Global carbon fibre market remains on upward trend

The association of composite companies and research institutes Carbon Composites e.V. has produced its fifth annual review of the global carbon fibre reinforced plastics market. Mark Holmes reviews the findings and outlook of the 2014 report, which continues to show carbon fibre use on the increase.

The composites market report produced by Carbon Composites e.V. (CCeV) and the AVK has appeared annually since 2010 and is now in its fifth year of publication. The authors believe that the report is also now steadily winning recognition beyond the borders of the German speaking world. With 251 members (August 2014), the CCeV represents a significant number of companies, research institutes and organisations operating in the carbon fibre (CF) and carbon composites (CC) sectors in Germany, Austria and Switzerland.

In the CF market, for example, CCeV members include SGL, Toray, TohoTenax, Cytec and Hexcel which were responsible for approximately 53% of global production in 2013 and an annual CF production capacity of 55,200 tonnes. These figures underline the international influence of the CCeV's membership. CCeV adds that the information in the report is drawn from various sources including data provided by its members. This has been supplemented and checked against current market data from reports produced by Lucintel and Acmite, among others.

The global carbon fibre market

CCeV says that the 2014 edition of the market report will continue to look at the development of the global carbon fibre market as it has done over recent years (Figure 1). At 46,500 tonnes, actual global demand for carbon fibre in 2013 was somewhat lower than estimated in last year's market report. Consumption was 6.9% higher than 2012 and has grown by a total of 47.6% compared to 2008 – this corresponds to an annual growth rate of 8.1%. If 2009, the year after the financial crisis, is taken as the base year (26,500 t), the annual growth rate calculated is even higher at 15.1%. According to Acmite, global revenues for the carbon fibre market in 2013 totalled US$1.77 billion. In 2012, this figure was US$1.63 billion.

The report looks at the development of carbon fibre demand over the last few years (Figure 1), and shows that the market has enjoyed steady and continuous growth since the general economic recession in 2009. During this period, demand for carbon fibre grew from 26,500 t in 2009 to 46,500 t in 2013 with high annual growth rates starting at an initial level of over 20% and easing to a current level of nearly 7%. This corresponds to approximately US$1.7 billion on the revenue side.

The demand forecast provided in the last market report for the next few years has been revised downwards slightly due to the availability of new and more up-to-date data. However, it still anticipates high annual growth rates of around 10% until 2020.

By manufacturer

The report continues that between 2011 and 2013 all the leading manufacturers of carbon fibre expanded their production capacity dramatically in order to cope with the continuously growing global demand. In addition, new capacity was built – especially in Russia, South Korea and India. Excess capacity of 41% is being reported for 2013 for carbon fibre based on polyacrylnitrile

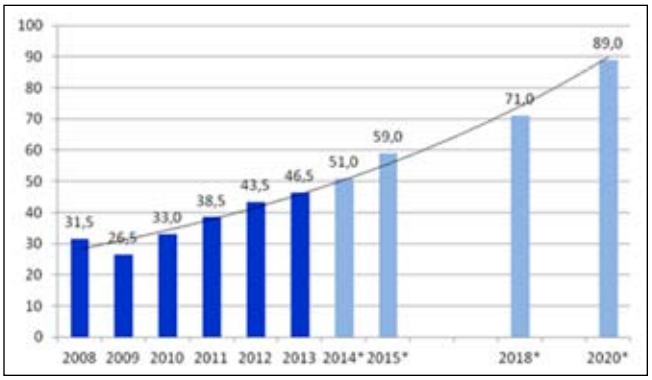

*Figure 1: Global demand for carbon fibre in thousand tonnes 2008–2020 (*estimate).*

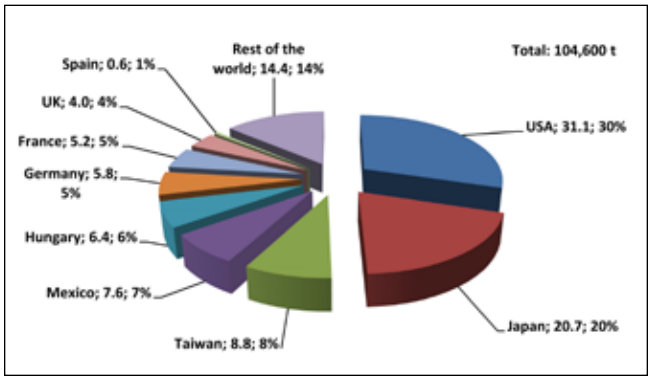

Figure3: Annual CF production capacity by country/region in thousand tonnes.

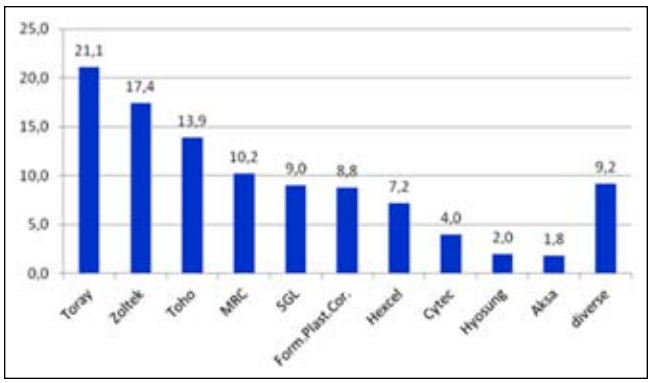

Figure 2: CF capacities by manufacturer in thousand tonnes (2013).

