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.

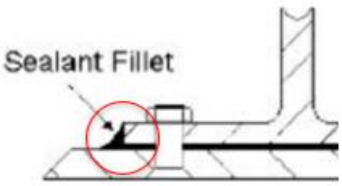
Scope: Target parts: complex 3D shaped parts with reduced accessibility

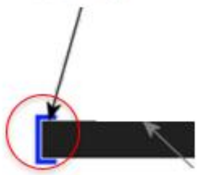
Technical issues:

- 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.

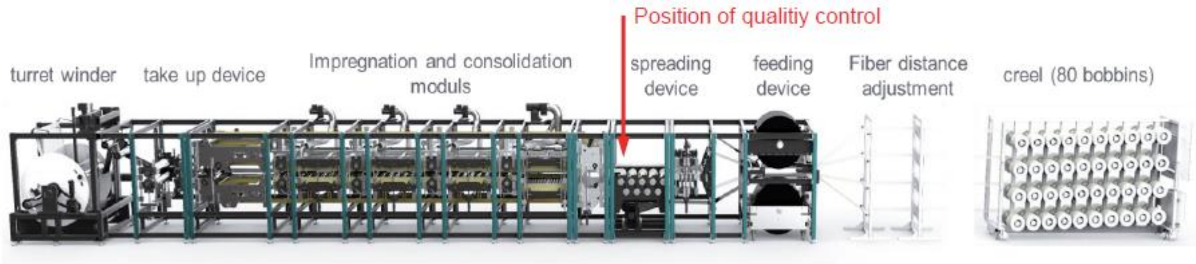

Fig. 1: Layout of the UD tape production line and position of the targeted measurement system

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

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- 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.

			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, re-spectively, riveting, bonded, pinned, nano-modified bonded and hybrid (i.e. and pinned-nanomodified) elements.

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5_A&A_PBC_CompoGEAR

Title: High-energy absorption composite landing gear for small helicopters

Summary

The crashworthiness requirements for landing gears are common to all the civil certification standards for helicopters (CS-VLR, CS-27, CS-29). Vice versa, for Ultralight (UL) helicopters these requirements do not apply, so it is possible to design and manufacture Composite landing gears, in order to save weight. The challenge we launch is the design of a light high-energy absorption landing gear for UL helicopters, light as much as a composite landing gear and energy-absorbing as a metallic landing gear. The solution of the challenge may produce for the winning SME a very interesting perspective for the application to other helicopters or vertical take-off and landing (VTOL) aircraft.

Scope

Design and prototyping (TRL7) of a landing gear for UL helicopter with crashworthy characteristics and extremely low weight. For the scope several technologies can be applied in the thermoset FRP domain and/or light metal alloys. Expected production is 70-100 items/year therefore compatible technologies/materials for the challenge should be identified by SMEs.

Operational temperature is -20 °C +80 °C.

Objectives

Design, prototyping and testing (up to TRL7) of a landing gear for UL helicopter with the following basic specifications:

- Compliancy with the crashworthiness requirements of CS standards
- Low weight
- Reasonable cost
- Easy to inspect with common NDT procedures
- Robust and reliable under normal use solicitations and under reasonably predictable slightly abnormal use (hard landings, light shocks due to impact with tools, etc...)
- Paintable
- EOL can be addressed as a plus.

More detailed specifications about aerodynamic requirements, mechanical interfaces, target weight and costs will be supplied on request.

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