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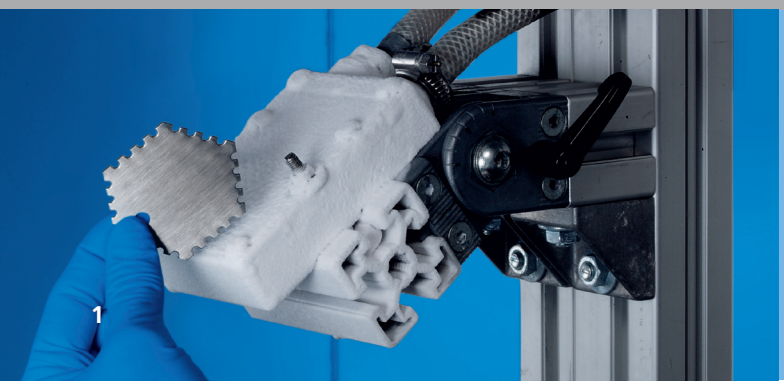
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1 *Analysis of the rime layer using a measuring comb.*
2 *Evaluation of rime adhesion using the rime adhesion test developed at Fraunhofer IFAM.*

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ANTI-ICING COATINGS

Ice formation on surfaces – A challenge

The icing of surfaces is a widespread problem that incurs high costs and impairs functionality and safety. For example, icing can adversely affect aircraft, ships, rail vehicles, cars, roller shutters, cooling systems, and wind turbines. The deposition of ice on surfaces leads to higher energy consumption, lower energy output, e.g. for wind turbines, and an increased risk of accidents. Icing also causes increased maintenance and downtimes, negatively impacting the efficiency of the relevant equipment.

Development of anti-icing coatings at Fraunhofer IFAM

New techniques for the nano-structuring of surfaces and their anti-icing effect

The topography of a surface has a major influence on the run-off of water and hence on the adhesion of ice and rime. Fraunhofer IFAM has investigated a variety of approaches for structuring surfaces.

Hydrophobic and superhydrophobic coatings

Hydrophobic coatings change the wetting of a surface by water via chemical and topographic effects. In the ideal situation the water droplets then run off the surface before they freeze. In addition, ice and rime adhesion is minimized. This reduces icing and facilitates ice removal.

Heatable coatings

The heatable coatings developed at Fraunhofer IFAM are based on the principle of resistance heating. Electrically conducting particles are incorporated into the coating and applied to the surface using conventional spraying or brushing methods. In contrast to heated mats, the material is easy to apply and repair.

Anti-icing tests for coatings

→ Icing chamber at Fraunhofer IFAM

The icing chamber developed at Fraunhofer IFAM is used to simulate the effects of freezing rain and rime formation on surfaces and coatings.

→ Icing laboratory with integrated wind tunnel at Fraunhofer IFAM

Realistic icing tests on wing sections and rotor blades can be performed in the icing laboratory with integrated wind tunnel at Fraunhofer IFAM. In addition, functional tests can be carried out on technical equipment, sensors, and wind/ice measuring devices.

- Air temperatures down to -30 °C
- Maximum wind speeds up to 350 km/h
- Icing due to supercooled water droplets

→ Icing test stand – Testing under real conditions

Coating systems that have been successfully tested in the icing chamber are exposed to the outside weather in an endurance test. This icing test stand is located on the Brocken in the Harz Mountains at a height of 1141 meters.

Biomimetic anti-icing coatings based on anti-freeze proteins

Mimicking nature, so-called anti-freeze proteins can be attached to the surface of coatings. Under certain conditions, these proteins then protect the surface from icing.

Temporary anti-icing coatings

This approach involves freezing point suppressors being washed out of a coating in order to prevent icing of the surface. The coating material must be regularly renewed to maintain the anti-icing effect.

Surface icing – Current research

Icing tests under realistic conditions

Fraunhofer IFAM has developed its own icing chamber (Fig. 3) for performing icing tests with clear ice and rime. Methods have also been developed for quantifying the adhesion of clear ice and rime to surfaces. Since mid 2014, Fraunhofer IFAM additionally has its own icing laboratory with integrated wind tunnel (Fig. 4). Realistic icing tests at temperatures down to -30 °C and at wind speeds up to 350 km/h can be undertaken on wing sections and rotor blades. For example, supercooled water droplets can be simulated and the formation of runback ice investigated. In additon, functional tests can be performed on technical equipment, sensors, and wind/ice measuring devices.

New R&D strategies

The Paint/Lacquer Technology department at Fraunhofer IFAM is currently working on a variety of strategies for minimizing ice formation. Our extensive knowledge of surface pre-treatment, coating development and testing is being utilized for this work, along with internal Fraunhofer IFAM expertise in the area of plasma technology for modifying surfaces. Complementing the aforementioned tests, computer-aided simulation methods are also being used to evaluate the adhesion and detachment mechanisms of ice and rime on coating surfaces. The findings are allowing acceleration and optimization of development work.

3 *Icing chamber developed at Fraunhofer IFAM.*

4 *Icing wind tunnel at Fraunhofer IFAM.*