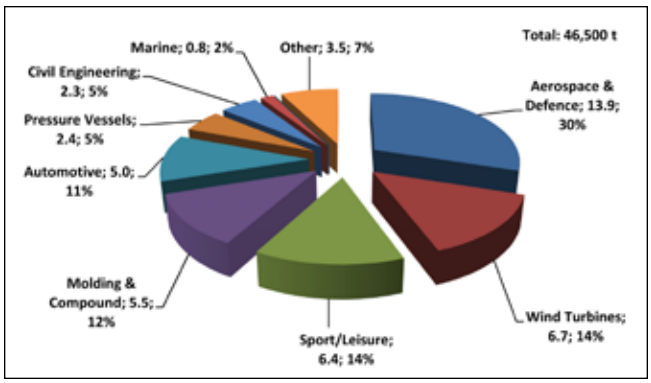

Figure 4: Global CF demand by application in thousand tonnes (2013).

(PAN). Consequently, the market leaders barely installed any additional production capacity in 2013 and the first half of 2014. This is probably due to the presence of unutilised existing capacity.

Figure 2 shows the carbon fibre production capacities of various manufacturers. Overall, the carbon fibre market is concentrated in the hands of ten market leading fibre manufacturers, who controlled over 91% of production capacity in 2013.

In March 2014, Toray completed its acquisition of Zoltek and thus significantly extended its market leading position. SGL has also announced that it will expand its annual production capacity. SGL and BMW invested US$100 million in a joint project and increased capacity at the Moses Lake facility in the USA from 3000 to 6000 t.

According to CCeV, as these production lines were not yet operational at the time of writing this market report, they have not yet been included in this overview of manufacturers. In 2014, the theoretical total production capacity is around 101,200 t of PAN-based carbon fibre. In Japan, the USA and China, carbon fibres are also manufactured using pitch as the precursor material. The total capacity for this method is around 3,400 t per year.

By region

The theoretical combined total capacity is therefore 104,600 t of carbon fibre in 2014. The annual production capacities by country/region are shown in Figure 3. The most important regions continue to be North America with 30% of production capacity, Europe (24%) and Japan (20%). 'Rest of the world' essentially combines the capacities available in China, South Korea, Russia and India. No reliable figures are available for the production capacity of companies registered in the People's Republic of China in particular. Contrary to the official figures, the actual total capacity of all manufacturers in the country is probably still well under 10,000 t. CCeV says that it continues to expect only moderate growth rates here as these companies only have limited access to the necessary technologies for manufacturing precursor materials and carbon fibre.

By application

Over the past year there have been a number of changes in the application areas for carbon fibre. Aerospace and defence applications have grown significantly and are now the largest consumers of carbon fibre – 13,900 t or 30% based on a total of 46,500 t (Figure 4). These are followed by products for the sport/leisure sector and wind turbines, which each account for 14% of total demand. The automotive segment is becoming increasingly important with consumption of carbon fibre more than doubling over the past year to approximately 5,000 t. This is probably due to the ramp-up phase for the production of the i-models from BMW. Other applications include moulding and compounding,

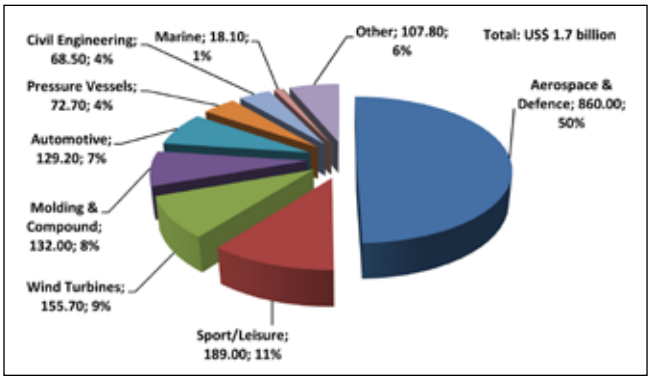

Figure 5: Global CF revenues in US$ million by application (2013).

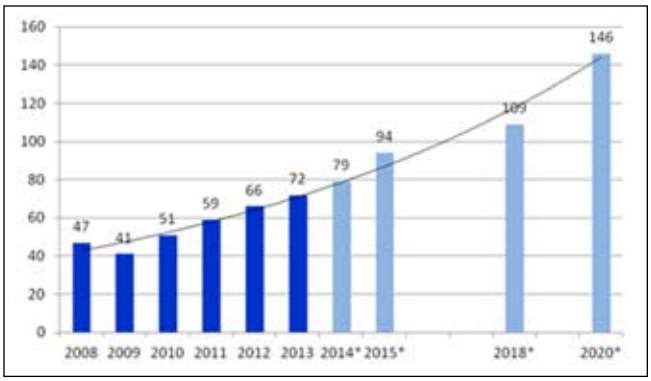

*Figure 6: Global CRP demand in thousand tonnes 2008–2020 (*estimated).*

plant construction, pressure vessels, civil engineering and marine.

