Aerospace looks to composites for solutions

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New materials to reduce weight and speed manufacturing processes are being demanded by the aerospace industry and composites are rising to the challenge. Reinforced Plastics reports.

The global demand for aircraft is growing and the aerospace industry is calling on composites to meet its needs to reduce weight, as well as improve manufacturing times and save costs. The composites industry is developing new products to meet these needs and increasingly many of these are out of autoclave.

Reducing costs is a major priority in the aerospace industry at present, according to Tim Herr, Aerospace Director at Victrex. “Aircraft manufacturers are pushing to absorb a 9–10 year backlog and need solutions that reduce manufacturing and operating costs,” he says. “In order to increase manufacturing throughput and satisfy growing demands for an ever faster aircraft build rate, one area of focus is composites. Composite manufacturing incorporates the design flexibility and fast production to improve manufacturing efficiencies, with the potential to simplify design, while providing weight savings to lower operational costs.

“As the industry continues to emphasize the buy-to-fly ratio, the efficiencies of continuous manufacturing and material utilization make composite solutions extremely attractive for aerospace applications. Analysts are projecting a 33% growth in the global composite market for aerospace to 96 million lbs. (43.5 million kg) in the next five years. Within that space, thermoplastic composites are expected to reach 2.1 million lbs. (1 million kg) representing 83% growth for reinforced thermoplastic materials.”

In order to meet these market needs Victrex has combined thermoplastic composite engineering and new manufacturing techniques with polyketone material technologies to create novel solutions for the aerospace industry. “The processing and performance benefits of polyketone composites are too compelling to ignore,” Herr explains. “When compared to thermoset composites, polyketone composites can be produced out of autoclave and dramatically reduce cycle times from hours to minutes, increasing throughput up to 90%. For conventional metal solutions, polyketone composites deliver weight savings of up to 60% with equal or better stiffness. Moreover, the design flexibility of polyketone composites enables engineers to design highly-functional components to simplify, standardize and consolidate parts to reduce assembly times and manufacturing costs. Structural or loaded brackets are an obvious choice for polyketone composite solutions. The technology reduces manufacturing processes and time when compared to thermoset and metal components while reducing downtime for maintenance because of the material’s high mechanical, chemical and corrosion resistance.”

Commercial aircraft use thousands of brackets and system attachments from the cockpit to the tail of the plane. The total amount of these components on an aircraft can add a significant amount of cost and weight especially if they are made from machined metal or thermoset lay-ups. The VICTREX PAEK-based components (Fig. 1) can be manufactured more efficiently than conventional thermoset alternatives, and can deliver significant weight savings compared to stainless steel and titanium while offering equivalent or better mechanical properties such as strength, stiffness and fatigue.

Chief Executive David Hummel adds that the company has an exciting opportunity to accelerate innovative and differentiated solutions for the aerospace industry in markets where polyketones have a strong advantage. “Our Aerospace Loaded Brackets program is a great example of how we can offer new forms and components, alongside supplying materials, and build a new supply chain to address the unmet needs of the aerospace industry,” he says.

According to Victrex, the main advantage of thermoplastic polyketone composites over thermoset composites is rapid manufacturing. “Thermoplastic composites are suitable for out of autoclave processes and reduce cycle times from hours to
minutes,” adds Tim Herr. “For OEMs and Tier 1 manufacturers, polyketone composites will reduce process bottlenecks and have the potential to increase throughput by up to 90%.”

In order to accelerate the commercial adoption of polyketone (PAEK*) composite applications within the aerospace industry, Victrex and Tri-Mack Plastics Manufacturing Corporation have established a joint venture, TxV Aero Composites. The multi-million dollar investment includes the establishment of a new US-based manufacturing facility. The new company will be a total solutions provider for polyketone composites, from concept development through commercialization. The companies add that by combining expertise in materials, engineering, development and manufacturing, TxV Aero Composites will be able to address customer challenges with dedicated speed and focus. The intent is to offer a range of PAEK composites, from custom laminates to pre-formed composite inserts for hybrid molding processes, as well as finished composite parts and complete overmolded hybrid composite components and assemblies. One example is VICTREX AE™ 250 composites, a new lower temperature processing PAEK-based composite product family that enables a hybrid molding process. This innovation is claimed to combine the strength of continuously-reinforced thermoplastic composites with the design flexibility and proven performance of VICTREX™ PEEK injection molding polymers (Fig. 2).

