Annex 2 Open Challenges description

AMULET

LIST OF CHALLENGES FOR 1st OPEN CALL

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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.

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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.

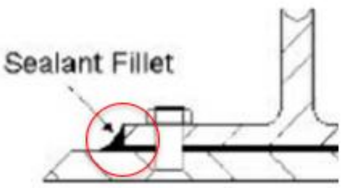
Scope: Target parts: complex 3D shaped parts with reduced accessibility

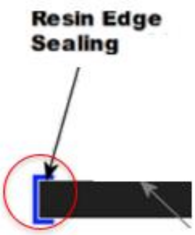
Technical issues:

- 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.

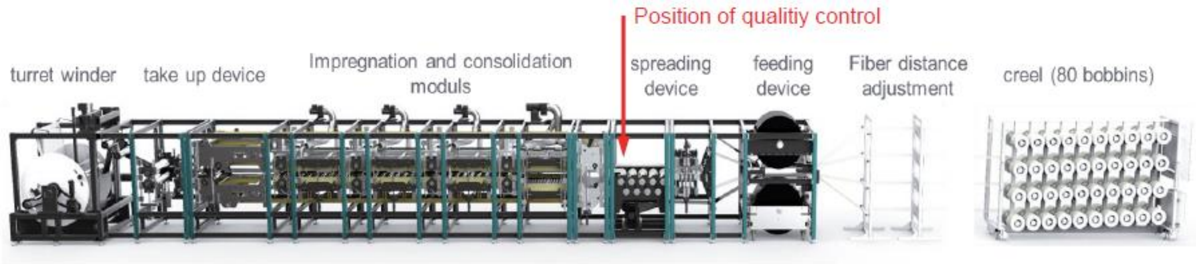

Fig. 1: Layout of the UD tape production line and position of the targeted measurement system

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, respectively, 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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Light Metal Alloys

6_A&A_LMA_MACOLI

Title: Clean and high-performance machining of composite and light metal alloy stacks

Description: The new CRFP, CMC and Ti/Mg alloys are bringing with also challenges how they can be more sustainably machined, in individual or stack applications. The solution has to meet higher performance, higher quality in combination with more health and environmental acceptable solutions – NO oil-based emulsion usage

Scope:

- Higher productivity
- Lower machining/manufacturing costs
- Substitution of oil-based emulsion
- Clean and dry machining process (especially in CRFP materials this improves the functionally of the produced parts)

Objectives:

- Find the solution for novel machining/processing of light weigh metals (Ti alloys, Mg alloys, Al alloys)
- Find the solution for novel machining/processing of CMC materials (C/C–SiC) and stuck structures with metals (i.e. Ti)
- Find the solution for novel machining/processing of CRFP materials and stuck structures with metals (i.e. Ti)

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7_A&A_LMA_ILOSI

Title: Innovative Lightweight structures for Optronic cameras and systems for Space Instruments

Description: Satellite payloads are nowadays encompassing more and more optronic systems, e.g., remote sensing instruments, cameras to provide imagery, star trackers etc… With the current boom of the Newspace and the development of nanosatellites or Low Altitude Platforms, the weight requirement of such assemblies becomes the main driver.

This challenge consists in proposing innovative lightweight material solutions to improve the weight of the instruments, and address their compatibility with the space sector and requirements, to enable innovative materials and assemblies to be used in this field

Scope:

- In space satellites, instruments weight is varying a lot for cameras, from 300kg for standard satellite payload (ex. Sentinel 2 MSI Instrument) up to a few kgs for smaller instruments (e.g. compatible with nanosats)
- The mechanical structure must be as light as possible, mechanically robust, and compatible with the optronic components: detectors, electronics, lasers etc…, contributing to thermal regulation to enable proper functioning of electronic parts; specific parts of a camera can be explored in a first instance if deemed necessary (ex. typical detector mechanical interface etc…)
- Several materials are conventionally used (see Edeson et. al., Acta Astraunotica 66 (2010) p.13); New materials or innovative material post process should be explored in view of enabling weight decrease and therefore performance increase of the whole system, especially for small satellites, nanosats and possibly drones

Objectives:

- Proposing lightweight innovative alternatives to currently used materials,
- Reducing the total camera weight by 10 to 50%
- Addressing -at least theoretically- their compatibility with space requirements as per ECSS-Q-ST-70C section 5
- Possibility to go towards a demonstrator if successful, in the frame of a cooperative project, depending on the outcomes

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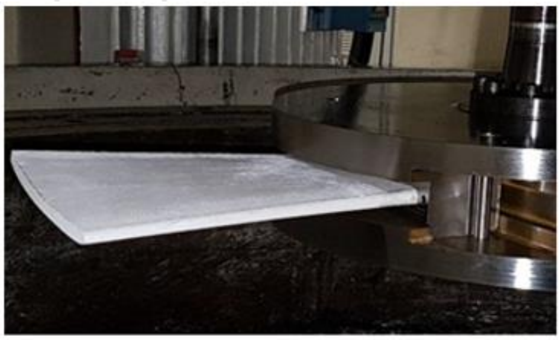
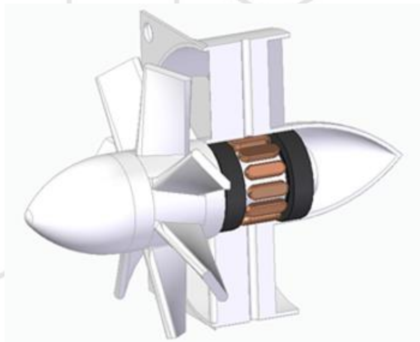
Ceramic Matrix Composites

8_A&A_CMC_CMCFan

Title: Lightweight CMC High-Temperature Fan for Aerospace Applications

Summary: Metal alloy fans are used in gas turbines, fire protection and for inflatable systems. There is experience with Ceramic Matrix Composites (CMCs) in aerospace applications such as atmospheric re-entry heat shields, mainly silicon carbide (SiC) matrix based. Lightweight oxide-based CMCs for fans offer up to a three-fold weight reduction compared to the best metal alloys at similar high temperatures. They can also enable innovative circular economy technologies like inflatable atmospheric decelerators (IADs) for reusable rockets, enabling CO_2 reductions in production and logistics for launch vehicles. The challenge is to demonstrate a working prototype (TRL 7) of a high temperature fan made of oxide-based CMC, based on experience with single fan blade demonstrations (TRL 4-5). The single blade was successfully manufactured and tested in a centrifuge test (Figure left). It exceeded the demanded 3000 rpm up to the point where the adhesive attachment of the blade to the test stand failed. The main goal is to improve the attachment in a real fan application (Figure right).

