AMULET

Report on “Industrial challenges under each category“

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Abstract

The deliverable reports the results and the process of the definition and validation of industrial challenges in the targeted fields of lightweight materials and sectors, which will be published as Open Challenges within the 2nd Open Call. These challenges build the basis for the thematic competitions, which will be kicked-off with the announcement of the 2nd Open Call.

The list of challenges is valid for the 2nd Open Call.

List of acronyms

Abbreviation / Acronym	Description
AMULET	Advanced Materials and Manufacturing Technologies united for Lightweight
SME	Small and Medium-sized Enterprise
TWGE	Thematic Working Group of Experts

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1. Introduction

The AMULET project aims to reach out to regional SMEs with worthwhile innovations in the light weighting area, and incorporate them in new value chains. In order to do so, AMULET firstly identifies and collects specific challenges based on real current needs of the industry (end-users, e.g., original equipment manufacturers and large companies). The partners prepared a list of challenges coming from one of the three types of lightweight materials (polymer-based composites, ceramic matrix composites, and light metal alloys) for four industrial markets (automotive, aerospace & aeronautics, energy, and building) forming 12 thematic domains of challenges.

Secondly, the list of industrial challenges is reviewed and each challenge scored by external experts with the expertise within the respective thematic domain, i.e. Thematic Working Groups of Experts (TWGEs). The final list of the most relevant challenges is then prepared with the detailed description of each challenge, forming the Open Challenges for respective Open Call.

Thirdly, the Open Challenges per call are publicly announced within the Open Call thematic competitions. The activities proposed by SMEs micro-consortia should address the development and implementation of demonstration activities around technology and system applicable to one of the Open Challenges.

2. Methodology

The thematic competitions within the two Open Calls are focused on real current needs of industrial end-users. For this purpose, AMULET partners run a communication and dissemination campaign to collect challenges from industry (e.g., original equipment manufacturers, Tier1,2 suppliers) and invite external experts from industry and academia to collaborate with AMULET.

The challenges were collected by sharing a template (provided in Attachment 15.1 of D1.1) on the guidelines for description of the challenges with the potential challenge givers, asking them to draft their respective challenges. Partners then collected the challenges from the members of their regional hubs and other hubs (from end-users, e.g., original equipment manufacturers and large companies) and prepared an expanded and detailed list of challenges. The partners reviewed and assessed the collected challenges and removed any sensitive or confidential information that challenge givers have provided in the template.

All the relevant challenges identified were discussed and evaluated by the external experts under respective TWGE, according to following criteria:

- Quality of the challenge in general,
- Conformity of the challenge description,
- Relevance to a real industrial need,
- Demarcation to added value or novelty,

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- Feasibility of addressing the challenge within the given time frame (15 months) of the AMULET support,
- Feasibility of addressing the challenge within the budget (120.000 EUR) of the AMU-LET support.

TWGE evaluation prioritized the main challenges, providing top challenges within each domain. The selection promoted the real need from the industry to work on that challenge (potential impact), the excellence needed to overcome it as well as the feasibility according to the time and budget limitations, and the addressed TRL value, among others. The project partners confirmed the selected top challenges to be prepared for the public unveiling with the Open Call. The descriptions of the challenges were updated according to reviewers' comments by the challenge givers in order to prepare a detailed description, specifying clear objectives, desired measurable results and expected impact, representing the basis for the thematic competitions.

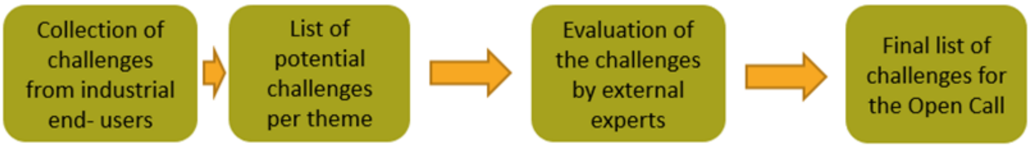

Figure: Definition of challenges for thematic competitions

The final challenges selected for the Open Call as well as details involved that need to be known by SME consortia will be made public with the announcement of Open Challenges with the Open Call launch for all the EU lightweight community. This milestone represents the official launch of the competition.

