC in terms of a temperature drop parameter that is easily measured on either direct or indirect dryers. Therefore, since only temperature sensors are in contact with the harsh environment inside-the-dryer, a precise, accurate, rugged, and reliable inline MC sensor is now available that does not require periodic re-calibration. Figure (6) describes four ways the delta t (Thot ï Tcold) parameter can be obtained for use in the Delta T MC sensor.

Figure (6) ï Various Methods For
Measuring The Delta T Parameter For Sensing MC

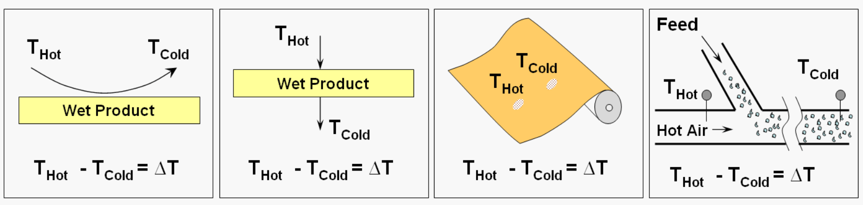
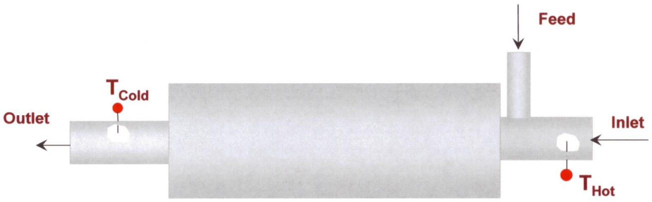


Figure (7) shows the temperature sensor locations for sensing product MC before the product exits a single-pass rotary dryer.

Figure (7) ï Temperature Location for Sensing Product MC
From a Rotary Dryer



## 2. A New Control Algorithm:

The Delta T model also provides a new control algorithm that enables continuous, precise calculation of the setpoint necessary to maintain the target MC in spite of changes in the evaporative load entering with the feed

## Results of Improved MC Sensing & Control:

This patented, award-winning Delta T technology has been validated by over 400 dryer installations. Figures (8) and (9) illustrate the effectiveness of the Delta T in reducing the MC variation at least 30% to achieve tight, precise biomass MC control required for pellet production. Figure (8) depicts the MC distribution for pellets destined for power plant use and figure (9) deepicts the MC distribution for pellets destined for domestic use where the mean may be shifted upward to sell more water without exceeding the upper specification limit of 10%.

Figure (8)

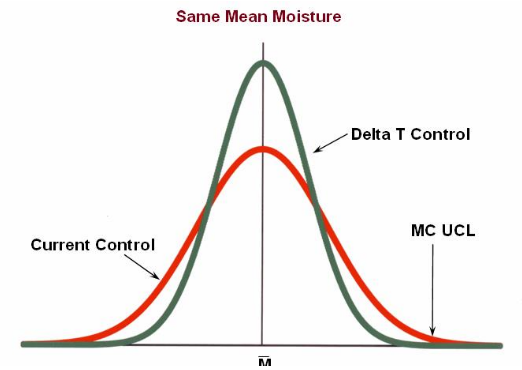
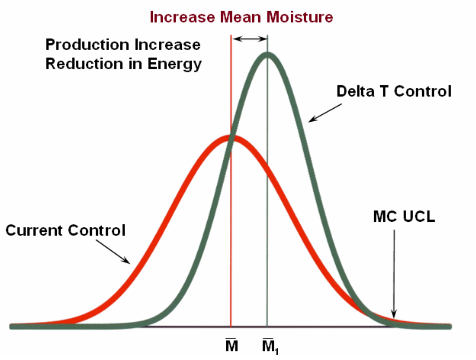


Figure (9)



## Summary & Conclusions:

Control systems based on traditional MC sensors that cannot be installed ñinside-the-dryer have on average a 33% chance of making the correct control decisions following a change in evaporative load. The Delta T MC sensor solves this problem with its exclusive capability for operating ñinside-the-dryer,ò thus decreasing the dead time and the standard deviation. The delta T MC sensor does not require the usual re-calibration as required by traditional MC sensor. In addition, the Delta T model provides an exclusive control algorithm that enables continuous re-calculation of the delta t setpoint that maintains the target MC following changes in evaporative load entering the dryer with the feed. In summary, the Delta T can reduce the probability of rejection of pellets due to MC quality problems, and especially for pellets produced for the domestic space-heating, it offers the possibility of increasing production, reducing energy consumption and improving quality simply by increasing the mean without exceeding the established upper specification limit.