How can mathematical modelling help in the coronavirus pandemic?

Covid-19 has directed an intense spotlight on to scientific research, instigating a call to arms for scientists from a wide range of disciplines. Mansfield's **Ian Griffiths**, a Professor of Industrial Mathematics at Oxford's Mathematical Institute, reveals one distinctive avenue of research.

When we think of the kind of scientists that are working on the pandemic challenge, the people who usually spring to mind are bioscientists toiling away in a lab to develop a vaccine, or statisticians analysing data to understand how to mitigate the spread of the disease. However, in addition to these vital research endeavours there's a host of other scientific disciplines all working in very different ways in an effort to gain understanding into how we can overcome the virus together.

A significant proportion of the research that I conduct in my Industrial Mathematics group is centred on the development of mathematical models that describe filtration processes. This could be anything from the cleaning of air by a household air-purifier, to an industrial-scale filter that removes sulphur dioxide from cooling towers in a power plant by converting it into sulphuric acid via a catalytic reaction. The mathematical models we derive have the effect of reducing, or in some cases even eliminating entirely, the need for costly and time-consuming experiments.

One project that we have been working on recently is in collaboration with start-up company Smart Separations. Its newest product, Gino, is a portable home air purifier capable of removing coronavirus from the air by neutralising it, using a biocide-coated surface (https://smartseparations.com/gino/). When designing these air purifiers, one of the first questions that Smart Separations faces is how to position the filters within the air purifier. This involves a delicate balance between the need to maximise purification efficiency, by packing in as much filter material as possible, and minimising the energy required to run the air purifier, which necessitates enough space in the device for the air to pass through easily. The problem can be distilled into an optimisation question, to which our mathematical models have provided the answer.

In another project, we have been looking at the behaviour of the non-woven material used for face masks. When someone breathes in while wearing a face mask, the filter material becomes compressed, which hinders the air passing through and so makes breathing more difficult. This poses an interesting design question: how should we manufacture the face mask filter such that, when the material becomes compressed, we are still able to breathe comfortably? Here we have an example of an inverse problem: we know the required output – a filter that has enough air space for us to breathe through – and we wish to know how to manufacture the mask in a factory to achieve this requirement. Again, our mathematical models provide the answers by allowing us to perform 'mathematical experiments', which enable us to 'reverse' the manufacturing process, going from the final product back to its construction.

In our group we are always looking to help industries overcome challenges by using our mathematical modelling toolkit. If you would like to learn more about our work, please visit our website: https://people.maths.ox.ac.uk/griffit4/.

Professor Ian Griffiths joined Mansfield as Tutorial Fellow in Industrial Mathematics in 2019. His interests lie in a broad range of fluid dynamical challenges, from water purification strategies to the manufacture of glass for computer tablet screens. His approach is to use a blend of modelling, asymptotic, and numerical techniques to enable predictions to be made for the behaviour of such physical systems, and in particular, to give insight into their optimal operating strategies.