De-icing using ns-DBD plasma actuation: experimental study

Jakob Van den Broecke
Delft University of Technology
Presentation outline

• Aerodynamic background
• ns-DBD plasma actuator
• The experiment
• Results
• Conclusion
Aerodynamic background

Flow Control

Postpone / prevent boundary layer separation

Increase lift
Decrease drag

• Vortex generators
• BL suction/blowing
• Plasma actuators

What if this device could also de-ice?
ns-DBD plasma actuator

Physical

• 2 electrodes: covered/exposed
• Dielectric barrier: Kapton

Electrical

• Electrode 1: nanosecond-pulsed signal
• Electrode 2: ground
• High voltage
• High frequency

Ultrafast gas heating mechanism
The experiment

OWI-lab

- Location: Port of Antwerp, Belgium
- Temperature range: -60 to +60°C
- Lab dimensions: 10.5 x 7 x 8 m³
- Installed power: 408 kW

- De-icing @ -20°C
The experiment
Qualitative analysis
Qualitative analysis
IR results
Challenge the future

De-icing efficiency: method proposal

\[ \Delta m: \text{before and after experiment} \]

\[ E_{\text{melting}}: \text{Determine theoretical energy required} \]

\[ E_{\text{input}}: \text{known from back-current shunt} \]

\[ \eta_{\text{de-icing}} = \frac{E_{\text{melting}}}{E_{\text{input}}} \]

Remove all water from plasma actuator after testing

1 calorie:

\[ E = \frac{V^2}{Z} \int_{t_1}^{t_2} dt \]

Input signal

Reflected signal

\[ t \ [s] \]

Input

10
Results

• Measurement uncertainties
• Ice parameter uncertainties
• Ice refreezing during test
Conclusion on using ns-DBD plasma actuation for de-icing

- **Flow control device**
  - Decrease drag and increase lift
  - Or: increase drag for aerodynamic braking
  - De-icing capabilities with same device

- **Speed**
  - Ultrafast gas heating mechanism
  - Produces heat where it is needed

- **Retrofit possible**
  - Film/electrode combination on LE of rotor blade
  - Hydrophobic material as dielectric barrier

- **Cons**
  - Electromagnetic noise production
  - New technology, needs accurate adjustment
De-icing using ns-DBD plasma actuation: experimental study

Jakob Van den Broecke
Delft University of Technology