Material world

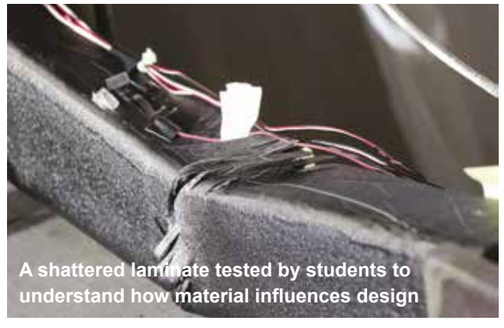
Composites are increasingly finding their way onto a variety of industrial applications previously thought unsuitable. Professor Kevin Potter reveals the latest trends

The drive to lighten materials across a variety of industries is fuelling research into composites. Professor Kevin Potter of the Bristol Composites Institute (ACCIS) at the University of Bristol is a 40-year research veteran who is currently managing an array of projects designed to push the material's boundaries.

Starting with automation and advances in manufacturing, Potter says, "Take, for example, large aerospace structures, where they are using automated fibre placement machines for a wing skin or spar, putting strips of fibre side-by-side before going on to be cooked and cured. The moment you want to make something more complicated – such as sandwich panels for the wing surfaces – these will be laid up by hand in the traditional way. There was a huge effort in the 1990s to increase robotic automation but it largely failed because of an underlying incorrect assumption, that hand lay-up is unskilled."

To remedy this the university is investigating the hand lay-up process in much greater detail. Potter continues, "We've spent a lot of effort trying to understand the skill levels of the operators, how to support them, put tools in place to predict material behaviour and examined their tools more thoroughly, and so we can use VR to aid in training, as it seems unlikely that any geometry you can define could always be manufactured by a robot."

With conventional additive manufacturing as with composites, one is making the material and the structure simultaneously, unlike machining an item from a block of metal where its properties are known in advance. Potter believes this limits additive manufacture's use to less critical components, where certification issues are more easily tackled. "You can buy additive layer manufacturing machines that use a continuous carbon fibre thread, but at the moment they are fairly limited in both properties and geometry capability. We're doing work studying whether it would be better to use very well aligned short fibres rather than continuous fibres. This helps with the geometry, and also recyclability," he observes. In fact, overcoming problems with recycling is another area the university is examining.



A shattered laminate tested by students to understand how material influences design

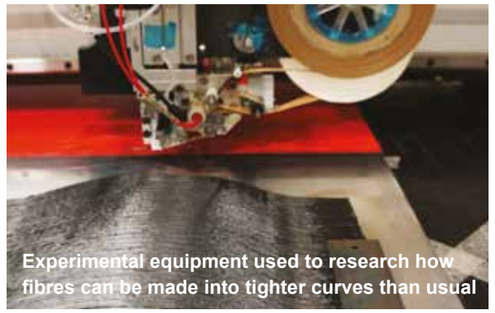
For in-process reuse, Potter cites the BMW i3 as one way to solve problems with this, as the off-cuts of the woven cloth material wasted when the side panels are created go back to the supplier, and are shredded into a loose mat which is then used in the roof panels.

"For end-of-life recycling, it's not so straightforward," Potter notes. "Of course you can chop it up, burn out the resin and sell the reclaimed fibres on for a variety of applications. The problem is that without an alignment process a lot of the value is lost. What's more, for certain applications, such as aerospace, the resin is more expensive than the fibre so it's not great to lose the most costly part to extract the fibres."

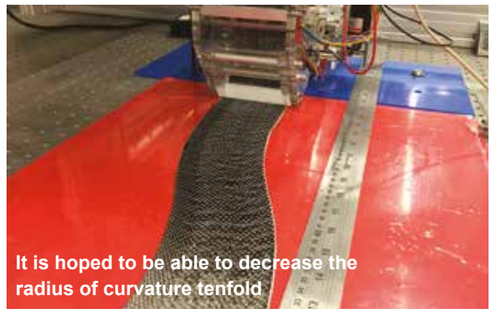
The alignment issue is something else currently being researched at the university, with efforts underway to develop processes to deliver highly aligned short fibres. A matrix designed to be easily removed can then be put on the fibre allowing the recovery and reprocessing of both fibres and matrix. Potter's ultimate ambition is full closed-loop recycling, but he doesn't see it happening soon. "It will have to happen one day though," he observes.

HEALING TOUCH

One interesting property of composites is the potential to include a self-healing ability. It is possible to generate a matrix that can heal damage, but the bad news is that these matrices have had relatively poor properties to start with, although the latest work on self-healing epoxies at Bristol shows promise. The university has also studied healing resins held in hollow fibres, so when a crack goes through the material the hollow fibres rupture to let out the healing agent. The latest research centres on a vascular system where an agent is pumped around. "It's a very long-term thing," thinks Potter. "Although there has been interest in the aerospace world, for medicine it's more difficult because of the greater variety of disciplines needed to be successful."



Experimental equipment used to research how fibres can be made into tighter curves than usual



It is hoped to be able to decrease the radius of curvature tenfold

HYBRID AIRCRAFT

While in contemplative mood, Potter suggests, "It's clear that cars are going electric, and the only way to get the weight out is with composites. What is less well known is that there is also a push for aircraft to use hybrid electric technology, albeit some decades down the line. As batteries will always weigh more than a liquid fuel source, there will be a considerable push to get even more light weight composites onto the aircraft. I think we will have to look at the certification process again to make this happen."

Another area where Potter sees growing reliance on composites is for civil engineering. "We will see changes in the way wind turbine blades are designed, as much due to logistics as technological changes. We're going to have to figure out how to assemble these things in situ as size increases seem likely.

"The other area of growth will be with bridge construction, where the deck area will increasingly be composite, and the next generation of suspension bridges will perhaps rely on carbon fibre to keep the weight down."