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AEngD Engineering Research Writer of the Year entry
Category: potential impact

"Let's get cracking!"

In the time it takes you to read this sentence at least 10 aircraft have taken off somewhere in the world. Thousands of aeroplanes fly overhead daily and we think nothing of it. However, there is an army of personnel whose job it is to keep aircraft in the air. It is not only the shiny new prototypes that need close attention but every single aeroplane, whether passenger, military or cargo. This article will outline my role as a Research Engineer in improving aviation safety.

I am in my final year of a four-year Engineering Doctorate (EngD) programme. This is equivalent to a PhD but with a very strong industrial connection. I am part of the Centre for Doctoral Training in Non-Destructive Evaluation (NDE). After one year at the University of Bristol, I have been based at Rolls-Royce plc.

Non-Destructive Evaluation is the use of techniques, such as ultrasound and radiography, to check engineering components for defects without altering or damaging them in any way. Approximately 25,000 NDE inspections are performed daily in the UK on a variety of components, from small bolts to giant aeroplane wings. These vital inspections are performed during manufacture and assembly of components and while the components are in service, ensuring safe operation of engineering structures with minimum disruption. I am focused on the latter type, inspecting for defects that occur during use. I work on ultrasonic testing which is an excellent technique for detecting defects that are 'sub-surface'; in other words ones that we have no direct access to. We use tiny piezoelectric crystals to send pulses of ultrasonic energy into the components being tested. Features that are different from the bulk of the material, such as edges and flaws, will reflect the energy and the same crystals are used to pick this up.

I am developing an ultrasonic inspection for an aero engine component that has the potential to suffer from stress corrosion cracking, which is the bane of many scientists and engineers. The initiation of stress corrosion cracking is difficult to predict because a very particular set of factors need to be just right (or wrong!) for it to occur. The cracks can grow very quickly and in a random, branched fashion so that on close observation they look like little trees. When inspecting with a single piezoelectric crystal, a lot of these cracks may be undetected because their branches reflect the ultrasonic energy in multiple directions and little gets back to the crystal. Ultrasonic array probes which consist of many piezoelectric crystals or 'elements' are therefore preferable because the energy is sent and received at many angles.

The aim of my EngD is to develop a computer model that simulates the interaction of ultrasound with these cracks and use it to optimise an array design for the engine component. There are many jokes about Engineers' tendency to make approximations and assumptions. One of my favourites is: "How do you calculate the volume of a camel? Firstly, assume it is spherical…" The approximation that is often taken in ultrasonic simulations for NDE is that cracks have simple shapes, such as narrow rectangular slots. This is fine when the cracks really are flat and straight, for example fatigue cracks, but not for complex shapes like stress corrosion cracks. I therefore had to develop a novel computer model into which I input intricate crack geometries obtained from real samples, and I have accomplished this.

My computer model outputs more realistic results because of the use of real crack geometries as input. This ensures that the best possible array probe is designed for the inspection and, compared to using off-the-shelf probes, a much higher percentage of the stress corrosion cracks and smaller ones can be detected. My research will produce an NDE technique with much higher reliability, allowing for a more cost-effective asset management approach to be used. In addition, my model is flexible enough to be applied to other components and industries, including civil nuclear where stress corrosion cracking can be a problem.

Nowadays, the extremely high levels of reliability associated with the aerospace industry mean that people can sit happily on aeroplanes without much thought to the engineering behind them – and there are about 700,000 people in the sky at any one time. Sitting in a rickety aeroplane a century ago, you would have been very conscious of how it was engineered, even if not an engineer yourself. As engineering systems and structures become increasingly reliable, the work being done by engineers can easily be forgotten. How much of a discrepancy is there between the importance of engineering in people's lives versus the importance people give to engineering? Is being out of the public's minds an indication of just how successfully engineers contribute to modern safety and comfort? Whatever the answer, I love my challenging job and am proud to be part of a team that makes such a positive impact on people's lives.

(821 words)

Figure on pg. 3

Caption: The complex 3D geometry of a stress corrosion crack. It was extracted from X-Ray Computed Tomography images of a cracked sample by Maria Felice.

Please let me know if you require a better quality image.