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AS LONG AS IT'S GREEN...

WITH FUEL COSTS RISING AND OIL RUNNING LOW, COMPOSITE MATERIALS MADE FROM NATURAL RESOURCES COULD BE SET FOR GREAT THINGS. BUT EVEN 'NORMAL' COMPOSITES HAVE MUCH TO OFFER IN TERMS OF SUSTAINABILITY

ABOVE: **DuraPulp – a mix of wood pulp and renewable polymers – is one of a host of new, more environmentally friendly composite materials emerging onto the market**

Offering the potential to increase fuel efficiency via weight reduction – thereby reducing CO_2 emissions and cost of ownership – composite materials have played a key role of late in improving the environmental impact of both off- and on-highway vehicles.

Yet although some operators still view their durability with a healthy skepticism, this is an area that is now further adding to the green credentials of composite materials. When used to substitute material that is prone to impact and damage, for instance, they can also support the strength and durability of products over time. They also offer the opportunity to introduce new solutions to shape vehicles for improved cosmetic and functional design, replacing materials that are less malleable or lose strength through processing.

Rodney Hansen, MD of Dark Matter Composites, a consultancy offering composite training and advisory services, certainly believes that maintainability is one reason composites should be employed, particularly as an alternative to steel: "The advantage they have over traditional metal and plastic panels is they're corrosion resistant and can be made impact resistant. Once you have corrosion resistance, you reduce maintenance costs."

Carbon fiber is, says Hansen, most commonly used today, but he thinks the biggest potential growth lies in thermoplastics and natural fibers. "A thermoplastic is quite a soft material, but with enough fiber reinforcement it becomes tough and impact resistant," he comments. "So it's perfectly suitable for use as an alternative to SMCs in body panels."

One US company, Advanced Composites Engineering, specializes in the manufacture of carbon fiber, composite-reinforced plastic structures and molded products. MD Joe Albertelli furthers the discussion of robustness: "If thermoformable composites are utilized, when a structure is damaged, it can be heated and reworked. There are plastic composites, such as Spectra that have damage-tolerant, impact-resistant laminates, which we use in high-impact environments."

However, Albertelli says higher costs are currently a deterrent in their wider implementation, but he believes that, as fuel costs continue to rise, this will change.

But John Darlington, head of product management at TenCate Advanced Composites, a developer and manufacturer of thermoplastic (TenCate CETEX) and thermoset composite materials, isn't convinced remolding after impact is practical: "Unreinforced thermoplastic sheet material is durable anyway – it will flex, but recover. Remolding it is possible, but requires the component to be raised in temperature to above the softening/melt temperature – sometimes above 200°C – to enable the part to be repaired. Ensuring that durability meets customer needs is the primary goal."

Weight issues

For some vehicles – those lifting pallets off the ground, for example – composites could make them lighter and, therefore, more fuel-efficient. TenCate's John Darlington believes

there's room to develop how composites are used in forklifts: "The forks on the front count against you weight-balance wise; they're no more than a simple I-beam design. With carbon fiber, the I-beam would become a durable, stiff structure at a reduced weight. This could be done in a thermoplastic or thermosetting resin matrix."

"Lighter-weight composites can certainly be an advantage for truck performance and fuel efficiency," says Craig Walby, director of product management at Toyota Material Handling Europe, "but maintaining overall vehicle weight can also be important when it comes to counterbalanced trucks."

And Walby explains just how robust composites can be: "We're using composite material on some panel areas of our trucks – this is instead of steel. On some high-impact panel areas that are prone to damage, composites can play a part in improving durability – and therefore cost of ownership for our customers."

TMHE is using composite material for improved strength and durability on its recently introduced BT Levio-P powered pallet trucks. The same material is also used in the automotive industry.

The OEM is investigating how composites could further innovate its forklifts. "However," Walby adds, "composites have scope to improve truck functionality and design by applying new possibilities into our thinking – but we need to ensure that their use will bring real operational benefits for our customers and that the cost of composites in our overall product cost supports our product value and price in the market. Any composite use also needs to support our goal of improving the recyclability of components we specify into the trucks we supply."

The end of the road

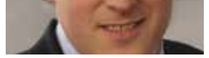
Indeed, as recycling legislation gets tighter, Rodney Hansen suggests the composite industry is investing in R&D to enhance recyclability possibilities: "There are ways to recycle glass fiber into cement production, coal, sand and aluminum oxide, which is used in cement processing." He cites the Compocycle process, where for 10 tons of fiberglass product, it's possible to replace 4.5 tons of coal, 2 tons of chalk, 2 tons of sand, and 1.5 tons of aluminum oxide.