When analysing carbon fibre revenues by application (Figure 5), CCeV explains that it must be remembered that there are differences between the sectors in terms of the standard manufacturing processes and quality requirements. For example, the aerospace and defence sector consumes 30% of the carbon fibre manufactured but generates 50% of global carbon fibre revenues. Aerospace and defence applications are not only subject to high quality standards but also incur high licensing and material inspection costs.

In all other application areas, the percentage is lower in relation to the quantity of material manufactured. However, the order is the same as that shown in Figure 4. There has been a significant increase in carbon fibre consumption and revenues generated, particularly in the aerospace and defence, civil engineering and automotive sectors, compared to 2012. In percentage terms, these gains have been at the expense of the wind turbine segment.

The global carbon composites market

Virtually all carbon fibre manufactured worldwide is used in combination with a binding matrix to produce carbon composites. As a result, the growth trends observed in the carbon fibre and carbon composite markets are very similar. The significantly higher tonnages stated in this section are due to the addition of the matrix component.

Figure 6 shows the development of global CRP demand in tonnes. In 2013, demand for CRP was around 72,000 t, an increase of 9.1% compared to the previous year. Growth in CRP consumption is forecast to continue at 10.6% until 2020, essentially matching that of carbon fibre.

By matrix

Carbon fibre reinforced composites are manufactured using a variety of matrices. Although carbon, ceramic and metal matrix materials are used in special applications, CCeV says that the focus of the following section will be primarily on carbon fibre reinforced plastics (CRP). In 2013, carbon composites generated total revenues of approximately US$14.7 billion, of which CRP accounted for US$9.4 billion (Figure 7). Composites based on a polymer matrix were therefore responsible for 64% of revenues.

The matrix polymers used in CRP production can be further divided into thermoplastics and thermosetting plastics (see right hand pie chart in Figure 7). Thermosetting plastics continue to be the polymer matrix used most commonly with carbon fibre. This is also reflected in the revenue shares of these two polymer types in the total revenues for CRP.

CCeV adds that a number of factors have contributed to the more established market position of thermosetting plastics, such as:

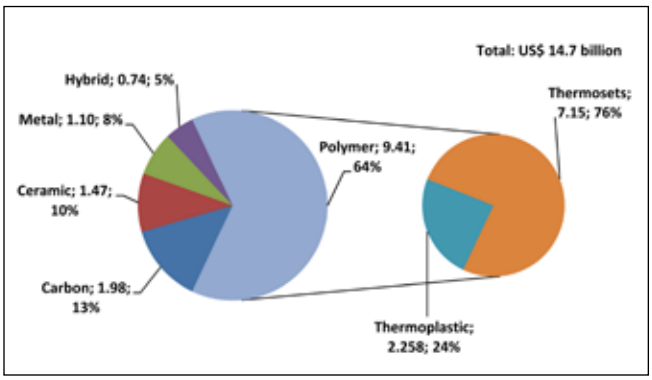

Figure 7: Carbon composite revenues in US$ billion by matrix material (2013).

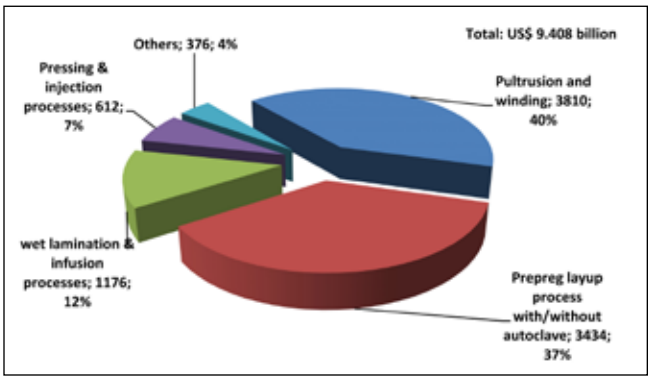

Figure 8: CRP market share in US$ million by manufacturing process (2013).

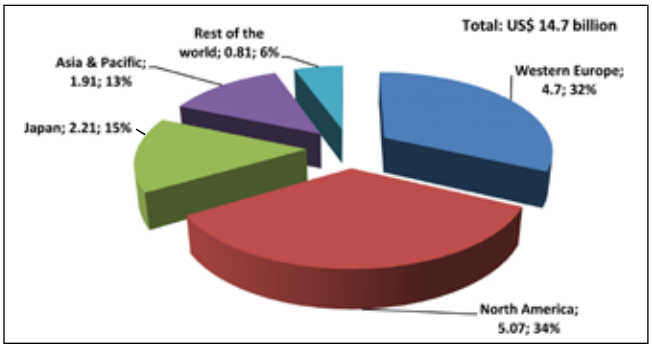

Figure 9: Carbon composite revenues in US$ billion by region (2013).