The identified relevant challenges are in line with the AMULET objectives to consolidate novel value chains for multi-sectorial industrial applications enabled by advanced materials and their related manufacturing technologies, ultimately contributing to decarbonisation and resource-efficiency.

The list of Open Challenges, as jointly agreed by the AMULET partners, selected for the 2nd Open Call is provided in the next chapter of this document. The list of these Open Challenges contains unaddressed challenges and the challenges with only one solution from the 1st Open Call, and new, unpublished and reviewed challenges. The total number of Open Challenges for the 2nd Open Call is 36.

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3. List of challenges for 2st Open Call

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.

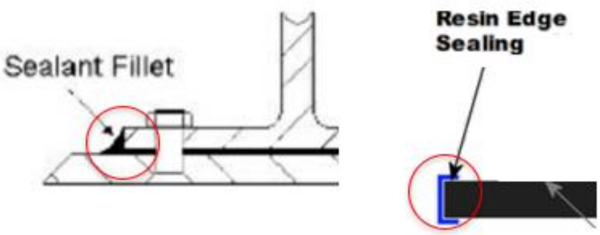
Scope: Target parts: complex 3D shaped parts with reduced accessibility

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.

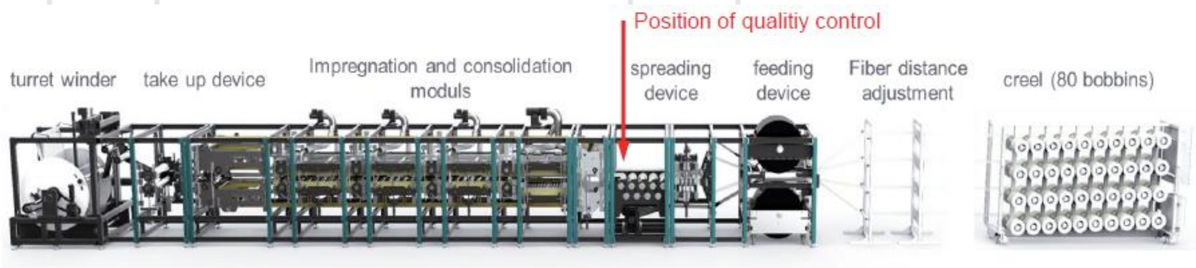

Fig. 1: Layout of the UD tape production line and position of the targeted measurement system

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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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.

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Objectives

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/m3 with thicknesses: 7mm; 8mm; 10mm; 12mm; 19mm.
- Airex Tegracore foam (or equivalent), 50kg/m3, with thicknesses: 7mm; 8mm; 10mm; 12mm; 19mm.
- Divinycell F (or equivalent), 50kg/m3, 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.

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Objective 3: Performing LCA and LCC analysis.

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

- Objective 1: Select vision system + SW for lay-up errors.

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

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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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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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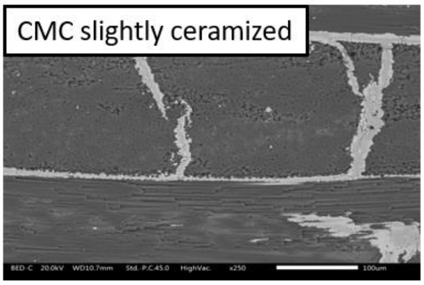
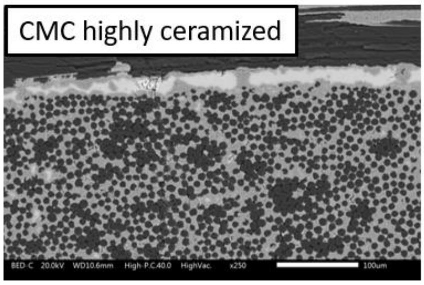
9_A&A_CMC_PrepregCMC

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 manufac-turing
- To improve the use of high performing CMC in aerospace applications
- To improve the use of high performing CMC in automotive applications

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

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

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

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 age-ing
- Cost of the adhesive is compatible with automotive targets

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

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.

