Wind Turbine Ice Protection System (WTIPS)

Erik Pederson, PhD
Kelly Aerospace Thermal Systems
Willoughby, OHIO, USA

Hans Gedda, PhD
MW Innovations
Boden, Sweden

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Agenda

- System Background
- Erosion Test Winter of 2007/2008
- V90 Installation

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Overview

- Electro Thermal Ice Protection System
- Originally Developed through NASA Grant
- Certified for use on several aircraft
- Designed to operate down to -40 Deg C
- Has been put through Highly Accelerated Life Testing (HALT) down to -70 deg C

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System Testing

- NASA Glenn Icing Research Tunnel
- Much Wind Tunnel Testing

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Icing Encounters

- System can be used as a De-Ice System or Anti-Ice System
- Pulsed power technique to lessen average power usage
- Shed zones raised to just above freezing
- NOTE: Show Video

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Icing Encounters

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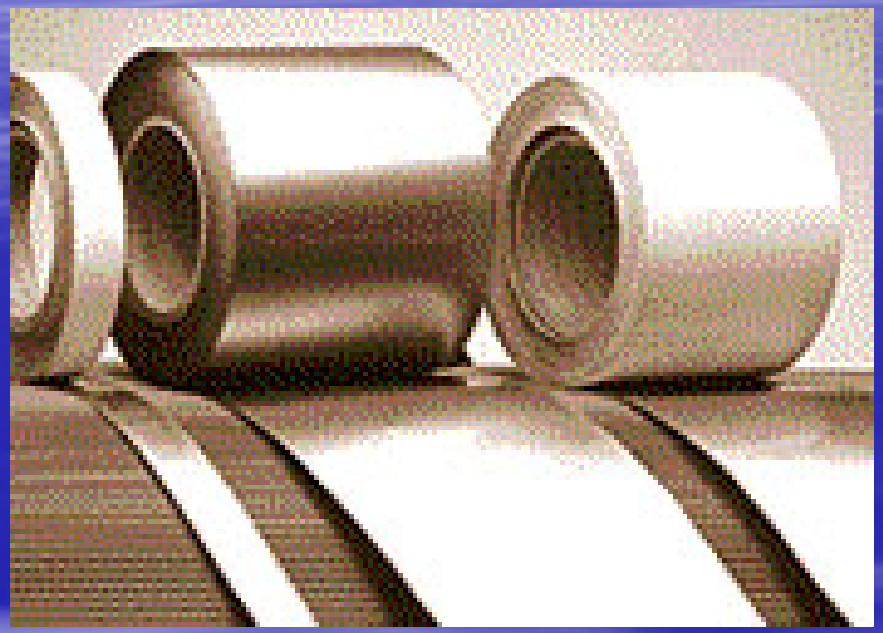
Heater Construction



- Flexible Graphite Material
- Continuous sheet
- Embedded in adhesives and protective erosion shield

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Heater Construction

- Connections are made through copper bus bars embedded in heater
- Heater constructed as a single sheet
- DuPont Tedlar Erosion shield
- Length, Width, Thickness is varied to match available power and required power density
- Aircraft Wing situations parting strip is required
- Rotating blades do not require the parting strip

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Heater Installation

- Heater formed as a flat sheet
- Adhesive backed

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Heater Installation

- Heat Gun utilized to warm heater to proper temperature

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Heater Installation

- Heater is warmed to 85 deg C to allow adhesive to flow
- Installed like a vinyl decal
- Continuous heat is applied to insure proper bonding
- NOTE: SHOW VIDEOS

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Installed Heater

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Wind Turbine Ice Protection

- Propose protecting the leading edge of the blades
- Scale heaters to match available power
- Pulse power between the blades

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Advantages

- Uniform Foil with no gaps heats up very quickly
  - Can be 1 deg / sec temp rise to 10 deg / sec temp rise depending on available power
- Low Thermal Mass, drops in temperature very quickly to prevent runback
- Quick Temperature rise and external installation minimizes energy usage
- Installed externally, blade modification not required
- Easy to repair, heaters can be patched
- Adaptable to available power and voltage
- Installed in field or in factory

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Erosion Testing

- Installed sample heaters with MW Innovations to verify erosion characteristics and durability
- Fall of 2007 on a 1 MW turbine in Näsudden, Sweden

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Erosion Testing

- Over 7000 hours of time on blade
- 70% of time blades are rotating
- Heaters are as they were when installed