Most of the fibers offered by Composites Evolution, a supplier of sustainable materials whose products include fiber reinforcements, resins, and intermediates based on natural, bio-derived, recycled and recyclable feedstocks, are continuous, aligned yarns. These are converted into a fabric, consolidated by thermoset and thermoplastic matrixes, and can replace fiberglass and thermoset resins, which have a variety of environmental impacts.

The company has investigated whether parts can be granulated and chopped at end of life and turned into an injection-molding grade material that can be formed into other parts, such as automotive parts and consumer goods. "You change from using a continuous fiber to a chopped fiber," sales manager Gareth Davies explains, "but you only lose a small amount of stiffness and strength each time you recycle the material."

To enable ease of recycling, the company is developing a range of self-reinforced polymers based around the PET polymer family because of the amount of PET recyclates there are from post-consumer sources. "At end of life, you can granulate and reprocess them into one material so that you don't have mixed waste that's generally burned," he explains.

And Telene is also looking at various end-of-life options, including recyclability – sales and marketing manager Ralph Hédel says the company has proven that it's possible to regrind Telene parts in normal recycling equipment and mix with other polymers or resins.



"COMPOSITES HAVE SCOPE TO IMPROVE TRUCK FUNCTIONALITY AND DESIGN BY APPLYING NEW POSSIBILITIES INTO OUR THINKING"

Craig Walby, director of product management at Toyota Material Handling Europe

MAIN IMAGE: **Emasia is a hybrid vehicle 'eco-designed' in partnership with Ecole des Mines from Alès and the automotive builder PGO (Hemra model), with the use of technical flax reinforcements from Dehondt Group's Flax Technic line**

RIGHT: **Composites are improving the strength and durability of Toyota's BT Levio-P pallet trucks**

NATURAL DEVELOPMENTS IN COMPOSITES

Researchers from the University of Texas have created a new carbon fiber from plants, which can replace common petroleum and oil-based products. Made from C-lignin, a linear polymer, this is claimed to be stronger and lighter than similar products on the market.

Nandika D'Souza, joint professor in the departments of mechanical and energy engineering, and materials science and engineering at UNT's College of Engineering, says, "Unlike carbon fiber made from other ligno-cellulose or lignin sources, C-lignin is ideal for creating naturally sourced carbon fiber because C-lignin fibers are linear and can easily be processed into carbon fiber with the same equipment often used to produce fossil-fuel-based carbon fibers."

Elsewhere, a British paper and technical fibers company, James Cropper Speciality Papers, and the Swedish forestry giant Södra, are now ready to commercialize DuraPulp, a sustainable alternative to plastic, claiming it's capable of carrying the weight of an adult and can be composted within 100 days.

The bio-composite material is made from pulp and a renewable polymer. Once additional processing has been carried out, it becomes moisture resistant, stronger and more rigid.

Wider adoption

It's legislation and the need to remove an over-reliance on crude oil that our experts agree may be the ultimate motivator for the wider adoption of composites.

CCP Composites develops, produces and distributes solutions for composites. A market leader in thermoset composites, it offers sustainable solutions – to produce these, the company's new Life Cycle Assessment (LCA) approach of the products can be systematized. The use of this multi-step and multi-criteria methodology makes it possible to take into account the overall environmental impacts of products, from extraction of raw materials to the end of lifetime, to evaluate all environmental impacts and adopt a truly cross-functional approach, avoiding pollution shifting from one step to another.

Jonathan Brunette, sustainable development manager at CCP Composites, says, "LCA studies can be carried out to compare the environmental performance and benefits of composites with those of other materials. Composites can be used for various applications and offer a lighter alternative to metallic parts, as well as strong mechanical properties."

Advanced Composites Engineering's Joe Albertelli suggests that in the future, "Instead of using a thermosetting-type plastic, we'll have automated manufacturing procedures combined with new ways of manufacturing, such as thermoformable composites instead of thermosetting composites. These have much quicker consolidation times; minutes instead of hours.

"There will also be an increase in the utilization of net-molded

ABOVE: **CCP Composites says its Life Cycle Assessment means the full environmental impact of its products can be evaluated**

BELOW: **Biotex Land Rover door module**

THE ONE-PIECE CAB?

