AEROSPACE & AERONAUTICS

Polymer-based composites

1_A&A_PBC_LightAIRCRAFT

Title: Wet lay-up/vacuum bag process optimization for lightweight aircraft structures

Challenge summary

Wet lay-up/vacuum bag process optimization for lightweight aircraft structures, comparing different carbon fiber fabrics and core materials regarding weight and mechanical properties.

Scope of the challenge

- Production optimization of carbon fiber reinforced epoxy parts for light-weight aircraft by wet lay-up/vacuum bag process to achieve maximal mechanical performance (tensile-, compressive-, flexural strength, modulus etc.)

Objectives of the challenge

- Objective 1: Producing test panels (monolithic and sandwich) for mechanical testing with wet lay-up technology, materials to be used:
    - 200 gsm carbon fiber woven fabric (aero grade)
    - 160 gsm carbon fiber woven fabric (aero grade)
    - 200 gsm carbon fiber biaxial non-woven fabric
    - 80 gsm UD carbon fiber fabric
    - 300 gsm UD carbon fiber fabric
    - Airex C-70 PVC foam (or equivalent) with 5 mm thickness
    - AHC-Hex-48 aramid paper honeycomb, 48 kg/m3 – 3,2 mm cell size, 8 mm thickness
    - MGS LR285 + MGS LH287 resin system
- Objective 2: Tests to be performed
    - ASTM D3039, ASTM D6641, ASTM D3518, ASTM D5379, ASTM D790, ASTM D7249
- Objective 3: Comparing fiber volume fraction, mechanical properties according to standards above.
- Objective 4: Based on results, define optimal process parameters and lay-up.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101005435

2_A&A_PBC_APoCoP

Title: Automatic placement of corrosion protection for hybrid light weight aeronautical assemblies

Summary

Structural assemblies using dissimilar materials require measure to limit galvanic corrosion between the different components. When combining CFRP materials with aluminum the current accepted protection scheme is using edge sealing of the CFRP part and using silicon fillet sealing of the aluminum parts. Today these measures are applied manually. The purpose of this challenge is to automate both the placement of the edge sealing of the CFRP part as well the placement of fillet seal between the edge of the Aluminum part and the CFRP.

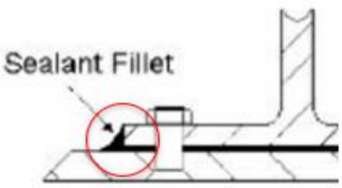
Scope: Target parts: complex 3D shaped parts with reduced accessibility

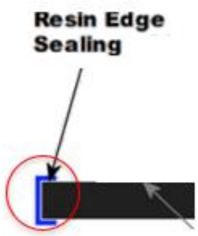
Technical issues:

- seal application is highly temperature humidity, batch and local geometry dependent and is requiring an adaptive approach
- Accessibility is poor so a compact solution is required

Targeted operations:

- Sealant fillet
- Resin edge sealing





Objectives:

- Define process parameters and process control means
- Develop automated head for application
- Automated for complex 3d shaped parts

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3_A&A_PBC_SpreadTape

Title: Quality assurance and measurement system for spread fiber tapes

Summary:

Unidirectional continuous fiber-reinforced thermoplastic tapes (UD tapes) are a playing an increasingly role as prepreg material in fiber reinforced plastics for many applications such as automotive, aerospace and consumer products. Essential quality criteria of UD tapes are among others highly aligned fiber orientation, homogeneous fiber area weight and constant thickness. There is a lack of knowledge and suitable systems for the quality assurance of this criteria based on inline measurement systems for dry spread fiber tapes. Aim of this project should be a selection and test of suitable commercially available optical measurement devices, development of a prototype in combination with a sophisticated evaluation software which can be tested on a tape production line.

Scope:

UD tape production lines are based on roll-to-roll processes pulling fiber rovings from creels, spreading them to a dry fiber tape and impregnating it with thermoplastic melt (Fig 1). Quality of the tape and thus, mechanical performance for lightweight applications, is mainly influenced by the spreading and impregnation process. Quality control is needed already after the spreading process to detect the tape thickness over the working width and thus, fiber area weight and most critical: gaps. Here optical measurement systems are favored but not yet suitable for the prevailing material and process conditions. Commercially available (optical) measurement devices should be researched and assessed on suitability. Based on a jointly selected preferred solution a prototype should be developed in combination with a sophisticated evaluation software. The system will be tested on a tape production line of challenge giver.

