Calibration of on-line NIR Moisture Measurement Systems in Food Production Processes

Euro Food Water 2010
Reims
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Calibration of on-line NIR Moisture Gauges in Food Production Processes

**Contents**

1. Installing on-line gauges
2. Estimation of total error in calibration
3. Gauge errors
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7. Summary
Installing on-line Gauges

Examples of moisture measurement

- Coffee
- Flour
- Cereals
- Ingredients
- Sugar
- Snack Foods
- Dairy Products
- Dried Fruits
- Tea
- Chocolate
- Animal foods
- Potato flakes
- Pasta, Noodles
- Breadcrumbs
- PET Foods
- Rice
- Confectionery
- Biscuits
- Starch
- Cheese
- Nuts
Benefits by using on-line gauges

- Increase yield
- Avoid over drying
- Improve product quality
- Reduced need for laboratory analysis
- Increase productivity
Installing on-line Gauges

Expectations by user

- Results are based on local reference method
- Reliable data
- No need for re-calibrating after installation
- Easy handling of the instrument
- Improved product quality by closed loop control
- No down time
Installing on-line Gauges

Calibration – why?

- Results are different from lab values
- Product shows different behaviour
- New developed product
- Process changes
- Gauge problem
Sources of errors

- Gauge itself
  linearity error of the gauge

- Reference laboratory method
  error in the method and procedure itself

- Sampling error
  not collecting the representative samples
Estimation of Total Error in Calibration

Total Variance in NIR Calibration

\[ \text{SEP}^2_{\text{total}} = S^2_{\text{gauge}} + S^2_{\text{sampling}} + S^2_{\text{reference}} \]

\[ \text{SEP} = \text{Standard Error of Prediction} \]
Reasons for re-calibrating

- Gauge design
- Environmental conditions
- Product or process changes
Critical factors for gauge design

- Temperature drift
- Selecting the right wavelengths for application
- Best algorithm for the parameter
- Changes due to source lamp variations
- Robustness of the gauge
- No down time
- Influence on pass height variations
Critical factors to design for environmental conditions

- Ambient light
- Humidity of the air gap
- Temperature and dust
Critical factors to product or process changes

- Seasonal variations
- Variations in particle size
- Irregular moisture distribution from top to bottom
# Improving Gauge Design

<table>
<thead>
<tr>
<th>Problem</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term moisture variations in product</td>
<td>Larger patch size up to 60 mm</td>
</tr>
<tr>
<td>Signal to noise ratio</td>
<td>Increased scanning speed up to 8000 scans/min</td>
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<td>Improve stability</td>
<td></td>
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<tr>
<td>Filters and algorithms</td>
<td>Up to 10 filters to measure fat and protein at the same time</td>
</tr>
<tr>
<td>Easier handling for user</td>
<td>Pre-calibrated gauges and on-line help for calibration - trim function - sampling function</td>
</tr>
</tbody>
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### On-line moisture applications

<table>
<thead>
<tr>
<th>Product</th>
<th>Typical Range %</th>
<th>Typical Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>0 - 5</td>
<td>0.1</td>
</tr>
<tr>
<td>Snack foods</td>
<td>0 – 25</td>
<td>0.1 – 0.3</td>
</tr>
<tr>
<td>Biscuits / Cookies</td>
<td>1.5 - 2.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Non-dairy creamer</td>
<td>0 - 5</td>
<td>0.1</td>
</tr>
<tr>
<td>Chocolate</td>
<td>0 - 5</td>
<td>0.1</td>
</tr>
<tr>
<td>Salt</td>
<td>0 - 2</td>
<td>0.05</td>
</tr>
<tr>
<td>Tea</td>
<td>0 - 80</td>
<td>0.1 – 1.0</td>
</tr>
</tbody>
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Factors of influence

- Drying temperature
- Drying time
- Product structure
- Distribution of the material
- Mass of the product sample
- No. of samples in the oven at a time
- Type of oven
- Weighing procedure
Estimated error in oven reference method

Sreference = +/- (0.1 – 0.3)% absolute error
Estimation of Sampling Error

Areas of influence

1. Gauge settings for sampling
2. Process conditions
3. Synchronizing gauge reading and sampling
4. Collect a representative sample from the line
Sampling Procedure

Steps for sampling

- Response time to 1 s
- Sampling time 10 s
- Evaluate product variations $\bar{x}$, s

- Process settings low, medium, high moisture
Sampling Procedure

Steps for sampling

- Collect samples within the preset 10 s
- Put samples in a plastic bag
- Standard deviation within expected magnitude?
- Transport to laboratory mixing in the closed bag
Application of NIR measurement

Moisture measurement in flour

Source: NDC Infrared Engineering
Example of total Error in Calibration

Total variance in calibration

Assumption: \[ S_{\text{gauge}} = +/- 0.1 \% \]
\[ S_{\text{reference}} = +/- 0.2 \% \]
\[ S_{\text{sampling}} = +/- 0.3 \% \]

\[ \text{SEP}^2 \text{ total} = S^2_{\text{gauge}} + S^2_{\text{sampling}} + S^2_{\text{reference}} \]

\[ \text{SEP total} = +/- 0.374 \% \quad \text{(including sampling)} \]
\[ \text{SEP total} = +/- 0.224 \% \quad \text{(without sampling)} \]

\text{SEP} = \text{Standard Error of Prediction}
Summary

- User should know about the errors in calibration
- Calibration has become easier
  - Pre-calibrated gauges
  - Trim adjustments
  - Sampling system
  - High stability by design
- Accuracy of on-line moisture systems
  - laboratory method on site,
  - sampling method
  - quality of gauge design