

PROFITABLE DDGS MOISTURE CONTROL

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By

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INTRODUCTION:

Drying is one of the most extensively used unit operation in the process industries. However, ineffective DDGS moisture (MC) control system operating on rotary, steam tube rotary, ring and flash dryers can negate the advantages of the best designed dryer by costing fuel alcohol plants approximately \$0.83 to \$1.26 per ton of dried DDGS in terms of lost production, higher thermal energy consumption, and lower product quality. The purpose of this paper is to point out the causes for today's poor MC control, calculate the cost of poor MC control, and supply criteria for selecting an effective MC control system to recover these costs.

IMPROVED MC CONTROL:

Improved MC control is achieved when a process or equipment change is made that causes a significant and sustainable reduction in the product MC variation exiting the dryer. The effect of this change may be measured by the variation (standard deviation) of MC samples distributed around the target mean MC value. This is illustrated by figure (1) which compares MC distributions for current vs improved MC control plotted around the same target mean.

Figure (1) -- Moisture Content Distributions

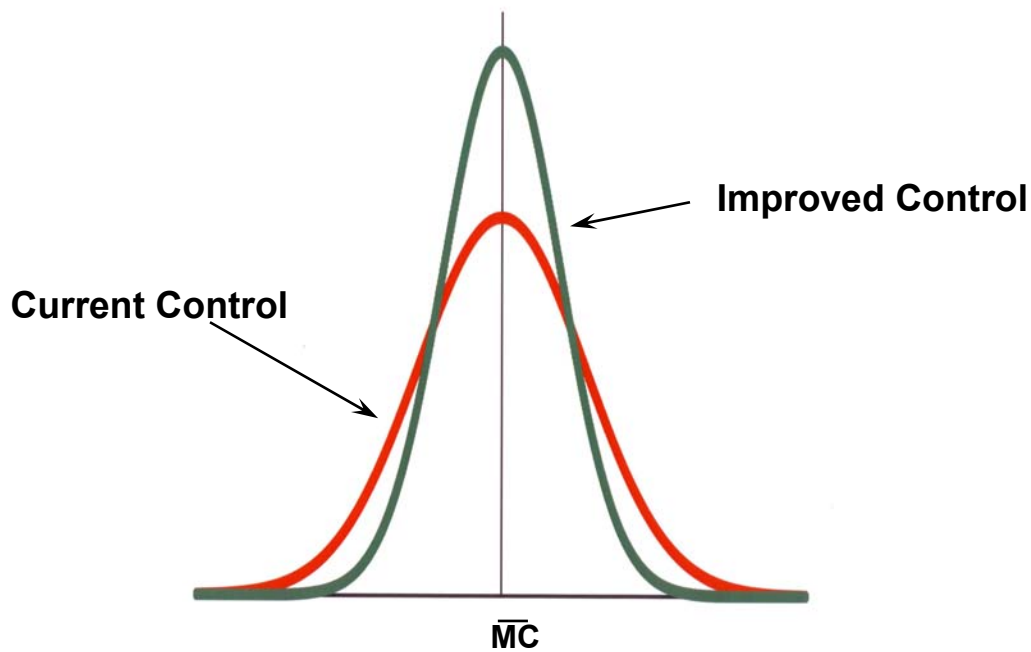


Figure (1) shows the normal distribution curve for actual production produced by the current MC control with a mean of 9.75% MC and s.d. of 0.75. The normal curve for Delta T control represents the same dryer using improved MC control operating at the same target mean but with the standard deviation (s.d.) reduced 30% to a value of 0.525..

PROFITABLE MC CONTROL:

Profitable moisture control is possible because current MC control is poorly conducted as a result of inherent weaknesses in available MC sensors. Consequently, product MC exiting a dryer varies widely thus exhibiting a relatively large s.d. The key to profitability is to be able to maximize the mean MC while producing a negligible amount of production above the upper specification limit (USL). The following relationship is useful in maximizing the target MC to achieve profitable MC control:

$$\text{Recommended Target MC} = [\text{USL}] - [N \times \text{s.d}] \quad (1)$$

This relationship states that if the target MC is maintained at $N = 3$ standard deviations below the upper specification limit (USL), on average there will be approximately 0.13% production above the USL. This is quite low and may be too tight for most operations; therefore, it may be decreased to 2.5 or even 2. Since the USL is usually fixed for a given product, and the number (N) of s.d.'s. are selected based on amount of product that can be tolerated above the USL, the only remaining variable involved in maximizing the target MC and thus maximizing return from improved MC control is the extent to which the s.d. can be reduced.

