Mathematics that makes you shiver

When aircrafts fly through cold clouds in winter months, ice is likely to form on the wings. This phenomenon causes aircraft manufacturers serious concerns as 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 would be tested in wind tunnels and the plane would be constructed and tested in icing. Mathematics and computers can assist engineers: new designs can be tested before the plane is built.

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 and finance.

How it works

Clouds are made of small droplets. Although their temperature is below $0^{o}C$, 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 runback and this water will freeze at some distance from the edge of the wing. Using fluid mechanics and mathematical models, 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 determine where devices that will prevent the development of an ice layer on the key parts of the aircraft should be placed. These devices are expensive to operate continuously. To limit their usage, before taking off planes may be cleaned using de-icing liquids that will prevent ice from forming but this effect only lasts for a few minutes.

Conclusion

Monitoring water droplets will determine where ice is likely to grow and where ice preventing devices should be placed. Understanding ice growth will be used in other areas: ice growing on wires will cause the collapse of power lines, ice growth can seriously damage 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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