ELG Carbon Fibre open house showcases recycling technology

Carbon fiber recycler ELG Carbon Fibre sheds light on its recycling and manufacturing operation in the UK.

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A section of BLS's Xenos chassis. ELG's recycled carbon fiber mat is beneath the surface layer of NCF that can be clearly seen. Only a small number of mechanical fasteners are used to hold the five separate sections together, while adhesive is injected into the tongue and groove joints.

Carbon fiber recycler ELG Carbon Fibre Ltd., formerly known as Recycled Carbon Fibre Ltd. (Coseley, West Midlands, UK), has come a long way since it was acquired in 2011 by ELG Haniel (Duisburg, Germany), a long-established recycler of high-quality metals, principally stainless steel and super-alloys. ELG Carbon Fibre hosted its first Open Day recently to showcase its technologies and materials.

Since the acquisition by ELG Haniel, Frazer Barnes, ELG Carbon Fibre's managing director, and his team have, via their close associations in industry and with academia across the globe, and with their very active portfolio of R&D projects, become well known for mastering the technology of high-quality carbon fiber recycling. ELG achieved quality accreditation to AS/EN9100 in 2015 and are currently implementing ISO 14001:2017 and its supporting standards with regard to environmental management and emissions.

ELG's first Open Day, after an introduction by Barnes, consisted of a guided tour of the ELG facility, followed by talks by two of ELG's customers on the application of recycled fiber with some interesting case studies.

Meeting the growing demands of cost and supply

Since 2011 the company has, year on year, doubled its output up to 2015, having produced more than 1,000 tonnes of reclaimed carbon fiber in that year. Historically, much of this material has been used by the oil and gas industries. However, since 2013, ELG has increased focus on the development and commercialization of products for the transportation industry. This was a prescient move, with the rapid fall of oil prices in 2015 leading to a significant reduction in the material volumes used by the oil and gas industries. As ELG has completed development of new products, attention is now focused on meeting the increased volumes required by the electronics and automotive sectors.

Barnes explained that the first two questions coming from automotive OEMs when considering carbon fiber use are cost and supply chain security. ELG can favorably answer both questions. Barnes explained that the cost of recycled carbon fiber is typically 40% less than virgin fiber on a unit cost performance basis. Further, by careful design, it is often possible to achieve very similar weight savings. The use of a sizable proportion of recycled fiber is therefore essential to meet the cost expectations of the automotive industry.

With regard to supply chain security, there are currently around 24,000 tonnes of waste carbon fiber generated each year as a result of manufacturing operations, although more modern processes such as automated fiber placement (AFP) lead to significant reductions in the amount of waste generated. However, Barnes went on to explain, with the overall expansion of the carbon fiber industry, ELG still expects the amount of waste generated from manufacturing operations to reach 32,000 tonnes by 2021. Much of this comes from established, long-term programs using high-quality fibers and ELG has contracts with a small number of prominent OEMs and Tier 1s to secure the materials it needs to feed its business until 2022.

A further benefit, particularly for the automotive industry, is reduced environmental impact. Recycled fiber only uses about 10% of the energy required for the manufacture of new fiber, and this gives a significant advantage when it comes to life cycle analysis. Whereas a vehicle may need to be driven 100,000 miles before there is a positive effect on global warming potential (balance between original embodied energy and fuel saving through vehicle life), for virgin carbon fiber products, this positive balance is achieved in less than 10,000 miles when recycled carbon fibers are used to achieve the same weight saving.

Returning to feedstock, the larger proportion of composite parts are yet still in service and won't reach end-of-life for some years. As an example, a conservative estimate indicates that an Airbus A350 contains about 14 tonnes of carbon fiber in its airframe and, perhaps by 2035, the first of these will arrive with the recycler at end-of-life. And, of course, commercial aircraft have been usimg a substantial proportion of carbon fiber in their construction in recent decades, and much of this will start to reach end-of-life soon. ELG are already prepared for substantially large composite parts with a large shredding machine that can handle the very toughest of matrix resins at a current rate of up to 4 tonnes per hour. In essence, ELG are well-prepared for the toughest jobs that come their way.

