Icing on Drones and Wind Turbines

Similarities and Mutual Benefits

A topic that has recently become a focus of research is icing on unmanned aerial vehicles, which in everyday language are known as drones. The wind power industry has a lot to gain from drone icing research. In this article, I will show that there are many similarities between icing on drones and icing on wind turbines in cold climates. The physics of ice accretion on these is very similar, which means that tools validated for drone icing will also be applicable to wind turbine icing. I will also give examples of how drones can be used practically to deal with the challenges of cold climate wind energy, for example to detect icing and even to de-ice turbines.

By Richard Hann, Norwegian University of Science and Technology, Norway

Unmanned drones are used for an increasing variety of tasks, also in cold climates. One of the main challenges of drones in the Arctic is atmospheric icing. I am writing my PhD thesis on drone icing at the Norwegian University of Science and Technology (NTNU). I previously worked in wind turbine icing and have detected many similarities between, and mutual benefits of, these fields.

The Effects of Icing

Icing on aircraft can have disastrous consequences. Therefore vast research has been done on the topic since the 1940s and effective anti-icing and de-icing systems have been developed for aircraft. Knowledge about aircraft icing can, however, not be directly applied to either drones or wind turbines. The conditions for manned aircraft and unmanned drones are different. The wings have different dimensions and types of airfoils, and they operate at different speeds and altitudes. This has an effect on how air flows around these objects, making it difficult to transfer knowledge from one to the other.

Modern wind turbines started expanding into cold climate conditions in the 1980s and many problems occurred with icing. Without proper protection systems, ice can severely reduce the power production of a wind turbine. In addition, it can also lead to vibrations and damage the wind turbine blade. There is also a hazard to people if pieces of ice fall from a rotating wind turbine. Much research has been conducted on the topic, and effective icing mitigation technologies have only become available during recent years.

Drone icing was first described in 1990 but is only now becoming a focus of research. Ice on a drone has negative effects on the aerodynamics and can lead to a crash. There is still much we do not know about icing in these conditions and a lot of further research is needed.

The physics of drones and wind turbines is more similar than the physics of drones and aircraft. Drones and wind turbines operate at approximately similar speeds and at approximately similar altitudes.

Icing Research

To be able to develop better icing protection systems for both drones and wind turbines, we need to learn more about how the ice is formed in different conditions. In my research, I am conducting three different kinds of tests for this purpose. I am doing numerical tests using simulations on a high-performance computer. Several icing codes have been developed for aircraft but we need to investigate whether they are applicable to drones. If they are, then they will also be applicable to wind turbines.

I am also doing real flight tests with drones with artificial ice attached, to learn about the impact of ice on the flight behaviour. Tests have shown that even small amounts of ice on the wing can have a big impact and have in several cases led to a crash of the drone.

Last but not least, I am conducting tests in a special icing wind tunnel, where icing conditions can be created in a controlled laboratory environment. The results from these experiments will serve to validate the numerical models. Since many of the test conditions and airfoils are similar to what wind turbines experience, these results can be transferred to the wind energy sector.

Autonomous Systems Needed

As stated before, the physics of icing on drones and wind turbines is similar. There are also similarities in the requirements for icing protection systems. Both drones and wind power plants need systems that detect ice and protect against icing autonomously. This is again different from manned aircraft, where there is always a pilot who can make decisions. The need for autonomy means a lot of challenges for the icing detection algorithms and techniques.

It is very important to be able to identify icing conditions. If icing is falsely detected, a lot of energy can be wasted. If icing conditions are not identified, there is a risk of losing the drone or losing wind energy production.

In my research, I start with icing tools developed for aircraft and develop and validate them for drone use. This means that at the same time I am validating them for wind energy applications. Because my research is open, the results will be shared with the scientific community and available to all stakeholders.

Practical Uses for Drones on Wind Farms

Besides the similarities between drones and wind turbines, there are also practical applications for which drones can be used when dealing with cold climate wind energy. These applications are constantly developing.

Drones can be used for the maintenance of wind turbines and for the inspection of blades. It is also possible to use drones to detect whether ice has accumulated on a wind turbine or ice has disappeared after an icing event. This can be very useful in locations where icing happens rarely. Furthermore, drones can also be used to inspect power lines for icing. Failure of the power grid due to icing can be a large concern in cold climate conditions and can be a risk to wind farm investments.

There are even start-up companies looking into using drones for actual de-icing of wind turbines. This is a solution for wind farms where icing is experienced rarely, since using drones for de-icing on a regular basis is still an expensive method.

At NTNU we have started a technology spin-off company called UBIQ Aerospace. UBIQ Aerospace aims to commercialise an effective drone icing protection system. The system is based on a nanocarbon material that can be heated when needed. Icing detection is achieved with an innovative approach to detect ice on the wings. Several prototypes have already been tested successfully and UBIQ Aerospace is in collaboration with several industry partners. The company sees a potential for some of its solutions to also be applicable to wind energy, such as its autonomous icing detection system. Since the UBIQ Aerospace system can be retrofitted, it could also be relevant for small wind turbines.

