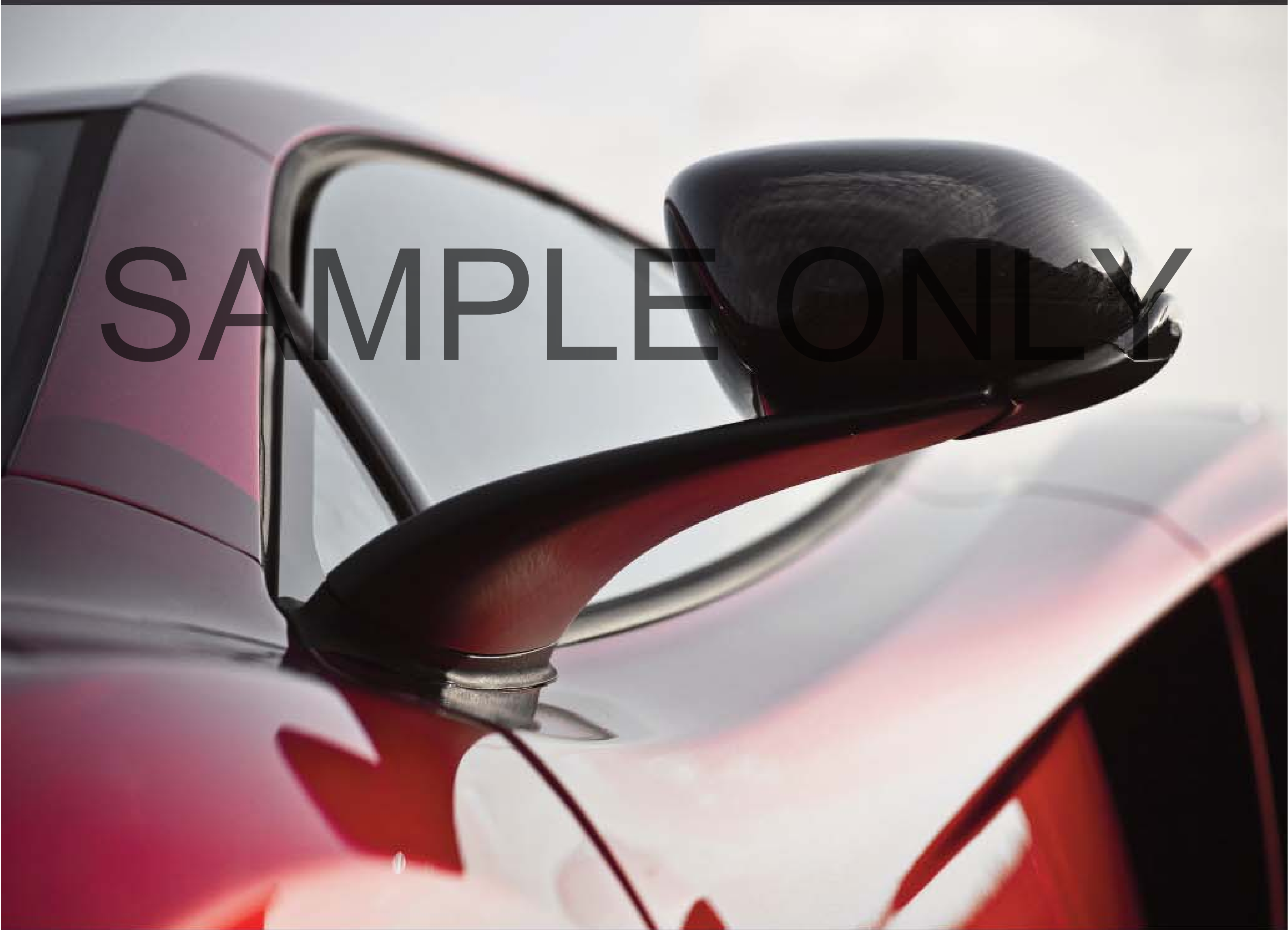
AUTOMOTIVE COMPOSITES

From steel to carbon and from glass to grass



Adrian Wilson

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Automotive Composites

From steel to carbon and from glass to grass

1st edition
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Chapter 1: Introduction: a paradigm shift

The global automotive industry's annual turnover is now approaching a value of €2trn. To put this in context, the UK, the sixth-richest country in the world, was worth an estimated €1.5trn in 2010, and France as the fifth largest, €1.7trn.