Scope: Single-blade demonstrations of all-oxide CMC fans have been conducted (TRL 4-5). The joining of a single blade and the rotor proved technically challenging. A feasible solution for joining multiple fan blades in a rotor needs to be developed and demonstrated. It is intended to demonstrate the all-oxide CMC fan in the context of use as an electric ducted fan (EDF) for inflatable atmospheric decelerators (IADs). IADs are at the cutting edge of atmospheric re-entry research conducted by NASA and ESA. The challenge giver is participating in the ESA Business Incubation Center to demonstrate innovative patent-pending IAD technology with the ultimate goal of making space transportation sustainable. With regard to the application, we intend to primarily use OCMC blades for the electric ducted fans of an IAD. There are other applications possible, such as micro gas turbines or combustion gas ventilators, but for an IAD, it enables a breakthrough in mass savings.

The state of the art in IAD technology uses heavy gas tanks for inflation (examples include IRDT or NASA HIAD). If we demonstrate the feasibility of using hot air during re-entry for

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inflation, this enables the use of extremely lightweight IADs for small rocket stages and return of cargo from space.

This would be a great step forward towards a sustainable, circular economy in space, leading to CO_2-reductions in the manufacturing and logistics of rockets. As SpaceX is currently the only company in the world partly reusing rockets, this project would be a great contribution towards building the first European reusable launch vehicles.

Objectives:

- Preliminary CMC fan design (feasibility study)
- Preliminary aerodynamic design (feasibility study)
- CMC fan blade Finite Element Method (FEM) analysis (Demonstration)
- Aerodynamic optimization using Computational Fluid Dynamics (CFD)
- Manufacturing and assembly of all-oxide CMC fan rotor (Demonstration)
- Demonstration run of 20 cm diameter, 12.000 rpm, 800 °C lightweight high temperature CMC fan

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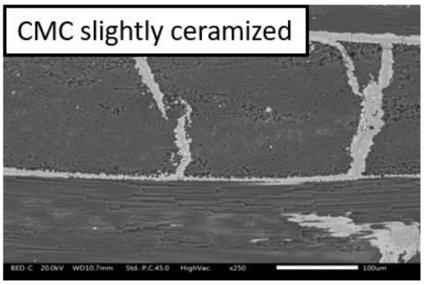
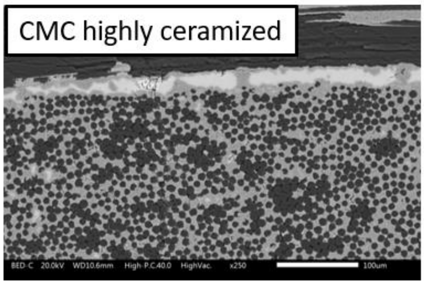
9_A&A_CMC_PrepregCMC

Title: Prepreg optimized for the Ceramic Matrix Composites production

Challenge summary: Ceramic Matrix Composites (CMC) are an enabling technology for the lightening of parts that have to operate at high temperatures. These materials are thus a key factor for the CO_2 reduction in several aerospace and automotive applications. Prepreg features strongly affect the CMC properties. Prepreg manufacturers are not involved in developing prepreg optimized for the CMC. This is due to the low volumes of the CMC market compared to the polymer composites market. The aim of the project is to establish a cooperation between CMC (1 SME) and prepreg producers (2 SME) in order to develop CMC for automotive and aerospace applications with improved properties.

Scope of the challenge: The aim of the project is to develop a CMC with improved thermo - mechanical properties and/or with an easier processability: The purpose is to understand how the fiber/matrix interaction in the polymer matrix composite affect the CMC properties. Different polymers interact differently with the carbon fibers and there is a non-trivial correlation between the polymeric preform properties and the CMC ones. This is a lack of knowledge that if solve can lead to the manufacturing of CMC with higher thermo mechanical properties. **The LSI (Liquid Silicon Infiltration) process must be considered as the reference CMC manufacturing process.**





The CMC ceramization grade is regulated by the polymeric pre-preg used for the preform manufacturing

Objectives of the challenge:

- To develop a not harmful and easy to use pre-preg, optimized for the CMC manufacturing
- To improve the use of high performing CMC in aerospace applications
- To improve the use of high performing CMC in automotive applications

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AUTOMOTIVE

Polymer-based composites

10_AUTO_PBC_FRA-TP

Title: Fire resistance additives for continuous fiber thermoplastics

Description: Develop additives to give fire resistant properties to continuous fiber thermoplastics. There is a market to develop composite battery housings (top cover or base plate) of BEV (battery electric vehicles). The housings must have fire resistant properties for thermal runaway of batteries and/or protection of batteries from external fire. Describe clearly your challenge. Current solutions are in metal (steel or aluminum) or in some case in thermoset composites. Fire resistant TP composites could reduce the CO_2 footprint of the car and be easier to recycle than thermosets. Composite solutions could be lighter than metals.

Additives should be proposed to be mixed with thermoplastics (PP or PA6). It should not limit the impregnation of the reinforcing fibers (glass in priority) with a high fiber content of 60-70 wt%.

Scope:

- No available "ready to use" additives that have the potential to improve the fire resistance of continuous fiber thermoplastics (PP or PA6) without limiting the fiber content and without reducing drastically the mechanical properties of the composite (strength, modulus, resistance to impact, thermal and ageing behavior)
- Initial objective is to have a UL94V0 classification of the composite with a glass content of 60 wt% of continuous fibers for PP and/or for PA6
- Cost of the additive should be "acceptable" for the automotive industry

Objective:

- L94V0 classification of the TP composite
- Reduction of mechanical performance is less than 10% vs. composite without fire additive
- Cost premium is limited to max 10% vs composite without additive

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11_AUTO_PBC_FRA-TS

Title: Fire resistance additives for continuous fiber thermosets (epoxy-glass)

Description: Develop additives to give fire resistant properties to continuous fiber thermosets

There is a market to develop composite battery housings (top cover or base plate) of BEV (battery electric vehicles). The housings must have fire resistant properties for thermal runaway of batteries and/or protection of batteries from external fire.

