Kevin T. Higgins, *Senior Editor*

Pinpoint moisture control

A quarter century after he developed his model, John Robinson continues to proselytize to process engineers about his dryer control system.

Delta T describes a finite increment in a variable, whether that variable is moisture content in food or the Earth's rotation. Among astrophysicists, delta T is the difference between Terrestrial Time and Universal Time. For John W. Robinson, delta T represents the moisture content of food in a dryer, as derived from the measurement of the differential temperature of hot air immediately before and after it contacts the product. It is the main variable in the model he developed to accurately predict the final moisture content of grated cheese or other products moving through a dryer and make finite corrections in drying time and temperature to ensure that the desired moisture level is achieved.

Robinson began developing the algorithm for his control system in the late 1970s, while working at a wood veneer manufacturing facility. At the time, the dry bulb temperatures of a dryer's heated air, the speed of the product through the dryer and steam pressure were the variables used to control moisture content. But the actual levels were never known until the process was complete. The result was a broad bell-shape curve indicative of significant variation in moisture content. If the temperature drop in the dryer's air was known, Robinson reasoned, a model could be built for a feed-forward control system to automatically adjust feed rate and heat input, regardless of the initial moisture content, thickness or type of product.

According to the US Department of Energy, which helped fund the model's development with a grant from its Inventions and Innovation Program, Robinson's control system narrows variance in product exiting a dryer by 33% to 50% and allows processors to increase average moisture content 0.5% to 2%, thereby reducing overdrying, eliminating underdrying, lowering energy use and improving yield.

Robinson graduated from the University of Oklahoma in 1957 with a BS degree in chemical engineering and did graduate work at Lamar University in Beaumont, TX. He gained exposure to model building in the mid-'60s while conducting air pollution research for the US Public Health Service at the Robert A. Taft Center in Cincinnati. Before establishing his firm, Drying Technology Inc., he worked for Dow Chemical and International Paper.

FE: How are you able to predict a product's finished moisture content without knowing the moisture level at the beginning of a process?

John W. Robinson, president, Drying Technology Inc., Silsbee, TX.

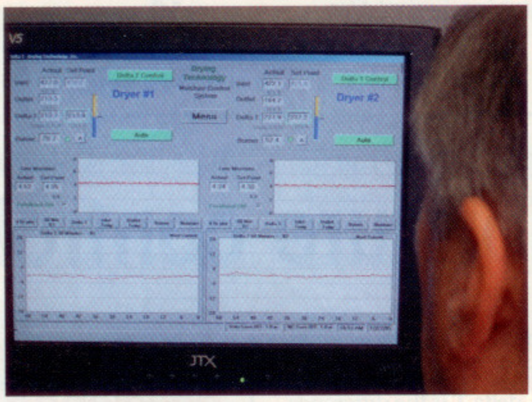
Robinson: The key is the delta T value based on two temperature sensors inside a dryer that measure the temperature drop of the air as it contacts the product. Our model processes this value to determine the moisture at that point inside the dryer. We establish a temperature drop of, say, 20 degrees that corresponds to our target moisture. If the actual value of the delta T departs from the target value, we adjust the air temperature or the dryer speed to attain the target moisture when exiting the dryer.

It's a complicated derivative, but our "cruise control" approach simplifies it. If 20 degrees is your target, the program will latch in all the operating conditions and adjust the dryer zones as needed, much like a car's cruise control speeds and slows the engine to maintain the set point of forward motion.

FE: When did you begin developing your model?

Robinson: I was working for a forest products company, doing environmental and plant engineering work. There wasn't much chemical engineering work involved. One day in the late '70s I was in a back office, daydreaming, when I came across a journal article concerning development of a drying model that was too cumbersome to be useful. I had modeled multi-stage filters for pollution control and decided to use that background to create a model for the wood-veneer dryers we had at the plant.

My model related the moisture content of the veneer exiting the dryer to the difference between the hot air supply, the surface temperature and the dryer speed. It worked well but wasn't practical because a good measure of the surface temperature was not possible. I was able to mathematically manipulate the model so that all I needed was the temperature of the air before and after it hit the product. We put the controls on the company's eight dryers. It eventually became the standard for veneer drying. When the company was purchased, I took advantage of early retirement in 1986 and started my own company.



