Moisture Measurement Comparison in Paddy Rice Drying

The objective of this document is to compare different methods of moisture measurement during rice drying. It will identify the most accurate and cost effective method of enabling automatic control of the drying cycle to reduce energy consumption and to increase the final quality of the end product.

Data was gathered from trials which were conducted at the plant of a leading grain processor during their normal processing operation. The tests were conducted by a Hydronix engineer in conjunction with the plant operator.

It is essential that rice processors have a quick method of determining moisture in order that results can be quickly actioned and the drying process stopped when the rice reaches the correct moisture level. The downside with this is that some instruments often sacrifice precision and accuracy in favour of ease of use and speed. Therefore results may not be a true indication of what is happening to the moisture content of the rice.

Comprehensive tests have been undertaken between offline moisture meters and Hydronix microwave moisture sensors to determine the best method and the most accurate results. When comparing measurement techniques it is important to understand the limitations of the different methods and also what is happening during the drying process.

How rice dries

During a drying cycle Paddy rice does not display a linear reduction in the moisture % as the moisture resides in two different locations: in the Hull and inside the Kernel. The Hull which is closest to the heat source will lose moisture rapidly, whereas, the Kernel will lose moisture slowly as it has to move from the centre of the rice to the surface before it can be released. Due to this delay in moisture evaporation from the centre of the rice, the drying rate will vary at different stages of the drying cycle. Figure 1 depicts the relationship between the temperature and the moisture percentage of rice during a typical drying cycle.

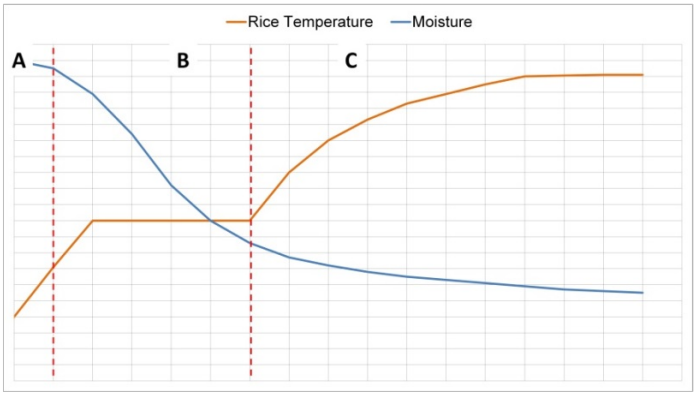

Figure 1: Rice Drying Rate (Theoretical)

A - *Very Low Drying Rate* - This is the initial drying phase where the temperature of the rice is increased until it reaches the required drying temperature. There is little moisture loss at this phase

B - *Linear Drying Rate*- Surface and outer moisture is rapidly removed and during this time the rice temperature remains constant.

C - *Reducing Drying Rate* - Once the outer moisture is removed subsequent moisture must be evaporated from deeper within the structure of the rice grain. This moisture must travel to the surface before being evaporated. The consequence of this is two-fold:

1. An increased drying time for a given moisture reduction.
2. An increase in material temperature due to a lower evaporation rate.

Towards the end of the drying process the amount of energy required to extract moisture from the inner core of the rice grain becomes even more apparent and the drying rate slows dramatically.

Comparing methods

To determine whether the theoretical drying rate model was accurate, laboratory tests were undertaken using heat as a method to determine moisture loss. The material sample is weighed and then dried until there is no moisture remaining in the sample. The material is then weighed again and the difference in weight allows the amount of moisture in the sample to be calculated. Although too time consuming to be used during production, this method has long been established as the most accurate method of calculating moisture in the material.

In order to determine the true accuracy of the sensors, a baseline method of moisture loss must be introduced to allow the independent comparison of both systems under test as they cannot be compared directly with each other. The results from both the offline moisture meter and the Hydronix sensor were compared to the results from the laboratory tests. This was used as our baseline method for determining the true accuracy of the systems being tested under real-time, in-situ trial conditions.

How the tests were conducted

Samples of material with a wide moisture range were collected periodically throughout the entire drying cycle and each sample was thoroughly mixed to ensure a good average of material. Each sample was then divided and tested using all three methods of moisture determination with the results recorded.

Figure 2 shows the results of tests undertaken using:

- Heat based laboratory moisture loss test
- The industry leading offline moisture meter
- A Hydronix sensor installed in the process.