Current solutions are in metal (steel or aluminum). Fire resistant thermoset composites could reduce the CO_2 footprint of the car. Composite solutions could be lighter than metals.

Additives should be proposed to be mixed with epoxy for use in a wet pressing process where epoxy is poured on glass fabrics and the impregnated fabrics are transferred in a mold for curing. The additive should not limit the impregnation of the reinforcing fibers (glass in priority) with a high fiber content of 60-70 wt%.

Scope:

- Available "ready to use" additives that have the potential to improve the fire resistance of epoxy resin reduce drastically the mechanical properties of the composite (strength, modulus, resistance to impact, thermal and ageing behavior) or reduce significantly the glass transition of the composite
- Initial objective is to have a UL94V0 classification of the composite with a glass content of 60 wt% of continuous fibers for epoxy
- Cost of the additive should be "acceptable" for the automotive industry

Objectives:

- UL94V0 classification of the composite
- Reduction of mechanical performance is less than 10% vs. composite without fire additive
- Tg of the composite is above 100°C
- Cost premium is limited to max 10% vs composite without additive

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12_AUTO_PBC_AdhesiveFilm

Title: Adhesive film to allow structural bonding of composite with metal part during ecoat process

Description: The standard process to manufacture a car is to weld steel part together to make a body in white that is protected for corrosion and painted. The integration of composite parts in a steel body in white is difficult and is today mainly done with adhesive bonding. In that case a liquid adhesive is dispensed on the composite which is then pressed on the metal structure. The adhesive cures in the oven that is used after the ecoat process. This process limits the geometry of the parts that can be assembled and the process is difficult to control.

The challenge proposed here is to develop an adhesive that could be solid when the composite is placed in contact with the metal body. Ideally the adhesive would be placed in the mold when the composite part is molded. The adhesive would then cure when the BIW is placed in an oven around 200°C for a duration of around 15 minutes to create a structural bond between the metal and the composite. Solutions for thermoset and/or thermoplastic composites are of interest.

Hybrid metal/composites structures have a high potential for weight savings

Scope:

- Create a structural bond between a steel part and a composite part (thermoset or thermoplastic) without liquid adhesive and use oven of ecoat process to cure the adhesive the bond between steel and composite. The adhesive should be dry and as a solid thin layer at the surface of the composite to make the assembly process easier for the automotive OEM
- Structural bonding with values of bond around 25 Mpa in simple shear test at new and reduction of less than 25% after wet ageing
- Cost of the additive should be "acceptable" for the automotive industry

Objective:

- Adhesive is delivered as a roll of material (solid)
- Adhesive cures at 200°C in 10 minutes
- Bond between composite and steel is structural (shear strength of 25 Mpa).
- Good resistance of the adhesive after thermal (range -30°C to 80°C) and/or wet ageing
- Cost of the adhesive is compatible with automotive targets

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13_AUTO_PBC_RESeat

Title: Novel child seat components made of recycled thermoplastic fiber reinforced plastic

Description: Development of child seat components with high crash performance for automotive application. New technology combines particle foaming, injection moulding and local continuous fibre reinforcement. This particle-foam composite injection molding (PCIM) process overs a weight and CO_2 saving of up to 30 percent. Re-use of recycled thermoplastic tapes for injection molding of FRP molded component improves CO_2 footprint of the manufacturing process.

This is a challenge in terms of material and technology. It is declared to use recyclates (re-use of thermoplastics tapes) for the child seat production. The product fulfills the criteria of a hybrid composite and combining production technologies and joining various materials, which is important for lightweight composites. Main objective – the development of thermoforming and injection molding in combination with particle forming is new, this is the challenge.

Scope:

- Weight and CO_2 saving of up to 30 percent
- Excellent crash performance for automotive application
- Energy-efficient production process (one instead of two manufacturing processes = CO_2 saving) by Particle-foam composite injection molding
- (Re-)Use of recycled thermoplastic tapes for injection molding of FRP molded component
- Partner for product design is a child seat manufacturer based in Poland

Objective:

- Main objective: the development of thermoforming and injection molding in combination with particle forming
- Development of a functional demonstrator based on a head rest of a child seat (The challenge focuses us on the head rest of the child seat. This is the main component of the child seat with high requirements to crash safety and it's a perfect technology demonstrator. For that reason, the predicted budget is suitable.)
- Development of re-use technology of thermoplastic tapes
- Material analysis and selection
- Topology optimization and numerical design of the structure
- Development of a thermoforming and injection molding tool as well as a particle foaming tool
- Implementation and optimization of the manufacturing process
- Crash tests of the technology demonstrator

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14_AUTO_PBC_SUSDELI

Title: Sustainable design for lightweighted & easy-to-recycle «front end module» automotive parts

Description: FEM parts are structural and multi-component automotive parts widely used in passenger and commercial vehicles. The challenge giver manufactures different types of FEM parts for different OEMs. Most of these parts are manufactured by overmolding onto metal inserts so that part can withstand necessary amount of deformation during its lifetime. Metal inserts and plastic material which is used in FEM parts have high value however recycling of these parts is quite challenging both for scraps and EoL.

FEM parts have a lightweight potential since including metal components and new design can make possible to recycle these parts without intensive labor force and at the end lower CO_2 emissions will be generated.

Scope:

- Replacing current design with new ones, considering design for sustainability. Upgrading the design by developing a new assembly technology which makes separation of components feasible.
- Replacing metal components with fiber reinforced thermoplastics. By doing this new part can be mechanically recycled if the fiber reinforced composites can comprise of same resin.

Objectives:

- Finding a solution to replace current design with new sustainable one which can be different way of metal-plastic bonding, using adhesives etc. By doing this, CO_2 emissions can be reduced and lighter parts can be manufactured.
- Developing new material which is suitable for replacing metal inserts in FEM parts. New material needs to be suitable for current production line and be compatible with plastic resin (PPGF) commonly used in FEM parts.

