Robots – the affordable alternative?

The Fanuc ultrasonic fibre placement robot: In operation at Fokker Aerostructures

A recently completed first stage of trials at Fokker Aerostructures in Hoogeveen, The Netherlands, has seen further development of the common industrial robot as an alternative option for the production of structural carbon fibre thermoplastic products with a novel new design. **Simon Lott** reports.

Efficient production of major structural parts is currently one of the major talking points for companies working across the whole composite industry and recent years have seen increasingly elaborate and complex methods for the laying-up of carbon fibre reinforced plastics (CFRPs).

Traditionally assembled by hand before curing, CFRPs have seen a shift to gantry-type and large, finely-controlled fibre placement machines over the years and the impending automation revolution is likely to be the defining factor in the expansion of carbon fibre products into the mass market. The trick now, is to reproduce results currently being achieved at the high end of the industry much more affordably, and in this respect the technology is still very much in its infancy.

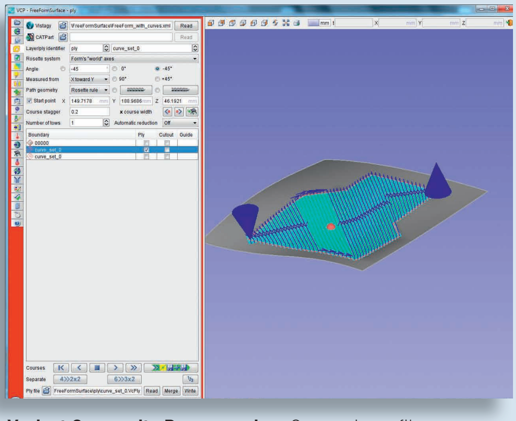
To solve this complex problem, a variety of blue-chip and government initiatives have sprung up across the industry and Fokker's solution falls under the umbrella of TAPAS (Thermoplastic Affordable Primary Aircraft Structures). The project is a collaboration between Airbus and key protagonists within the Dutch industry aimed at demonstrating the design techniques, manufacturing and assembly processes of thermoplastic materials and improving the commercial viability of the materials. By developing a robotic system, Fokker hopes to establish a process featuring key proprietary technologies that can do the same job at a fraction of the cost and with a smaller space penalty.

To get a sense of the difference, a ballpark figure for a typical industrial robot is in the region of €100,000, whereas a modern fibre placement machine can begin at anything upwards of €1 million. Although the working area of a robot is limited by its size to several metres, Fokker expects to eventually synchronise gangs of robots for fully scalable solutions to the lay-up of large parts.

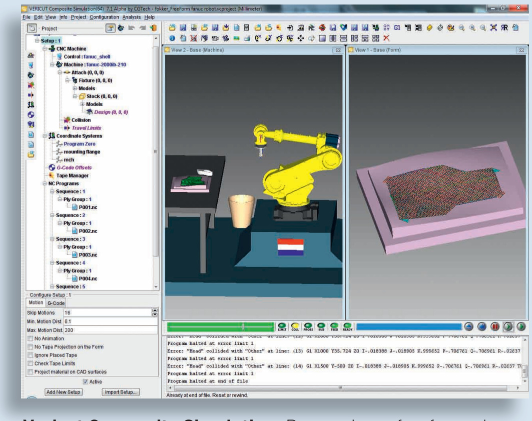
While there are already several early robot technologies in the marketplace for this application, Fokker's technology demonstrator offers a novel solution in that it has been able to configure an off the shelf Fanuc arm together with a custom-made tow placement head to apply thermoplastic CFRP, incorporating an ultrasonic torch for localised welding of individual plies. Currently, parts being produced are simply to prove the concept and are focused around a variety of wing and control surfaces, but as progress is made, the technology will be appropriate for any number of other applications.

"We expected Fokker would invest in a standard fibre lay-up machine," explains CGTech's export sales engineer Lee Fowkes, "but it then decided to develop its own technology because it saw drawbacks with all the existing options and thought it could do better. A key technology is the ultrasonic welding torch, which is roughly the size of a ballpoint pen. While there are several alternatives to this method, ultrasonic welding torches have been used in manual lay-up for many years so it's a well-established technique, relatively cheap, safe and environmentally friendly."