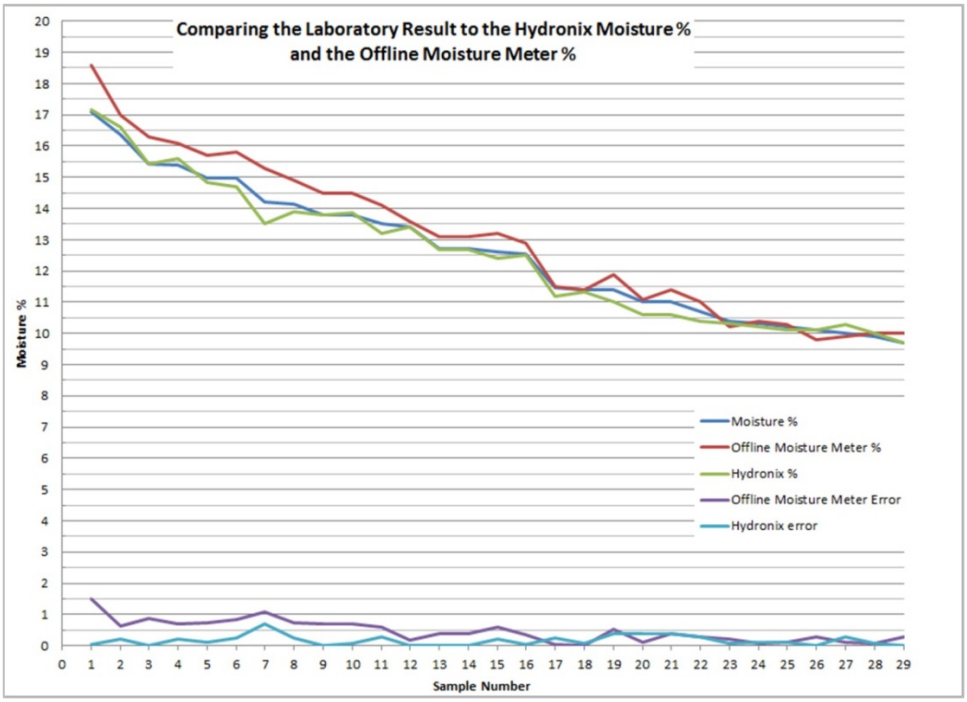

Figure 2: Comparison of different methods

Results

- The laboratory results provide the baseline moisture value against which to compare the other sensors.
- It can be clearly seen that the Hydronix sensor tracks most closely to the laboratory results over the full range of moisture during the drying cycle.
- The average error of the offline moisture meter is 0.47% while the average error for the Hydronix sensor is 0.18%

Proving the theory

It can easily be seen in Figure 3, which is the data from a heat based laboratory system operating at a constant temperature, that the curve matches the theoretical drying rate and proves the theory shown in Figure 1.

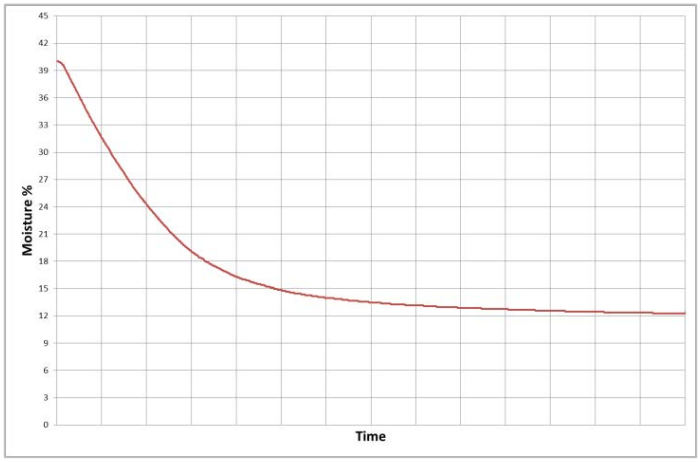

Figure 3: Laboratory Recorded Moisture % (Actual)

Figure 4 depicts an actual drying cycle recorded by a Hydronix sensor across a more narrow moisture range and it can be seen that the results very closely follow the results from the theoretical graph when compared with the same moisture range (16.5% down to 10%).

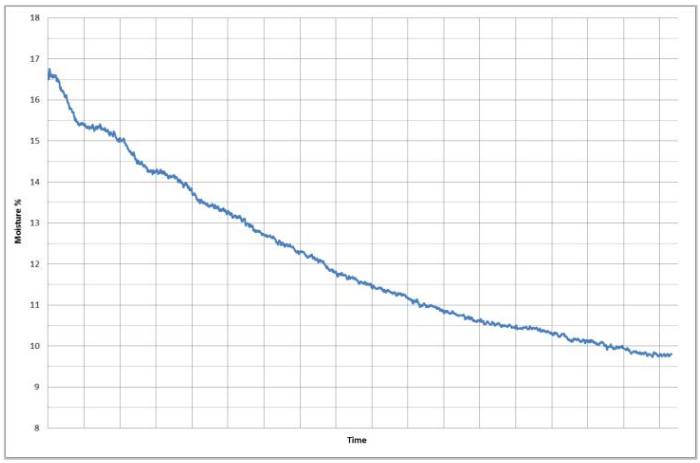

Figure 4: Hydronix Recorded Moisture % (Actual)

Conclusion

The objective of the testing was to determine the best method for automatic control of the drying cycle to ensure that the dryer stops when the correct moisture % is reached.

The Hydronix sensor accurately indicates the true moisture value of the grain throughout the entire drying cycle and also has the following benefits over offline sensors:

- Extremely accurate
- Quick testing method – real time at 25 measurements per second
- Automatic with less need for human intervention
  Time saving – less moisture tests to conduct which save times and reduces potential errors
- Precise timing of discharge
- Lower energy consumption and a lower cost, high quality product.

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