Clarification on composites

Where are we heading regarding the use of composites in military and commercial aircraft? GKN Aerospace explained at this year’s Farnborough International Airshow. Andrew Allcock was there

GKN Aerospace has set itself a target to become one of the world’s top three tier 1 aerostructures businesses, and is also “dedicated to being first in the efficient manufacture of large composite structures”. So says technical director and chief technologist Philip Grainger who is based at the Isle of Wight facility that is leading the company’s charge towards a ‘plastic’ plane future.

CARBON FIBRE WING
The company has already celebrated the delivery of the first set of A400M military transporter carbon fibre wing spars (picture, page 24) – a part that would previously have been made of aluminium. It is the “first ever application of carbon composites to a primary structure on a large transport aircraft wing,” Mr Grainger underlines. Small business jets already use the carbon fibre approach.

And the future is very definitely increasingly composite. As Mr Grainger points out, in the 1970s the Airbus A300 was only 1 per cent by weight composites and, on the military side, the F-16 was only 3 per cent. Today, Boeing’s 787 Dreamliner, which takes to the skies commercially in 2008, will be 50 per cent composite, while the F-35 Lightning II military aircraft, for which deliveries start in 2009, is 45 per cent. Already Airbus has announced its A350XWB, available in 2012, which it says, “will have the highest content of new and advanced materials of any aircraft, including an extensive use of advanced alloys and CFRP (Carbon Fibre Reinforced Plastic)”. In fact, GKN Aerospace’s Mr Grainger says that the next generation of single aisle commercial aircraft will be 60 per cent composite by weight (although for the A350 this also includes aluminium-lithium – carbon fibre composite is nearer 45 per cent). As for the military market, the F-35 is widely reckoned to be the very last of the manned fighter aircraft. Unmanned aerial vehicles (UAVs) are where the future lies and GKN predicts they will have a composite content of 70 per cent by weight. Indeed, the company is already building 45 per cent of the entire structure – all composite – of what was the joint unmanned air combat system (J-UCAS), now the N [Navy]-UCAS (picture, below). Entry into service is currently targeted for 2018.

JET ENGINE POTENTIAL
What is more surprising, perhaps, is that there is potential for a much greater use of composites in jet engines. This area is a bit more contentious than airframes, but GKN Aerospace is keen to push ahead with partners in this area. Mr Grainger says that the next generation of single engine will be 60 per cent composite by weight (although for the GE’s GEnx engine is currently the leader in use of composites (see box,
page 22), in fact. And GKN has been selected by General Electric to develop and supply the first large turbofan containment case to be produced in composite for the new GEnx engine (but not the fan blades), and is also working with Rolls-Royce on the development of all-composite blades for large turbofan engines.

**EFFICIENT MANUFACTURE**

Jet engine parts are smaller, however, and it is in the area of efficient manufacture of large, single-piece composite parts manufactured by automated techniques that the company is focusing its current efforts.

The two main manufacturing techniques used in production of carbon fibre parts are Resin Film Infusion (RFI) and Resin Transfer Moulding (RTM), the latter used for smaller parts such as fan blades and also for the fan frame on the F135 engine for the F-35 fighter, for example. (GKN is focusing on reducing RTM mould tool costs). In RFI, used for the A400M, fibres in tape format are placed over formers/moulds, then transferred to an autoclave where they are subject to pressure and temperature to compact the fibre sheets/tapes and ensure resin permeation. In RTM, pressure and vacuum are employed to force resin through dry fabrics in an enclosed mould tool.

GKN Aerospace has been involved in a number of research programmes which have driven forward its composite knowledge – AWIATOR (EU FP5 – carbon composite large winglets), EFFICOMP (DTI – textiles and new materials including resin systems) – both now complete – and Airbus-led ALCAS (EU FP6 – for a complete carbon composite wing including spars [ends December 2007]) and another current FP6 programme VITAL (Environmentally Friendly Aero Engine) led by SNECMA. GKN Aerospace is also involved with an Airbus co-ordinated UK DTI-funded programme, Integrated Wing, Advanced Technology Verification Programme (IW-ATVP) aimed at delivering a step-change in wing technology and manufacture by 2020, and has itself set out on a three-year research programme to examine how recently developed composite manufacturing techniques can successfully be applied to the closed cell box structures that make up approximately 30 per cent of an airframe’s weight.

In parallel with all this, GKN Aerospace has been developing the A400M military transport plane wing spar. “The A400M spar is an autoclave cured product and I don’t think we’ll make a manufacturing decision to go that route again. But the good thing about A400M is that it has taken us forward in terms of automated manufacture,” Mr Grainger reveals.

**AUTOMATIC TAPE LAYING**

In RFI, the company foresees out-of-autoclave curing as the future (part of ALCAS). This obviates the need for the very large autoclaves currently required which can cost well over £1 million. But apart from their cost, they affect the speed with which parts can pass through the factory.

The future is seen as laying up parts in the ‘flat pack’ form using automatic tape laying machines, taking these flat items and forming them in hot drape forming machines fitted with heated tooling to both press parts to shape and cure them. “We think there are ways of
making parts using hot-drape forming; basically, you can make things as quick as you like and as big as you like,” says GKN.

The hot drape forming technology using self-heated tooling is a UK developed technology with equipment built by a UK firm. The A400 wing spar was shaped but not cured this way.

Supporting this future approach, the company has “a unique tape laying machine which shares some features with the one used for A400M part tape lay-up” housed in its recently built Isle of Wight Advanced Composites Centre, adjacent to its existing facilities.

Automatic tape laying technology (from M-Torres, Spain) obviously reduces labour compared with hand lay-up, but also improves quality – debulking every few layers taking an hour is entirely eliminated.

The A400M wing spar is 23 m in length, comprising two parts, as there is an engine in between. The production process sees the automated tape layer lay up the whole spar in flat form. The edge is trimmed, then the spar turned over and put on a carbon fibre preformed tool. This is then put under a double diaphragm forming press which with pressing the spar to shape takes about 20 minutes. It then goes off to the autoclave. The company has not yet made the next step to heated tooling for this part, but adds that it has not yet found a part that the process cannot deliver.

**INSPECTION ECONOMIES**

Improvement provided by these manufacturing processes will also present the opportunity to depart from the 100 per cent inspection demanded by the use of backing film, which is a feature of manual lay-up. "Sample inspection would be a huge step forward for the carbon fibre industry. There is a big opportunity to do so with automation, because machines don't make mistakes,” says GKN.

The benefits in all this are amply demonstrated by reference to the A400M wing spar. First parts were made via the hand lay-up method. It took 180 hours to lay-up this part, but just one and a half hours with automated tape laying. Even if the tape layer is charged out at £150/hour, it still delivers a cost saving over the £40/hour manual charge. But more importantly, the manufacturing time is dramatically reduced. With a move to out-of-autoclave curing and sample inspection, the benefits are amplified further.

And these benefits are not only seen for new parts on aircraft. There are currently numerous parts already in service which are made via hand lay-up over formers that then have to go into autoclaves. With aggressive cost-down targets to meet in the aerospace industry, many minimally curved parts could benefit from automated flat lay-up and hot drape forming using heated tooling, followed by routing. “This would be a significantly cheaper process than the current method,” says Mr Grainger. Fan cowl doors are a specific example that is “crying out for this process” and the company hopes to have a solution in place by the middle of next year. 

An A400M military transporter carbon fibre wing spar. GKN Aerospace is targeting more efficient manufacture of such large parts at its Isle of Wight facility