Carbon Fibres & Advanced High Performance Composites Cluster (CFPC)

March 2017

Introduction

The project clustering activity under H2020 aims to bring together EC funded projects to enable the sharing of ideas, results and concepts and to use the synergistic effect to improve the dissemination and exploitation of the project results and enhance their impact and to contribute to the Strategic Research Agenda and Roadmaps. The main goal is to gather the scientific partners, research groups, technology providers and industries engaged in the development and manufacture of carbon fibres (CFs), carbon fibre reinforced polymers (CFRP) and other high performance composites, in order to promote the successful results of the organized research of the involved partners. Dissemination and management actions will be carefully organized and promoted in order to attract the interest of research and industry for higher awareness. The intention is to enable as many stakeholders as possible to participate in a highly integrated innovation environment.

Five projects initially formed this Cluster, related to the sustainable production and recycling of carbon fibres (CF) and carbon fibre composites. CARBOPREC, FIBRALSPEC and NEWSPEC investigate the development of cheaper CF reinforcement, REFORM deals with the recycling of CF composites and EU-CARBON concentrated on the production of high performance CF in Europe. Subsequently more projects, engaged with the development of carbon fibre structures with improved multi-functionality and performance such as MODCOMP, GREENLIGHT, SC EUMAT are being included in this clustering activity.

Objectives

- Development of a competitive network for the production, assessment and marketing of carbon fibre based materials.
- Development of a European carbon fibre manufacturing network, improving performance through the sharing of expertise, know-how and technology within the CFPC.
- Development of an international business network collaboration and establishment of European Strategic Partnerships through linking and sharing of information.
- Dissemination of the CFPC objectives, challenges and results both to specific sector audience (scientific and industrial) and to the large audience.
- Promotion of European groups contribution to the emergence of new value chains and the aim to take a leading position globally, supporting internationalization towards developing countries .

Stakeholders

Stakeholders relevant to the CFPC are:

- Carbon fibre & preform manufacturers
- Materials manufacturers and integrators (industrial end-users of fibres, intermediate carbon fibre-based products and composites)
- Standardisation Bodies and Metrology institutes

Themes

The focus is on carbon fibres & advanced high performance composites to support upscaling and industrial exploitation, together with impact of the European economy. In this context, the following themes and topics are considered:

- Fibres
- Matrix & Modification
- Hybrid materials
- Smart structures
- Textiles & Preforming
- Surface & Interface - Functionalization
- Manufacturing/Processing
- Market, Application, SMEs, Industry
- Pilot & Upscaling
- Green & Low Cost (LCA, LCC)

A wide range of application fields includes:

Lightweight materials including composites, Hybrid and functionally graded materials, composites for energy technologies (storage, conversion) and climate change.

Specific Areas of Research

- Optimization of precursor characteristics to further improve carbon fibre performance properties, through the fostering of collaborations between partners from different countries and effective exchange of innovative ideas.
- Implementation of pilot/industrial facilities capable of manufacturing innovative carbon fibres, as well as carbon fibre preforms and semi-finished products.
- Focus on more efficient and sustainable products and processes based on life cycle assessment studies.
- Development of modelling and simulation tools to provide further understanding of properties and phenomena towards the optimisation of innovative carbon fibres, as well as carbon fibre preforms and semi-finished products and related manufacturing processes.
- Networking and interaction with other networks to promote multidisciplinarity and cooperation in the production of carbon fibres based materials.

By elaborating on these themes the CFPC will support horizontal actions towards:

- Policy & Strategy
- Characterization, Modelling & Design
- Safety & Standards
- Dissemination and Networking

Governance and structure of the CFPC

Membership

Initially membership will consist of projects that were involved in the setup of the Carbon Fibres & Advanced High Performance Composites Cluster activities following the March 2015 workshop. Membership will then be widened to include relevant H2020 projects that include fibres and advanced high performance composites in their core description.