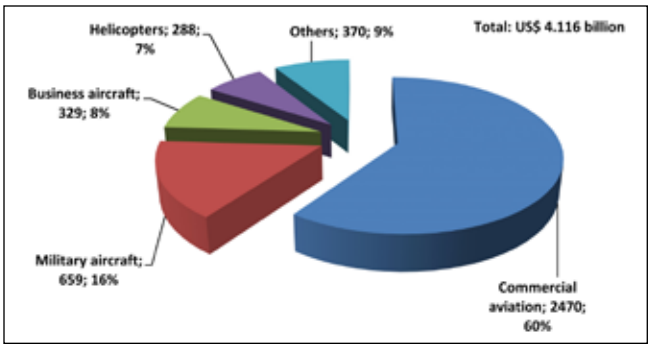

Figure 10: Carbon composite revenues in US$ million in the market segment Aerospace and Defence by sub segment (2013).

- good mechanical properties
- temperature resistance
- low moisture absorption
- lower material costs for the user (less value added for the manufacturer of the material)
- large selection of matrix systems, material manufacturers and manufacturing processes.

Thermoplastics, on the other hand, offer advantages, which will probably lead to them being more widely adopted in future, for example:

- short processing times (no chemical reaction required, unlike thermosetting plastics)
- impact resistant, high damage tolerance
- good formability and weldability
- easy storage
- easy to recycle

So far, elastomer matrices are not widely used although this may change in the future, for example, for elastic, hingeless shaft connections in mechanical engineering applications.

By manufacturing process

A variety of different production processes are used in the manufacture of CRP materials/components (see Figure 8). In this year's report, the processes have been classified in a slightly different way from last year. Layup processes using prepregs (37%) continue to account for a major proportion of processes employed. However, pultrusion and winding are gaining importance and now represent a combined total of 40% of the market as they capture market share from prepregs. As well as easy-to-automate pressing and injection processes (e.g. RTM), the manual processes of wet lamination and vacuum infusion/infiltration are also frequently used.

Growth in CRP consumption is forecast to continue at 10.6% until 2020, essentially matching carbon fibre

By region

Figure 9 shows carbon composites revenues by region. North America and the USA, in particular, as an important manufacturer of aircraft and military equipment, account for approximately US$5 billion of global revenues – over one-third of the total. According to this breakdown of the market, Western Europe is the second largest region in the carbon composites economy generating around US$4.7 billion in revenues. However, if Europe were considered as a whole, including Hungary (Zoltek), it would in fact push North America down to the No. 2 spot. As well as having an aviation industry to rival that of North America, Europe is also home to many manufacturers in the wind turbine, automotive and mechanical engineering sectors, which also create strong demand for carbon composites. Japan, due to its many fibre manufacturers, is the third largest carbon composites market earning US$2.2 billion in revenues. In Asia (including the Pacific but excluding Japan), China's ambitions in the wind energy sector, in particular, helped to generate revenues of US$1.9 billion.

By application

The following sections provide a breakdown of the carbon composite revenues for the four most important market segments and their sub segments.

Aerospace and defence

The USA and Europe are the most important economic regions in the aerospace and defence sector with demand being driven by aircraft manufacturers such as Boeing and Airbus. The market segment is dominated by commercial aviation and the production of large passenger and cargo jets, which account for approximately US$2.5 billion (60%) of total revenues. Military combat and transport aircraft generate revenues of US$700 million and are the second largest area in this sector followed by business aircraft, helicopters and other products, primarily destined for applications in space and sport aviation.

Wind turbines

The wind turbine market is the second largest segment in terms of carbon fibre consumption. Global wind energy capacity has been expanding continuously since 2005 (Figure 11) and reached a total of approximately 318 GW in 2013. The

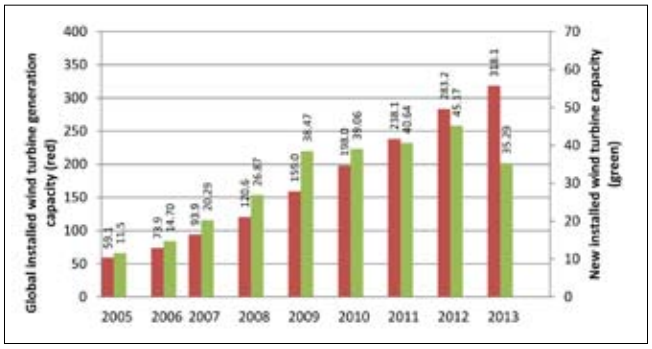

Figure 11: Global installed wind turbine generation in GW.

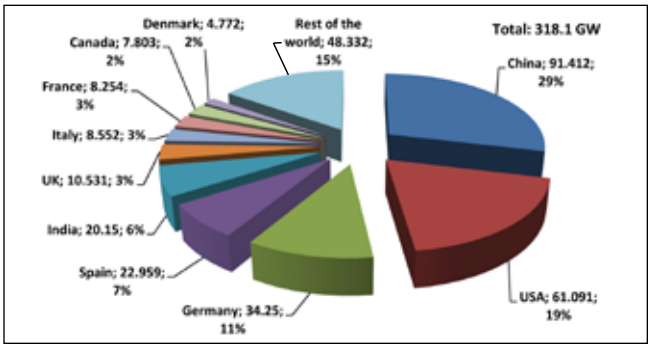

Figure 12: Installed wind turbine capacity by country in GW (Dec 2013).

electrical output of each wind turbine is a quadratic function of its rotor diameter so manufacturers are under pressure to develop ever longer and lighter rotor blades. In 1985, the average rotor diameter was just 15 m with an average output of less than 1 MW. In 2013, wind turbines had an average rotor diameter of 100 m and an average output of 2.5 MW. These multi-megawatt wind turbines are increasing the demand for carbon fibre because it is the only material suitable for the construction of rotor blades with a length of 40 to 50 m.