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Design Process

- Analyze Blade Airfoil Shape and Aerodynamic parameters using LEWICE
- LEWICE is a software code developed by NASA to predict ice formation and power requirements on aerodynamic surfaces
- Results produce requirements for blade coverage area and power density
- System design is then a matching of available power to coverage area requirements

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V90 Installation

- Bleikevare, Sweden in September 2008

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V90 Installation

- Heaters installed while blades were on ground in Dorotea, Sweden

Layout

- V90 Utilizes 93 heaters, 31 per blade
- Heaters are wired in series to produce large heater zones
  - Each zone contains 8 – 10 heaters
  - 7 zones per blade, 21 total zones
- Power is pulsed between each zone to raise its temperature and de-ice the blade
- 1 – 3 deg per second rise in temperature
- First V90 utilizes 23 kW of Power

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Operation

- Power is cycled around the wind turbine to maintain symmetrical / balanced deicing characteristics
- Each zone will take 20 – 40 seconds to de-ice, depends on blade temperature
- Total De-Ice time 7 – 14 minutes
- Measure Relative Humidity, Blade Temperature, Ambient Temperature to determine when to de-ice

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Power

- With more power de-ice cycle time decreases
- Number of heater zones decreases
- Number of individual heaters remains the same
- System could be operated as an Anti-Ice System

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Power

- Available Power for De-ice changes number of zones and de-ice time
- V90 23 kW – 21 zones, 7 per blade
  - De-ice time 7 – 14 minutes
- > 50 kW – approximately 9 zones, 3 per blade
  - De-Ice time 3 – 6 minutes
  - Possibility of using system as an Anti-Ice
- > 100 kW - approximately 3 zones, 1 per blade
  - De-Ice time < 1 minute
  - Capable or operating as Anti-Ice system

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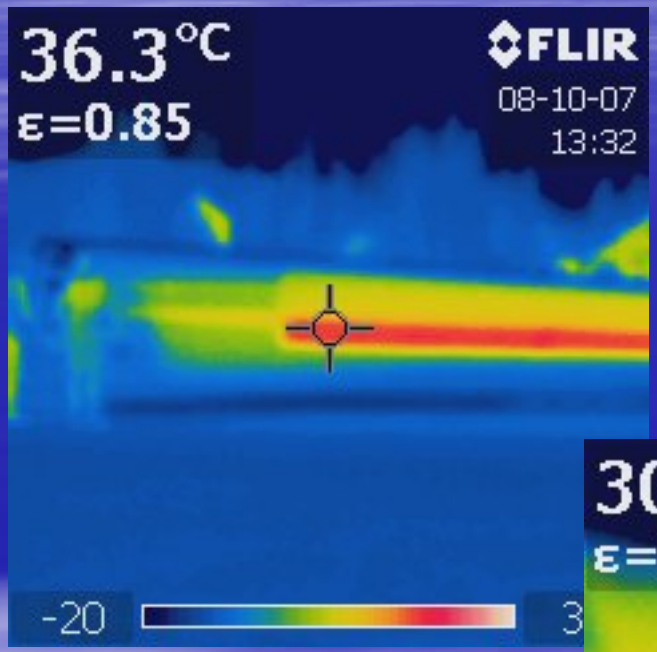
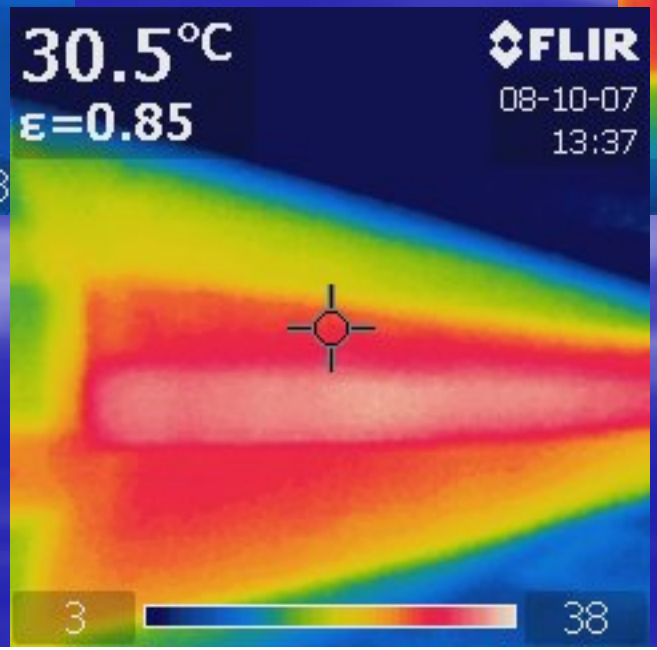
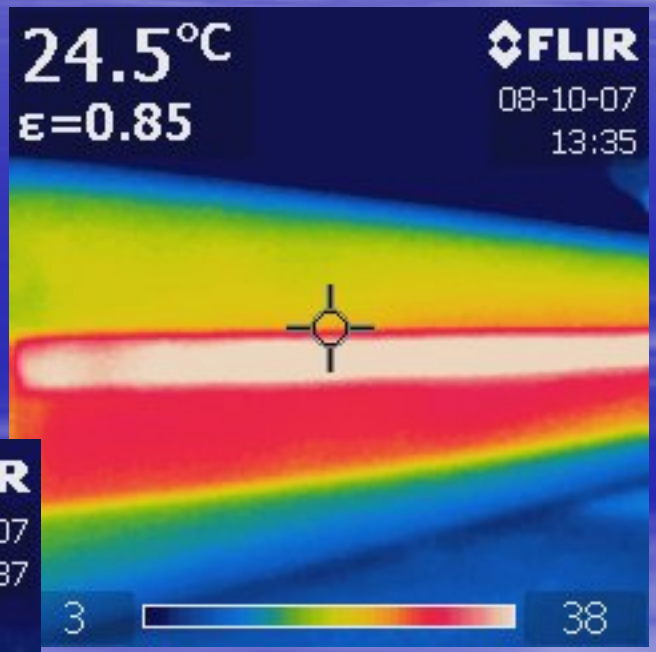
Turbine #13 Bleikevare