Leadership and management

The CFPC will be managed by a Governing Board (GOVB) and WG Leaders and Vice Leaders consisting of project members and Experts supported by the EC. The GOVB will work with the EC PO to determine the organisation of potential external advisory actions and relationships to other initiatives. The GOVB will be supported by the EC (Policy Officer Achilleas Stalios), in particular John Yellup (Project Technical Assistant), who has been involved in the Cluster activity from the beginning. The GOVB consists of (apart from PO and PTA) I. Verpoest, C. Charitidis, N. Correia, M. Falasconi.

Working Groups

Working Groups (WG) will be established to cover a wide range of topics. Some of these Working Groups have already been established, while others will be formed based on identified needs. Each Working Group will define its scope, objectives and planned actions in a Charter document. As a basis for the Charter documents, Discussion Notes from previous meetings will be used.

WG: Leader and Vice Leader

WG 1 Policy & Strategy: PO and GOVB

WG 1 contributes to the manufacturing and technoeconomic aspects that are perceived as key for determining the feasibility of commercially viable, mass-produced smart composite containers, in line with JRC report[1]. The scope of this WG is to set the key aspects and priorities, with currently available technology, that will define the backdrop for future commercial and policy developments. This policy framework and the prospect for CEN guidance are paving the way for verification of composite structures realized with fibre-reinforced polymers (FRPs); the purpose and justification for a new Eurocode for FRP composite materials outlines the specific aims and reasons for standardization in this area[2], and the main interested parties (industry, consumers, trade, standardisation authorities and distributors) who will benefit from it.

WG 2 Materials: NTUA, CANOE

WG 2 addresses all materials involved in the fabrication of high-performance carbon fibre reinforced composites, of hybrid materials and of smart materials and intelligent structures.

[1] JRC Scientific and Policy Reports: "Review of industrial manufacturing capacity for fibre-reinforced polymers as prospective structural components in Shipping Containers: Approximate cost, production methods and market drivers", 2013, ISBN 978-92-79-28120-4

[2] JRC Scientific and Policy Reports: " Prospect for new guidance in the design of FRP: Support to the implementation, harmonization and further development of the Eurocodes", 2016, ISBN: 978-92-79-54225-1

Concerning the precursor for carbon fibres, some alternative materials to polyacrylonitrile can be studied: bio-based materials such as cellulose or lignin and also polyethylene, textile grade of polyacrylonitrile or silicon carbide. It is important to look closely to the cost and the carbonization yield of these precursors. One way to increase the properties of these alternative precursor fibres is the use of nanomaterials such as carbon nanotubes or cellulose nano-whiskers.

Concerning the polymer matrix, some recent developments are aimed at replacing the use of thermoset resins which present health and safety issues and which are not recyclable. Some alternative materials to thermoset resins can be studied: high temperature polymer such as polyaryletherketone (PAEK), polyethylenimine (PEI) or polyphenylene sulfide (PPS) and also new grades of liquid acrylic-based resins. Some matrix modification can also be investigated in order to provide carbon fibre reinforced composites with improved properties and new functionalities (fracture/impact resistance, electrical/thermal conductivity, fire resistance, self-healing).

WG2 also involves the new category of fibrous composites, which are synthesized by using two or three different types of fibres in the same matrix, so called hybrid materials. The densities of different fibres, their orientations, molecular characteristics and compatibility with matrices will be the main objectives of WG's activities. In addition, as it is observed that such systems present high anisotropic properties, innovative processes and methodologies for the homogenization of the final composites will be investigated and described in details. New strategies and technologies for the manufacturing and up-scaled production of such systems will be developed.

WG 3 Processing: INEGI, KU LEUVEN
WG 3 contributes to the development of efficient and high performance manufacturing processes for composite materials based on carbon fibres.
Targeted processing technologies will include conventional composites manufacturing processes (prepreg hand/automatic lay-up, autoclave, fibre/tape placement, filament winding, pultrusion, resin infusion, resin transfer moulding), as well as emerging manufacturing technologies (such as collaborative robot layup, additive manufacturing etc.), which will be considered as a baseline for the development of future processes with a better cost efficiency (reduction of energy consumption, tooling cost, processing times, raw-materials cost), with lower environmental impact (scrappage reduction, recyclability, energy consumption), and with better performance (per part weight, multi-functionality, complex shaping, defects reduction, process automation).

