



Metrology for Humidity at High Temperatures and Transient Conditions – the Challenge

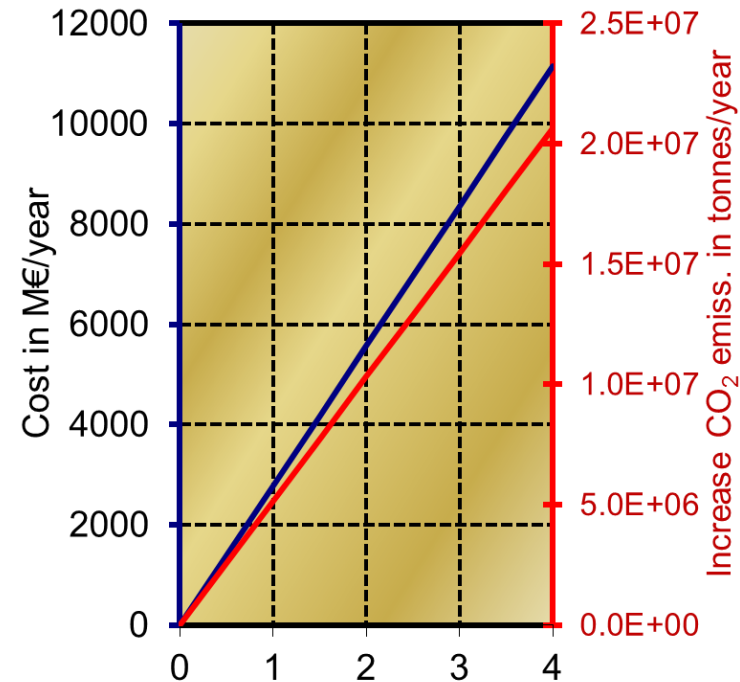
Workshop: Measurement and Control of Humidity and Moisture in Industry

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Martti Heinonen, VTT MIKES, Finland

Industrial humidity measurements and climate change

- Heating and vaporising water require significantly more energy than many other liquids
- Drying = vaporising water
- In 2012, the annual energy consumption in Europe was about 2×10^7 GWh
 - It's estimated the 15 % of this consumed in drying processes
- More reliable humidity measurement in drying
 - => less over drying
 - => reduced energy consumption



Humidity and product quality (1/2)

- In many applications humidity is measured for determining the dryness of material flow in a process:
 - Paper mills
 - Wood driers
 - Raw material dryers (plastic)
 - Etc.
- Material properties and final product quality is highly dependent on the dryness
- E.g. in food production, the most important moisture related parameter is water activity:
 - Water activity = equilibrium relative humidity on scale 0 to 1



Humidity and product quality (2/2)

- Storage conditions are important e.g. in production of pharmaceuticals and various bioproducts
 - Effect on product quality and shelf life
- Environmental tests are vital for ensuring and improving characteristics of e.g. electronic components and products
 - Operation and safety in various conditions
 - New materials and features