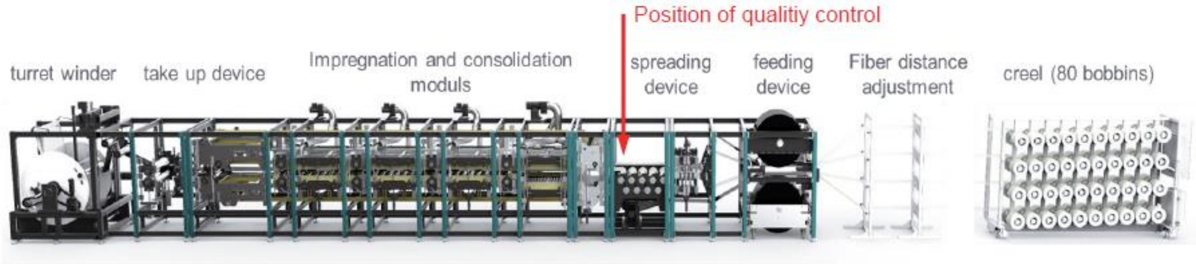

Fig. 1: Layout of the UD tape production line and position of the targeted measurement system

Objectives:

- Rating list of commercially available measurement devices considering the prevailing material and process parameters as well as measurement requirements
- Design proposal for measurement prototype with budget estimation (cooperation partner 1)
- Software implementation for signal processing and evaluation (cooperation partner 2)
- Stand-alone prototype for functional tests (in cooperation with challenge giver)
- Installed prototype on challenge giver’s tape production line in the development centre

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4_A&A_PBC_CFRPwing

Title: 3D-printed micro-pins and nano-enhanced adhesives

Summary Composites have flown on commercial safety critical aircraft primary structures for more than 30 years, but only recently have conquered the fuselage, wingbox and wings, most notably on the Boeing 787 Dreamliner and the Airbus A350 XWB. These carbon fiber-reinforced plastic (CFRP) structures, however, still require assembly with thousands of mechanical fasteners, which are today the most convenient and least expensive way to meet current certification requirements with addition of significant weight penalties and high environmental footprint. Adhesive composite joints have been progressively replacing mechanical fasteners, mainly for secondary aircraft parts, and only in exceptional cases safety-critical aircraft primary structures. For aero-structure manufacturer, the general view prevails that the full cost and weight savings of composites cannot be achieved until bonded joints can be certified without fasteners. A breakthrough joining technology is needed where the currently used technique (adhesive bonding and bolting) are coupled in a structured manner to overcome the major drawbacks associated to each joining technique. Current advancement in 3D printing of micro-pins and nano-enhanced polymers are promising candidate to progressively replace current joining techniques.

The present challenge proposes a novel solution enabling composite joining for aerostructures but also secondary parts for automotive and for segmented wing blades within the energy sector, exploiting the combination of 3D-printed micro-pins and nano-enhanced adhesives which could finally meet in-service loadings requirements (aeronautics) and reduced time of assembly (aeronautic/automotive) leading to substantial cost and weigh savings as well as extended fatigue life (energy). The proposed challenge focus on the optimization of shape micropin and development of nano-based filled adhesive to improve the damage resistance behavior of composite-to-composite joint for part assembly and repairing process.

Taking the most out of micropin interleave layer optimized by modelling technique and manufactured by 3D printing process and developing new nanofilled adhesive to improve surface interface and fracture performance also by "ad hoc" synthesized nanoparticles, enhancement of the final composite-t0-composite joining and also composite-to-metal could be attained as also, recently, reported within the frame of a FP7 funded EU project, titled EXTREME. The ultimate goal of this challenge is to test feasibility and effectiveness of the proposed solution by comparing CtC and CtM engineered joints comparing them with traditional adhesive and riveted analogous items.

Scope

- Improve the joining behavior of composite-to-composite primary element;
- Enhance repairing technique by use of novel engineered interface solution;
- Demonstrate the reliability and effectiveness of through-thickness micro-reinforcements and nano-filled adhesive to strength composite joining;
- Exploit new morphologies and geometry of nanoparticles to achieve superior matrix damage performance and resilient performance;
- Micro-pin shape and density optimization for the required service loads and application
- Modelling the effect of different pin shape on the damage tolerance in the joining element;
- Implementation of computational technique to predict delamination phenomena in unidirectional and multidirectional composites under out-of-plane loading to model both interlaminar and intralaminar cracks.