Tri-Mack Plastics is a long-standing partner of Victrex and has a reputation for developing and manufacturing complex parts and assemblies for the aerospace industry. TxV Aero Composites will establish a purpose-built polyketone composite center of excellence in the USA, due to be completed in 2017. Commenting on the joint venture, Will Kain, President of Tri-Mack states: “With an estimated 35,000 new aircraft to be launched in the next 20 years, the aerospace industry is embracing thermoplastic composites as a cost-effective solution to support this growth. The efficient processing and performance advantages of PAEK thermoplastic composites combined with state-of-the-art automated manufacturing will position TxV Aero Composites to meet the industry’s cost and weight challenges.”

Tim Herr also believes that the joint venture offers a great many advantages to advance the use of polyketone technology in aerospace. “The supply chain for PEEK overmolded hybrid composite components is in its infancy and the learning curve can be lengthy and complex,” he says. “TxV Aero Composites brings together Victrex’s experience of making markets where polyketones have a strong advantage with Tri-Mack’s more than 40 years of specializing in high temperature thermoplastics and thermoplastic composites. TxV Aero Composites is positioned to address the unmet needs of the aerospace industry by combining expertise in materials, engineering, development and manufacturing.”

Herr adds that TxV Aero Composites will operate globally as a total solutions provider capable of assisting customers in all stages from concept development, through prototyping, and on to commercialization.

There are no plans for further manufacturing facilities elsewhere in the world at present. However, he says that Victrex remains open for new challenges and opportunities in the aerospace industry.

The companies believe that there are also likely to be many new applications for polyketones in the future. “Any applications where weight, cost, efficiency or performance are critical engineering requirements are a good fit for polyketone composites,” concludes Tim Herr. “By fine tuning the material properties, we can envision significant opportunities for structural brackets in the fuselage, engine and landing gear, for example. Moving beyond existing design, new electric/hybrid propulsion systems is a topic that may play a significant role in future aircraft. If strength-to-weight ratio and manufacturing efficiency remain key requirements, the future looks bright for polyketone composite solutions.”

**Reduced carbon footprint**

Saving weight and making aircraft more fuel-efficient to reduce the carbon footprint continue to be the main drivers in the aerospace
industry, according to Bertrand Germain, VP Aerospace Marketing Europe at Hexcel. “Opportunities for new composite solutions can be found across the full spectrum of aerospace programs,” he says. “These include commercial aircraft structures and interiors, aircraft engines and nacelles, helicopter structures and rotor blades, defense aircraft, space launchers and satellites, UAVs, and the tooling required for composite structures.”

There is also a significant move toward cutting manufacturing costs. Germain continues: “This has led to greater automation and the development of new product forms for prepreg – optimized width and thickness such as for slit tape – as well as new out of autoclave technologies, such as HiTape, HiMax™ NCF and RTM6-2. In addition, there is a requirement for complex shaped parts that could not be made from traditional composite forms, which has led to the development of HexMC molding composite. Other products we have developed recently for aerospace applications include: HexPly® M92 for higher performance from a lower temperature curing prepreg; Acousti-Cap for the development of quieter aircraft engines; and HexTool® for high temperature resistant tooling suitable for curing aircraft structures that could be modified when design changes were required without any loss of integrity.”

The company says that HiTape® high performance dry unidirectional reinforcements are designed to meet the requirements of aircraft primary structures made by cost-effective out of autoclave technologies, such as vacuum infusion or injection (Fig. 3). HiTape® allows dry preforms to be manufactured in a fully automated lay-up, similar to the AFP and ATL processes widely used for UD preps. The tight width tolerance of HiTape® gives total control of the automated dry preform process – and it is a waste-free operation, even for complex structures, as the materials are placed exactly where required. Using out of autoclave vacuum infusion technology, aircraft structures made with HiTape® demonstrate fiber volume content and mechanical properties that are very similar to parts made with the latest generation primary structure prepregs. HiTape® gives particularly high compression after impact (CAI) performance, which Hexcel says is a real breakthrough in infusion technologies with unidirectional carbon reinforcements. Based on HexTow® carbon fibers, Hexcel also supplies HiTape® with HexFlow® infusion epoxy resins for optimum mechanical performances and infusion/injection processing (Fig. 4.).

