VTT Icing wind tunnel 2.0
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VTT ICING WIND TUNNEL 2.0

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NEED – Icing Wind Tunnel 2.0

- By 2012, 24% (69 GW) of global wind in Cold Climate (CC) /2/
- 2013-17 forecasts 10 GW/a in CC!! /2/
- Cold Climate solutions, especially the different anemometer, ice detector and coating markets in the wind power industry, resemble “the Wild West”
  - **Missing standards and guidelines** to verify the instruments and coatings for CC!
- Controlled laboratory environment is needed to solve the above mentioned challenge to accelerate R&D cycles and lower LCoE
Performance of Icing Wind Tunnel:

<table>
<thead>
<tr>
<th>Property</th>
<th>Range in the facility</th>
<th>VTT’s Reference conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In-cloud icing, stationary components</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In-cloud icing, wind turbine rotor blades</td>
</tr>
<tr>
<td>Temperature [°C]</td>
<td>-20…+25</td>
<td>-5</td>
</tr>
<tr>
<td>Wind speed [m/s]</td>
<td>0…50</td>
<td>7</td>
</tr>
<tr>
<td>Water content [g/m³]</td>
<td>0.1…1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Droplet size, MVD [µm]</td>
<td>17…35</td>
<td>20</td>
</tr>
</tbody>
</table>

Droplet size distribution:
The journey of the VTT Icing Wind Tunnel

Inauguration

Spray nozzle matrix

First commercial tests

First heated blade demo

Spray bar nozzle update

MVD validation

Spray bar heating update

MVD validation

2008  2009  2011  2013  2015
Approach – Icing Wind Tunnel 2.0

- Controlled, calibrated and proven laboratory environment provides repeatable in-cloud icing conditions in the VTT wind tunnel
  - glaze, rime and mixed ice can be formed on the surface of different test specimens
Approach – Icing Wind Tunnel 2.0

- For creating new ideas, testing prototypes and their functionalities, optimizing design and performing verification of different products in controlled testing environment

- Pre-certification test procedure & test conditions -5°C, 10 m/s:
  - LWC_1 = 0.1 g/m³; Light icing condition
  - LWC_2 = 0.2 g/m³; Standard icing condition
  - LWC_3 = 0.4 g/m³; Harsh icing condition
  - LWC_3 = 0.6 g/m³; Extreme icing condition

- VTT is an independent research institute that has globally unique capabilities to provide development services and pre-certification tests for different instruments, coatings, products and concepts for Cold Climate conditions.
Validation of MVD

- Validated by FMI with CAPS (Cloud, Aerosol and Precipitation Spectrometer Probe)
- MVD was just right, not what we feared 😊

Droplets size distribution:
Validation of MVD

MVD vs. water amount

- 11.65 kg/h
- 5.83 kg/h
- 2.9 kg/h

MVD vs. wind speed

- 7 m/s
- 10 m/s
- 20 m/s
- 40 m/s

MVD vs. temperature

- 5.5 °C
- 21 °C

MVD vs. atomizing air
Benefit – VTT Icing Wind Tunnel 2.0

- What is the benefit for the customer?

- End user: developer or turbine OEM
  - Know what you are buying!
  - Know ice detector performance and application options!

- Sensor manufacturer
  - Faster R&D cycles
  - Increase sales & confidence with pre-certification report
Benefit – VTT Icing Wind Tunnel 2.0

Applications

- New advanced VTT ice adhesion test method with high accuracy and repeatability compared to the rotational ice adhesion testing method /3/
  - Multiple, simultaneous coating specimens for faster and more comparative results /4/

- Coating tests can be performed on blade section /4/
  - Coating durability tests also possible
VTT Icing Wind Tunnel 2.0
Applications

VTT basic ice adhesion tester /4/

VTT multiple coating specimen /4/
Summary

- VTT Icing Wind Tunnel facility has a unique potential for creating new ideas, testing prototypes and their functionalities, optimizing design and performing verification of different products in controlled testing environment.

- Droplet size distribution (MVD) is validated by Finnish Meteorological Institute (2015) /1/
References

1. Droplets Size Distributions Measurement by Finnish Meteorological Institute (FMI), Atmospheric Composition Research with CAPS (Cloud, Aerosol and Precipitation Spectrometer Probe) at VTT Icing Wind Tunnel 2015.