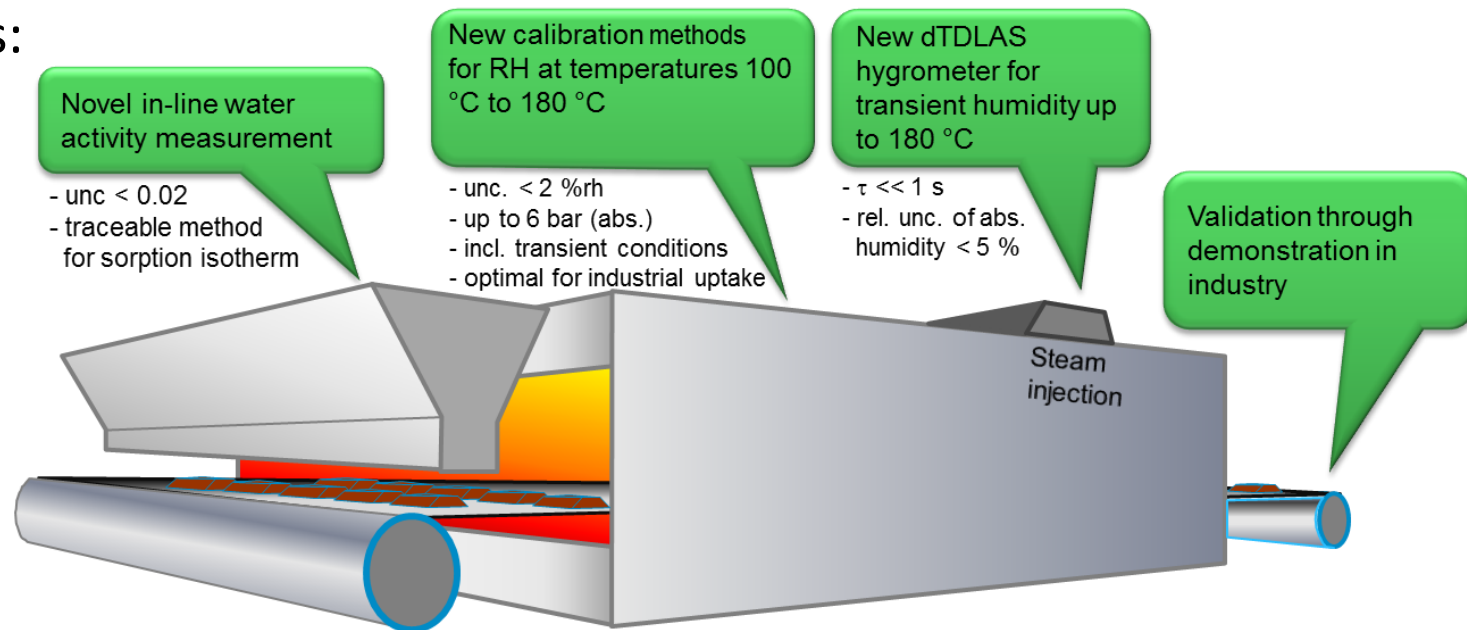


Traceability challenges in humidity measurements

- Relative humidity measurements at high temperatures ($> 100\text{ }^{\circ}\text{C}$)
 - Humidity sensors are only calibrated at lower temperatures: How representative are the calibration results?
 - Humidity realisations (national standards) are limited to lower temperature range
 - How to estimate measurement uncertainty? (e.g. effect of thermal radiation)
- Humidity measurements in non-static conditions:
 - Fast transients in e.g. baking control
 - Humidity ramps in e.g. electronic testing
 - Non-static spatial inhomogeneities in e.g. product storages
- Traceable in-line water activity measurement
 - E.g. in food and feed production

EMPIR 14IND11 HIT

- HIT = Metrology for Humidity at High Temperatures and Transient Conditions
- Objectives:



Novel in-line water activity measurement

- unc. < 0.02
- traceable method for sorption isotherm

New calibration methods for RH at temperatures 100 °C to 180 °C

- unc. < 2 %rh
- up to 6 bar (abs.)
- incl. transient conditions
- optimal for industrial uptake


New dTDLAS hygrometer for transient humidity up to 180 °C

- $\tau \ll 1$ s
- rel. unc. of abs. humidity < 5 %

Validation through demonstration in industry


New measurement approach for microbiological sample storage

- influence of microbiological processes on humidity gradients and transients
- unc. < 2 %rh




New approach for maintenance of equipment

- dynamic humidity measurement
- unc. < 2 %rh
- calibr. time reduced by 50 %
- new field calibrator




Content in a nutshell

-  **HIT** project is developing:
 - New RH calibration methods for temperatures up to 180 °C
 - New laser-based hygrometer for transient measurements up to 180 °C
 - Novel in-line water activity measurement method
 - New measurement approach for microbiological sample storage
 - New approach for on-site humidity calibrations

Content in a nutshell

- Key outcomes:
 - National Metrology Services extended to high temperatures
 - Recommendation on calibrating humidity sensor
 - Covering:
 - air temperatures above 100 °C and absolute pressures from 0.5 bar to 6 bar
 - applicable to non-static conditions
 - Recommendation to be published as EURAMET Guide
 - A new laser-based hygrometer direct for process environments with temperatures up to 180 °C
 - Tuneable Diode Laser Absorption Spectroscopy (dTDLAS)
 - A method for analysing unwanted high humidity occurrences in transient condition within sterile Petri dish samples stacked in a large climatic sterile room
 - A new in-line water activity measurement method
 - New techniques for calibrating humidity sensors on site



Status of the project

- Project will end in August 2018
- Status:
 - National Metrology Services extended to high temperatures **Completed**
 - Recommendation on calibrating humidity sensor
 - Covering:
 - air temperatures above 100 °C and absolute pressures from 0.5 bar to 6 bar **Industrial demonstrations on-going**
 - applicable to non-static conditions **Guide under preparation**
 - Recommendation to be published as EURAMET Guide **Guide under preparation**
 - A new laser-based hygrometer direct for process environments with temperatures up to 180 °C **Validation on-going**
 - Tuneable Diode Laser Absorption Spectroscopy (dTDLAS)
 - A method for analysing unwanted high humidity occurrences in transient condition within sterile Petri dish samples stacked in a large climatic sterile room **Industrial demonstrations on-going**
 - A new in-line water activity measurement method **Industrial demonstrations on-going**
 - New techniques for calibrating humidity sensors on site **Several techniques & protocols made**



Thank you!

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