Thermoplastic composites production by room-temperature vacuum infusion

The CANOE technical platform recently produced the largest thermoplastic composite boat ever manufactured by vacuum-assisted resin infusion at room temperature. This 9-metre long pirogue opens the way to the production of large, recyclable composite parts with performance similar to epoxy but shorter cycle times.

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Continuous fibre-reinforced thermoplastics (CFR-TP) are gaining more and more importance within the composites industry due to their higher performance and recyclability. However, CFR-TP production generally involves high-temperature moulding, which requires expensive tooling and machines. This is especially prohibitive for large parts (> 4 m²) such as boat hulls or wind blades. Moreover, among the engineering thermoplastics that are cost-compatible with these industries, the water uptake of most of these polymers leads to poor mechanical performance with time.

Thermoset-like processes

The new Elium® thermoplastic resin developed by Arkema overcomes these issues and makes it possible to mould large parts with thermoset-like processes. Its low viscosity at 20°C allows fast and complete infusion without heating. No post-curing is necessary for most applications, due to a high degree of conversion, typically higher than 98%, achieved at room temperature. Post-curing may be recommended for high-end structural parts to obtain maximum performance.

With mechanical properties similar to epoxy, but higher toughness and shorter production cycle times, the Elium® technology is mainly focused on structural parts (Table 2).

Curing at room temperature

CANOE participated in the development of the Elium® technology, specifically providing composite know-how to scale-up the production of large parts. The recent moulding of a 9-metre long pirogue (a boat used in tropical regions) demonstrates the effectiveness of this technology. The pirogue is made of four composite parts that were assembled together by adhesive bonding: a hull, a deck and two watertight bulkheads. All of these parts and the four seatings were bonded with AEC Polymers®' meth-

Tab. 1: Main properties of the Elium resin (source: Arkema)

Heat deflection temperature	109°C	ISO 75/A
Maximum continuous temperature service	85°C	-
Water uptake (8 days)	0,5%	ISO 62
Coefficient of Linear Expansion	0,065 mm/m/°C	ISO 2155-1
K_{Ic}, Fracture Toughness Stress Intensity	1,2 MPa.m$^{0.5}$	ISO 13586

Tab. 2: Main properties of Elium®-based composites using plain weave glass fabric (source: Arkema)

Properties of a composite structural part	Value	ISO method
Tensile strength	557 MPa	527
Tensile modulus	27 GPa	527
Flexural strength	700 MPa	14125
Flexural modulus	27 GPa	14125
Compressive strength	347 MPa	14126
Compressive modulus	28 GPa	14126
In-plane shear modulus	5.600 MPa	14129
Charpy impact strength (un-notched)	206 kJ/m²	179/2D

Fig. 1: Production of the pirogue

Fig. 2: The pirogue in the Arcachon sea

acrylate structural adhesive (SAF® 30), which provides structural bonding with Elium® composite parts, high elongation at break and curing at room temperature in a short time.

Infused under vacuum

The deck was gelcoated with 800 microns of an Iso-NPG gelcoat specifically recommended for marine parts and showing good adhesion with the Elium® resin (Figure 1). The 22 kg of Elium® resin were infused under vacuum in 15 minutes, with a good permeability of the glass reinforcement to this resin. Triaxial non-crimp fabrics (NCF), unidirectional (UD) fabrics and glass mats were used as reinforcements for the part. The hull infusion took 35 minutes for 45 kg of resin. Due to the size of this part, a resin with a long open time was used, and the demoulding process took 6 hours after the end of the infusion. With more reactive grades, demoulding times between 1 and 2 hours can be achieved.

As a conclusion, this first pirogue moulding (Figure 2) demonstrates the availability of a new thermoplastic technology that was developed to decrease the cost of recyclable composite parts in order to make composites an even more environmentally-friendly material. ■

More information:
www.elium-composites.com

Focus

Established in 2008 under the leadership of the Aquitaine Regional Council, CANOE is a scale-up technology platform based in Bordeaux and Pau, in the South West of France.
It is staffed by a team of 25 qualified engineers and technicians with expertise in chemistry and materials. The platform has pilot facilities to help the industry (SMEs and large groups) develop products/processes in the field of composite and advanced material technologies, including:
- synthesis and formulation,
- thermoplastic and elastomer mixing,
- thermoplastic impregnation,
- composite processing,
- thin film deposition,
- spinning technologies,
- additive manufacturing,
- materials characterization and non-destructive testing (NDT).

CANOE covers the whole value chain of composite materials, from the design step up to the industrialization stage: formulation chemistry, characterization and prototyping.
The platform provides research and training services in response to industrial needs. It coordinates both national and European cooperative R&D projects.
Its industry customers are recognized leaders in the fields of transportation (aeronautics, automotive, railway, sailing and marine), renewable energy (photovoltaics and wind blades), green chemistry, printed electronics and sustainable building.