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			Current SotA	Current Challenge Contribution
Specific Challenge	*Polymer-based composites*	*Aerospace & Aeronautics*	*Repair is still costly and time-consuming due to uncertainty in residual strength and quality.*	*Improve repairing methods and implementation monitoring system*
		Automotive	*Penetration volume rate is lower than 2% because manufacturing processes are not suitable for large-scale production.*	*Improve process technology for joining and fast production of assembled parts*
			Current adhesive systems in headlamps are mostly based on thermoset which very rigid and non-reversible. The substrate materials are difficult to be recycled or repaired. A thermoplastic adhesive could offer advantages w.r.t. re-use of components.	*Enhanced joining technique for repairing with extended service life*
		Energy	*Main applications for renewable energy e.g. wind industry; FRP are effective as blade materials since they can bear high stress while being lightweight. Current commercial solutions mainly rely on discontinuous fibres; use of continuous fibres with enhanced performance is limited to lab scale (TRL4).*	*Exploitation of nanofiller effects to improve damage performance and fatigue life*

Objectives:

- Simplifies the joining methodology eliminating holes and riveting or bolting
- Achieve a nanoparticles-based material to improve adhesion;
- Optimization of pin shape, location and associated 3D printing process for specific use case applications
- Development of nano-reinforced adhesives, resins and automatic fiber placement preforms manufacturing
- Demonstrating and validating the technology in five distinct case demonstrators, respectively, riveting, bonded, pinned, nano-modified bonded and hybrid (i.e. and pinned-nanomodified) elements.

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27_A&A_PBC_InjectModel

Title: Development of flexible technology modules for injection molding

Summary

Development of flexible technology modules for injection molding machines and injection molding lines for processing fiber-filled thermoplastics (fiber composite plastics) into lightweight molded parts in automotive and aerospace applications.

Injection molding of thermoplastics is one of the main technologies for the production of molded parts. Special injection molding processes are suitable for applications as lightweight molded parts in vehicles and in aerospace, which use fiber reinforcements to increase the mechanical characteristic values of the molded parts and/or to reduce the mass of the molded parts by processing foamed thermoplastics. For large-area molded parts with low wall thicknesses and thus long flow paths of the melts in the mold cavity, equipment (devices / assemblies) to be specially developed are required for injection molding machines and injection molding systems.

Main components and functions of these components to be developed are:

- Hot runners for leakage-free absorption of the thermoplastic melt from the plasticizing and injection unit for largely loss-free onward transfer to the sprue bush of the mold-forming die.
- Sensors for recording the parameters of the melts as they flow through the hot runner (data acquisition for AI and Industry 4.0).
- "Housings" (holding devices) for the hot runners adapted to the machine or system, which thermally insulate them and absorb forces acting on the hot runners from the outside, e.g. the nozzle contact pressure of the plasticizing and injection unit.
- Opening and closing devices for the hot runner to prevent melt leakage.
- Flow-optimized design of the geometry of the melt channel in the hot runner to minimize damage to mold fillers, e.g. fibers.

Molded parts made from reinforced thermoplastics have lightweight potential compared with those made from metallic materials due to lower densities, while retaining virtually the same mechanical properties. This reduces the mass of the vehicles, which will lead to CO_2 savings in operation. Furthermore, molded parts made of thermoplastic are recyclable - at the end of their service life, the molded parts can be recycled mechanically and/or chemically.

Scope

For the production of thermoplastic lightweight molded parts by injection molding, injection molding machines and injection molding lines are required in addition to the mold-forming tools. Commercially available machines and systems are limited in terms of their flexibility for technology and application trials. Flexible technology modules to be developed, e.g. in the form of hot runner adapter plates, enable the melt to be conveyed to the mold sprue bush largely independently of the respective machine. Furthermore, it is possible to easily introduce additives, e.g. fibers, into the melt flow and to record process parameters with suitable sensors.

Objectives

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Development of flexible technology modules for injection molding machines and injection molding lines for the production of thermoplastic large structural parts for lightweight applications, enabling:

- Processing of long fiber additives,
- Processing of high-temperature plastics, e.g. PEEK,
- Production of foamed lightweight molded parts with Class A surfaces.

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28_A&A_PBC_AirIntake

Title: Cost-effective lightweight design and tool-less manufacturing for an Air Intake duct of ECS application

Summary

The component proposed for the technological study in this project, selected on the basis of the OEM's choice to identify a material and process that can lead to a considerable reduction in weight and in cost is the Air intake duct of the Environment Control System (ECS). Challenges when designing ECS ducting can stem from the complexity of component configuration, a powerful solution for overcoming these difficulties could be additive manufacturing.