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

37_AUTO_PBC_Material2design

Title: Material selection tool prior to design phase

Description: Current process solutions enable the production of multi-material composite parts at high lot sizes allowing to replace heavier metal parts in automotive applications. However, this is only possible if the part design is near to optimal. This optimal state is defined by having the minimum amount of the "right" material (for example continuous fiber composite material patches or metal inserts) at the "right" place which allows to comply the specifications while achieving the overall best part weight or cost. One main issue in current design approaches is that a first design must be selected before starting a part optimization. In the latter it is possible to define the lay-up of the composite patches or the exact shape of a metal insert. This first design creation is generally guided by the experience of the engineers and eventually leads only to non-optimal solution.

The goal of the challenge is to create a tool which, starting by a given design space and loadcases, identifies a zoning of the design space which roughly describes which material is to be put in which zone of the design space to achieve the optimal weight or cost. The tool should follow objective rules and have a short runtime. Based on the tools output a first design can be created which can thereafter be optimized in a second step.

Scope:

- To authors knowledge there is no tool on the market supporting the material selection for zones of a multi-material part using objective criteria.
- A link with existing simulation tools (or other supports) can be possible.
- The tool should be able to consider different loadcases on the same part.
- The evaluation time should be reasonable (max 1-2 days or less depending on the part complexity) as used prior to design start.

Objective:

- A tool supporting to select the best material for different zones in a design space prior to defining a proper part design.
- Main criteria: robustness and evaluation time.
- Optimization criteria: Part weight or cost.
- Definition of use cases can be provided as the testing**.**

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

38_AUTO_PBC_SUSMA

Title: Sustainable Material Usage in Automotive Industry by Developing New Easy-to-recycle Coating Technology

Description: Recycle and bio plastics are currently using in automotive industry however there are still big hurdles to expand the usage of this materials such as unpleasing odor and insufficient aesthetic properties (especially in the condition of applying foaming technologies). Interior hard trim PP parts have big potential for application of sustainable materials. Easy to recycle, de-bondable coating systems can be developed by using similar thermoplastics so that aforementioned problems can be eliminated. By achieving this, CO_2 emissions will be reduced owing to not using fossil derived sources and lightweighting technologies will be applied such as physical or chemical foaming.

Scope: Usage of recycled or bio plastics has vital importance for automotive industry.

- Enabling the such sustainable materials considering lightweighting and fully replacing with fossil derived plastics.
- To achieve this, developing new coating (including IMD and IML technologies) or additive technology (preventing odor and surface defects) or combining thereof.

Objectives:

- Elimination of surface defects in the condition of fluctuating material properties.
- Lightweighting the parts by using physical & chemical foaming without sacrifising mechanical & thermal properties.
- Developing new coating technology which is applicable for variety of thermoplastics so that preventing unwanted odor and covering surface irregularities could be possible.

Considering design for sustainability, it is expected that whole part needs to be fully recyclable as scrap on EoL. Therefore, new coating or additive need to be compatible with PP so that after end of life it can be recycled and used again without significantly reducing its properties.

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

39_AUTO_PBC_FEPREV

Title: Feasible Low-Medium Volume Part Production in Automotive Industry: Focus on customized EVs

Description: Rapid growth in the EV industry leads us to find more agile solutions & processes for manufacturing diversified plastic parts with lower volume compared to injection molding expected part volume. Injection molding is an excellent manufacturing method for high volume production, however it is not feasible for under thousands of parts. Therefore, this technology needs to be substituted by other growing Technologies such as additive manufacturing, in-situ polymerization techniques, or other, when it comes to lower production needs. For instance, reaction injection molding can be applicable and feasible for this situation since mold & equipment investment and the energy consumption is lower. On the other hand, suitable raw materials prices are challenging compared to thermoplastics in the market.

Scope:

- New technology & process adaptation to automotive parts considering feasibility & lightweighting & sustainability in order to make low & medium volume production possible especially for under the hood EV components which only needs up to 10000 annual productions.
- Customizable manufacturing to merge different production lines into one.
- Cost-efficient raw material development for selected manufacturing Technologies.

