

Multiple-use robots for composite part manufacturing

By



CLÉMENTINE GALLET-HAMLYN
CEO AND CO-FOUNDER
CORIOLIS

For a long time, the composite sector lagged behind in robotics, but its efforts are finally paying off. The use of robotics is a reality, and even growing rapidly in high-tech segments such as aerospace. This development is driven by the search for productivity gains and impeccable quality.

Parts, geometries, materials

Various types of parts can be produced with fibre-placement machines. Many of them are currently made by hand lay-up due to a lack of suitable equipment for automated processes. A variety of parts with particular specifications are currently used in aeronautics.

The main classes of composite parts used in the aerospace industry are:

- Panels and barrels: fuselage, doors, wings, vertical and horizontal tail plane skins, nacelles, tail cones
- Closed surfaces: tail boom, O-spars
- Spars and profiles: C shapes, small corner radius, about 1/4"
- Stiffeners: frames and stringers, Z or omega or delta cross sections, double curved, variable thickness
- Blades: monolithic, closed-mould co-curing of intrados and extrados

When manufacturing such parts, the key issue is to find suitable equipment to work on sandwich or complex composite laminates with the following geometry and processing challenges: Production rates may vary from 10 to 50 kg/hour for parts from 10 kg to 500 kg.

Different materials can be used in the manufacture of pre-specified parts, including thermosets (BMI, phenolics, epoxy), thermoplastics

Table 1: Processing challenges for automation

Sandwich structures	Monolithic structures
Core materials: - Ramps from 30° to 45° - Thickness from 1/4" to 1" - Low-density core-	Lay-up on stringers and/or flexible cores Female or male lay-up
Complex contours and cut-outs Part geometry - Panels or barrels - Female or male lay-up - Double-curved shapes	Double-curved shapes Pad-ups with ramps up to 1/5 Caul-plates, co-curing or co-bonding

(PEEK, PEKK, PPS, PEI, PA, etc.) and dry or bindered tow for out-of-autoclave processes.

Economical aspects

Machine costs, including investment and running costs, should meet changing markets needs. More parts are now sub-contracted to tier-one or tier-two suppliers, who do not have the same potential return on investment as final end-users.

Automation should be affordable, even for small parts which cannot be easily subcontracted in low-cost countries where it is difficult to achieve high-quality primary structures.

Automation should be flexible and

modular, be adaptable or re-programmable for different processes and applications, and reduce the risk of dependence on a single program or contract.

Automation should satisfy the composite material concept instead of the black-metal concept. That means that it should be able to adapt to a variety of different parts/shapes and be compatible with other composite techniques (Z reinforcement, pick-and-place, trimming and non-destructive inspection).

The automation concept should be able to adapt to larger markets (wind blades, automotive, general industry) for greater reliability and performance-to-cost ratios.

State-of-the-art machines and robots

Fibre-placement machines

Most of the fibre-placement systems currently available on the market are based on machine-tool concepts. They were developed on the basis of a milling or drilling machine and optimized for each part or application.

The positive aspects of these machines are that they have no part-size limitations; the negative ones are the huge costs and the risky return on investment (specifically designed buildings, large surface areas, high ceilings and expensive foundations).

Robots

Robots in the industrial world
Standard "off-the-shelf" poly-articulated robots have been developed and produced for many years to meet the requirements of the automotive industry. They have been thoroughly tested, providing users with high efficiency levels and worldwide maintenance knowledge. There are a number of global robot builders, the biggest of them selling

up to 10,000 robots a year. These robots have a payload from 6 kg to 1 ton, and are capable of repeatability from 0.15 mm to 0.5 mm. They can be combined with linear axes up to 60 metres long and spindle axes up to 40 tons.

Robots can collaborate together.

They are mainly used in welding, pick-and-place, milling, drilling, gluing, inspection, food and medical applications. Their mean average costs range from €50,000 to €120,000 per robot cell, the average time between failures being 40,000 hours. The robots can be supplied for APPEX, clean room and water or dust atmospheres.

Fibre-placement robots

Feeding fibres from the creel to the head limits the head movements. Also, embedding the fibres into the head increases the head dimension and weight required to use heavy

robots, but reduces accuracy.

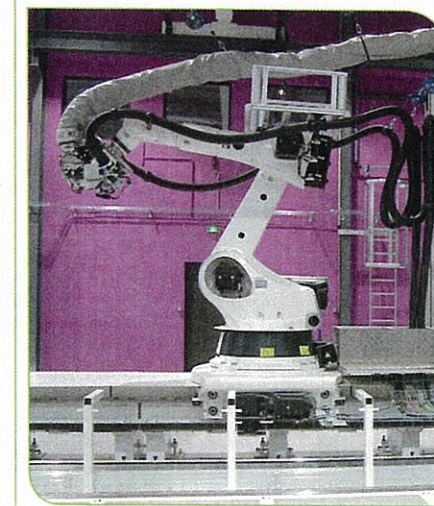
Robots have now reached a level of maturity, accuracy and payload that allows their use in fibre-placement applications. The key issue of using a poly-articulated robot for fibre placement is how to feed the fibre from the creel to the head.

Existing methods are based on feeding or guiding the fibres from the creel using a pulley system, which is too complex. Using a pulley with a robot involves a high risk of fibre damage, due to non-cartesian kinematic movement. Another problem caused with pulleys is the bobbin re-spooling method when the arm comes back from the lay-up position. A possible solution is to build the spools (or the creel itself) in the deposition head.

This leads to either a limited number of fibres laid-up by the head, or the use of heavy payload robots which are slower and less accurate.

A technical platform dedicated to composite materials processing

With the use of composite materials on the rise, the aim is to make Compositadour into a centre of excellence dedicated to processes for the production of composite parts. Becoming more competitive and ensuring process control for industrialized production requires a working knowledge of robotics and automation technology and integrating such technology into the process. To do so, Compositadour is working with public, private and academic partners with the following objectives:



- acquire the technical skills needed to control new material processing technologies as well as structural control and assembly processes;
- develop high-performance composite materials;
- develop and pool new skills around which local training institutions can develop first-rate expertise;
- transfer industrial know how to small and medium-sized regional companies;
- propose the creation of pooled services;
- promote the cluster's/players'/platform's R&D and R&T expertise and the associated production performance.

www.compositadour.estia.fr