Trending graphics and operating parameters on operators' screens have improved significantly over the years, but actual dryer adjustments are performed automatically with the delta T control system. Source: Drying Technology Inc.

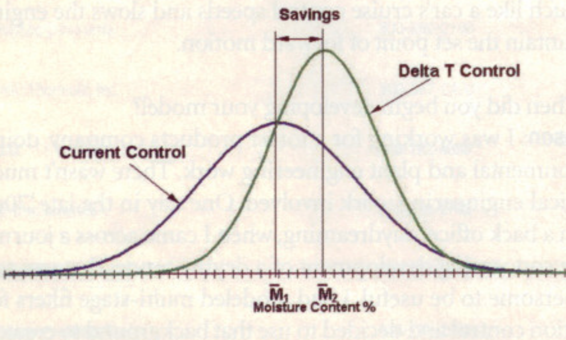
FE: How had the plant controlled veneer drying prior to this system's deployment?

Robinson: They actually were measuring wet spots in the veneer with a resistance/capacitance method. It wasn't calibrated very well, and the sensors were at the end of the dryer. If more than 15 % of the sheets were too wet, they'd slow the dryer's conveyor down and end up overdrying, which they didn't have to worry about. The problem with that, of course, is that throughput is reduced, and in industries like food where companies sell by weight, they lose 0.5% to 2% of yield that must be evaporated to prevent wet product because the controls weren't tight enough.

RF and near infrared sensors often are used to measure moisture, but those technologies must be installed at the end of the dryer, which means a less efficient feedback control. They also are subject to drift and must be recalibrated often. They're useful as a trending tool, but people in process industries don't trust them for closed-loop control. This system doesn't require calibration. When wet product enters the delta T control zone, the necessary adjustments are made to keep moisture on target.

FE: How has the technology changed since you introduced it?

Robinson: We used to install RTD or thermocouple sensors and other hardware, but now it's really just a software program. It's compatible with PC-based operator stations like Wonderware and plant PLCs, although it can be supplied independent of existing hardware. Early on, we used single-board computers and monochrome terminals, which didn't allow us to generate any graphs or do continuous plotting. PLCs were just beginning to be used in plants, but we didn't want to put the program on a PLC because there was so much proprietary information. People would have just bought one program and duplicated it. Now there are hardened [industrial] PCs available that allow us to do statistical calculations we weren't able to do before.



This bell curve dramatizes the reduction in moisture-content variation achieved in a dried pet-food application of the delta T predictive model. Source: Drying Technology Inc.

FE: What are the program's limitations?

Robinson: Vacuum dryers might pose a problem, though we haven't attempted one. The model has been used with conveyor dryers, rotary dryers, fluidized bed systems, flash dryers and other types. Kraft Foods uses it with a spray dryer at the Maxwell House coffee plant in Houston. In an article published in 2000, they really bragged about it and the improvement it provided over the feedback system based on exit controls.

We've applied the model to high-moisture products. The results were inconclusive and didn't yell out, "This is it." But in products with up to 15% to 20% moisture content, it works very well, and it works with conductive heat transfer as well as convective.

FE: After 20 years, how much penetration into the food industry have you made?

Robinson: There are about 250 to 300 systems installed overall, and about 5% to 10% of those are in food. We've done grated Parmesan cheese, cooked rice, dry cereals, beef jerky, corn wet milling and pet food, where we're having a lot of success.

It takes about five days to install a system and train people to use it, and the payback is always less than a year; in some cases, it's a matter of weeks or even hours. But there are fewer and fewer engineers in house at food companies, and the ones left simply don't have the time to do a project, regardless of the payback.

FE: How would you assess the system's commercial success?

Robinson: It hasn't made us millionaires. But it's adaptable to just about every process industry. One thing I've learned from this is you can have a good idea, but you still have to sell it. The first system we installed is still running in Louisiana. Operators who couldn't read or write have operated a dryer with this program. ◆