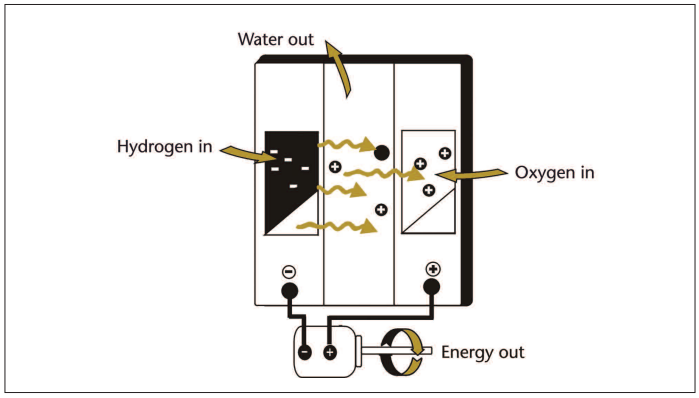
MATHEMATICAL MODELLING Series 1

Mathematics driving the future

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.

Hydrogen fuel cells are widely considered to be the most promising alternative to the internal combustion engine found in the majority of cars. One of the biggest differences between the two types of engine is that the only emission given off by a fuel cell is water. A major problem with fuel cells is that this water can cause the engine to flood and stop working. Mathematical models are used to find out exactly how much water builds up when the engine is running and how it can be removed.



Hydrogen fuel cell.

How it works

In order for a fuel cell to produce power it needs a certain level of moisture. For this reason vaporised water is fed in with the hydrogen fuel. When the reaction between hydrogen and oxygen occurs, even more water is produced, which can cause flooding. The challenge is to remove enough water so that the cell won't flood, but leave enough water to enable the cell to produce power. By using Newton's second law, it is possible to derive a set of equations to model the movement and amount of water everywhere in the cell. Another equation models how the water will evaporate in heat. When these equations are solved using a computer, it is possible to determine how much water is present in the cell and how much power the cell will produce.

Conclusion

When the cell temperature is around 80°C, at twice standard atmospheric pressure and a relative humidity of between 80 and 90% (a comfortable level for humans is about 50% at 21°C), a hydrogen engine can produce up to 100 kilowatts of power, enough to power your home for three days!

Parts of the curriculum used in this project:

- Differentiation
- Liquid pressure
- Newton's second law
- Ordinary differential equations
- Integration
- Matrices
- Energy conservation
- Sequences and series

ACKNOWLEDGEMENTS AND MORE INFORMATION
This research is supported by the Mathematics Application Consortium for Science and Industry (MACSI) funded by the Science Foundation Ireland Mathematics Initiative Grant 06/MI/005.

If you want more information about MACSI and this project:

- Contact Martina O'Sullivan (project facilitator) – martina.osullivan@ul.ie
- Visit the MACSI website – www.macsi.ul.ie.