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Light Metal Alloys

15_AUTO_LMA_DIJOALS

Title: Dissimilar joining for serial applications.

Description: Dissimilar joining of:

- aluminum-steel
- Steel- composite
- Aluminum- composite for serial applications.

Dissimilar joining can be possible with only possible with screw and nut and some rivets technology in serial productions.

These have some limitations; therefore, we need alternative solutions:

- More aesthetic
- Faster
- Cheaper
- Lighter

Objectives:

- Increasing the lightweight material on vehicle
- Give design convenience to designer
- Faster, more reliable and lighter joining
- Less heat generating during joining (like arc welding)

Challenges:

- Dissimilar joining without extra fastener usage (no screw, no nut) or very small low cost elements. Constraint: the mechanical properties of the joining area must be bigger than the lowest properties of sheet metal in the mechanical structure.

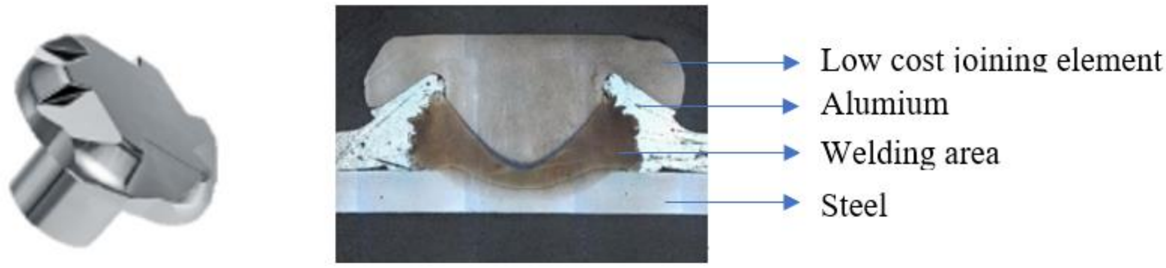

Figure 1: Example of low cost element

- Joining without pre-readiness (hole opening, nut welding etc.), for current solutions, we need to make extra operations for joining. Opening holes, welding nuts, tuckers etc. We are looking to eliminate opening holes, welding nuts, tuckers etc, and create easy assembly ways. Example: self-drilling screws

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Figure 2: Self drilling screws

- We want to use hole expansion index properties to create a nut with sheet material itself. We want to create a norm about it

Figure 3: Hole expansion index

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16_AUTO_LMA_E-carGEAR

Title: Light metal alloys for e-car gearbox

Summary: Light weight alloy (or as more challenging alternative fibre reinforced polymers) with noise reduction characteristics to be utilized to realize e-car gearbox and differential housings. Possible application extension (depending on production cost) also on industrial gearboxes. Start TRL4/5, end TRL7

Description:

New e-vehicle will require a big attention to weight, to improve the overall efficiency of the vehicle, penalized by the big mass of the battery pack. Innovative solution will be necessary either to reduce the weight of the vehicle transmission (gearbox and differential) or to reduce NVH (in particular, noise) due to the fact that to improve e-motors performances their max speed is already above 20K rpm. Innovative solutions can identify new material that can replace aluminum/cast iron die casting and that could be more efficient in terms of NVH and weight, i.e., composite material with sandwich structure. Obviously, cost could be another important driver.

Please note that the challenge doesn't consider battery pack production, as the reference on battery pack is only to remind that the e-vehicle with heavy BP, could need to improve their weight but on other components (like transmission or other components).

New materials and production technologies will be necessary to take up this challenge

Objectives:

- Objective n.1: alternative material/solution to aluminum housing of a gearbox, with a weight reduction at least of 30% and a cost increase not higher than 10%. As output of the Project a sample of gearbox/ generic housing, to show weight reduction at same mechanical overall performances.
- Objective n.2: improve NVH emission by at least 30-50% with a laboratory simulation at different frequencies.

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

Ceramic Matrix Composites

No challenges provided.

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

ENERGY

Polymer-based composites

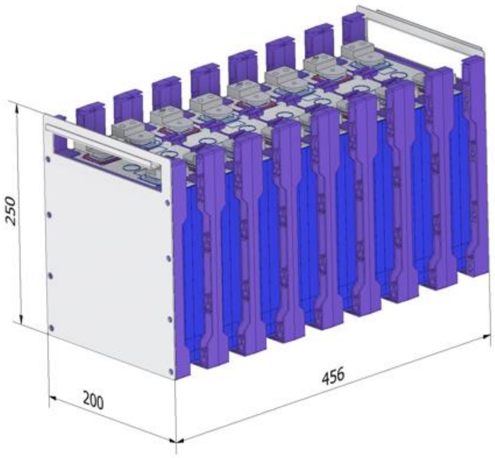
17_ENER_PBC_BATTERYpack

Title: Modular Battery Pack

Summary: Main purpose of the modular battery pack is to design a product, that will provide a strong and lightweight base for modular battery pack assembly.

Scope: We are developing new modular battery packs for Li-Ion technology and for this purpose, and are looking for new designs with advanced materials, that could improve the quality and durability of the battery housing.

- The new housing design will be used in different applications, ranging from material handling batteries, to stationary applications for energy storage.
- To ensure longevity for the product and to extend its life expectancy, the new housing must fulfil special requirements, that are described in objectives.
- The battery housing must fulfil requirements described in Ecodesign directive (2009/125/EC).
- We are looking for companies, that have extensive knowledge in advanced materials and product design.



Objectives:

- New product design, that fits required dimensions.
- Lightweight product.
- Easy assembly and disassembly.
- Product must sustain 300kgf on prismatic cell walls.
- Thin side walls for easy cells insertion.
- Product design prepared for automatic assembly.
- Use of recyclable or reusable materials is advantageable.

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

18_ENER_PBC_LightHtank

Title: Lightweight gaseous hydrogen storage tank for aeronautical application

Summary: Hydrogen application is one of the most promising solution to decarbonize the aeronautical industry. The storage of hydrogen in a lightweight tank is one of the biggest challenge. This project proposes to develop a new type of tank in order to make gaseous hydrogen storage a feasible solution for aviation. New composite materials could be investigated as well as new design for the tank.