The world's vehicle population is now more than 1bn (while in 2011, the world's population is estimated to hit 7bn). But there is currently a sense that this huge industry is poised to change as never before, opening up a wide range of new opportunities.

The key issues driving this change most certainly include the ongoing global shift in mass vehicle manufacturing centres from the US, Europe and Japan, to developing countries, notably China and to a lesser extent India, and the attendant migrations in both the markets and the balances of power between the automotive manufacturers.

China

Just six years ago, in 2005, it was widely predicted that China would account for approximately 50% of automotive growth in Asia between 2006 and 2010, and that some 6.5m vehicles would be made in the country in 2010.

This turned out to be something of an underestimate, and as automotive production collapsed in the US, Western Europe and Japan, 8.9m light vehicles were produced in China in 2008.

China then became the world's largest car market in 2009, when sales in the country climbed by 45% and production reached 13.6m units. In 2010, China's production of cars and commercial vehicles was 18.3m units.

Economic crisis

The economic crisis of the past few years also continues to have far-reaching effects on the automotive industry and the way it operates globally. At the same time, massive efforts are required to harmonise requirements and technology, with marked differences from one country to another, resulting from different public policies, local conditions, infrastructures and economies of scale.

Beyond this, however, are environmental and social concerns that call for a paradigm shift – not only in the way the automotive industry is structured, but also in what it is producing.

Safety and environment

The two key factors influencing this – improving safety and reducing environmental impact – are nothing new in themselves, but while today there are more vehicles on the road

Chapter 4: The composites market

As has been established, the global composites industry is now producing an annual 8m tonnes of product, worth an estimated €60bn in 2010, and with an average value of €7.2 per kg. However, the per kg value of that product currently differs widely from region to region.

With a 36% market share by value and 35% by volume, the value of North American composites production is estimated at €22bn, equating to an average unit price of €8.2 per kg. Overall production volume in 2010 was 2.7m tonnes.

In the EMEA (Europe, Russia, the Middle East and Africa), 2m tonnes were produced, 33% of the market by value and 22% by volume, with a value of €20bn and an average unit price of €8.4 per kg.

In Asia-Pacific and the rest of the world (including Australia and South America), the average unit price of composites is much lower, at €5.5 per kg. The 3.3m tonnes produced in these regions in 2010 had a value of €18bn, representing 43% of the market by volume, but just 31% by value.

This is explained by the increasing use of primarily carbon composites in higher-end applications in North America and EMEA – most notably so far in aerospace and wind energy – with consequently higher prices.

Table 9: The composites market, 2010

	Production volume (m tonnes)	Production value (€bn)	Share by volume (%)	Share by value (%)	Average unit price (€/kg)
North America	2.7	22	35	36	8.2
EMEA	2.0	20	22	33	8.4
Asia/Rest of world	3.3	18	43	31	5.5
World	**8.0**	**60**	**100**	**100**	**7.2**

Source: JEC Composites

Growth similarly varies greatly by sector, with the smaller markets – by volume, though certainly not added value – continuing to grow rapidly. Between 2004 and 2008, for example, the wind energy market grew from 102,000 tonnes to 322,000 tonnes.

Wind Energy

By individual region, composites for wind energy grew from 70,000 tonnes to 123,000 tonnes in Europe between 2004 and 2008.

Chapter 7: Carbon fibre automotive applications

Carbon fibre reinforced plastic (CFRP) has a wealth of benefits as a material for a vehicle body. It is extremely corrosion resistant and does not rust, giving it a far longer lifespan than metal. Complex corrosion protection measures are unnecessary and CFRP retains its integrity under all climatic conditions.

In its dry, resin-free state, CFRP can be worked almost like a textile, and as such allows a high degree of flexibility in how it is shaped. The composite only gains its rigid, final form after the resin injected into the lattice has hardened.

The high tear resistance along the length of the fibres also allows CFRP components to be given a high-strength design by following their direction of loading. To this end, the fibres are arranged within the component according to their load characteristics. By overlaying the fibre alignment, components can also be strengthened against load in several different directions.

As a result, the components can be given a significantly more efficient and effective design than is possible with any other material. The ability of CFRP to absorb energy is also unique.

Formula 1 and beyond

At the beginning of the 1960s, Lotus introduced the monocoque to Formula 1 (F1) racing by placing thin plates around the bars of the car frame to increase the stiffness of the chassis.

