MATHEMATICAL MODELLING Series 1

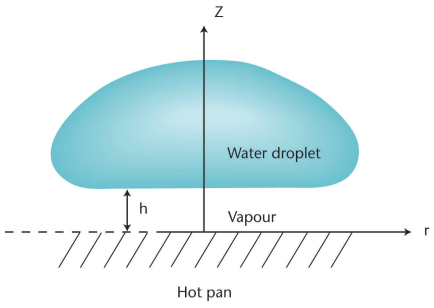
MACSI

STEPS ENGINEERS IRELAND

Can mathematics slow down fires?

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.

If a fire starts in a building, you need to bring it under control as soon as possible. A standard security measure is to install sprinklers in the ceiling. If there is a fire, the sprinklers will automatically spray water droplets. To be as efficient as possible, the sprinklers need to release water droplets of the minimum possible size. However, if the droplets are too small, they will evaporate before they can reach the regions with the highest temperatures. Mathematics can help to calculate the appropriate size for the droplets.



How it works

When water droplets fall through hot gas they start to evaporate, and the layer of gas insulates them from the high temperatures around. It will take them much longer to evaporate than normal water at the same temperature. The same phenomenon can be seen when a water droplet is thrown into a hot pan: very quickly, the bottom of the droplet evaporates and the droplet hovers over its own vapour. This gas layer protects the droplet from the hot pan and so it takes the droplet a long time to evaporate.

This is where mathematics becomes useful: you need a good mathematical model to provide you with numbers. The solution of an ordinary differential equation provides the shape of the droplet. Its weight can then be calculated using integration. The behaviour of the droplet can then be studied using Newton's second law and an energy balance. This leads to two ordinary differential equations. These can be solved using a computer and will tell you how long it will take before the droplet evaporates.

Conclusion

Small droplets of 1mm in diameter can take up to 40 seconds to evaporate over a pan heated at 300°C. If they are released from a sprinkler, enough droplets will be able to put out the fire. However, this will only slow the fire down when it reaches its typical temperature of around 1,000°C.

Parts of the curriculum used in this project:

- Differentiation
- Integration
- Geometry, volumes and area
- Newton's second law
- Energy conservation
- Ordinary differential equations

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If you want more information about MACSI and this project:

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