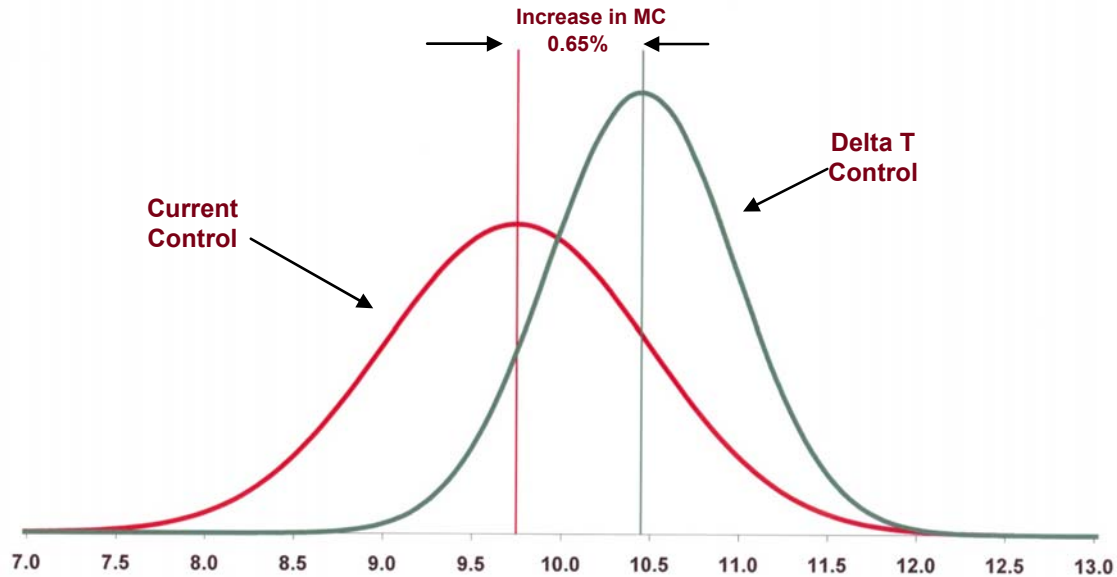
SAVINGS CALCULATIONS:

Assuming the upper MC specification limit (USL) for dried DDGS is 12%, $N = 3$ s.d., and the s.d. has been reduced 30% to 0.525 by improved MC control (as shown by figure 1), substituting these numbers into equation (1) gives the recommended target MC for negligible production above the USL:

$$\text{Target MC} = [12\% - 3 (0.525)] = 10.4 \%$$

Figure (2) shows plots of normal curves for current and improved MC control using the Delta T Control System. Notice that the curve for improved control is shifted such that the USL of the improved control curve coincides with the USL of the current control curve. The mean MC for improved control is now 10.4 %. The difference in means $(10.4 - 9.45) = 0.65\%$ and is equivalent to an increase of 0.65% in production without the expense of raw materials and thermal energy.

**Figure (2)
Current vs Delta T MC Control**



Assuming DDGS value at the plant is \$160 per dried ton, savings for this 110 mgy plant would be approximately \$329,000 in water sales and \$49,500 in energy savings for a total of \$379,000 per year.

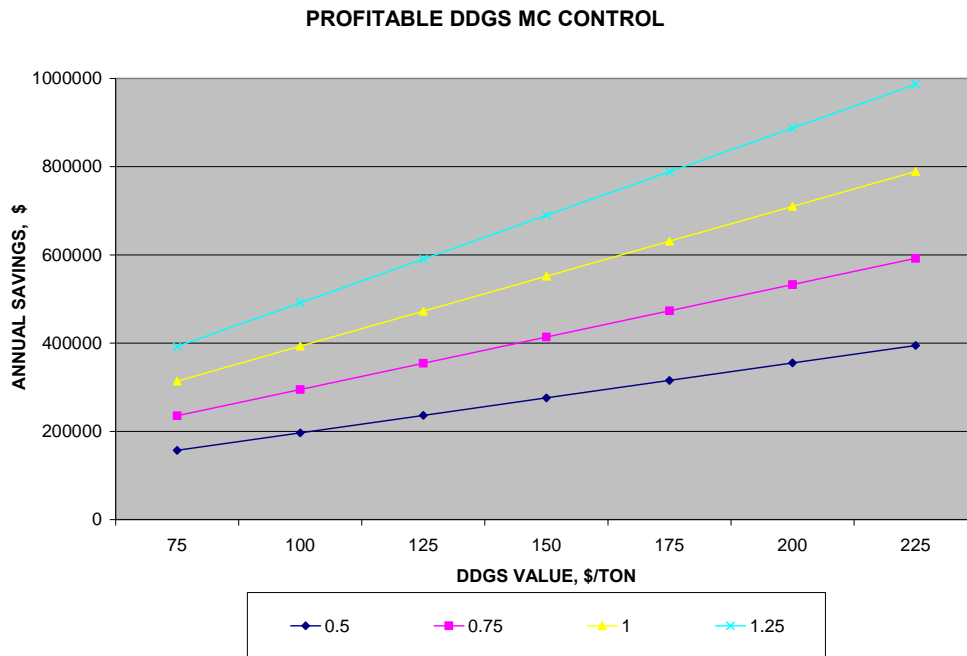
ADDITIONAL SAVINGS POSSIBLE:

