Project title	Efficiency and influence of heating device on wind turbine blades
Project number	TG6-2
Organisation	Luleå University of Technology, Mechanics of Solid Materials
Project leader	Jan-Olov Aidanpää
Other participants	LTU, Swerea SICOMP, Chalmers
Report for	2013-01-01 – 2015-01-31.
Participating companies	Vattenfall AB, Skellefteå Kraft, H Gedda Consulting, Bollebygd Plast.

Project description

The project will mainly be performed by one senior at LTU and one senior at Swerea SICOMP. Chalmers will contribute with the knowledge on modelling and evaluation of available as well as novel developed sensor technologies for ice detection. The industrial partner Skellefteå Kraft will plan and perform the measurements at the wind power unit together with the research partners. Vattenfall have a long experience of wind power in cold climate and is performing own projects in this area. Vattenfall will contribute with experience and participate in planning of the whole project. H Gedda consulting has long experience from deicing equipment and will assist in the planning and evaluation of the measurements. Bollebygds Plast will contribute with laminates of own design which will be evaluated in cold laboratory at LTU.

The project will be running over two years. During this period experimental techniques will be developed at university and on real wind power turbines. At LTU analytical modelling and FEM will be used to develop tools for simulating the deicing process which will be evaluated both in lab and on real turbines. At Swerea test laminates will be manufactured and modelling of degradation of material due to heat will be initiated. At Chalmers the knowledge gained within the running SWPTC TG6-1 project “Sensors for ice detection on wind turbine rotor blades” will be used to study the possibilities to increase efficiency of de-icing system due to available sensors for early ice-detection.

The project will be initiated by a planning meeting for the wind power measurements. Suitable machines with icing conditions will be evaluated and a plan for the measurement will be made. The target of the first year is to evaluate equipment and techniques for measurements during year two.

In the project, lab-tests were used to develop techniques for modeling and measurements. The analytical modeling consists of heat transfer modeling of heated laminate with ice and degradation of the laminate due to heat. In these tests test plates of 0.5×1m was used with heating introduced by electric connection to one layer of carbon fiber mat. Several sets of test plates was manufactured by SICOMP and Bollebygds Plast and evaluated in climate room at LTU. The target was to develop experimental technique and theoretical models of the deicing process. From the experiments the simulation models was evaluated.

On the test site in Uljabouda measuring techniques was evaluated for measuring the functionality of the heating system. Before each winter it is essential to verify that the heat is uniform on the blade to avoid failure during the winter. Typical problems are hotspots which make the heating impossible to use and therefore severe loss of power is expected during the winter season due to ice. A technique with thermal camera on a mini helicopter was selected and evaluated during the project.

The initial plan was to run the project for two years but due to the delay to introduce phase 2 of the center the project was extended to the end of mars 2015. See Figure 1. During this time the experimental technique in the climate room was further developed.

The project was directed by steering group meetings each quarter consisting of all the partners. The main task of the steering group is to direct the research into questions of industrial interest and to follow up the planned activities. An important task for the steering group is also to facilitate the full scale measurements on real wind turbines.

Results

During 2015 the project has been presented at Winterwind 2015, Piteå, 2-4 February, 2015 (Efficiency and influence of heating device on wind turbine blades). New tests was performed with developed test plates and technique for thermal measurements on real wind turbines was developed. At the university some student projects were used to evaluate new techniques for deicing. Below some key progress are listed.

In the project there is an aim to get thermal measurements on a real wind turbine the deicing process. To do the measurements we early selected a mini helicopter with thermal camera. The idea was to inspect the blades with the camera during the deicing process. It was however not so easy to control the helicopter and no successful measurement were completed until October 2014. During this measurement the temperature distribution was evaluated during the heating process. It was concluded that the method is useful for detecting hotspots but the temperature resolution is not enough for detailed calibration of simulations. The method is also too sensitive to whether conditions why a better method has to be used in future. With higher resolutions on heat cameras it is likely that a method with measurements from the ground can be used in a near future.

Previously manufactured second set of test plates with balsa core was complemented with an extra plate with Lycel. The new plate will be used to compare the performance of using Lycel instead of balsa.