Automotive OEMs driven by environmental legislation

It is also the case that automotive OEMS are driven by legislation. For example, the European Union end-of-life-vehicle (ELV) directive requires that 85% of the material of vehicles manufactured from 2015 onwards must be reusable or recyclable. Recycling of CFRP, once considered not viable, is now a “must-do.” ELG's efforts of recent years have provided a solution and recycled carbon fiber will be vital to fill the cost/supply gap. As well, the OEMs have to provide the lightweight solutions that carbon fiber can provide. At the time of writing (June 2017) typical emissions of a new larger automobile are around 115g CO_2/km. The target for 2021 is 95g CO_2/km. The penalties for non-achievement could be significant, being as much as $1 billion for a larger OEM explained Marco Gehr, ELG's chief operating officer, in a recent ELG Technical Note.

Gehr also highlighted that ELG currently processes about 125 kg of product per hour and about 25% of this is manufacturing waste, i.e., remnants of prepreg and offcuts of dry carbon fiber. And the collection of this waste is no random unmanaged process. Gehr went on to explain ELG's focus on quality. Every received batch of material can be fully traced back to the originally manufactured carbon fiber batch and identified to type. ELG does not directly disclose the source of its waste, but suffice to say that much comes from transportation industries.

ELG's product range

ELG Carbon Fibre produces products under the trade name of Carbiso for the composites and the plastics processing industries. Carbiso M series are drapable mats of 100% carbon fiber that can be processed with thermoset liquid resins by most conventional means; Carbiso TM are mats comingled with thermoplastic fibres for thermoforming processes. The mats are available in standard weights from 150-500 gsm and in widths up to 2.7m; bespoke sizes to customer specifications can also be supplied on request.

As well as the Carbiso mats, of which ELG produces up to 250 tonnes per year in either the Carbiso M and TM ranges, it also produces up to 1,000 tonnes of milled carbon fiber destined to thermoplastics compounding. ELG also manufactures up to 200 tonnes of chopped fiber 3-24 mm long, and 1,200 tonnes in the 30–150 mm range. The chopped fiber can be supplied as is, or in the form of pellets mixed with thermoplastics for injection molding.

Product testing and R&D

Gehr explained that although the mats are composed of randomly distributed fibers and are of essentially isotropic nature, the intrinsic strength of the fibers is only marginally reduced by ELG's pyrolysis process, and the stiffness/modulus of the fibers is hardly affected, if at all. During processing the fibers are reduced from continuous fibere to millimetr lengths. However, as Gehr pointed out, the typical fiber diameter is around 7-8 microns, meaning that the aspect ratio of the fiber is still considerably high, which explains the good properties achieved by ELG's material.

ELG routinely tests the properties of its fibers with a Favimat single filament testing machine in its well-equipped R&D laboratory. The R&D laboratory and associated facilities also feature:

- Two development non-woven lines
- An impregnation line capable of producing development prepreg and SMC
- Manufacturing station for vacuum infusion, liquid compression moulding and prepreg compression moulding
- A heated 150-tonne 600 by 600-mm press for manufacture of thermoset and thermoplastic laminates
- A Zwick testing center for testing laminate mechanical properties
- Various test equipment for measuring fiber length and fiber length distribution, moisture content, flow characteristics of milled fiber and fiber contents.

ELG receives two types of carbon fiber for recycling: manufacturing waste and end-of-life parts. At present waste predominates. The first stage involves the removal of any material that may be disruptive of the process — metal, for example. Much of the waste is remnants from prepreg cutting machines and generally arrives complete with the original polythene backing still in place. It is not necessary to remove this, as polythene is completely combusted in the pyrolysis process.

