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LASING ON THE WING

Matthew Dale on some of the laser processing that goes into building aircraft, from treating carbon fibre wing skins to 3D printing lightweight brackets

Efficient flight is influenced by aeronautical design and weight. In the past few years, metal additive manufacturing has come to fruition for fabricating aircraft components, largely because of the weight-saving advantages offered by the technique. Airbus began series production of 3D-printed titanium parts earlier in the year, concentrating first on a double-walled pipe elbow, part of the fuel system of the A400M transport aircraft. These complex components were previously produced from individual cast parts that were then welded together to form one assembly, but are now built additively using machines from Concept Laser.

Surface enhancement via direct metal deposition

Additive manufacturing tends to deal with smaller parts that fit inside the printing machines. Saving weight on larger sections of the aircraft, like the wings, is also important and most of these components are made from high-strength carbon fibre for this reason. At a conference on laser processing, run by the European Photonics Industry Consortium (EPIC) and held in Vilnius, Lithuania in September, it was stated that the use of these construction methods – both additive manufacturing and techniques for carbon fibre processing – will influence how lasers are adopted by the aeronautics sector in the future.

Lighter and stronger

Sections of the wing, fuselage, and the tail assembly are now made largely with carbon fibre. The established processes for building these structures are by automated fibre placement (AFP) and automated tape laying (ATL), but dry carbon fibre techniques that rely on lasers are improving the fabrication method considerably.

Spanish firm MTorres supplies high-speed ATL machines, Torreslayup, and AFP machines, Torresfiber, used to manufacture wing skins, as well as the stringers and spars that support the skin. 'These processes have seen strong development in the past few years since the first ATL machines have been on the market,' said Xabier Montón, a research and development engineer at MTorres. 'The reason for this is that carbon fibre is being increasingly introduced into the aerospace industry.'

AFP and ATL operate by laying strips of carbon fibre tape across both simple and complex surfaces in multiple layers to form carbon fibre stacks. As the tape is layered, it passes in front of an infrared lamp and under a roller. Pre-impregnated (prepreg) composite fibres bound with an epoxy resin matrix are heated to 45°C by the lamp. The tape becomes tacky, allowing further tape to be layered over it and pressed down by the roller. The resulting structure is then hardened in an autoclave at high temperature and pressure, where the epoxy inside the prepreg material sets. This setting process takes time however, and the prepreg material can be expensive.

These processes are used to build a wide range of parts, with MTorres using them for the tail assembly and fuselage sections, in addition to the wing components. Since 2012, however, MTorres has introduced alternative dry carbon fibre techniques, which rely on lasers, into its build processes.

Dry carbon fibre methods differ from those that use prepreg material, as the laid-up material does not contain any epoxy resin, but rather additives that allow the material to become tacky. Here, a diode or fibre laser heats the dry material additives to 120-180°C in order to layer and bind

MTorres supplies automated fibre placement and automated tape laying machines to produce carbon fibre wing skins

more tape. After that, the material is infused with an epoxy resin similar to that of the prepreg. The structure is then cured in an oven, rather than an autoclave, which greatly reduces the time needed for the structure to set, along with reducing the investment and operation costs.

'Dry carbon fibre is a process that may grow in the future,' said Montón. 'There are some customers who are starting to use dry carbon fibre materials, since they are cheaper to produce.'

At the EPIC event in Vilnius, Montón expressed in a keynote speech that heat treating dry carbon fibre with lasers is becoming more widely adopted in the aerospace industry. Montón also hinted that modular optical systems with auto-focusing capabilities may be required to process the increasing complexity of parts that can be achieved with these new manufacturing techniques.

Making the right cut

With the increased adoption of carbon fibre materials, manufacturers will require tools that are able to process them efficiently. 'There are two approaches that can be used to cut carbon fibre,' explained Klaus Kleine, director of laser applications at Coherent. 'If you want to melt the material at a fast pace on the front of the cutting curve you use fibre lasers in the kilowatt power range, and for high quality cutting you use a pulsed UV laser in a 305-355nm wavelength range.'

> Heat treating dry carbon fibre with lasers is becoming more widely adopted in the aerospace industry

UV lasers offer strong wavelength absorption with a small heat-affected zone, enabling them to produce relatively slow but high-quality cuts. Radiation from CW fibre lasers in the range of 1,070nm is also absorbed well by the material, although the heat-affected zone is broader, resulting in a higher speed, lower quality cut. Rofin FL fibre lasers operating at 2-3kW – technology now owned by Coherent – are used to make these faster cuts, while pulsed UV lasers are used to achieve the slower but higher-quality results.

Coherent's lasers also play a role in cleaning carbon fibre material during production. 'Our nanosecond and picosecond lasers are used in laser ablation processes for surface treatments, where the surface is cleaned to improve the bonding strength of carbon fibre reinforced plastic components,' commented Kleine. Ablation can additionally improve the operating efficiencies of mechanical parts. 'Lasers are also used to treat the side wall surfaces of piston engines,' Kleine explained. 'This process reduces friction and increases the lifetime of the piston itself.'

Layer by layer

Several of Coherent's customers build aerospace manufacturing equipment. 'One of the biggest applications that we see in aerospace is additive manufacturing with fibre and diode lasers,' Kleine observed. The diversity offered by producing structures layer by layer has led to metal additive manufacturing being used for both part maintenance and the manufacturing of complete components, making it a key technique in the aerospace industry.

The additive manufacturing systems provided by Coherent's customers use a method of powder deposition to spread a metal powder layer between 20µm and 100µm thick onto a substrate plate. Once the powder layer is distributed, a laser is used to melt and bond successive layers together. For these applications, a CW fibre laser typically in the range of 500-1,000W is used; however, a diode laser operating at similar powers is sometimes used when high beam quality is not required.

Additive manufacturing is an important technique for repairing damaged parts. 'It has big applications in the repair of turbine blade tips, as well as general repairs to turbine engines,' Kleine said. 'The laser beam quality is not that important in this use of additive manufacturing.' A diode laser is sufficient in this application to clad or coat material to worn sections of the turbine that have been damaged by the 1,400°C engine temperatures, allowing them to be returned to near-pristine condition.

Manufacturer of industrial laser systems OR Laser provides both direct metal deposition