Objectives:

- Creating manufacturing Technologies that usage of thermoplastics can be possible to produce low-mid volume parts cost-effectively. These Technologies demand customized production aiming at the manufacturing of different variations of the same functional parts with identical equipment.
- Expanding the usage of in-situ polymerization techniques in automotive applications focusing on customized EVs such as AM, RIM, RTM, vacuum infusion by applying thermoplastics to these techniques.

Developing new materials to be cost-effective and to replace thermosets with thermoplastics to rely on circularity. More specifically expanding usage of thermoplastics (PA, PMMA, PBT etc.) in in-situ processes combining them with carbon and glass fibers according to part specifications.

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

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.

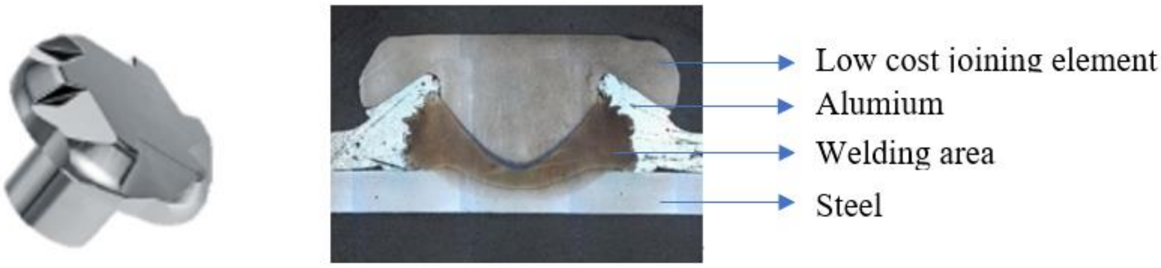


Figure 1: Example of low cost element

- 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

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

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.

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40_AUTO_LMA_ALUweld

Title: Reducing aluminium oxidations on the surface for laser welding applications

Description: Aluminum is important to the automotive industry because of its lightweight, strength, flexibility, malleability, conductivity, reflectivity, and resistance to corrosion. Aluminum is light, with about one-third the density of steel.

Vehicles made from aluminum have better acceleration, better braking, and better handling. The rigidity of aluminum provides drivers with more immediate and precise control.

Scope of the challenge

One of main challenge of welding aluminum involves the formation of oxide film on the work surface. The melting point of aluminum oxide is approximately 3x the melting point of pure aluminum, which can result in particles of aluminum oxide contaminating the weld and leading to porosity issues. In most cases, oxide film must be removed either by mechanical or chemical means prior to welding. Aluminum oxide can affect laser welding: oxide films can change the reflectivity of the parts surface, which negatively impacts the amount of laser energy making it to the base metal. To avoid oxide films and hydrocarbon contamination, aluminum to be laser welded must be thoroughly cleaned. This is often achieved mechanically, using stainless steel wire brushes, grinding, filing, or scraping to remove any oxides. Alternatively, there are chemical cleaning methods utilizing immersions in caustic solutions and water that are effective at removing aluminum oxide.

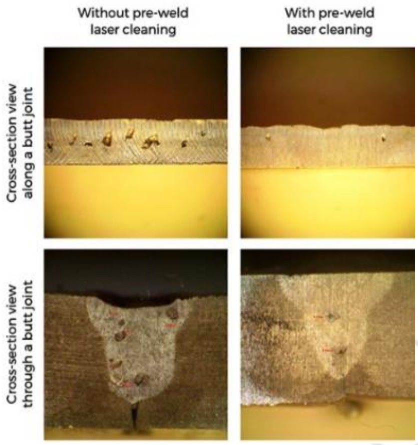

Figure: Welding result with cleaning the oxidation; Source: https://www.laserax.com/blog/cleaning-aluminum-welding

Objectives

Development of an alternative aluminium surface processing enabeling following benefits in comparisson to the conventional processes:

- Reduction of the cost for surface preparation by 20%,
- Deaccelerate the oxidation process on the surface by 30%,
- Reduction of porosities in the welding pool by 20%.