During the 1970s, aluminium was mostly used for these constructions, but when they proved to be not as resistant as required to deal with the downforce of the wings, a self-supporting chassis made with carbon fibre was introduced, initially by McLaren – the McLaren MP4/1.

This offered an unbeatable combination of strength and lightness. It had an immediate dynamic impact, with John Watson winning the 1981 British Grand Prix at Silverstone. It also proved an effective safety cell – Watson walked away from a dramatic high-speed crash at Monza, Italy, later that season. Within a few years, every other Formula 1 team had followed suit and today, most parts of the racing car chassis – the monocoque, suspension, wings and engine cover – are built with carbon fibre.

The chassis is usually the first part of the car to be built, owing to the amount of time required, and F1 teams generally use the prepreg-in-autoclave method involving carbon fibres, a pre-impregnated epoxy resin and an aluminium honeycomb layer, which is sandwiched between two layers of carbon fibre.

Chapter 8: Carbon fibre companies

Japan's Big Three – Toray Industries, Toho Tenax and Mitsubishi Rayon

The production of viscose (rayon) fibres in the early part of the 20th century, followed by the advent of synthetic fibres, can be considered the pivotal period in the industrial awakening of Japan, and led to the growth and development of three highly diversified multi-corporations of today – Toray Industries, Teijin (the parent company of Toho Tenax since 2007) and Mitsubishi Rayon.

Toray first emerged as a producer of rayon staple fibre in the late 1920s, before diversifying into synthetic fibres and other businesses. The Azuma Rayon plant, which was established even earlier, in 1915, spawned today's Teijin empire, while its subsidiary Toho began separate rayon production in the 1930s, as did Mitsubishi Rayon (then known as Shinko Jinken).

As detailed in Chapter 6, these three Japanese groups now account for a significant percentage of global carbon fibre production, with Toray claiming a leading share of 34%.

There is a notable drive by the research and development (R&D) departments of all three companies to develop faster moulding processes for carbon fibre reinforced plastic (CFRP).

Toray Industries

With 2010 sales of US$18.5bn, Toray's activities by business segment and percentage of sales for the year to March 2011 are shown in Table 26.

Table 26: Toray Industries, net sales by business segment, 2011[1]

Business	Net sales (¥bn)	%
Fibres and Textiles	584.1	38.6
Plastics and Chemicals	382.3	24.5
IT-related Products	262.0	16.9
Carbon Fiber Composites	67.0	3.7
Environment and Engineering	178.2	11.8
Life Science and Other	52.4	4.5
Total	**1,526.0**	**100.0**

[1] year ended 31 March

Source: Toray Industries

Because the Japanese fiscal calendar falls awkwardly (the year ends on 31 March), it is worth noting that 2010 sales for all Japanese companies showed results for only the first

Chapter 11: Glass fibre composite automotive applications

As noted in Chapter 3, the transportation industry accounts for around 28% of all composite end-uses worldwide, and as high as 43% in some regions. The bulk of this consumption, however, is currently in public and industrial transportation vehicles, where applications include:

- large panels for trailer walls;
- floor panels for railway carriages;
- truck cabins;
- exterior body moulding;
- bus body shells;
- cargo containers.

The lightweight, high-strength, corrosion resistance and design flexibility afforded by glass fibre reinforced plastic (GFRP) translate into greater fuel efficiency, dimensional stability, greater cargo/passenger capacity, lower manufacturing costs, lower maintenance costs, enhanced aesthetics and parts consolidation in such applications.

A company such as Acrosoma (formerly Composittrailer) based in Belgium, for example, has made a considerable number of composite transportation trailers and containers with materials based on a patented process, which combines pultrusion with an adapted version of the tufting technology generally used for the production of carpets.

This gives the company continuous production of around 150 m^2 per hour, or 250,000 m^2 annually, of continuous quality product. The resulting material is lightweight, with high buckling resistance, strength and stiffness.

The full benefits of composites in the goods transportation sector, meanwhile, are defined by Martin Marietta Composites in Table 39. These advantages are particularly relevant when considering the challenges faced by the trucking industry, including:

- fuel costs;
- driver shortages and retention;
- government regulations in respect of weight, emissions, fuel economy and hours of service;
- congestion;
- motorway maintenance.

Chapter 12: Leading glass fibre manufacturers

Owens Corning

Following the completion of its acquisition of Saint-Gobain's Reinforcements and Composite Fabrics businesses for US$640m in November 2007, Owens Corning considerably strengthened its position as the market leader in glass reinforcements and composites.