Rodney Hansen points out that the moldability of composites should be taken advantage of. "With tractors, for instance, you need a cab and body panels as housings," he explains. "If you used moldings that were single pieces, large pieces, or replaceable panels, the parts count can be significantly reduced. So you could update a product rather than buy the next one.

"In addition, the operator's cab and body panels need to be impact resistant and withstand the elements. A range of composites could be used for this, including glass fiber, natural fibers, polyester resins and thermoplastic resins."

He suggests that composites could be designed and molded into one piece to do a structural job – in a cab, for instance, for ease of maintenance, environmental resistance and impact resistance. "It's the optimum design," he says. "You could create a standard cab, which could fit onto a range of items, and a standard dash control, which could map onto a range of products."

Composites Evolution's Gareth Davies agrees there's more scope for composites in cab flooring and panels: "Natural fiber-based reinforced plastics are noise and vibration absorbent, ideal for over-the-engine applications."

ACE's Joe Albertelli also recognizes the benefit of molding a one-piece cab: "Building complicated 3D shapes that are aerodynamic is more costly for steel parts, but entirely possible with composites. And as fuel continues to become more expensive, and more aerodynamic vehicle structures become a necessity, the demand for composites will continue to grow."

SUSTAINABILITY IN COMPOSITES

composite parts instead of overmolded composite parts," he adds, "where in a standard vacuum-forming, compression-molding technique, a technician might put so many parts of composite in, and then the part is formed under heat and pressure. After the cure cycle, dwell time, and the part comes out of the mold, it has to be trimmed and drilled.

"Utilizing net-moulding, using a closed cavity tool, could get costs down to where parts could be mass manufactured, as with steel – where, instead of having a dwell time, the roll of steel goes through the tool and die quickly."

There are new materials that are thermoformable, analogous to a standard vacuum forming or thermoforming of a plastic sheet such as an AVS, where you can take a very thin sheet of a polycarbonate, and pre-laminate or pre-tack it to a sheet of carbon fiber or fiberglass, then run it through vacuum forming, compression molding, or blow-molding equipment, so that there is no dwell time, aside from the heating and cooling.

"That's where I believe the future of composites large-scale will be going," Albertelli states.

Sustainable targets

With forecasts suggesting that crude oil resources may only last another 60 years and with prices high, many industries are looking at turning to bio-composites as a way of becoming more sustainable.

BELOW: **Electric tricycle SCUBE with bodywork made of technical flax**

REINFORCING THE IMPRESSION

In a recent TenCate project, composites were used in crop-spraying equipment, the Wingssprayer. The boom on the back of a tractor where the spray heads sit is made of metal and there is only a certain length it can be because of the weight on the back of the tractor. By making the back section out of fabric-reinforced thermoplastics (TenCate CETEX TC1100), it is possible to have a boom that is 2m longer.

It's also chemically resistant – important because pesticides can be abrasive – and there was a considerable weight reduction. Selecting the correct resin was critical to meet the performance requirement, without over-specifying and making a costly solution.

FiMaLin is a non-profit-making association of over 20 companies in France whose purpose is to organize an industrial supply of high-quality technical flax fibers for composite applications, improve the fibers' mechanical properties, and develop a quality label, Qualiflax, to award to producers able to guarantee their supply with respect to fiber and semi-product properties.

Vice President Marc Audenaert explains, "Flax-reinforced composites are lightweight and high performance. With equivalent stiffness, you can expect weight savings of 10-15% over composites with glass fibers if you take the same polymer or the same resin. And if the mechanical properties improve, you can expect 15-20% weight savings."

As flax fibers cannot be processed above 230°C, it's in the interest of the processing industry to closely collaborate with fiber and polymer suppliers. "That's what FiMaLin is able to achieve," he says.

There's ongoing research into the composites' moisture absorption and its influence on their mechanical properties, but "it'll greatly depend on the kind of polymer you use in combination with the flax", Audenaert explains. "The bio-based polyamides, produced by Arkema, are in that respect good candidates for reaching high-performance properties."

Composites Evolution offers a couple of families of natural fiber reinforcement, flax and jute, which are suitable for semi-structural applications. Its Biotex Flax woven fabrics are reinforcement textiles based on natural flax fiber and designed for fiber-reinforced polymer composite applications. And Biotex Jute offers a favorable stiffness-to-weight ratio, but at a price that rivals glass fiber.

Davies comments, "There's a question mark over the long-term supply of carbon fiber, and with the move to decouple resources from oil, our natural fibers are the perfect solutions. They provide the high performance and easy processing normally associated with glass fiber composites, but with lower weight and less environmental impact." **iVT**