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

41_AUTO_LMA_ASAS

TITLE: Removing Zinc impurities in 6xxx billet casting

Description

Casting the 6xxx Al series after the 7xxx Al series:

- 7020 to 6063
- 7020 to 6082
- 7005 to 6063
- 7005 to 6082.

Nowadays, it is expensive to cast 7xxx series aluminum alloys especially for large industries. Since 7xxx series have lower demand compared to 6xxx series, current demands cannot meet big furnaces capacity. As a result, large extrusion companies cannot give respond to these demands. Zinc content in the furnace after casting 7xxx alloys has to be removed which reduces the quality of the 6xxx cast. Solving this issue would allow reducing the price and therefore increase the competitiveness of 7xxx series. Automotive OEMs who are eager to replace steel with 7xxx alloys would benefit from the reduced prices. There could be a great progress in replacing steel with aluminum for improving lightweight performance. Large companies' investment in these works will also pave the way for research and R&D studies for 7xxx series aluminum alloys.

At the manufacturing stage, billets are input of the extrusion process and they are produced by direct chill casting (DC). 7xxx series alloys have Zn as main alloying element. 6xxx series alloys have Si and Mg as main alloying element. When the 7xxx series are casted, the 6xxx series cannot be casted in the furnace because of the remaining Zn impurities. The furnace must be cleaned to remove impurities. That's why in the passing from 7xxx series casting to 6xxx series casting, 2 scrapyard castings are made. Casting of the 6xxx series is a problem. In order to ensure its continuity, at least 2 castings are wasted. These wasted castings cannot be used as scraps.

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

- More sustainable
- More efficient
- Cheaper
- Faster

Challenges:

On the one hand, 7xxx series are the most valuable alloys of the Challenge giver. According to EN 573-3 standard for alloys, the composition is shown in Table 1.

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Alloy/Element	Si	Mg	Zn	Al
7020	0,35	1,0-1,4	4,0-5,0	Remain
7005	0,35	1,0-1,8	4,0-5,0	Remain

Table 1. 7020&7005 Alloy Content (only major elements are shown)

On the other hand, 6xxx series are the most common alloys, which composition is shown in Table 2 according to the same standard.

Alloy/Element	Si	Mg	Zn	Al
6063	0,2-0,6	0,45-0,9	0,10	Remain
6082	0,7-1,3	0,6-1,2	0,20	Remain

Table 2. 6063&6082 Alloy Content (only major elements are shown)

The problem is that after casting the 7xxx alloy, the Zn element does not leave the process while casting the 6xxx alloy. Zn needs to be removed from industrial casting furnace reverber type, which is achieved with 2 extra scraps waste castings. Constraint: element content of 6xxx series billets must be lower than the 0.1% zinc content after the 7xxx series billets.

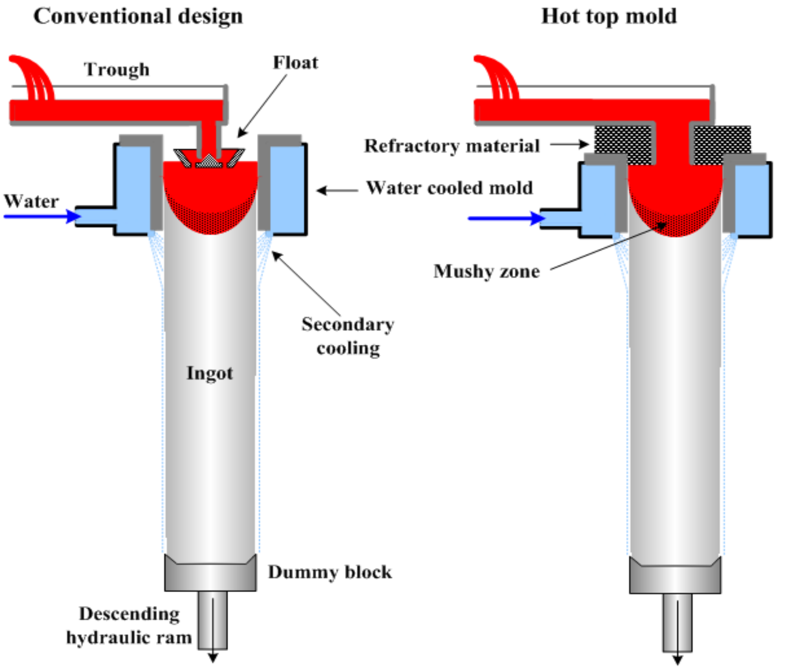

Figure 1. Vertical Direct Chill (DC) Casting

Objectives:

- Faster, more reliable and efficient casting,
- Less time passing during the casting,
- No Zinc content (at least lower than 0.1%),

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- No other impurities,
- Lower CO_2 emissions.

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

Ceramic Matrix Composites

42_AUTO_CMC_ASIL

Title: ASIL factor calculation for Battery disconnection fuse

Description:

Battery disconnection fuse is a device for disconnecting direct electric circuits, which takes advantages of the method of disconnecting an electric circuit with pyro switches and melting fuses in parallel connection with pyro switches. The product has several patents (Pat. Nr. WO 2019/027373 A1, WO 2019/027373 A1) related to the principles of operation and actuation. The Battery disconnection fuse allows a rated current of 600A at a maximum voltage of 800V d.c. and overloaded up to 2700A for 10s. Triggering is external (ECU or BMS) and internal (REED contact, pat. Nr. WO 2019/027373 A1). The product is fully developed and internally and externally validated and customer homologated and has a superior performance/weight ratio. It is used in the serial electric super cars which is the fasted EV car on the world with speed world record (412km/h). The Battery disconnection fuse design is superior compared to the fusible link design and other solutions that exist on the market. Technical Breaking capacity factor (kA d.c.)/weight is much greater than that achieved by the fusible link and other similar pyro-switch solutions. By obtaining the ASIL product reliability factor, according to standard ISO26262, the potential market for sales in the automotive and other markets will increase greatly.

Objectives

1. Calculation and acquisition of FIT (failure in time) factors from suppliers for individual Battery disconnection fuse components.

2. Based on FIT factors perform calculation of ASIL factor for Battery disconnection fuse (according to standard ISO26262). Technical data of the Battery disconnection fuse will be provided by the challenge giver at the start of the project.

3. Minimum ASIL B is final requirement for automotive market.

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ENERGY

Polymer-based composites

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

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.

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

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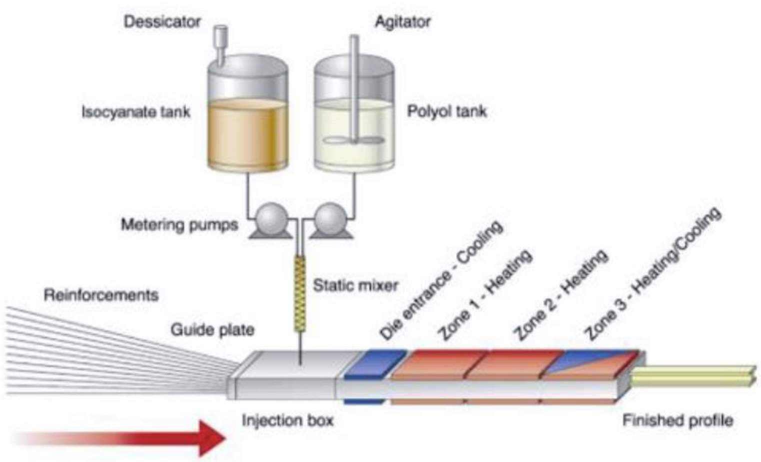
43_ENER_PBC_SimulOpt

Title: Simulation of curing processes for better defect image analysis in pultrusion

Summary: For an increase in economic efficiency and a simultaneous increase in the acceptance of FRP in various areas, a simulation option of the pultrusion process is required. In particular, the focus is on the curing process in the mold, which is still a "black box" today. Problems and challenges that lead to process abortions or component rejects are to be investigated by simulation before the actual production runs and process windows are to be limited. In this way, resources and energy are to be saved and reliable and, above all, economical lightweight construction is to be created for a wide range of applications. Current TRL: 4