The second set of test plates were first evaluated in room temperature. Due to the balsa core it was essential to calibrate the thermal properties of balsa. It was found that there was a big difference in thermal properties compared to tabulated values. A possible reason is that the vacuum injection method will force resin in to the core material. The plates were then evaluated in the climate room where ice of different thickness was melted during different heat input. See Figure 20. The plates were measured in vertical position and the initial slide of the ice was detected as the time for deicing. This point was also easy to detect from the temperature sensors. These tests were then used for evaluation of the simulation models.

The simulation models has been calibrated (the properties of balsa) against experiments on the new test plates in room temperature. The models were then validated against experiments on the test plates II with ice. In the one dimensional FEM the ice was modeled including the transition from ice to water. In Figure 21 the measurements and simulations are compared. Two cases are shown 300W/m^2 and 500W/m^2 for 10 mm ice on the plate. Following the red temperature at 300W/m^2 the temperature rises the first 15 minutes until the ice starts to melt. Then the temperature stays at about 0 deg for 10 minutes before the ice is sliding from the surface. This is shown on the rise of temperature after 25 minutes. Comparing with different ice thicknesses the measurements show that it takes shorter time of melting when the ice thickness is increased.

Figure 1 Test setup in the climate room.

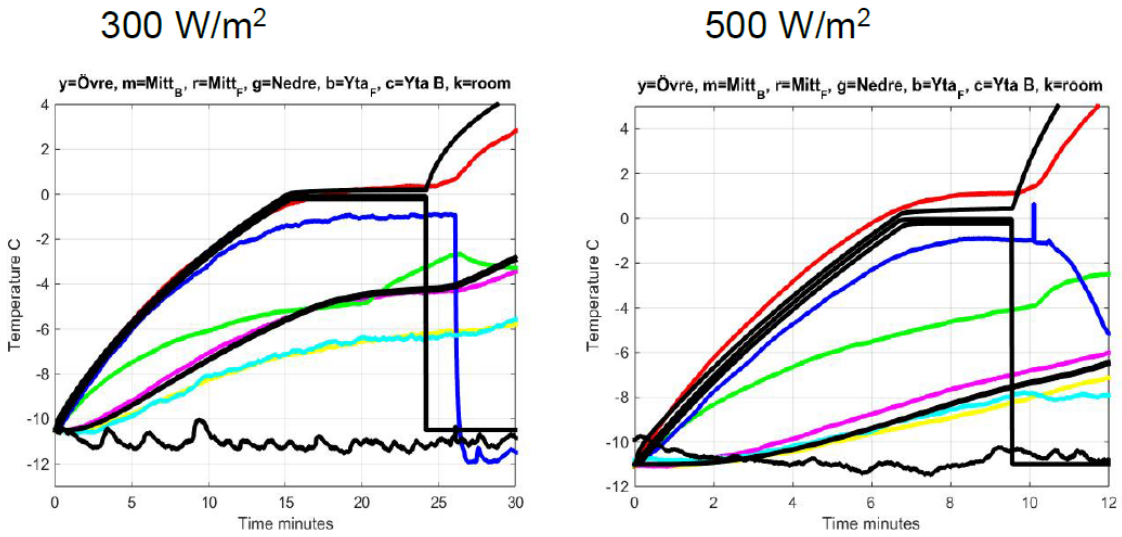

Figure 2 Experiment and Simulation of the deicing process for the test plate. Pink- measurement back side of the core, Red- front side of the core, Red at the interface ice/plate, Black- Simulations for the same positions.

Several student projects have earlier been performed to evaluate different deicing techniques. During this period one project on piezoelectric actuators has been investigated to see if it is a possible method for deicing. The results are promising and we will continue with a master theses project to evaluate the method experimentally.

Paper I from the experiment will be published at a suitable conference. So far some of the results has only been presented at Winterwind 2015.

Fulfilment of SWPTC's goals

Cold climate issues are a new area of SWPTC and the theme group (6) was initiated during 2012. The research from theme group 6 will contribute to increased reliability of wind power in cold climate and thereby facilitate the development of new wind farms. The research will also contribute to the possibility of new industries by developing measuring techniques and new ideas on heating systems.

Deviations from project plan

No further deviations during this period.

Publications

J-O. Aidanpää, *Efficiency and influence of heating device on wind turbine blades*, Presentation at Winterwind 2015, Piteå, 2-4 February, 2015

External activities

No external activities were performed during this period.