For our airship application, 6000 T of CO_2eq can be saved per airship and per year if using hydrogen instead of kerosene, and we plan to manufacture and operate 100 airships for the first 10 years.

Scope:

Hydrogen will be the enabler to decarbonize aviation. However, it must be done without impacting the performances of the aircraft i.e. as light as possible.

Gaseous hydrogen storage is the most mature technology since it has widely been developed for automotive. But the aeronautical constraints in term of weight have not been considered.

Thus, there is a need to design gaseous hydrogen storage for aviation. The airship can therefore be a first application given the less constraining design, especially regarding the volume constraint: dozens of cubic meters. This leads to investigating big and light vessels with possibly lower pressure than the common 350 or 700 bars.

The outcomes of this project could be adapted not only to airships. Indeed, GH2 tanks are first easier to be designed with as few constraints as possible. So, not considering the volume constraint (for airship application) will help to converge on different architectures. Then, it will be easier to take account the volume variable for other applications such as maritime or in energy.

Objectives:

- The main KPI for developing a hydrogen tank for aviation is its weight.
- An output of the project could be a parametric model coupled with an optimization algorithm that proposes different gaseous hydrogen tank designs (variables = inner pressure, materials, manufacturing process, dimension(s) of the tank, etc).
- Challenge giver can provide the specifications for such a storage as well as some preliminary results.
- The model shall take into consideration new materials & processes and their compatibility with hydrogen, and tank design (parametric model).

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

19_ENER_PBC_ETAlightFRP

Title: Energy harvesting by innovative Thermoelectrically-enabled Advanced structural & lightweight FRP composites

Summary: Printed thermoelectric generator (TEG) thin film-consisting devices onto glass fiber (GF) reinforcement substrates, and the integration of GF-TEG as functional/ system laminae in carbon FRP structural laminates for thermal energy harvesting could allow multi-functional lightweight structural with energy harvesting capabilities. TEG-enabled structural composites with energy power output of higher than 10mW (in several hot spots and thermal losses existing in structural composites) could allow the self-powering of low-power electronics for e.g. IoT sensors, machine-to-machine communication towards E-mobility, SHM functions, etc. This will a) increase the operational lifetime of structural composite materials, b) decrease the regular maintenance and inspection costs, c) increase the safety of the users (e.g. passengers in automotive, aeronautics, etc.) all of which could have a i) significant impact in the reduction of CO_2 emissions, and ii) decreased weight of the structures via decreased usage cables due to the “stand-alone” structural parts with energy harvesting capabilities that can power integrated electronics.

The above concept could be realised with TEG devices printed by sheet-to-sheet (S2S) & roll-to-roll (R2R) technologies on glass fiber substrates utilising highly efficient, abundant and environmentally friendly thermoelectric nanomaterial inks. Carbon nanoallotropes are envisioned to be the best candidate for printed TEGs due to their high thermal stability as well as the ease of tuning their semiconductor characteristics (p- and n-doping efficient processes, engineered shift of Fermi level, etc.).

Representative Target values: power factors PF> 100 μWm-1K-2 for p- and n-type materials, and ZT: 0.1-1.0) reaching TEG device efficiency of n= 5-10%. Lifetime of TEG devices >10 yrs with proper Effective Encapsulation.

Selected sectors of application: Automotive (e.g. Automotive: TEG-enabled FRP bonnets); Aeronautics (TEG-enabled FRP leading edge, fuselage, etc.); Aerospace (TEG-enabled FRP coverage of Radioisotope TEGs, etc.). Start TRL4-5, end TRL7.

Scope:

- Printed TEGs on glass fiber reinforcements (woven or non-woven substrates) at large scale with a power output of Pout>10mW at $\Delta T = 100$ K
- TEGs with nanomaterials exhibiting a thermoelectric figure of merit (ZT) >0.1 and up to ZT=1.0, allowing TEG device efficiency of n= 5-10%.
- Proper doping of carbon nanomaterials is missing to go achieve ZT>0.1; while keeping environmentally friendly solvents e.g. water for the inks medium
- Integration of flexible GF-TEG laminae in structural FRP laminate composites for the efficient thermal energy harvesting and utilisation of the energy produced by the advanced composites for self-powered low-power electronics

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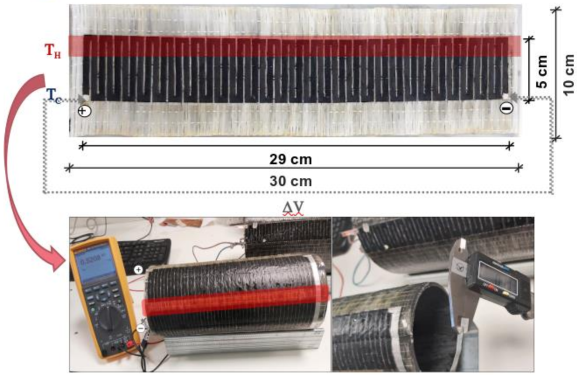

Figure: Printed TEG on a glass fabric and integration in a tubular FRP structure

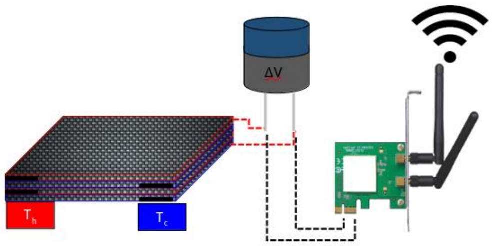

Figure: TEG-enabled structural FRPs for self-powered functions…

Objectives:

- Seebeck coefficient and conductivity of p- and n-type semiconductors via e.g. doping with acidic- proton donating conjugated (p-doping) and conjugated amines/ base molecules for e-donation (n-doping): Performance Targets: Seebeck coefficient S >50 μV/K for p-doped and <-40 μ V/K for n-doped nanomaterials, electrical conductivity σ = 104 S/m with power factors PF> 308 μW/mK2 and 258 μW/mK2 for the p-type and n-type films, respectively at ΔT=100K (KPI-01):
- Power Factors (PF = σ S2) increase by at least 2-3 times for carbon nanoallotrope thermoelectrics; and figure of merit (ZT) from 0.1 (currently achieved) to be increased to ZT = 0.5-1.0 (KPI-02),
- Power conversion efficiency (PCE) from current values of 2-3% to PCE or n=5% (KPI-03) at material level
- The TEGs onto glass fiber reinforcements to be highly scalable fabricated in a continuous printing process (KPI-04)
- TEG Devices for TEG-enabled FRPs with the ability of operating at high temperatures up to 200°C at ambient conditions (1 atm, relative humidity: 50±5% RH) (KPI-05)
- Maximum power density of the TEG device >5 W/m2 and 10.0 W/m2 at ΔT=50K and ΔT=100, respectively (KPI-06)
- TEG-enabled FRPs (TRL7) with self-powered capabilities e.g. powering a strain gauge sensor for SHM, a temperature sensor, etc. (KPI-07: demonstration of the FRP produced energy for a self-powered function)

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20_ENER_PBC_CFNWfabric

Title: Carbon fiber spayed non-woven fabric

Summary: The basic problem is to produce a non-woven carbon fiber non-woven material from recycling, mainly from pyrolysis. The problem is that the existing textile techniques should be adapted to the needs of producing carbon nonwovens of appropriate quality, enabling their further use - processing. According to our tests, the production of such nonwovens is possible by combining several techniques known from the textile industry, including: needling, binder spraying combined with calendering, sewing, e.g. with the Maliwat technique.

In case of great problems with achieving cohesion after needling, it is possible to add other fibers improving the cohesion of the non-woven fabric, including natural fibers.

Scope: Carbon nonwovens are currently produced mostly by needling, we want to produce them by blowing them without needling. Currently, we do not know the possibility of such production.

Should be also examined the market to see if there is a demand for such nonwovens.

Objectives:

- to create inflatable nonwovens
- the pyrolysis process we have carried out allows the recovery of long fibers, up to 2 meters in length, which allows the creation of nonwovens from longer threads, which will significantly affect the strength of the non-woven fabric.
- creating a closed loop for carbon fiber
- new product on the market
- Possibility of cooperation with biggest producers and recyclers of such.

The main goal is to obtain nonwovens made of pyrolytic carbon fibers suitable for the formation of:

a) pre-impregnates

b) nonwovens for infusion and RTM techniques

c) stitched nonwovens for the production of open and closed profiles using cheap techniques

d) manual lamination.

Referring to the current geopolitical situation, the techniques and materials from the submitted task will enable the production of cheap drones and other military flying means that strengthen defence.

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Light Metal Alloys

21_ENER_LMF_EDLCcapacitor

Title: EDLC capacitors with anodized aluminum foil

Summary: The basis of this challenge is to create a product, an EDLC capacitor that has an anodized aluminum foil. However, we must not forget that the capacitor is made from several different components and not just an anodized aluminum foil, and all components work together simultaneously to get the best capacitance values. Among these components, we give a high importance to the cohesion between the anodized aluminum foil and electrolyte.

Challenge is to develop EDLC capacitors with anodized aluminum foil. In combination with a suitable electrolyte, it has a higher specific surface area, which in turn allows us to have higher capacitance values. By achieving higher capacitance values with less material we are bringing lightweighting to the field of capacitors as well by reducing the materials and implementing new modern material we are reducing CO_2 emissions as well will develop and implement new production technologies with aiming to reduce CO_2 emissions.

We have chosen the material for the heart of the capacitor - the capacitor roll as aluminum. The metal itself is very reactive and spontaneously forms a thin transparent oxide layer, upon contact with atmospheric conditions, which provides great stability. The oxide layer has the properties of a dielectric, and its surface is porous, which increases its active surface. Therefore, we want to use it as a dielectric, and with its properties significantly increase the capacitance of the capacitor at the same dimensions. It is possible to form an oxide layer to the correct thickness and porosity by various electrochemical processes. This allows us maximum capacity per unit volume. Therefore, in the field of technology, it will be necessary to develop the process of anodizing the aluminum foil to gain the required specific active surface needed.

The electrolyte in an electrolytic capacitor supports the operation of the capacitor. When impregnating the capacitor element - coil, with liquid electrolyte, we electrically connect the cathode and anode material. In the presence of a layer of aluminum oxide formed on the anode foil and acting as a dielectric, a capacitor with a high capacitance value is obtained. In this case, the electrolyte has a cathode function. The basic properties that the electrolyte must meet are electrical and ionic conductivity, chemical stability and compatibility with other capacitor components, superior impregnation characteristics, low viscosity and good surface tension.

Scope:

- In the field of capacitors, we want to increase the capacitance value of the EDLC capacitor by increasing the specific surface area by anodizing the aluminum foil, which is achieved in combination with a specific electrolyte.
- It will be necessary to determine the thickness of the anode layer, porosity and other properties of the material.
- In the field of technology, it will be necessary to specify the process of anodizing aluminum foil so that it will achieve the required dielectric (aluminum oxide) properties.

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- Activities to be carried out will also include research and development of a suitable electrolyte, a fluid with a wide range of electrical properties from ESR (Equivalent Series Resistance), a range of capacities ranging from millifarads onwards, electrolyte leakage, life-enhancing additives, operation and maintenance of primary functions at high temperatures, vibrations, pressures and other severe environmental conditions (humidity,…)
- Missing knowledge is also on the material side when speaking of the electrolyte composition. The technology side mentioned before (anodization process) will be determined in next future steps. – When an ideal solution for the EDLC has been determined, the production technology comes. This means that after the goal has been reached, a production process is to be developed.
- Laboratory equipment is also missing to provide right and fully need to successfully finish the project.
- Missing knowledge and equipment can be provided by Institute – if we do not have the required analytical equipment for certain required analysis, or, if there is a question on which we cannot give the answer to, an external Institute or University can be found as a subcontractor.

Objectives:

- determine the appropriate thickness of the anode layer
- ensure a porosity standard
- development of new technological processes for the production of new capacitors
- achieve other material properties (basic electrolyte properties: electrical and ionic conductivity, chemical stability at temperatures up to 120 °C and compatibility with other capacitor components, does not cause corrosion in other elements, superior impregnation characteristics, low viscosity and good surface tension).