According to Hexcel, HiMax™ multiaxial reinforcements, also known as non-crimp fabrics (NCF), are multiple layers of unidirectional fibers, with each ply placed in a different orientation or axis (Fig. 5). These layers are then typically stitch-bonded to form a fabric. Multiaxial reinforcements provide strength and stiffness in multiple directions depending on the controlled orientation of the fibers. The weight distribution in the fabric is optimized and it is possible to mix fiber types. The straight uncrimped fibers allow good resin penetration and flow which is ideal for infusion and light-RTM, while the stitching aids resin migration through the layers (Z-direction) which is suitable for maximizing infusion rates. The non-crimp concept allows in-plane mechanical properties to be enhanced, such as tension and flexion. In a complex lay-up there is less material waste and the lay-up time is reduced by using thicker materials.

The latest generation of commercial aircraft and engines have an increasing number of large flight critical composite structures, and a number of smaller parts with complex geometries are required to connect these structures together. In the past these connector parts would have been made from metal and be susceptible to fatigue and
corrosion. Hexcel’s HexMC® technology is based on high performance aerospace grade carbon fiber/epoxy materials that can be molded into complex shapes in cost-effective series production (Fig. 6). The resulting parts demonstrate performance levels comparable to carbon fiber/epoxy prepregs and the weight savings reduce aviation fuel consumption and increase aircraft payload.

HexPly® M92 prepreg is claimed to combine all the major benefits achieved individually with other 125 °C curing epoxy resins in one new ‘multi-purpose’ system. These benefits include good hot wet Tg performance at 115 °C, allowing HexPly® M92 to operate at higher service temperatures from a lower cost 125 °C cure. The system is self-adhesive to honeycomb, making it suitable for sandwich structures, as well as monolithic components. Other benefits include high toughness, fire resistance, low exotherm and a long out/tack life. HexPly® M92 is available in a wide range of prepreg forms (woven and UD tape).

Also for aerospace applications, HexTow® HM63 has the highest tensile strength of any high modulus carbon fiber and provides good translation of fiber properties in a composite, including interlaminar shear and compression shear strength.

According to the company, HexWeb® Acousti-Cap® sound attenuating honeycomb enables aircraft engine designers to achieve good acoustical performance, including significant noise reduction during take-off and landing without a structural weight penalty (Fig. 7). This marks an improvement on current technology which requires trade-offs between weight and noise reduction. HexWeb® Acousti-Cap® consists of permeable cap material embedded into honeycomb core to create an acoustic septum. Customers specify the flow resistance characteristics, overall core thickness, and number of caps in a cell and insertion depth. The result is a product tuned to the acoustic requirements. HexWeb® Acousti-Cap® honeycomb is used by GE and Rolls-Royce to save weight and reduce engine noise by up to 30%. It is used in the LEAP engine on the latest Boeing 737 MAX, which entered into service in May 2017.

Hexcel adds that HexTool® composite tooling material enables the high tolerance accuracy of metals to be combined with the extreme lightness of carbon fiber composites (Fig. 8). This new concept for lightweight, efficient large-scale tools is cost-effective compared with conventional composite tools and metal molds, especially those made from Invar®. Long tool life, ease of use, and the machinability of cured structures are some of the primary reasons HexTool® is being chosen for the tooling for composite structures on new generation aircraft, says the company.

**Structural prepregs**

Solvay has also developed out of autoclave composite technologies suitable for aerospace applications, which include vacuum bag only (VBO) prepregs and compatible adhesive and surfacing films. These structural prepregs include the CYCOM® 5320-1, MTM® 44-1, MTM® 45-1, and VTM® 260 series. The company says that they are engineered to give low porosity, long out-life and simple cure cycles. Film adhesives, such as FM® 309-1, FM® 209-1 and VTA™ 260 have been developed for VBO cure and offer good mechanical performance. Surface Master® 905 and VTP® 266 are claimed to be ideal surfacing films for VBO applications.

The company has also introduced PRISM® EP 2400 and PRISM® TX 1100 dry tape for resin infusion technology. PRISM® EP 2400 is a toughened epoxy system with a long pot life and low viscosity, making it ideal for large primary structures. PRISM® TX 1100 is a compatible dry carbon tape used to build an infusion preform with automated fiber placement (AFP) equipment. These materials have been qualified by United Aircraft Corporation for the Irkt MS-21 wing structures developed and manufactured by AeroComposite. In addition, CYCOM® PR 520 is a tough resin offering good damage tolerance and strain capability, allowing the replacement of metals. It is used on highly engineered parts such as the fan blades and containment case on Safran’s LEAP engine.

