ON-LINE CONTROL OF WATER ACTIVITY

Introduction;

Proliferation of mold and other harmful micro-organisms is of major concern in many food products prepared for animal and human consumption. Fortunately, such products have a critical water activity (aw) value below which such organisms will not grow. Heretofore, no on-line aw control systems were available due to the absence of an on-line aw sensor. The control system described herein has proven highly effective as an indirect, on-line method for controlling aw using the highly effective Delta T moisture control system.

Present Water Activity Control:

Moisture content (MC) is related to aw (see figure (2) below) for specific products; therefore, it is possible to indirectly control aw by controlling MC. However, present aw control practice is to determine from an isotherm the MC value that corresponds to the critical aw for a specific product, then use a laboratory or a down-stream conventional moisture sensor to maintain that MC. An alternative method is to use a portable aw and make periodic analyses on the finished product. Both methods are ineffective because they measure MC and aw in an "after-the-fact." Consequently, the dead time (time to detect a change entering with the feed) is too high; and since the dead time is directly proportional to the standard deviation (moisture variation) of the product MC exiting the dryer, the variation in MC and aw are not controlled effectively, thus causing under-dried product that might exceed the target aw.

The Delta T moisture control system solution, outlined below, will reduce the dead time so that the standard deviation and thus the moisture variation are reduced. A lower standard deviation assures that aw will be more precisely controlled, and at the same time the maximum amount of water will be left in the product for sale and that water will not have to be evaporated. Additionally, the Delta T non-conventional moisture sensor is much more reliable than a conventional sensor because it can operate in the harsh environment of a dryer, oven, kiln, etc.

The Control Solution:

A non-conventional MC sensor was invented, patented and became the basis for the DELTA T moisture control system. It uses two temperature sensors and a mathematical model derived from first principles,

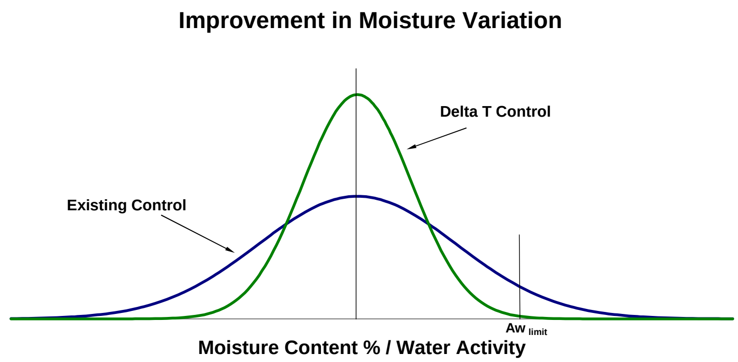
$$MC = K_1(\Delta T)^p - K_2/S^q$$

to measure MC, where the moisture content (MC) is related to the temperature drop (ΔT) of hot air after contact with the wet product and the dryer production rate (S). It can be installed “inside” the harsh environment of dryers, ovens, kilns, and the like; consequently, the dead time is reduced to the extent that the standard deviation of the exiting MC is reduced a minimum of 30% to as much as 45%. This control system has been effectively used in such industries as food, petfood, snackfood, textiles, carpet, corn wet milling, animal feed, forest products, chemicals, etc., and for such dryer-types as conveyor, rotary, flash, spray, and fluidized-bed.

Result of Using the Delta T:

Figure (1) compares before and after Delta T MC moisture control of a dry petfood. Notice that there is no production above the critical aw value when using the Delta T, whereas, there is production above the critical aw value during use of the existing control system.

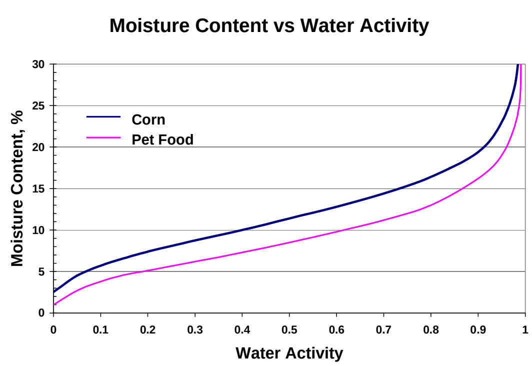
Figure 1 – Moisture Distribution of Existing Control Vs Delta T Control



Conclusion: Water Activity can be Effectively Controlled:

The literature indicates that the lowest aw at which the vast majority of food-spoilage bacteria will grow is about 0.90 aw; the lowest aw for mold and yeast growth is about 0.61; and the lower limit for the growth of mycotoxigenic molds is about 0.78 aw . Figure (2) shows MC Vs aw relationships for corn and petfood.

Figure (2) – Isotherms of MC Vs aw



If aw is controlled below the critical value, the manufacturer may be assured that the product will be safe from growth of mold or other harmful microorganisms. Now that there is an effective MC control system and a relationship between MC and Aw (that can be updated by lab samples), it is possible to indirectly control aw on-line, thus allowing safe maximization of the water content of the product without producing product that would support the growth of mold or harmful microorganisms. Figure (3) is an example of the actual and potential savings derived from safely maximizing the moisture content of a particular dry petfood product.