With the company's drone icing protection system, it will be able to develop drones for Arctic purposes. The aim is to have drones that operate in remote Arctic and marine environments. For this, UBIQ Aerospace receives funding from The Research Council of Norway. Potential applications are ship-based iceberg detection, oil spill response, search and rescue, and remote sensing.

Future Outlook

Even though there are many possibilities for drones in the Arctic, icing is far from limited to high latitudes. Just as for icing on aircrafts or wind turbines, atmospheric icing on other objects can occur all around the globe. In the future I believe that there will be many more synergies to be investigated between wind energy and drones and the hope is that both industries can profit from each other in finding new solutions of benefit.

Biography

Richard Hann is a second-year PhD student at NTNU. He has been working with icing on wind turbines and drones for seven years and has collaborated with industry and research partners. He holds a master's degree in Aerospace Engineering from the University of Stuttgart.

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Figure 1. Drone flying in Ny-Ålesund, Svalbard (courtesy the Northern Research Institute, Norut)

Figure 2. Drone launching in Ny-Ålesund, Svalbard (courtesy Kim Sørensen, NTNU)

Figure 3. Ice accretion on an unmanned aerial vehicle airfoil in a wind tunnel (courtesy Richard Hann, NTNU)

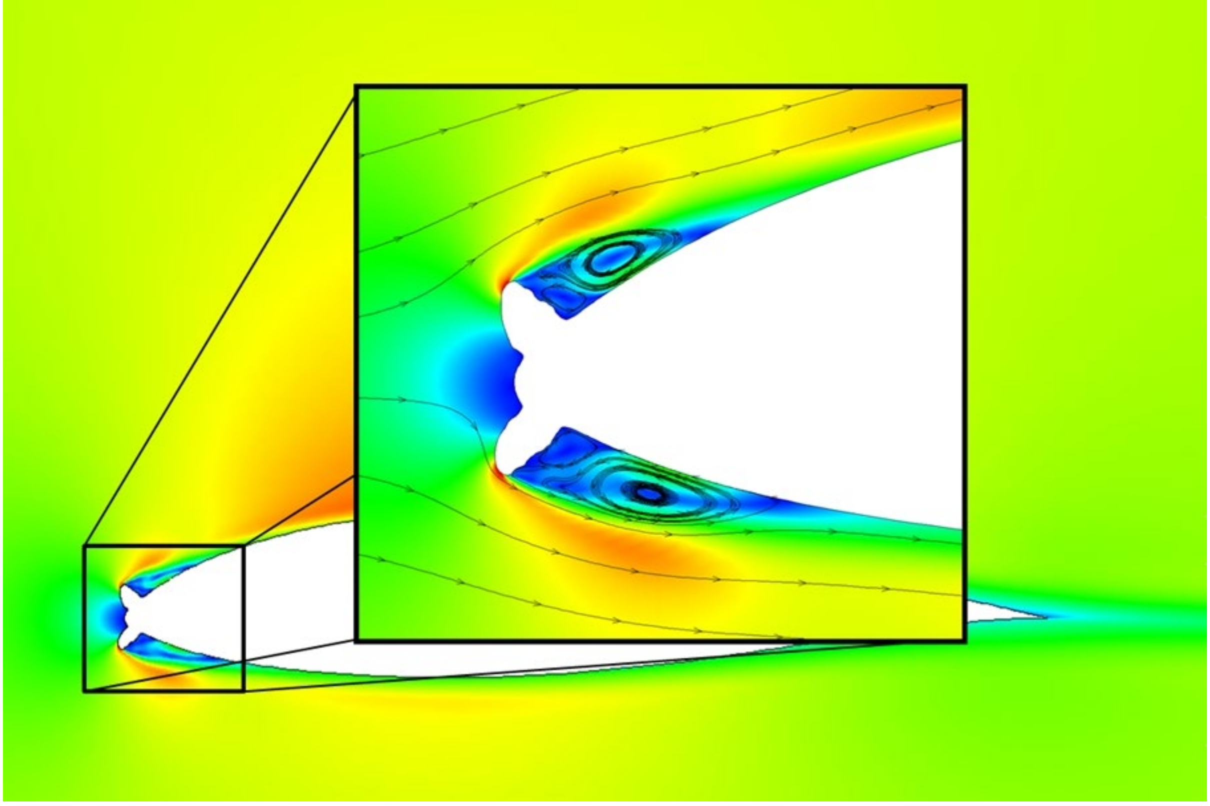

Figure 4. Computational fluid dynamics simulations of flow around an iced airfoil (courtesy Richard Hann, NTNU)

Figure 5. Drone launching in Ny-Ålesund, Svalbard (courtesy UAV Lab, NTNU)


Figure 6. Drone flying in Ny-Ålesund, Svalbard (courtesy UAV Lab, NTNU)