GERMANY

Cluster Forum: Materials for the Future – Fibre Composites

The New Materials Cluster of Bayern Innovativ GmbH/DE in cooperation with the Centre of High-Temperature Materials and Design HTL at Fraunhofer ISC/DE issued invitations to the forum "Materials of the Future – Fibre Composites" in Bayreuth on 17 July 2019, where the centre is based. The event was oriented to experts from the composite materials sector and associated user industries, offering opportunities for sharing information and ideas with experts and for discussion of potential projects and cooperation.

Fig. 1
Auditorium in Bayreuth

Introduction

Where material properties have to meet extreme requirements and customized solutions are needed, fibre composites are used and therefore found in a wide range of industries. Fibre composites boast high strength and stiffness, and often outstanding temperature and chemical resistance with simultaneously low density. Therefore, they have great potential for use as lightweight structural materials. Some fibre composites can also tolerate extreme environments involving high temperatures and chemicals.

Prof. Dr Friedrich Raether, Director of the Centre of High-Temperature Materials and Design HTL at Fraunhofer ISC, together with Dr Nicole de Boer, Director of the New Materials Cluster, and Astrid Lang, Project Manager for Technology/Materials at Bayern Innovativ, welcomed over 50 attendees to the forum at their introduction to the topics addressed.

In the following papers, the potential of the different fibre composites was presented in detail, future technologies were described, technological challenges explained, practical applications shown, and sustainability aspects examined.

Strategies for Sustainability

Thorsten Pitschke (bifa Umweltinstitut GmbH) spoke on challenges in the recycling of composite materials. Products made of fibre composites promise outstanding properties and optimum performance during their service. In contrast, the situation today regarding the disposal of such products at the end of their use is comparatively sobering. With reference to composites comprising carbon, glass and natural fibres, the intrinsic motivation for high-quality recycling and the current disposal situation were described in an overview. On this basis, the current hurdles and obstacles to recycling were then characterized.

Dr Henning Schliephake (NoWASTE Georgsmarienhütte GmbH) addressed the question: "Can CFK waste be used as primary coal substitute in electric arc furnace in steel production?". Every year, around 1,5 billion t steel are produced, ultimately incorporated in a wide range of products and used. At the end of its life cycle, steel is available as a waste-derived raw material in the form of scrap for the production of new steel. Today, around a third of the global steel production in electric arc furnaces is produced by smelting of scrap. Material development enables the same or even a better steel quality to be produced today than the steel from which the scrap comes. During the recycling process from scrap to new better steel, primary resources such as coal are used. As part of the NoWASTE initiative of Georgsmarienhütte GmbH, the question arose regarding which carbon carriers from other material cycles can be used to substitute coal. First tests with carbon-fibre-reinforced materials, financially supported by Carbon Composite e.V./DE, have been conducted in the small electric arc furnace of

Fig. 2
Dr Nicole de Boer (l.) and Prof. Dr Friedrich Raether welcoming the participants

Federal Institut for Materials Research and Testing (BAM) in Berlin and returned positive results.
The recycling and reuse of fibre composite structures was addressed in the closing talk of the first forum focus by Marcel Hofmann (Sächsisches Textilforschungsinstitut e.V. – STFI, Saxony's Textile Research Institute). With the increasing quantities of carbon fibres used in various sectors, the waste produced in each processing step increases. The recycling of carbon fibre waste from different processing steps and the reuse of the recycled fibres by means of different textile processing options has been and is part of diverse project work for more than 15 years within the STFI.
In the scope of this work, extensive studies have been conducted on issues concerning the collection/logistics of the different waste types, the processing of textile waste, the production of semi-finished textiles with various possibilities for non-wovens and finishing on the basis of the recovered fibres as well as potential areas for reuse in different branches. In the paper, possibilities developed for the return of carbon fibre waste into the value creation chain as well as potential applications were presented in detail.

Materials and Future Technologies

Prof. Dr Friedrich Raether began by speaking on Ceramic Matrix Composites (CMC) as innovative materials for high-temperature applications and gave a general introduction to the structure and properties of CMCs. In this context, the various fabrication processes were presented in detail, with the focus on non-oxide CMCs. Another focus were recent works on design and testing of CMCs as well as a concluding outlook on future research topics.
Subsequently, Dr Rolf Terjung (Graphite Materials) addressed the field of CFC components in high-temperature applications. Applications of components made of carbon-fibre-reinforced carbon (CFC) imply temperatures from 1000 – 2500 °C in vacuum or oxygen-free inert gas atmospheres. The CFC features material properties that make it especially suitable for this temperature range. Materials with extraordinary properties become suitable for industrial use as components when they are available on production scale as semi-finished products.
On the way "from the idea to the component", the material technology, design and fabrication have to be coordinated. The paper showed with reference to various applications how, through the semi-finished material, the CFC endows the CFC component with the special properties described.
Yves Mattern (Lignoa Leichtbau GmbH) showed keenly why wood has to be regarded as an innovative fibre material of the future. Lignoa Leichtbau has developed and made the lightest pipes in the world from wood, with perfect fibre orientation, free-form structures and variable wall thicknesses within one profile. These pipes show a similar quality to those made of carbon-fibre-reinforced plastics (CFRP).
In his paper, Prof. Guntram Wagner (TU Chemnitz, IWW – Institute of Material Science and Materials Engineering) addressed the effect of different reinforcement structures in MMCs.
Metal Matrix Composites (MMCs) can be tailored based on selection of the metal matrix as well as the form and type of the reinforcement in a unique way with regard to their mechanical, technological or physical properties to meet specific requirements. As a function of the material of which they are fabricated, reinforcements, like whiskers, fibres or particles in micro- or nanoscale dimensions, have a different effect within metallic materials, which can be exploited to selectively influence several or certain properties. Various reinforcement structures in MMCs and their active mechanisms were explained, a particular focus being placed on particle-reinforced Aluminium Matrix Composites (AMC).
To conclude, Prof. Klemens Rother (Munich University of Applied Sciences. Faculty of Mechanical Engineering, Vehicle and Aviation Technology) spoke in the scope of the second focus about innovative methods for the design, construction and fabrication of fibre composite structures. New concepts for the design, construction and fabrication of fibre composite structures that were developed and tested by an international consortium of researchers and industry partners under the direction of Prof. em. Stephen Tsai from Stanford University/US were presented. With these methods, thanks to a new laminate architecture, dimensioning can be performed more efficiently, and the constructive design determined more definitely, easily and at lower cost. De-

