USING NIR MOISTURE SENSORS TO IMPROVE DRYER PERFORMANCE
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PRELUDE

Near Infrared Moisture Monitoring provides tremendous opportunity for efficiency and process improvements in textile dryer performance.

THE APPLICATION

Dryers are commonly used in textile carpet ranges to dry the product; this typically follows the application of dyes on continuous dye ranges or to dry and cure the backing on coater ranges. In the dyeing application, steam and hot water are heavily applied to the product to aid in the proper absorption of the dyes. However, the product must also be properly dried prior to the backing application on the coating range, or else potential failures or separations can occur. These failures can result in customer claims and drying reruns and can be extremely costly to production.

POTENTIAL SOLUTIONS

MANUAL ASSESSMENT

In the past, several methods have been used to monitor the moisture of the carpet. One of the most common methods calls for experienced operators running their hands across the carpet as it runs through the range to determine if it is too wet or dry. This is extremely subjective; it is unreliable and inconsistent and, often, thousands of yards of defective carpet are processed before a moisture issue is discovered.

Samples are often taken and the moisture value is tested in the lab, but this is not done in real time and, if there is an issue, it is not typically identified until after a run is completed.

INFRARED TEMPERATURE SENSORS

Another method is to use Infrared (“IR”) temperature sensors to measure the temperature of the carpet to infer moisture level. While this is an improvement over the “manual” method, it still has several shortcomings.

First, IR temperature sensors are very susceptible to changes in the density of the carpet, color changes, and reflectivity. Second, the “inference” made of the carpet moisture based on the backing temperature can reflect changes in room humidity and ambient temperature. Therefore, the moisture inferred from the backing temperature measured in the cool dry months of January may be much different for the same backing temperature measured in the humid months of July and August.
RESISTANCE MEASUREMENT

There are a few accepted methods of measuring moisture continuously without contact or damage to the product. In the past, resistance measurement was very common. This technique basically induces an electronic current through the product surface and measures the resistance of the product. The moisture value is inversely proportional to the resistance. This method can be fairly repeatable, but does not measure accurately. This is especially true in the lower ranges, which are typically seen on these types of applications.

ADDITIONAL METHODS

Radio Frequency, or capacitance, was often a very common method for measuring carpet moisture for the last 10-15 years. While some still use radio frequency, and it is an improvement over previous methods, proper calibration of the device is critical. This technology does penetrate the entire thickness of the carpet, but can be susceptible to style or density changes in the carpet and can result in the requirement of a different calibration for each style. Distance changes from carpet flutter can also affect the readings.

In some instances, a microwave moisture sensor can be used to measure the moisture of carpet. Microwave, like Radio Frequency, does have the advantage penetrating through the entire thickness of the carpet. Also like Radio Frequency, it can be affected by density changes, so proper calibration is critical. Unfortunately, these units are often more difficult and time consuming to calibrate than radio frequency units.

In addition, microwave sensors require both a transmitter and a target, making the application and mounting more difficult and expensive. The target and transmitter must be kept in line, making a traverse of the entire width of the frame a more challenging motion control application.

WHICH METHOD IS BEST?

In reviewing all of the requirements for this application, customers should look for a reliable and repeatable measurement that is cost effective, easy to calibrate, non-contacting, and can be easily traversed for real time viewing and historical data archiving.

The solution that meets all of these is the Near Infrared Moisture (“NIR”) sensor.
HOW DOES NEAR INFRARED WORK?

NIR sensors use a halogen source lamp to generate light energy that is directed toward the subject to be measured—in this case, the carpet. The sensor has a built in filter to collect the amount of reflected light energy, which is measured through a lead sulfide detector cell. This filter is designed to gather light energy at 1.94 microns, which is the resonance frequency of water. The more water molecules in the carpet, the more light energy is absorbed and less energy in the 1.94 micron band is reflected. This technique is the basis for measuring the moisture in the carpet.

With NIR, the moisture calibration curve is typically linear, so only a few samples are required in order to create a valid calibration.

WHAT IS UNIQUE ABOUT THE MOISTURE REGISTER PRODUCTS NIR SENSOR?