In 2013, the wind energy market consumed approx. 6,700 t of carbon fibre and generated carbon composite revenues totalling approximately US$1.8 billion. However, demand for carbon fibre in the sector was lower than in 2012 (10,000 t). The reasons for this were the continuing, low level of automation and delays to the construction of offshore wind parks due to financial and technical difficulties. For example, only 35 GW of new wind energy generating capacity was installed worldwide in 2013 (Figure 11).

This sector is dominated by three major national economies: the People's Republic of China has significantly expanded its capacity over recent years and increased its total to 91 GW in 2013 – almost 30% of global wind energy capacity. This is followed by the USA with 62 GW and Germany with 34 GW of capacity (Figure 12).

Sport/Leisure

The Sport/Leisure market segment generated revenues of around US$1.5 billion with carbon composites in 2013. This sector, together with space travel, was one of the first to use and develop carbon composites. Carbon composites are now not only used in professional and high performance sports but also in many products for a wide variety of sports: golf clubs, tennis and badminton rackets, bicycle frames etc. are the most important products in this segment and, taken as a whole, account for nearly three-quarters of the revenues (Figure 13). There are also many other applications, such as winter sports (skis, ski poles, snowboards) and water sports (paddles, windsurfing masts).

Automotive

CRP is considered a key material in many areas of the automobile industry relating to the reduction of CO_2 emissions, lightweight construction and e-mobility. The use of CRP in automotive applications is still at an early stage and offers excellent potential for the future – although this depends on further significant reductions being achieved in the prices of CRP components.

In the 1980s, the first carbon fibre applications, such as drive shafts, began to be adopted outside the motorsport sector and establish themselves in small series production vehicles. Carbon composites are now used in an extensive range of structural and outer skin applications in cars – from ceramic brakes reinforced with carbon fibre to crash elements and monocoques, passenger compartments and semitrailers. Carbon composites are also assuming a greater role in applications for the railway industry, for example, from small components such as windscreen wipers to complete front ends and underfloor structures.

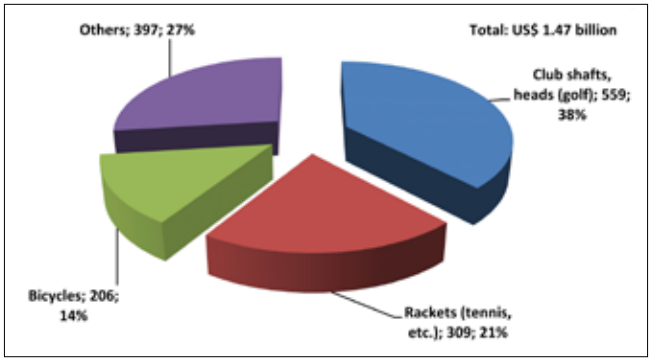

Figure 13: Carbon composite revenues in US$ million in the market segment Sport/Leisure by sub-segment.

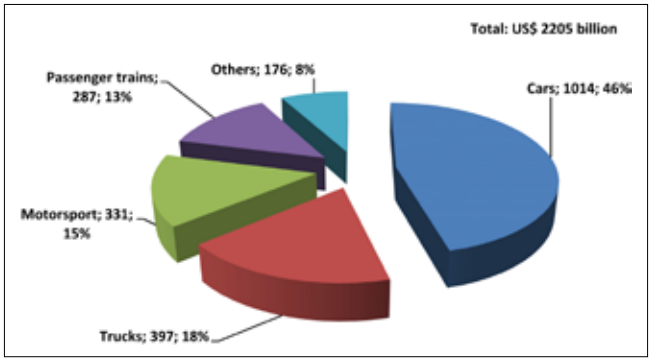

Figure 14: Carbon composites revenues in US$ million in the automotive sector according to sub-segment (2013).

With approximately US$2.2 billion in revenues, the report adds that the automotive segment is increasingly important to the carbon composites market. Cars are the most important area generating 46% of the sector's revenues. The continuing high cost of carbon composite components has until now restricted their use primarily to luxury cars. The sub-segments trucks (18%), motorsport (15%) and passenger trains (13%) also make noteworthy contributions to the total revenues generated by the automotive sector.

Trends and outlook

For the next five years, analysts predict an annual growth rate of nearly 9% for the carbon fibre market. This will then rise further to around 10% (Figure 1). Based on this estimate, global demand for carbon fibre can therefore be expected to reach 89,000 t by 2020 and generate revenues of over US$3.3 billion. Despite the availability of existing excess capacity, a number of fibre manufacturers have announced that they intend to invest in further facilities:

- SGL and BMW will invest a further US$100 million in their Moses Lake facility (bringing the total to US$300 million) in order to expand the production capacity from the 6000 t stated to a medium-term target of 9000 t per year.
- Mitsubishi Rayon will expand production capacity by 2000 t at its carbon fibre factory in Sacramento, USA, by mid-2016 – doubling its total capacity.