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22_ENER_LMF_contactPADS

Title: Contact pads $AgSnO_2$ and AgW

Description: Improving the balance of conductivity in low voltage switchgear products by improving existing or providing alternative materials (metal or ceramics)

We want to improve the materials with which we achieve the mechanical properties required in low voltage switchgear, especially by improving the balance of transportability by changing the hardness, strength, resistance of contact surfaces to welding in electric arcs, weight and CO_2 friendliness.

Scope: When we are switching load, contact pads hit with each other and electric arc is created. This electric arc burns out contact pads and lifespan of the switch is shortened.

We want to develop materials that will be more resistant to contacts, while we want to meet the new market requirements for the implementation of new advanced materials and internal and external needs to reduce CO_2 footprint.

The standards IEC/EN 60947-4-1 and IEC 62955 specify:

- short-circuit tests (3000 A with pre-fuse): At short-circuit tests very high temperatures are generated which can melt or evaporate copper and the contact material/pads.
- switch on test at full load (high switching currents, high inrush current): electric arcs are created burning down the contact material.
- allowable heat on the contacts: Contact material such as AgW can have higher contact resistance causing non-conduction through the pole and overheating.
- switches' mechanical durability: 3 million cycles with no load.

Objectives:

- Improving the balance of conductivity – mechanical properties (hardness, strength,
- resistance of contact surfaces to welding in electric arcs and CO_2 emissions)
- Improving technology of production targeting CO_2 footprint reduction
- utilization with standard category AC-1 and category AC-3

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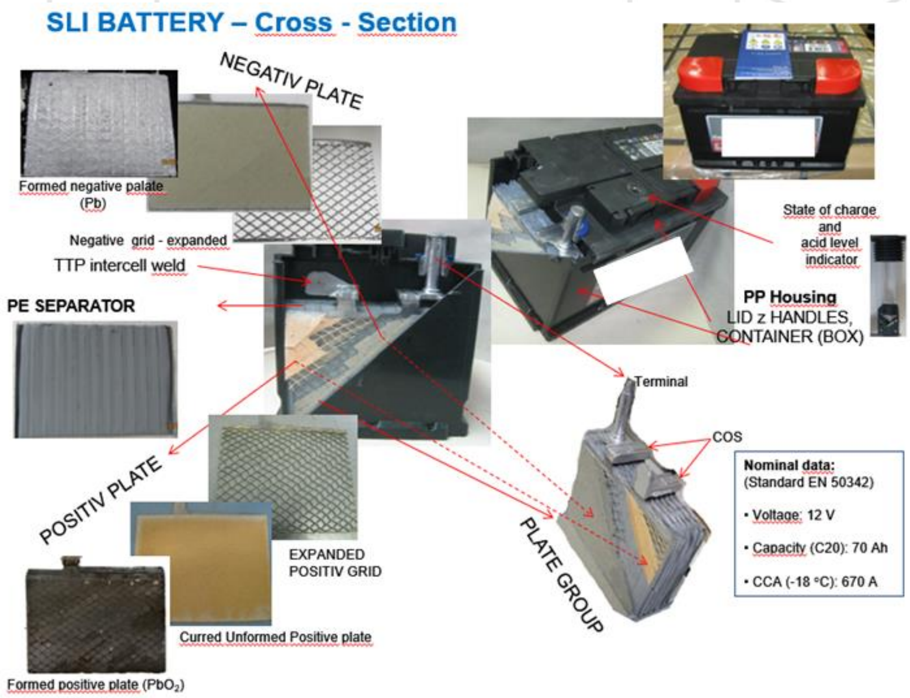
Ceramic Matrix Composites

23_ENER_CMC_LightGRID

Title: Lightweight active grid

Description: Replacement of lead alloy grid with lightweight material with better conductivity and resistant in dilute sulfuric acid. Seeking for lightweight material for active grid with electrical conductivity and resistant in dilute sulfuric acid. Achieving adhesion with active material to collect electrons from chemical reactions in active mass in batteries electrodes.

Figures: top – active grid, bottom – battery components



Objectives:

- Higher energy density (weight reduction)
- Reduce the use of lead
- CO_2 emissions reduction

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BUILDING

Polymer-based composites

No challenges provided.

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Light Metal Alloys

24_BUILD_LMA_WAAMconnectors

TITLE: WAAM technology for structural steel connections with advanced design

DESCRIPTION

This challenge aims to improve the methods and practices used in the design and fabrication of steel connectors for new and existing structures exploiting the potential of novel 3D printed metal technology (such as WAAM) in terms of new geometries and improved structural performances.

Nowadays, steel connectors are a crucial point in both design and construction phases of steel frames, especially in seismic prone areas where high demand is requested for moment resisting frames thus requiring ad-hoc costly solutions (high strength bolts, stiffners, full penetration weldings,..) . New layouts and geometries are currently realized using fused metal and cast iron with specific formwork that involve:

- waste of material
- poor flexibility (difficulty in adapting to changes in plan)
- high costs
- time consumption

The proposed solution is to use metal 3D printing technology for large parts such as Wire and Arc Additive Manufacturing (WAAM) to design and manufacture a new class of steel connectors for frame structures with high flexibility in the geometry and structural performances of the outcome.

The following technological results will be achieved during the project:

- Off-site manufacturing of novel steel joints for moment resisting frames
- Development of new designs methods for efficient steel connectors exploiting the potential of WAAM fabrication methods.

Objectives of the project:

- Reduction of manufacturing time
- Increased productivity
- Reduction of weight
- Increased geometrical flexibility towards a new class of efficient connectors
- Reduction of material waste
- Reduction of environmental impact

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Ceramic Matrix Composites

25_BUILD_CMC_HEALmortar

Title: Self-healing mortar

Summary If facade final coats are cracked rain water penetrates inside the facade system, which reduces thermal insulation properties of the ETICS system and can damage also the buildings load-bearing structure. The developments of new materials, like self- healing materials, are highly needed to repair cracks instantly to prolong facade service life.

External thermal insulation composite facade system (ETICS) is assembled from different materials and each has its own specific function.