While the dimensional accuracy of the system is not expected to rival heavyweight machine producers – with 0.1mm rather than micron accuracy – a substantial amount can be regained through the intelligent use of encoders and feedback



Vericut Composite Programming: Generating a fibre placement path for output as NC programs



Vericut Composite Simulation: Processing a freeform shape with the fanue robot

loops to carefully monitor and control actuator positions and is accurate enough for the applications being developed so far.

This is where CGTech comes in. Fokker has been using the software developer's Vericut product for metal cutting simulation since 1992 and began looking into its composite products in May last year. As well as being affordable, processes carried out by the robot arm have to be highly repeatable in order to be suitable for production as well as take advantage of its inherent flexibility.

Despite this, Fowkes reports that the whole process was actually quite straightforward, utilising two of its off the shelf products – Vericut Composite Programming (VCP) and Vericut Composite Simulation (VCS). The former has been developed specifically for the generation of fibre placement paths across a range of platforms and is already used to drive more typical fibre placement machines at customers such as Spirit AeroSystems, a primary Boeing supplier. As much of the machine technology was already established, development concentrated on understanding the robot's six axes of motion and developing a specific post-processor to ensure it could be programmed correctly.

"There's a lot of pretty mathematics behind it," adds Fowkes. "Making the jump from the metallic machining workshop to the composites laboratory was also a bigger leap than one might expect. We were working with plastics experts and chemists, rather than CNC machinists, so it was quite a challenge to get our heads around the processes involved. A lot of our work was actually done with the system integrator, the Dutch automation specialist Boikon, who also assembled the mounting frame and tooling, some of which required integration of additional axes, such as a rotating drum for leading edge parts."

Once up and running, the whole programming process, claims Fowkes, is a quick and easy process. Speaking about an example part – a freeform surface (see images above) – "From loading the native CATIA or STEP CAD model, choosing the boundaries, filling the boundaries with material, linking the boundaries in the required order, and making the NC program takes just a few minutes. Then it is simply post-processed for the Fokker robot."

The second half of the package is VCS, which as the name suggests, simulates the entire process to ensure that parts are produced effectively. Having previously simulated robotic manufacturing for a number of years, this was not a problem for CGTech, requiring just a few tweaks to replicate the distinctive head.

"In terms of simulating composites I think we've solved all the difficult problems." concludes Fowkes. "The big challenge I see people facing is to develop an automated lay-up system as flexible and affordable as hand lay-up. There are several competing technologies at the moment and all these people are trying to crack the same problem."

Arnt Offringa, R&D director at Fokker Aerostructures adds: "The proper solution depends on the product size and shape, and its build rate. If you're making a limited size product in small numbers, say a business jet flap of 80cm by 300cm, then a single robotic solution may be a good way to go. But if you want to make something bigger or in larger quantities, like a tail or airliner fuselage panels, systems with multiple synchronised robots and several material widths are more appropriate."

Having now proved the concept with its initial robotic fibre placement cell, Fokker has already commissioned CGTech and Boikon to work on a larger cell with multiple tows. |

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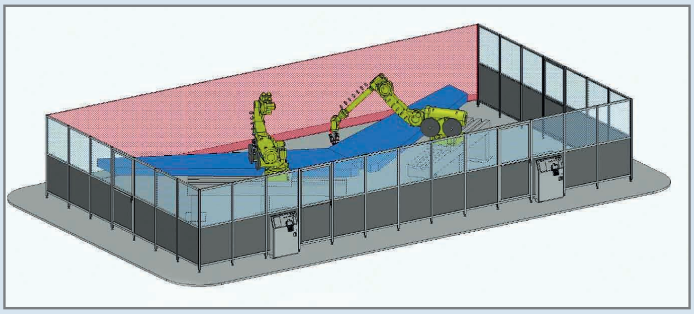

Bigger and better: Synchronised robot cells are the next step