The company operates within two segments – Composites, (which includes the Reinforcements and Downstream businesses) and Building Materials, (which includes the Insulation, Roofing and Other businesses).

Table 41: Owens Corning: financial performance, 2006-2010

(US$m)	**2006**	**2007**	**2008**	**2009**	**2010**
Net sales	5,399	4,978	5,847	4,803	4,997
Net earnings (loss)	407	95	-813	64	933

Source: Owens Corning

Composites accounted for approximately 37% of total net sales in 2010.

Table 42: Owens Corning Composites business: financial performance, 2006-2010

(US$m)	**2006**	**2007**	**2008**	**2009**	**2010**
Net sales	1,382	1,695	2,363	1,633	1,906
EBIT	108	123	208	-33	175

Source: Owens Corning

Like many other companies, Owens Corning's performance bounced back in 2010 following the recession years of 2008 and 2009, and in its latest report it was predicting an increase in earnings before interest and taxation (EBIT) of 25% in 2011 for the Composites business.

Owens Corning's glass fibre materials can be found in more than 40,000 end-use applications within seven primary markets:

- power and energy;
- housing;

Chapter 15: Natural fibre automotive applications

The return of the utilisation of natural fibres in automotive applications began in the 1990s, initially in Europe, and a few years later in North America.

Car makers started advanced developments on door panels, headliners, package trays, dashboards and trunk liners based on natural fibre composites with a thermoplastic or thermoset matrix, challenging mainly glass fibre reinforced plastic (GFRP) composites.

Of particular influence was the introduction of the door panels in the Mercedes-Benz E

Table 54: Examples of established natural fibre automotive components, Europe

Manufacturer	Models	Applications
Audi	A2, A3, A4, Avant, A8, Roadster, Coupé	Seat backs, side and back door panels, boot lining, hat rack, spare tyre lining
BMW	3, 5, 7 Series and others	Door panels, headliner panel, boot lining, seat backs
Daimler/Mercedes-Benz	A, C, E and S Series	Door panels, windshield/ dashboard, business table, pillar cover panel
Fiat	Punto, Brava, Marea, Alfa Romeo 146, 156	Various
Ford	Mondeo CD 162, Focus	Door panels, B-pillar, boot liner
Lotus	Eco-Elise	Sisal carpets, hemp Class A panels
Mercedes-Benz Trucks	various	Internal engine cover, engine insulation, sun visor, interior insulation, bumper, wheel box, roof cover
Peugeot	New model 406	Seat backs, parcel shelf
Renault	Clio	Rear parcel shelf
Rover	Rover 2000 and others	Insulation, rear storage shelf/ panel
Saab	various	Door panels
Seat	various	Door panels, seat backs
Toyota	Brevis, Harrier	Door panels, seat backs
Vauxhall	Astra, Vectra, Zafira	Headliner panel, door panels, pillar cover panel, instrument panel
Volkswagen	Golf, Passat, Bora, Fox	Door panel, seat back, boot lid finish, boot liner
Volvo	C70, V70	Seat fillings, cargo floor tray

Source: ADAS

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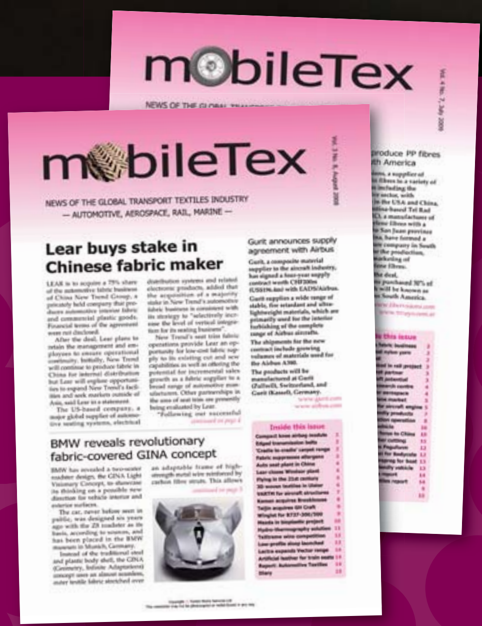

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— AUTOMOTIVE, AEROSPACE, RAIL, MARINE —

Lear buys stake in Chinese fabric maker

Gurit announces supply agreement with Airbus

BMW reveals revolutionary fabric-covered GINA concept

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