Fig. 3
Networking during breaks

sign solutions for high-performing panel structures and the technology for their fabrication were presented. With these solutions, much less cutting waste is produced than in the traditional construction.

Industrial Impulses and Applications

To kick off the last topical focus of the forum, Prof. Hubert Jäger (TU Dresden, Institute of Lightweight Engineering and Polymer Technology, Chairman of the CCeV Board, Carbon Composites e.V./DE) together with Dr Bertram Kopperger (MTU Aero Engines AG) looked in their paper at the use of high-end ceramics composites in aerospace applications. With increasing global population to over 9 billion by 2050 and international industrial networks, increasing mobility is also expected. Increase rates in passenger numbers of 4–6 % per year will lead to a doubling of the aircraft fleets and a new demand for over 1000 new airports is emerging. Without a significant reduction of the associated emissions in air traffic such as CO_2 and NO_x and also noise nuisance, it is not possible to gain any acceptance for these new developments. This predestines the field of new material and further developed systems, both with regard to the drive (turbines) and the aeroplane structure. In the high-temperature range of the turbines, improvements in efficiency with new high-performance ceramics made of silicon carbide and oxide ceramics will be at the centre of efficiency improvement. In the aeroplane structure, all combinations of lightweight materials including those with carbon fibres will make the running.

Florian Funk (LAMILUX Composites GmbH) presented sandwich floor materials as wood substitute. In utility vehicles and mobile homes, predominantly wooden floors are used, although sandwich structures are suitable as alternatives here. These generally consist of at least three layers: two cover layers made from fibre-reinforced plastics and a core with low density and sufficient strength. Lifetime increases with, for example, the avoidance of damage caused by damp, and fuel reductions thanks to significant weight savings can be achieved, the integration of useful functions in the sandwich element often being another, market-relevant aspect.

A low-cost solution for aesthetic composite parts for the automotive and transport sectors was presented with reference to StyLight by Pierre Juan (INEOS Styrolution Group GmbH). StyLight – a thermoplastic composite based on SAN (Styrene-Acrylonitrile-Copolymer) enables a production of carbon aesthetic applications on an industrial scale. Delivered in sheets, StyLight can be thermoformed and then back-molded with glass-filled ABS grades favouring shorter cycle times and function integration. StyLight's very good surface quality of parts after demolding allow single layer paint for a surface free defect, scratch resistance and UV resistance according to automotive requirements. ARRK Shapers validated StyLight on a center console component. Comparing the costs of the carbon thermoset solution with the StyLight thermoplastic carbon composite solution, ARRK Shapers´ figures clearly showed a possible cost reduction of up to 50 %, for larger productions quantities. Moreover, the centre console has recently been fully validated according to the automotive interior specification of Renault for an inner trim application.

Component design and configuration for Ox/Ox fibre composite ceramics was the topic of discussion in the last expert talk at the forum, held by Dr Mathias Kunz (WPX Faserkeramik GmbH). In the temperature range 800–1300 °C, Ox/Ox fibre composite ceramics offer unique material properties in that they combine the high-temperature and corrosion resistance of oxide ceramic materials with the elasticity and shock resistance of metals.

These advantages are implemented in a large number of applications, as for example gas turbine components, burner nozzles, charging racks for the heat treatment of steels, components for induction heating, tube reinforcement, etc. On account of the high price of the high-performance ceramic fibres used, application is only economically viable when the fibre use is optimally exploited in the design, engineering and fabrication. In the paper, typical applications are presented from which the specifics of fibre-reinforced ceramics in respect of design, engineering and fabrication were derived.

To round off the successful cluster forum, the tour around the laboratory of the Fraunhofer HTL provided excellent opportunities for making specific contacts and holding further talks. The highlight here was the viewing of the newly built fibre pilot plant, unique in Europe, with which oxide and non-oxide ceramic fibres can be fabricated on the scale of several tonnes per year – an investment totalling EUR 20 million, including EUR 11 million for the two production lines, with a useful area of 2000 m^2. MM