MATHEMATICAL MODELLING Series 2

MACSI

STEPS ENGINEERS IRELAND

De-icing maths

Mathematics and applied mathematics are used in everyday life. Stock markets, mobile phones, car manufacturing, Google, Hollywood special effects, digital TV and satellites all use cutting-edge mathematics tools in their basic functions. The Mathematical Modelling Series presents a number of applications of mathematics in domains as varied as the human body, volcanology, telecommunications or finance.

When aircraft fly through cold clouds in winter months, ice is likely to form on the wings. This phenomenon is a serious concern for aircraft manufacturers because a thin layer of ice (less than a millimetre) on the leading edge of the wing can cause a plane to crash. In the past, wings were tested in wind tunnels to determine the effects of ice formation. Nowadays, mathematics and computers can assist engineers to test for icing without having to spend vast amounts of money constructing prototypes.

How it works

Clouds are made of small droplets. Although their temperature is below 0°C, they are still liquid. When they hit the wing of a plane, they freeze instantaneously or sometimes remain partially liquid. A liquid layer may then run back, and this water will freeze at some distance from the edge of the wing. Using fluid mechanics, mathematical models can follow the water droplets and predict where they are going to hit the surface of the plane. An energy balance can then predict the amount of ice that will be formed. These models help to determine where to put devices that prevent the development of ice layers on the aircraft. However, these devices are expensive to operate, which means their use needs to be limited. Therefore, before taking off planes are usually cleaned using de-icing liquids to prevent ice formation.

Conclusion

By monitoring water droplets we can determine where ice is likely to grow and where ice-preventing devices should be placed. Understanding ice growth will enable improvements in other areas such as preventing ice growing on electrical cables and on the blades of wind turbines. The mathematical model for ice growth developed here has many other applications.

Parts of the curriculum used in this project:

- Differentiation
- Integration
- Fluid mechanics
- Geometry
- Differential equations
- Vector analysis
- Energy conservation
- Collision
- Optimisation

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If you want more information about MACSI and this project:

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