Solvay has also supplied Torlon® polyamide-imide (PAI) to Performance Plastics Ltd., an injection molder of precision
engineered components, for its new line of EnduroSharp™ Scraper Blades for aerospace maintenance applications. The company says that Torlon® PAI enables these new tools to be tough enough to maintain their edge longer than blades molded from competitive polymers, but safe enough to remove challenging materials from delicate surfaces.

The Torlon® PAI blade handles and inserts enable aerospace maintenance professionals to remove elastomeric coatings, boots, tapes, sealants, adhesives, gap fillers and tape residue safely from fiber reinforced composite, plastic, glass, ceramic or metal substrates and fasteners. The PAI blades can also be used in conjunction with heat- or chemical-assisted skiving processes to permit material removal. The company says that Torlon® PAI combines the performance of thermoset polyimides with the melt-processing advantage of thermoplastics.

TenCate Advanced Composites has introduced TenCate Cetex TC1225 – an engineered PAEK-based thermoplastic prepreg that harnesses high performance mechanics with lower processing temperatures for aerospace applications. Suitable for overmolding with PEEK, the PAEK composite materials are claimed to enable form freedom and part consolidation in the highest performance applications. They are available in carbon-based UD tape, laminates and semi-preg fabric formats. The company has also developed TenCate TC380 – a toughened epoxy with good compression after impact and open hole compression strengths, making this system ideal for aerostructure applications on helicopters, UAVs and military aircraft.

TeXtreme® Spread Tow carbon fabrics and UD tapes from Oxeon have been certified for use in commercial aerospace applications and qualified by a leading aircraft manufacturer. HAECO was searching for a material that would reduce weight and enable significant savings in fuel costs for airlines. HAECO turned to TeXtreme® to help optimize its current seat design for weight, while still maintaining mechanical properties. TeXtreme® used calculation, simulation and manufacturing support to help HAECO reduce the weight of the aircraft seat by almost 20%. This part made of TeXtreme® is now in production and is scheduled to be delivered in 2017.

Diab has signed a long term agreement with Diehl Aircabin to supply Divinycell F and other structural foam core materials for aircraft cabin interior applications, including the Airbus 350 XWB and Boeing 777. Diab says that increased production rates for new aircraft require more industrialized manufacturing. Traditional honeycomb solutions require intensive labor to get a good surface finish, as well as closing edges to avoid moisture absorption. Divinycell F minimizes the need for labor intensive and costly putty, sanding and sweeping steps to achieve a high-quality surface finish. Featuring closed cells and minimal water absorption, Divinycell F also eliminates the need for edge fill. Many honeycomb panel designs now incorporate Divinycell F as an edge close-out.

According to the company, using Divinycell F can save up to 20% weight compared to Nomex honeycomb solutions, which translates into substantial cost savings. The Divinycell F production line also has the industry’s shortest lead time and highest production capacity. Divinycell F is claimed to withstand high temperatures and exceeds all Fire, Smoke, Toxicity (FST), and OSU heat release requirements for aircraft interiors. The thermoplastic foam adapts to multiple production processes, reducing cycle time and cost to yield more design freedom. Current applications include first and business class seats, as well as lavatory interiors, galleys, luggage bins, cabin air distribution and window frames for the Airbus 350 XWB and other aircraft.

Henkel Adhesive Technologies has started construction of a new production facility for aerospace applications at its Montornès del Vallès site in Spain. The new line will serve the growing demand for high-impact solutions supporting key trends in the global aerospace industry, such as lightweighting and automation. The facility will include new buildings and equipment for additional production and warehouse capacities. The first customer deliveries are projected for 2019 (Fig. 9).

“The global demand for passenger aircraft is expected to double by 2034, making this a very attractive growth market for us,” says Jan-Dirk Auris, Executive Vice President Henkel Adhesive Technologies. “Aircraft manufacturers and their suppliers are ramping up capacities to support this significant increase in the build rate. Our investment in Montornès will provide additional production capabilities in order to further support global growth in the aerospace market. We believe that our high-impact materials and our expertise are essential for our customers to effectively increase efficiency and to respond to the key market trends.”

**FIGURE 9**

Henkel has a long-standing partnership with Airbus.