Scope: The continuous pultrusion process (see figure) already impresses with its cost-effectiveness and ability to produce high mechanical load-bearing structures. Due to the complex and constantly parallel process steps, a high level of effort is required in process control and design. This know-how is currently distributed among very few people and is mostly based on years of experience. An adaptation of simple profile geometries to complex cross-sections is not easily possible and again requires a great deal of try and error. The same challenges arise with new material systems, which require a great deal of practical preliminary work and investigations or trial-and-error. This situation is to be changed with a preliminary or accompanying simulation, so that a lot of time and, above all, costs can be reduced. The focus should be on the simulation of profile hardening in the corresponding mold - combined with the question of occurring error patterns. In concrete terms, these are cracks and internal stresses.



Michael Connolly, John King, Trent Shidaker u. Aaron Duncan: Pultruding Polyurethane Composite Profiles: Practical Guidelines for Injection Box Design, Component Metering Equipment and Processing. 2005

Objectives:

Simulation model for the pultrusion process (simple geometry, one material system)

- Consideration of the curing behavior of the plastic in the mold,
- Display of internal stresses and cracks.

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

44_ENER_PBC_CompTape

Title: Reinforced polymeric materials for capacitor housings

Introduction: Challenge giver produces thermoplastic composite tapes, mostly with continuous glass fibre and polypropylene. Normally these tapes are wound on a liner, plastic or metal, to guarantee water and/or air tightness. During the winding process the thermoplastic material in the tapes is melted again.

Figure: Thermoplastic composite pressure vessels. Thermoplastic composite tape wound on PP (left) and steel (right) liners

The challenge in the composite pressure vessel industry is to find a cheap liner solution. PET, well-known by its use in the blow moulding of soda bottles, offers a versatile and cheap opportunity to produce liners with. The aim is to find a technology partner that can develop and produce PET liners with a volume of 10-20 liters and more, where soda bottles are normally 1-2 liters. Blow moulding of PET for much larger volumes is not state of the art.

The final application is pressure vessels. The composite that is wound on the liner will handle the strength/stiffness requirements that result from the burst pressure requirement. So, the liner itself does not have a specific strength requirement apart from the connection(s) at the poles.

Scope: The (technical) scope of the project is:

- The liner will be used in the manufacture of composite pressure vessels.
- Blow moulding is the foreseen liner technology but other technologies are welcome.
- PET is the required liner material.
- The volume of the liner should be 10 liters and more.
- Roughly, the shape of the liner consists of the two hemispherical domes and a cylindrical part in between for an optimal strength.
- One or two openings at the poles of the domes with flange or screw connection.

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

Objectives:

- Objective 1: Demonstration of the blow moulding of a PET container with a volume of at least 10 liters.
- Objective 2: Design of a flange or screw connection that can withstand an internal (burst) pressure of 30 bar at least.
- Objective 3: Realisation of (a functional model or prototype) of a liner consisting of two hemispherical domes and a cylindrical part in between.

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

45_ENER_PBC_FuseCoat

Title: Low-temperature glaze – coating components for middle voltage MV fuses

Summary: Components of middle voltage fuses, used also for a safe interface of green electricity generators like wind turbines to the grid, include among others, ceramic tubes and ceramic support. According to customer requests, we can finish tubes by several specific design and various technologies: cutting, grooves grinding, centreless grinding and others. Tube surface can be glazed with white or brown colour.

Glaze is a glass coating on the surface of ceramic tubes. We can achieve the impermeability of the porous ceramic coating, smooth surface and shine, and we can increase the mechanical strength of the product by glazing. With colouring of the glaze, we hide the colour of the base and improve the look of the ceramics. The glaze is usually applied to the ceramic product in the form of a suspension. This is followed by drying and sintering, where the components of the glaze react, melt and form a glassy phase that fuses with the base. Under current production conditions, the glaze is sintered together with the product at temperatures around 1300°C. The thickness of the glaze application is 150 - 300μm.