The carbon composites market, valued at a total of US$14.7 billion in 2013, is expected to grow at approximately the same rate. CRP is the most important area here generating US$9.4 billion of the total. CCeV adds that the CRP market continues to promise stable and outstanding growth potential. As well as the aviation and wind energy sectors, the growing use of CRP in automotive construction and industry are key factors driving the market. Market studies predict average annual revenue growth of between 6 and 11% over the next five years and then a sustained rate of over 10%. For example, in

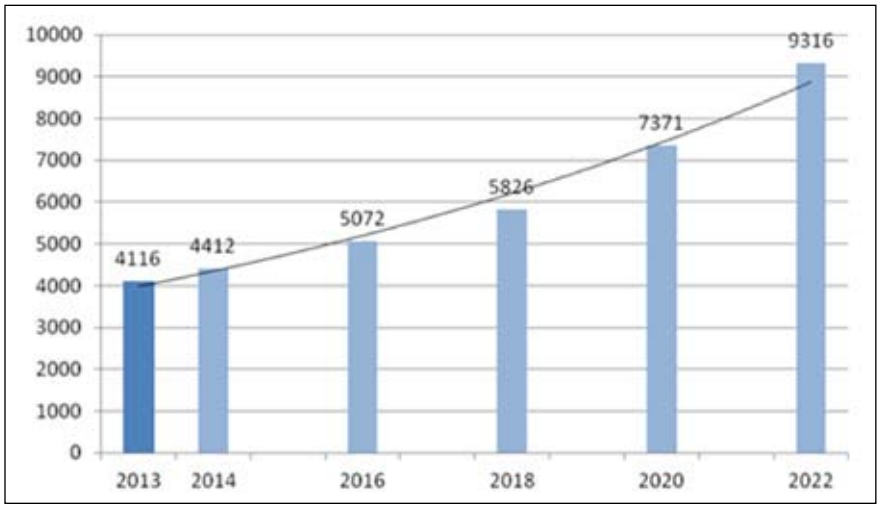

Figure 15: Development of carbon composite revenues in US$ million in the Aerospace and Defence market segment.

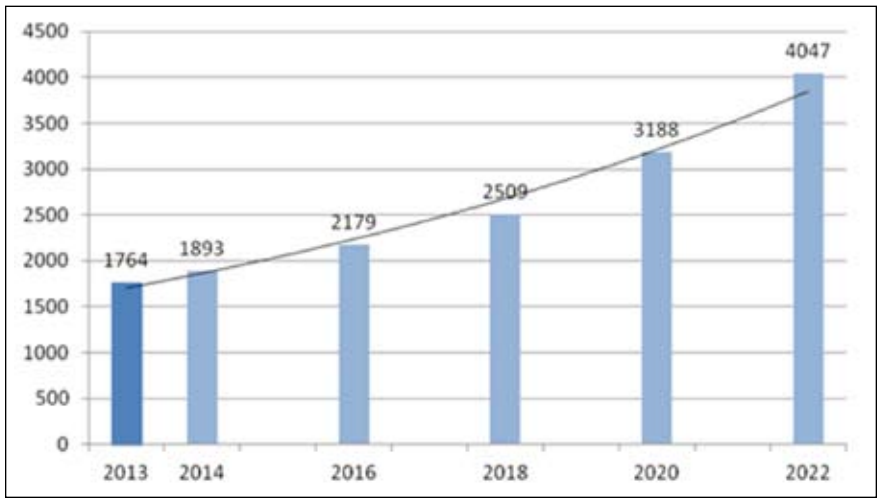

Figure 16: Development of carbon composite revenues in US$ million in the Wind Turbines market segment.

2020, the industry is anticipating demand for 146,000 t of CRP and revenues of over US$16 billion. For 2020, revenues for the entire carbon composites market, including other matrices, are forecast to total around US$25 billion.

Aerospace and defence

CCeV predicts that the aerospace and defence sector will continue to play a critical role in the growth of the carbon composites market. Both Airbus, with the A380, and Boeing, with the Dreamliner 787, have started the production and delivery of their latest wide-bodied passenger aircraft. Both models use a significant proportion of carbon composites in their structures and provide an enduring, growing source of demand.

At the time of this market study, Airbus is building 25 to 30 of these aircraft per year and has received orders for a further 180. Boeing has also currently received orders for a total of 887 Dreamliners that have yet to be delivered. Future projects, such as the A350XWM, 53% of which will be made from composites, or the Boeing 777X with carbon composite wings, show that demand for carbon composites from aircraft manufacturers will continue to expand well beyond the lifespan of the A380 or the 787. Industry analysts expect growth of between 8 and 13% over the