The pyrolyzing furnace is capable of producing 1,500 tonnes of clean carbon fiber a year. However, the precise design of the furnace is an incremental work in progress to further improve efficiency, both to reduce costs and to ensure that ELG continues to meet its obligations of environmental compliance. The output emissions of the furnace are carefully monitored to ensure that the type and quantity of emissions are well within the regulatory limits. In normal conditions, with waste from a well understood source, all is well. But, if any contamination has entered the process, or if the material is from a less well understood source, trials are necessary so that process conditions can be optimized for both fiber mechanical performance and emission levels.

Production of nonwoven recycled carbon fibre mats

Mathilde Poulet, lead product development engineer, was on hand during the factory tour to explain the process of the manufacture of non-woven recycled mat. The product running at the time was one of ELG’s Carbiso TM range with polypropylene fiber; the process for 100% carbon fiber mat is essentially the same.

Poulet explained that the first stage of the process was one of “opening.” On exit from the furnace the fibers are still lightly adhered together in the general form of the fabric from which they were originally made. These fiber bundles need to be opened up into loose fiber bundles before the machine carding operation.

Poulet further went on to explain some care is needed here to ensure the best final product; not enough “opening” means more work for the carding machine to perform and a risk of unopened fiber bundles in the finished product; too much opening may weaken the fibers and hence reduce the quality of the final product.

The talks

The day finished with two invited speakers who have used ELG products.

An interesting presentation was given by Rob Elliot, technical manager, Sanko Gosei UK Ltd. (Skelmersdale UK), manufacturers of thermoplastic injection molded parts for the automotive industry. Elliot presented to the audience a structural beam (see photos) that had been trialled with a thermoplastic compound containing ELG recycled material; the original parts are glass filled. Elliot explained that while work would be required to optimise the process, nonetheless their trials were very promising. A drop-in replacement of ELG carbon fiber for a similar volume of the currently used glass fiber gave promising indications of better cost, weight, strength and part stiffness. Their work continues.

The other talk was given by Antony Dodworth, chief technology marketing officer, Bright Lite Structures (Peterborough, UK). Bright Lite Structures (BLS) pride itself on innovation and has developed its own process of composite structure manufacturing. Amongst other things they company has designed and built the chassis of the *Xenos* E10 sports car, which features a big proportion of ELG’s recycled carbon fiber mat in its construction. The essence of BLS’s design is simplicity. The chassis consists of five parts that are adhesively bonded together via simple tongue-and-groove joints.

BLS uses ELG mat in combination with noncrimp fabric from Hexcel (Duxford, Cambridge, UK). They also include other forms of virgin carbon fiber, e.g. UD material, in some areas of the structure where extra stiffness and /or strength are required

BLS’s chassis design also features a unique light-weighting core material. Dodworth explained that he was inspired by his daughter playing with drinking straws in MacDonald’s. Dodworth needed a core that, unlike hexagonal honeycomb, showed no directionality in its properties, a circular cell core being ideal. BLS now makes its own core from “straws” of recycled polycarbonate. The best bond possible was needed to bond the composite skins to the core. To meet this need BLS worked closely with Huntsman Advanced Materials UK Ltd. (Cambridge, UK), which developed a BLS PU/epoxy resin that is compatible with polycarbonate. Dodworth explained that the polycarbonate “squeezes down to nothing” in parts of the molding where it isn’t required.

The future

ELG is perhaps fittingly situated in the heart of the UK's industrial "Black Country" in central England, alluding to the region's coal-fuelled industrial past. It is certain though that ELG doesn’t dwell in the past. The ELG plant is the first and largest of its kind in the world and growth is certain. Recently ELG have announced its intent to expand with a new plant situated in the USA. To facilitate its intent to achieve this goal in the next five years, ELG has recently joined the Institute for Advanced Composites Manufacturing Innovation (IACMI, Knoxville, TN, US). ELG is also a member of the UK’s National Composite Centre in Bristol, UK.