Figure (3) – Safely Maximize MC in Product

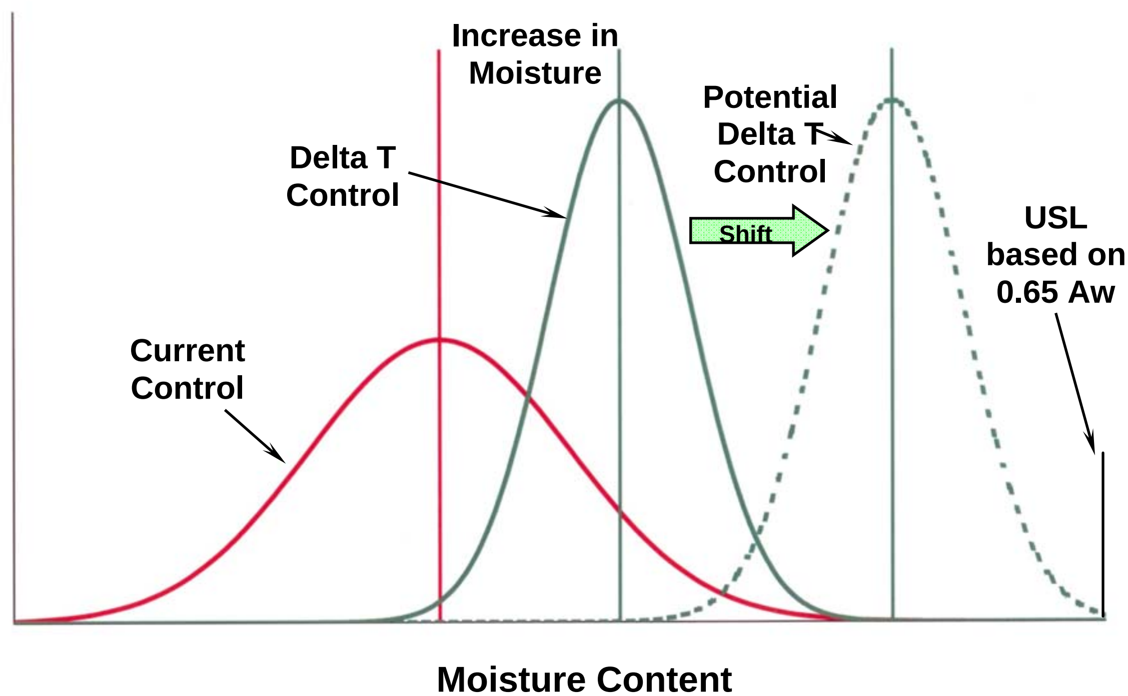
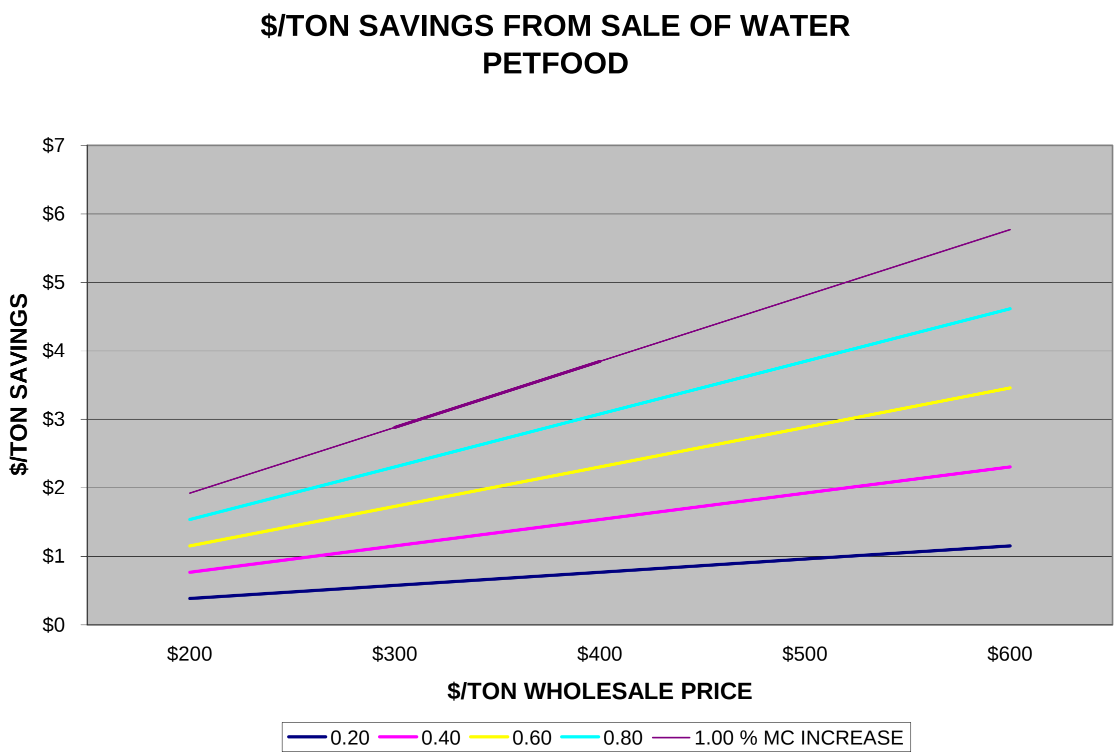


Figure (3) shows the improvement by converting from the current "after-the-fact" control system to the Delta T control without aw control to be an increase of 0.66% in MC without exceeding the upper specification limit (USL). If the aw control option had been available at the time, the potential total additional increase in MC of the product would have been 1.0% for an overall total increase of 1.66% in MC at the USL which coincides with the 0.65 critical aw value. Figure (4) shows results in terms of increased production, energy conservation, and product quality if on-line aw is incorporated into the Delta T MC control system.

Figure (4) – Possible Savings from Improved MC Control



A petfood dryer producing 75,000 tons/yr of a product at a wholesale price of $.20 per lb ($400/ton) and a mean MC increase of 0.60 % would net $175,000 annually with no additional raw material or operating costs.