Industry Fellow: Surface Chemistry Effects on Single Crystal Aerofoils
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The Issue
Commercial aeroengines are complex engineering marvels, and the technology and materials used in their manufacture face an extreme environment – for example, the turbine entry temperature (TET) of the Rolls-Royce Trent 900 engines used on the Airbus A380 is about 1580°C. The demands on the turbine aerofoil design and materials are great; consider that the TET is 1580°C while the melting temperature of the alloy used for the turbine blades is just above 1400°C!

The production of these advanced turbine blades involves casting the aerofoil as a single crystal of a complex alloy known as a nickel superalloy. The casting process used is thousands of years old – used by ancient civilisations to produce intricate metal statues – and is known as lost-wax or investment casting. The cast blades are then heat treated to produce the desired mechanical properties for use in the turbine. The blades must pass rigorous checks before they are placed in an engine, and there are many defects that may be found. One of the first defects encountered on the production line is known as surface scale.

My industry fellowship focuses on understanding surface scale. This scale results from mould-metal interaction and causes significant technical issues as well as millions of pounds of wastage. The surface scale strongly influences the heat treatment as shown below. After heat treatment, the upper 50 μm of the blade are not longer single crystal. With aerofoil cross-sections on the order of 3 mm, this reduces the load-bearing section to an unacceptable value.

My Industry Fellowship provides me with valuable ‘research space’. Balancing teaching, research and administration – a challenge all academics face – and after recently pushing forward my research after concentrating on a young family, the Fellowship allows me to build my links with industry. It gives me the opportunity to explore a complex casting problem that is not only scientifically interesting, but is of huge everyday importance to Rolls-Royce. The contact with the company also provides the opportunity for me to explore contacts in other areas relevant to my research.