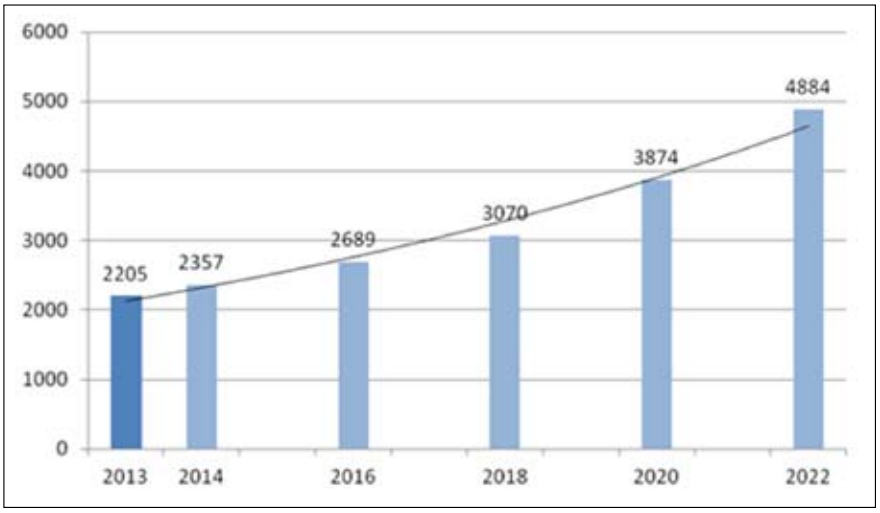

Figure 17: Development of carbon composite revenues in US$ million in the Automotive market segment.

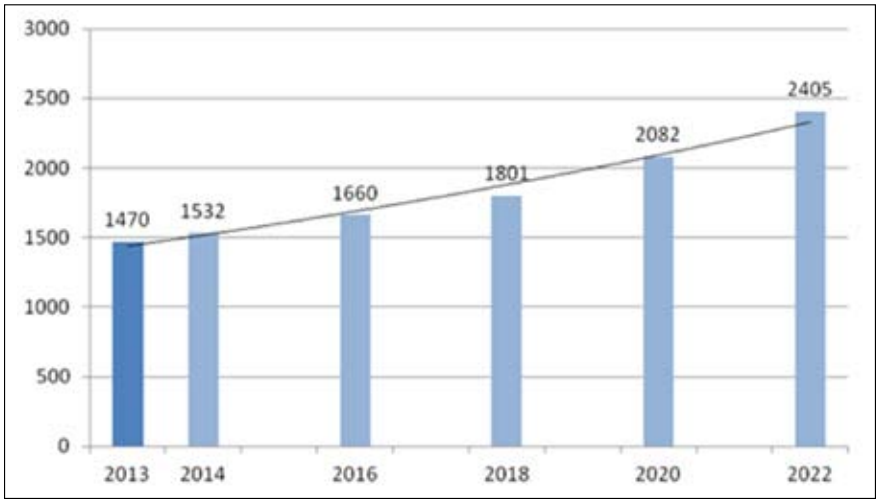

Figure 18: Development of carbon composite revenues in US$ million in the Sport/Leisure market segment.

coming years. Carbon composites revenues of around US$6 billion have been forecast for the passenger aircraft sector alone in 2022.

Carbon composite structures are already relatively well-established in the defence segment. All modern defence projects, such as the A400M, F-22, F-35, Eurofighter or Eurocopter Tiger, are increasingly based on composite materials. However, budget cuts in defence departments and export restrictions imposed by industrial nations will constrain growth. Despite these factors, strong annual growth of between 6 and 12% is also expected in this segment. By 2022, it is expected to generate revenues of US$1.4 billion.

Wind turbines

Above average annual growth of 9.7%, driven by the switchover to renewable energy and the associated expansion of wind farms, is anticipated for the wind turbine segment. Analysts are currently forecasting carbon composite revenues of around US$4 billion by 2022. New multi-megawatt turbines with ever longer rotor blades are being developed and used in both offshore and inland wind farms. For example, wind turbines with an output of 7 MW and a rotor blade length of 83.5 m are due to be operational in the North Sea from 2015. According to Fraunhofer IWES, 20 MW turbines with even longer rotor blades should be feasible by 2020. They, like the latest high-tech aircraft, depend on a higher proportion of carbon fibre in the supporting structures for the rotors in order to guarantee stability and acceptable weight.

Automotive

The CCeV report adds that with the large scale production of its new i-series, BMW has taken a pioneering step. Production began in September and was ramped up to around 100 i3 models a day in 2014. The BMW Group also plans to expand the use of CRP in its other ranges. To do this, BMW is not only extending its carbon fibre manufacturing partnership with SGL but also increasing its own CRP production and processing capacity. Recently, the company invested €20 million in a CRP stacking plant in Wackersdorf. Other manufacturers are also using CRP more widely but are more cautious due to the continuing high cost of carbon composite components.

Demand for carbon fibre can be expected to reach 89,000 t by 2020 and generate revenues of over US$3.3 billion

Revenues are expected to grow by 7% annually until 2018 before accelerating to approximately 12%. By 2022, annual global carbon composite revenues are forecast to reach US$4.9 billion corresponding to 20,000 t of carbon fibre. Automotive applications would therefore rise into second place ahead of wind turbines in the league table of market segments.

Sport/Leisure

The sport/leisure market segment has always been one of the strongholds of the carbon fibre and carbon composite industries. Due to strong pricing pressure, revenues are expected to grow only slightly (4% annually) over the coming years. From 2018, the annual growth rate will be around 7.5%, i.e. below the growth rates in the aircraft, automotive and wind turbine markets.

