Project title	Increased reliability of heating systems on wind turbine blades
Project number	TG6-21
Organisation	Swerea SICOMP AB
Project leader	Lars Liljenfeldt
Other participants	Daniel Eklund, Runar Långström, Kurt Olofsson, Rolf Lundström
Report for	2016-01-01 – 2018-09-30
Participating companies	Skellefteå Kraft, Blade Solutions

Project description

The project has mainly been performed by senior personnel at Swerea SICOMP. The industrial partner Skellefteå Kraft has supported with specifications for monitoring system, specifying typical damages, giving requirements for repair methods and accommodating repair on selected damages on wind turbine blades. Blade Solutions has contributed with experience and has participated in the development of repair methods. Blade Solutions has also verified developed methods by conducting repair on site.

The project has been running for over two and a half years. During this period experimental techniques have been developed at Swerea SICOMP as well as on real wind power turbines. The main activities conducted by Swerea SICOMP have involved repair methods, inspection of de-icing systems and damage studies. Reliable methods for blade repair are still a very important issue. It is essential to improve both methods and material used to achieve accurate and fast repair on damaged areas. New types of hotspots and electrical cable breakage are occurring on certain locations. Reasons for that need to be understood and solved, combined with dedicated methods for the different types of damages. One task has involved inspection of de-icing systems to verify the functionality. This inspection must be fast and easy to operate in order to minimize time and cost. Methods and equipment commercially available today have been looked into. Damage studies focused on documented damage reports from the wind park Blaiken. Initially the damage studies were aimed to study the observation that wind turbines located in northern areas seem to be affected by more and severe damages on the blades compared to wind turbines placed in non-arctic conditions. Efforts were made but no relevant data was found, therefore the studies have instead focused on data from Blaiken.

The project was initiated by a start-up meeting with the involved partners, followed by project meetings on a regular basis to report conducted work and to decide on coming activities. In this project, it was vital that activities were in line with the industrial partners' development areas. Even though the main activities still were valid, new focus areas were looked into when appropriate for the project. After completed activities, decision was made by the project group if the activity was to be continued or if the achieved results were sufficient.

An important task was information collection as well as dissemination. Winter Wind, a Swedish conference and exhibition, is one source of interest that has been visited. The project has also been disseminated at other seminars and conferences.

Results

The main focus in the project has been on repair methods. One repair method has been verified on-site and another repair issue has been investigated. In 2016 an activity started how to exchange/repair electrical cables inside a 45 m blade that supports the heating system. Two cables are used for the heating system. When one gets broken, the other cable overloads leading to hotspots/burning and the whole heating system will be out of order.

Inside a blade, it is possible to work approximately 20 m into the blade until it gets to narrow. Then you have >25 m with a very limited space where you must find a possible repair method.

The main activities during the project have been:

2016

- Contacts with companies relining pipes. They are accustomed to working in narrow and long pipes.
- Experiments with different techniques to place a tube inside the prototype blade and evaluating adhesion for different material combinations.
- A box in wood was built to simulate the inside of a narrow and long blade, see Figure 1 below. A prototype equipment was designed and manufactured in order to conduct different experiments.

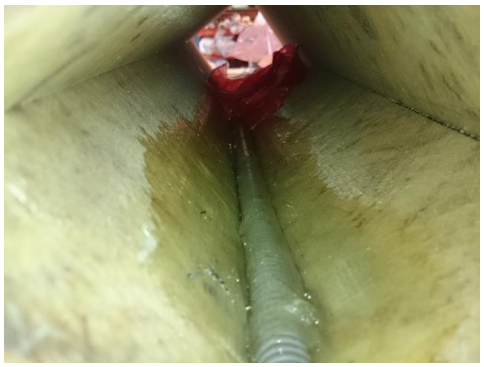

Figure 1: Wooden box with an imbedded tube where an electrical cable can be placed.

2017

- Development of equipment, see Figure 2, to be able to place and attach a tube with glass fiber reinforcement and resin inside a blade.
- Verification test in laboratory where a tube was attached in a 12 m narrow box. The experiment was successful and documented with video camera.
- On-site verification test was conducted in December 2017 inside a wind turbine blade by Blade Solutions with support of personnel from Swerea SICOMP. The wind turbine is owned by Skellefteå Kraft and is located in the wind park Jokkmokksliden in the vicinity of Malå.
- In this particular case, a 3 m cable was attached directly on the inner surface of the blade. The same carriage as in the earlier verification test at Swerea SICOMP was employed.
- Two studies were conducted and completed:
  - A survey of temperature sensors in windmill blades.
  - Thermography for inspection of active blade de-icing systems.

Figure 2: Development of equipment for attaching a tube in narrow spaces.

2018

- A blade heating system with two overlapping carbon fiber layers in the leading edge has been investigated. Cable breakage with this design can cause major problems for a blade. Test plates were manufactured to simulate the design and the problem. A project meeting involving service personnel at Skellefteå Kraft has been conducted with the purpose to make them aware of the problems and to discuss how to monitor and avoid them.
- Long-term testing to monitor the heating system, see Figure 3, and to find a method to detect cable breakage with RCD-equipment. The long-term testing caused no major damages as Skellefteå Kraft has experienced but indications exist for failure. The method for detecting cable breakage seams promising and should be developed further.
- Damage studies: Data has been received from Skellefteå Kraft but the analyses gave no clear conclusion when and why the damage occurred and how to prevent the observed damages.

Figure 3: Outside long-term testing of test panels.

Fulfilment of SWPTC's goals

Cold climate issues are central for SWPTC as well as for wind turbine operators such as Skellefteå Kraft and for repair and maintenance companies as Blade Solutions. The overall goal with the research project was to secure the operation of wind turbines in icing conditions and facilitate the development of new wind farms. The project was well in line with SWPTC's intensions.

Deviations from project plan

No major deviations during the project. Some activities have been adjusted to adapt to industrial needs.

Publications

A ¨Good example¨ has been published by Swerea from the work with the repair method.

Four reports have been written and reported:

- Swerea SICOMP CR17-009 Temperature Sensors in Windmill Blades
- Swerea SICOMP CR17-010 Thermography for Inspection of Active Blade De-icing Systems
- Swerea SICOMP CR18-005 Methods for replace of electrical cables inside a wind turbine blade
- Swerea SICOMP CR18-013 Investigation and long-term testing of blade heating system with dual carbon fiber layers

External activities

The project has been presented at:

- Wind power conference at Chalmers, Gothenburg 2017-04-03
- A seminar in Varberg 2018-04-24 within Swedish Composite Association.