Three standard deviations were used in calculating the recommended target MC of 10.4%. This extremely tight control has a price. For example, if 2.5 s.d.'s were used, the increase in MC in the exiting product would be:

$$[12 - 3.0 (0.525)] - [12 - 2.5 (0.525)] = 0.263\% \text{ MC}$$

Consequently, the production above the USL would on the average be 0.69% as compared to 0.13% at 3.0 standard deviations. Increasing the chance production of an additional 0.56% (0.69 – 0.13) above the USL by using 2.5 s.d.'s. rather than 3 s.d.'s. would contribute approximately \$150,000/yr additional savings, and when added to the above savings would total approximately \$529,000 per year for a 110 mgy ethanol plant that increased its exit MC by 0.913% (0.65 + 0.263). This would equate to about \$1.50 per ton of dried DDGS.

Figure (2) is a chart for estimating the savings from improved MC control for various selling prices of DDGS and percent increases in mean MC achieved.



WHAT'S WRONG WITH CURRENT MC CONTROL?

The two main obstacles to improving MC control are moisture sensor related. These are: (1) use of unreliable moisture sensors; and (2) use of untimely “after-the-fact” moisture data.

Untimely MC data causes relatively high dead time (time to detect a disturbance entering with the feed). Since the moisture variation, measured by the standard deviation (s.d.), is directly proportional to the dead time, longer delay in receiving moisture data use in making control decisions forces operation at lower target moisture content; consequently, less water will be sold. The ideal solution would be to have a highly reliable and rugged MC sensor that could be installed inside the dryer to reduce the dead time (delay).

Unreliable moisture data usually results in conventional in-line MC sensors being removed or relegated to that of a trending indicator and not as the basis for a closed loop control system. Alternatively, hourly laboratory MC samples are more reliable and sometimes used as the basis for manual control of MC; however, such practice adds dead time thus causing an increase in the s.d. and ultimately forces operation at a lower target MC.

An additional method for sensing MC is use of the exhaust temperature from the dryer as a surrogate for MC. This method has been proven to be unreliable

because as soon as a disturbance enters the dryer, the poor correlation between exhaust temperature and MC fails; consequently, the operator is always hunting for the correct setpoint to produce the target MC. There is no available automatic method for properly finding the correct exhaust temperature setpoint. This type moisture control system results in relatively lower target moisture and less water can be sold.

MC CONTROL SOLUTION:

Since the main obstacle to achieving improved MC control involves problems with moisture sensing and control, a criteria (Table I) has been prepared for use in selecting a MC sensing method for use as the basis for designing an effective and profitable moisture control system.:

TABLE I -- CRITERIA FOR SELECTING AN EFFECTIVE MC CONTROL SYSTEM FOR FOUR MC SENSING METHODS				
<u>CONTROL SYSTEM CAPABILITIES</u>	<u>LAB SAMPLES</u>	<u>CONVENTIONAL IN-LINE</u>	<u>EXHAUST TEMP.</u>	<u>ΔT MODEL BASED</u>
ACCURACY	Excellent	Fair	Fair	Excellent
RELIABILITY	Good	Fair	Poor	Excellent
CALIBRATION LIFE	Fair	Poor	Poor	Excellent
SCIENTIFIC BASIS	Good	Fair	Fair	Excellent
DECREASES s.d.	Poor	Poor	Poor	Excellent
AUTOMATIC CONTROL	Poor	Poor	Fair	Excellent

SUMMARY AND CONCLUSIONS:

Improved MC control for DDGS is achieved when an economically feasible and practical change is made in the process control system that reduces the product moisture standard deviation, thus enabling the product target mean MC exiting the dryer to be significantly increased. It has been shown that fuel alcohol plants can recover from \$0.83 to \$1.26 for each ton of DDGS dried. This excellent return on investment (less than 6 months) is not being captured today by fuel alcohol manufacturers because of inherent weaknesses in existing MC sensors and controls. Improved MC control can be achieved by designing a system according to the criteria of Table I above.