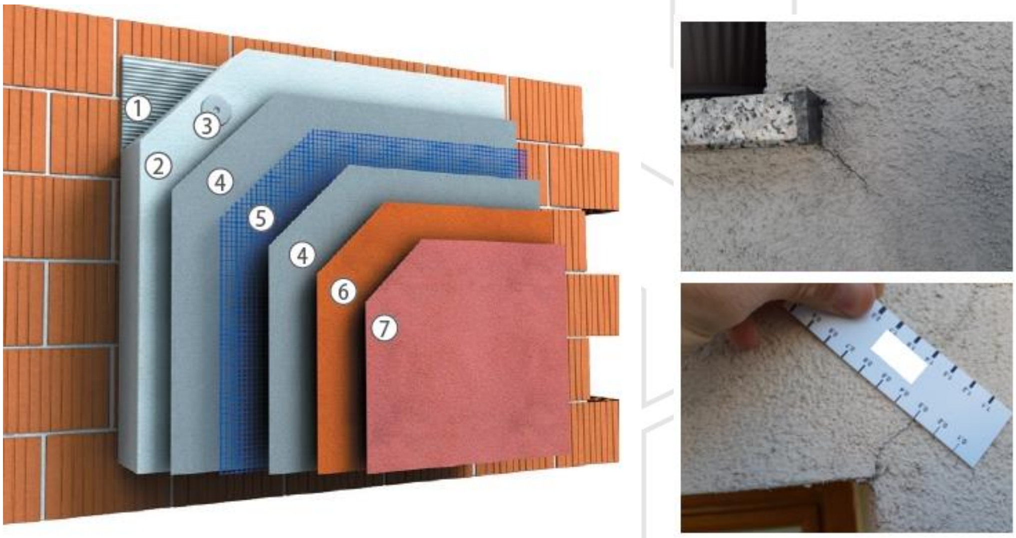

Figure: left - 1 Primer, 2 Thermal insulation, 3 Anchor, 4 Base coat, 5 Reinforcement mesh, 6 Primer, 7 Top coat; right - crack examples

Basic function of Base coat is to bear stresses due to thermal expansions and possible impacts (e.g. hail, ball...). Usually base coat is made by cementitious mortars in thickness 3 to 5 mm and reinforced with glassfibre mesh. Quite common cracking of base coat occurs (up to 0.5 mm) together with decorative top coat before end of life, which is usually considered to be 25 years.

Concrete self-healing solutions are already on the market, but self-healing solutions for cement-based mortars are still not well defined. From literature the known self-healing solutions are: superabsorbent polymers (SAPs), shape memory polymers (SMP), bacteria- based self-healing, encapsulated healing agents (macro and microcapsules), engineered fibres, which provide crack closures for crack widths greater than 0.15 mm; while shape memory composites (SCMs) seal smaller cracks widths (< 0.15 mm).

Scope of the project would be to develop self-healing mortar for base coat that in the case when cracking occurs cracks up to 0.2 to 0.3 mm would self-filled and prevent water to penetrate deeper into the facade system. We prefer the solutions with microencapsulated agent, which is present in mortar and it is released when crack occurs. Solution with SCMs and expansive minerals as fly ash, silica fume, BFS,

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CSA, bentonite clay or any other material which make a strong bond between the crack faces… It would be desired using waste material from local productions, that we can contribute to circular economy and also, we would like to contribute to reducing pollution.

We are seeking self-healing solution for achieving crack-free mortars in normal conditions (without further heating or compressing). The know how should include the knowledge about the effect of self-healing additive on the properties of cement mortar especially durability improvements. Challenge-giver would provide basic formulation of the mortar.

Objectives:

- To develop formulation of mortar with self-healing properties.
- To quantify properties of developed mortar (chemical, mechanical, applicable, healing).

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26_BUILD_CMC_MgOconstruction

Title: Magnesium-based by-products and slags for alternative construction materials

Summary: The challenge is focused on the potential application of two magnesium-based compounds. On the one hand, the reuse of Magnesium oxide by-products obtained during the industrial calcination process of magnesite. On the other hand, potential uses of refractory ceramic residues from steel industry.

MgO by-product relevant information: collected as the cyclone dust from the kiln as a fine brown powder. It is mainly composed by MgO, and carbonates from the mineral ore because of the uncompleted calcination decomposition. The MgO content is between 60-65% (on ignited basis) and the CaO, SiO_2 and Fe_2O_3 around 7, 3 and 2,5 % respectively. This by-product is currently used as soil stabilization agent, and as a precursor for developing alternative cements, such as Magnesium Phosphate Cements (MPCs), among other applications. MPCs developed by using this by-product presents excellent properties as insulating material, as repairing material, and as matrix of natural fibers due to its neutral pH. However, the cost is very high in comparison to Portland Cement, mostly due to the cost of the phosphate source.

Refractory residues relevant information: refractory material obtained after service in the steel industry. These refractory residues contain different metals that can be cleaned by magnetic treatment. Subsequently, the material is properly conditioned reducing the particle size by crushing and milling. It is mainly composed by Mg, Si, Ca, Al and Fe. The main issue is the large amount of these type of wastes obtained by the steel industry. Besides, they are poured into landfills. Our company seeks for a valorization of this kind of wastes in order to reduce CO_2 emissions and to enhance the sustainability by promoting the circular economy.

Scope: The main purpose is based on the development of sustainable and valuable construction materials as an alternative to the conventional ones. To seek the CO_2 emission reduction, and the development of lightweight construction materials with relevant properties. Start TRL4, end TRL7.

Objectives:

- Use of both materials in the development of sustainable construction materials considering or including lightweight brick and mortar material solution (under the material classification considered into the UNE EN 998). This can be achieved by using them as secondary raw materials, and/or as an addition for improving some properties of conventional construction materials.
- Economically viable construction materials (brick and mortar) for the proposed alternative construction solutions. Realistic scenarios in order to be competitive in the market.
- Interesting technical targets are considering, regarding their properties, for these objective and developed products/materials in this project: densities around 500-525 kg/m^3 and 1000-1250 kg/m^3 (UNE EN 998), for the brick and mortar respectively, and thermal conductivities ((UNE EN 1745 for thermal properties) of no more than 0,4 W/mK for both products, are targeted for these sustainable construction materials/products to be developed in this project, by keeping resistance and other expected and required properties for the conventional construction materials solutions.

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"This deliverable is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101005435".

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