The manufacturing of intermediate products, such as pre-impregnated materials and reinforcement fabrics, will also be considered, since these are the typical formats in which carbon fibres are used by composite parts manufacturers. In this context, processes to obtain complex fabric architectures, weaving of special types of fibres, and their combination, to achieve low thickness preforms, and new fibres/resin combinations will be covered in this WG. WG3 will also address strategies to perform surface functionalisation to provide enhanced compatibility between fibres and the matrix and multifunctionality to the final composites.

Development of future carbon fibre-based composites manufacturing processes will consider the need to combine expertise on process simulation, capacity to design, implement, test and validate processes from laboratorial to semi-industrial scale, and a strong involvement of end-users to understand their needs and to make them aware of potential benefits of using under development technologies.

Synergistic collaborations with other WGs is expected, in particular with WG2 to contribute to the development of processes that are able to use the new materials, with WG4 to develop processes that are in-line with industry needs and capacities, and with WG5 because materials modelling is an important reference for composites process design and to their validation.

WG 4 Market & Upscaling: OSM, IRES, SGL, INNVENTIA
WG 4 informs about the range of applications and the market demand of CF based materials and advanced CF reinforced polymers (CFRP). This demand has been steadily increased during the last five years and is estimated to be continuously rising by at least 10% per year until 2025. Next to the field of aerospace, this tremendous increase is also identified in many industrial fields, such as automotive, civil engineering, wind energy and sport equipment. The main target of these sectors is the fabrication of lightweight materials with structural performance, in an effort to improve energy efficiency, namely fuel efficiency for cars and human energy efficiency for sports, and to optimize the durability of structures (like fatigue resistance of windmill blades).

A major challenge to the exploitation of the unique properties of CFRP composites consists of the intrinsic brittleness of CFRP's, and rather high environmental impact of CF production. Extended theoretical and experimental researches were initiated in order to improve the strength and fracture toughness of CF reinforced composite materials. Further improvements can be expected by enhancing the base materials (carbon fibres and polymeric matrices) and by optimizing the associated manufacturing processes. Also the combination with growing technologies, based on nanomaterials or the development of thermoplastic-matrix carbon fibre composites, is expected to bring CFRP materials to a new level of performance. A lower environmental impact, which will also result in a reduced cost, can be achieved in a near future by developing low energy CF production methods and by the use of alternative precursors. Although there has been a large amount of research into this field by universities, research institutions and industries, this relatively new area of materials science and technology is still in the development stage with great potential for future growth.

Another important aspect is that the CFRP sector is still highly dependent on non-European sources for the carbon fibres. In fact, Europe is the largest CFs consumer (45%), followed by the USA (29%) and Asia (23%). On the other hand, currently, more than 43% of CFs production comes from Japan, followed by Europe (23%) and the USA (30%). The composite industry (CFRP, glass fibre reinforced polymers (GFRP) etc.) is a strategic EU sector (10,000 companies, 150,000 employees). The deployment of composite structures with overall performance comparable to existing technologies but at lower material (and environmental) cost will increase Europe's competitiveness and limit the imported amount of carbon fibres.

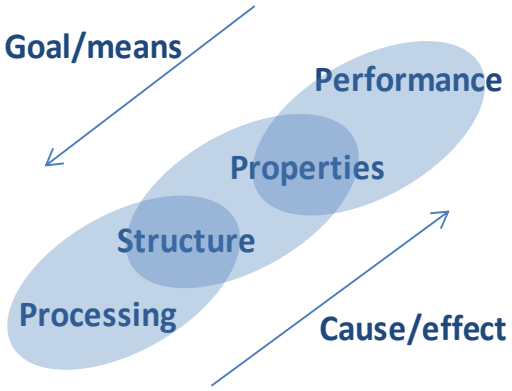
WG 5 Characterization, Modelling & Design: POLITO, ITA, KU LEUVEN
WG 5 establishes a community of European stakeholders in the process of developing and improving characterisation tools in order to bring the development of carbon fibres and advanced high performance composites in Europe into end products more successfully.
In this sense, the CFPC will provide a forum to identify the needs of the community considering both experimental characterisation and modelling points of view.