Carbon composite revenues should reach US$2.4 billion by 2022. The segment will therefore fall behind the automotive sector.

Construction

Analysts believe there is excellent potential for the use of carbon fibre in the construction industry, explains the CCeV report. As well as new filigree architectural structures, concrete reinforced with carbon fibre ('carbon concrete') is increasingly being used to repair bridges and other ageing structures. Although the cost of the material is higher than that of steel reinforced concrete, this is counterbalanced to some extent through faster and lower costs of installation, lighter transportation and the ability to stabilise buildings and structures over the long-term.

The construction sector offers enormous opportunities if the cost of carbon concrete can be brought down still further. In the USA, nearly half of the country's approximately 600,000 bridges are in an unsatisfactory condition. In Europe, too, many bridges are reaching the age at which they require restoration or replacement. According to one study, Germany alone will have to invest €16-17 billion in such projects by 2030. In 2013, demand for carbon fibre in this sector was estimated at 2300 t. Carbon composite revenues (Figure 19) totalled around US$590 million. An annual growth rate of 6% has been forecast for the next five years with a long-term growth rate of 9%.

Final observations

After exceptional growth in the early years and in the wake of the global economic and financial crisis in 2009, the carbon fibre market has now stabilised at a healthy and steady growth rate of around 10% (average 2010-2013). Likewise, the CRP market has grown at an annual rate of 10.5% over the past three years. In 2014, carbon fibre consumption is expected to exceed 50,000 t for the first time and generate revenues of approximately US$1.77 billion. For the carbon composites market, total annual revenues are estimated to be in the region of US$15 billion in 2014.

Continuous growth of around 10% is forecast for the coming years with stability guaranteed by the aerospace and defence, wind turbine and sport/leisure sectors.

There is also exceptional, but less certain, growth potential in the automotive and construction market segments. In both these sectors, the large scale use of carbon fibre and carbon composites depends heavily on the industry's ability to reduce the prices of these materials. This uncertainty is reflected in the revenue forecasts for the overall carbon fibre and carbon composite markets.

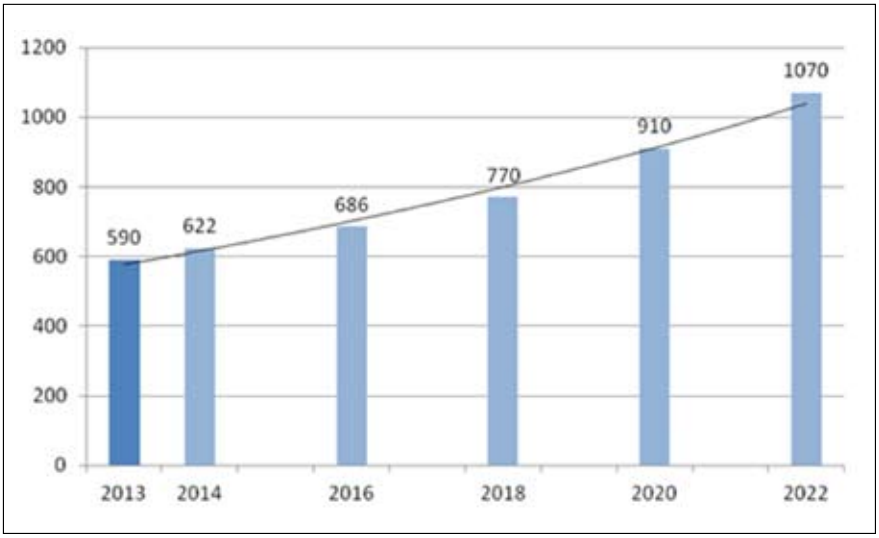

Figure 19: Development of carbon composite revenues in US$ million in the Construction market segment.

The authors

Thomas Kraus and Michael Kühnel are project architects at Carbon Composites e.V. (CCeV) and took over from Bernhard Jahn as the authors of the CCeV market report in 2014.

Carbon Composites e.V. (CCeV) is an association of companies and research institutes in Germany, Austria and Switzerland for the entire value-added chain of high performance fibre composite materials. It plays an important role in networking scientific research and businesses.

CCeV sees its role as a network of competence for promoting the application of fibre composites with a focus on 'marketable high performance fibre composite structures'. The emphasis is on fibre composite structures with plastic matrix materials, familiar to the wider public in many applications, as well as on fibre composite structures with ceramic matrices, which have higher resistance to temperature and wear, and high performance fibre composites for the construction industry.

The generally positive outlook is also reflected in recent results of the Composites Germany market survey, which is conducted twice annually among the business association's members. Composites Germany was founded in 2013 by the four major organisations representing the composites industry in Germany – AVK, CCeV, CFK Valley Stade and VDMA Forum Composite Technology. Overwhelmingly, the association's members described the growth of their companies as positive or very positive.

Even conservative estimates predict an extremely vibrant future market. However, the industry must also overcome a number of hurdles, for example in automation, cost-cutting and the development of manufacturing processes suitable for mass production. The price-performance ratio will decide which materials or combinations of materials will be adopted in which application areas. Ecological aspects – if these are demanded by lawmakers or not economically disadvantageous – are likely to assume greater relative importance than pure business considerations. ■

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