There are many variances in how the moisture signal is generated, depending on the manufacturer, but in our experience the best performance is provided by the initial product designer, Moisture Register Products (MRP). Many of the current NIR sensor designs on the market today are modeled after the patent which was held by MRP. The patent designated the use of “raw light”, referring to full spectrum white light as the primary source to reflect onto the target sample.

In order to avoid Patent infringement, competitors chose to filter the light frequency needed to resonate water molecules (1.94 microns) before exposing the samples to the light. To help compensate for potential measurement issues – such as changes in product color, ambient light, dust, and distance fluctuations – a second reference filter that is unaffected by water presence is added to also measure the reflected light energy at 1.8 microns. The final signal is then correlated from the difference in measurement of the light from these (2) filters. Therefore, any of these factors that affect the measurement filter will also affect the reference filter by the same amount, and are cancelled out by using the difference in the measurements. This differential measurement technique is used by several manufacturers, but in all other units besides the MRP design, a series of mirrors are used that require tuning and adjustment; these are susceptible to problems and may require adjustment. The MRP design uses a fixed PRISM with no mirrors to avoid displacement issues.

MRP also uses an electronic auto-ranging feature to adjust the measurement for slight distance changes caused by carpet flutter.

"The MRP design uses a fixed PRISM with no mirrors to avoid displacement issues."
WHY TRAVERSE THE COMPLETE FRAME?

The NIR sensor is a point source measurement. In order to get a full profile of the moisture along the carpet, it is recommended to traverse the complete frame. In this instance, a linear actuator is used to allow the NIR sensor to continuously traverse the width of the frame to take moisture samples at specified points along the frame. This provides a complete profile snapshot so that high moisture streaks can be easily and quickly detected.

These narrow bands of high moisture can be caused by dryer zones, damper issues and/or extractor problems. These types of problems can be caught immediately, in real time, before hundreds of yards of bad product are processed. This has been proven to greatly reduce claims and issues in carpet production.

Running a dryer without this system has been compared to driving a car without a speedometer.

SUMMARY

1. Moisture Register Products uses full spectrum white light which provides more energy for better resolution and better penetration through the sample, and less susceptibility from interferences such as ambient light, dust, product color changes, etc.

2. MRP provides an auto-ranging feature that detects the amount of reflected light, and will automatically adjust the sensitivity of the sensor for a better measurement on darker surfaces or when the distance changes (carpet flutter). This feature, along with the reference filter measurement, is what allows the MRP unit to measure a wide range of carpet thicknesses and colors with a single calibration table.

3. MRP does not “split the source”. Sensors that use this technique require multiple mirrors with delicate adjustments within the sensor to properly handle the beam. MRP uses a PRISM permanently fixed with no adjustment necessary.

4. MRP has minimal electronics in the sensor itself, which provides an extremely rugged instrument that can withstand high-temperature industrial environments without external cooling.

NIR sensors in a complete traversing and archiving system have been proven to provide real-time viewing of the complete moisture profile of carpet ranges. This can be a valuable asset to help reduce claims, reduce costs, or increase productivity and efficiency.
5. MRP maintains the lead sulfide detector cell at a constant temperature, thus eliminating any temperature-associated drift. Competing units use the extra (2) beams and filters to compensate for this drift, which provides additional complexity, adjustment, and susceptibility to problems in the system.

6. NIR can be easily traversed for a real-time profile of the complete carpet width.

**Diagram of MRP NIR Sensor**

**Sample Moisture Profile**
CLOSING

While this whitepaper discusses using NIR Moisture sensors for a textile carpet application, a similar concept can be applied for other materials and requirements.

Innovative Controls has extensive experience in design, implementation and integration of these and other controls and automation systems and can assist customers in providing a solution for their particular needs and requirements. Please feel free to contact us to discuss your specific application.

ABOUT JEFF MORTON, FIELD ACCOUNT MANAGER, INNOVATIVE CONTROLS SYSTEMS

Jeff has 23 years of experience in providing engineering services and integration projects to industrial and municipal customers. Jeff has been at Innovative Controls since May of 2001 and worked for Siemens Moore selling Moore APACS Distributed Control Systems prior to that.

Jeff started his career working inside sales after graduating from the University of TN in 1990 with a BS in Electrical Engineering.