This goal will be done in collaboration with the European Materials Characterisation Council (EMCC, http://www.characterisation.eu/), which has a wider scope. On the other hand, the present WG5 will focus on peculiarities of carbon fibres and advanced composites.

One of the objectives of the WG is to carry out the identification, classification and evaluation of models and experimental techniques commonly used in this specific field, in order to determine the range of application and their use in a complementary way. In a multi-scale approach, as required by these material systems, it would be helpful to identity:

- Characterization tools that can be used for validation/corroboration purposes,
- Characterization tools that can be helpful to feed models at different scales (determination of inputs needed),
- Current limitations in input/output data needs in multi-scale chains

Moreover WG5 aims to promote the use and the effectiveness of modelling and simulation for assessing novel composites and estimate their performance. This activity includes discrete models, as well as continuum models, and covers modelling focused on material/product response evaluation and process modelling. The latter point is essential because the process history is essential in determining the final nano-/micro-structure of the composites and hence their performance. Also about modelling, this activity of WG5 will be done in close collaboration with the European Materials Modelling Council (EMMC, http://www.emmc.info/).



Determination of process/structure/properties/performance relationships

In addition, this WG will stimulate the development and use of "standard" or widely agreed characterisation/modelling protocols, particularly for those methods commonly used to characterise the materials covered by the cluster.

Finally, both characterization and modelling insights converge into better design practices, which are intended to guide the next generation of advanced composites in Europe. One of the goals of this WG5 is also to disseminate these design practices and to develop educational tool in order to spread them as much as possible in the large community dealing with carbon fibres and advanced high performance composites.

WG 6 Safety & Standards: IRES, TUD

WG 6 collects all the necessary information about the standards that have been developed for the synthesis and characterization of carbon fibres and their composites, as well as all the safety issues that arise during the employment of carbon fibres.

After 50 years of development and use in specialized applications, Carbon fibres are now on the brink of broad commercialization. Their use is growing rapidly, powered by important price reductions during the '90s and a significant increase in availability during '00s. These alterations in the performance/price ratio resulted in a massive penetration of composites into applications formerly held by metals and also enabled their utilization in applications previously not feasible with

the existing materials. Moreover, the market demands, increasingly favour the design of commercial products, which are lighter, stronger, faster and more fuel efficient, by incorporating carbon fibres.

The different grades of carbon fibres available in the market, along with the different required characteristics for each application, led to the development of technical standards for the manufacturing processes and the characterization of carbon fibres. This standardization process facilitated the transfer of composite carbon-based materials from lab to the market.
The extended use of carbon fibres in both research and industrial environments also demanded the establishment of safety rules for handling the carbon-based materials. The goal was to examine and gather all the health and environment risks posed by the use of carbon fibres and hence put safety concerns in perspective. Fundamentally, risk assessment involves an estimation of the potential for exposure and characterization of hazards.

WG 7 Dissemination and Networking: BEWG
WG7 promotes the CFPC objectives and activities of the various WGs. The main goal of dissemination is to gather the attention of relevant stakeholders and to enlarge the Cluster membership. Indeed, the development of new industrial value chains calls for the collaboration and networking of different synergic actors: universities, research centres, large enterprises and especially SMEs, across different sectors towards the implementation of a joint vision on future advanced high-performance composites. The Cluster will periodically organize meetings and workshops connected with important events in the sector of FRPC. All information will be accessible through the dedicated Cluster website and a periodic newsletter will be published.

Communication

A website was established in 2016: http://technologycluster.eu/.

CFPC internal communication is set up via intranet.

Collaboration with other European initiatives - International Collaboration

The CFPC will seek close interactions with other Clusters/Clusters, in particular the EMCC, EMMC, EPPN, NSC and the Engineering &Upscaling Cluster, the EuMat Technology Platform, the Research Data Alliance (RDA) and the Nanofutures initiative. There will be a strong link to the Alliance for Materials (A4M) as well as to the large European Materials Societies (EMRS, ESCM, EUCIA).

Join or contact the CFPC Cluster