- Heaters have been installed







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Turbine #13 Bleikevare

- Turbine has been erected

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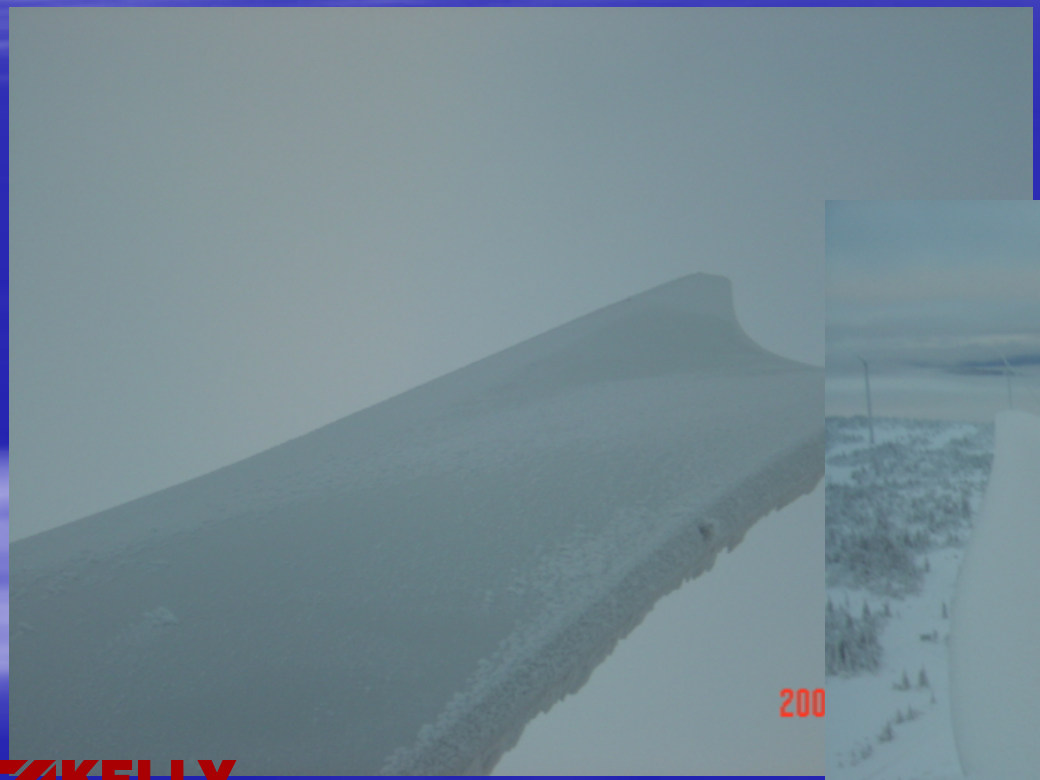
Turbine #13 Bleikevare

- Electrical Control System install expected to be finished near the end of January 2009



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