Scope

Create a demonstrator with an alternative material and process of the Air intake duct of the Environment Control System (ECS), and test it statically. Air Intake Duct is made of autoclave-cured carbon fiber material and is already manufactured in one piece.

The scope is to identify a material and process that can bring significant weight and cost savings on this component and on all similar complex shaped parts. In particular, the challenge is to identify a process and a material able to introduce any change easily, without high costs.

For a real possession of the technologies (possibility of certifying the product) it is necessary to have a potential qualification of the candidate material and process.

- Processes that can be used to build parts with complex shapes as monolithic as possible.
- The search for lower cost materials to Qualify and search for Eligible ones to be used for a possible Product Certification.
- A structural testing campaign (at coupons level if needed) for the previous purpose and to support the process, up to the full-scale test of ECS Air intake duct.

The component proposed for the technological study in this project is the Air intake duct of the Environment Control System installed on an aircraft.

Objectives

Realize a demonstrator in alternative material and process of the Air intake duct of the Environment Control System (ECS) taken as a reference. The main objectives of this challenge are:

- Weight reduction 20-25%
- Cost reduction 20-35%.
- Set-up method to qualify material and process, to apply the same material and process on similar items.
- Organize a dedicated aeronautical supply chain.

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29_A&A_PBC_GreenAircraft

Title: Novel interiors cabin design for greenest Aircraft

Summary

Development of a novel design of Cabin and Cargo aircraft interiors in accordance with the use of materials and processes conceived for an environmentally-friendly lightweight solution of the cabin items, 100% from recyclable sources, and more affordable technologies for materials treatments and processes with the aim to promote the use of recycled carbon fibers for semi-structural applications.

Scope

Production and testing validation of cabin&cargo interiors items by re-generating and returning back to process of hybrid CF/GF reinforced epoxy scraps coming from manufacturing process (figure 1), and uncured CF reinforced epoxy scraps in the form of preimpregnated patch, to achieve comparable mechanical performances (tensile-, compressive-, flexural strength, modulus etc.) with respect to state of the art as well as compliancy to flammability requirements.

Figure 1: hybrid CF/GF reinforced epoxy scraps from manufacturing process.

Objectives

Objective 1: Producing small panels (sandwich) for both mechanical and flammability testing with the materials to be used:

- Hybrid CF/GF reinforced epoxy prepreg scraps provided by challenge giver.
- CF reinforced epoxy scraps of prepregs provided by challenge giver.
- PET foam (or equivalent) 50–70 kg/m^3 with thicknesses: 7mm; 8mm; 10mm; 12mm; 19mm.
- Airex Tegracore foam (or equivalent), 50kg/m^3, with thicknesses: 7mm; 8mm; 10mm; 12mm; 19mm.
- Divinycell F (or equivalent), 50kg/m^3, with thicknesses: 7mm; 8mm; 10mm; 12mm; 19mm.

Objective 2: Tests to be performed: flame Vertical V-60 (CS-25.853), Smoke Density/Toxicity (CS-25.853-a), Heat Release Rate (OSU-method); mechanical ASTM D7249, ASTM C297, ASTM C365, ASTM D1781.

Objective 3: Performing LCA and LCC analysis.

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Objective 4: Reduction of weight (at least -8%) and recurring costs (at least -5%) with respect to state of the art.

Objective 5: Production of large panels/full scale items for final experimental validation to be performed by challenge giver.

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30_A&A_PBC_AVIC

Title: Automated visual inspection of composite parts

Challenge summary

CFRP parts are produced by manually or automatically drape layers according a defined pattern and assisted by laser projection. Especially in manual lay-up, this process is prone to errors like missed layer, wrong layer, wrinkels, edge effects or a protection foil not removed. This results in an expensive repair or even a scrapped part.

In case of CFRP the layers are black which makes it particularly challenging for a visual system based on a camera and image treatment. Both prepreg and dry fibers are considered as base material.

After curing and machining, the parts pass through NDT but also visual inspection for any external defects. Automating this process could then lower cost and be more accurate than the human eye.

Scope of the challenge

- Target parts: all CFRP/GFRP parts with manual lay-up operation

- Technical issues:
    - Define a set-up with the sensor, camera, lighting and image treatment to detect the errors during lay-up.
    - Define a set-up with the sensor, camera, lighting and image treatment to detect the errors after cure.
- Robotize and automation of this process.

Objectives of the challenge

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- Objective 1: Select vision system + SW for lay-up errors.
- Objective 2: Define vision system + SW for visual defects.
- Objective 3: Elaborate a POC for an automated inspection.

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research and innovation programme under grant agreement No 101005435