The development of new tube production technology presents the application of glaze – coating, great challenge. We would significantly reduce technological waste (sintering), from 25% to 5%, which cannot be avoided with existing technology. Technological waste, which is produced in its raw state, would be used as a secondary raw material in the process of preparing the material. In this way, the amount of raw material needed to produce the material would be reduced.

Figure 1: examples of current products with brown and white glazes.

Scope of the project is to develop a new glaze-coating that will be applied at much lower temperatures to the sintered ceramic fuses. The glaze should be electrically insulating. The current glaze material fulfils standard IEC 60672 – 3 group C120 with a sintering temperature of 1300°C and thermal expansion coefficient α 30-600 °C 4–7 x 10^{-6} K^{-1}.

Objectives:

Develop a glaze-coating (preferably polymer-based) that will retain all the functions of the glaze:

- Ensure impermeability of the ceramic tiles,
- Provide a smooth surface and shine (Figure 1),
- Increase mechanical strength of ceramic part (by 20%),

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- Connects to the ceramic tube and will not cause deviation or cracks,
- Possibility of application without heat treatment or treatment at low temperature (preferably below 300°C),
- Retain the brown (RAL 8016/8017) and white (RAL 8011) colour, possibility of colour adjustments,
- Electrically insulating,
- Applied as a thin coating (not increasing the mass of the product importantly).

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Light Metal Alloys

21_ENER_LMA_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_LMA_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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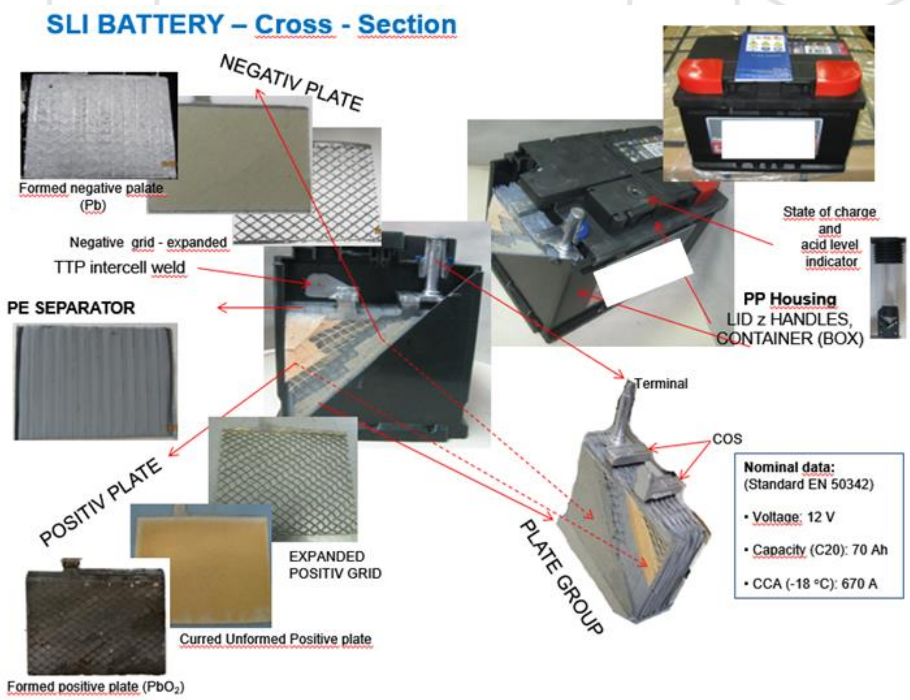
Ceramic Matrix Composites

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.

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

46_ENER_CMC_siliconeFIRESTOP

Title: Arc extinguishing material on the melting elements of fuse link

Description: We currently use a special silicone named FIRESTOP with the addition of aluminium trihydrate to limit the electrical arc inside the fuse link during fuse operation on DC voltage (up to 1500V d.c.). Electrical arc made chemical reaction which aluminium trihydrate "change" to water and aluminium oxide. Energy consumption from chemical reaction reduce the temperature of electric arc. Additional material which is added to silicone is SILAN which improved adhesion to the melting element.

Silicone is applied to the melting elements which is a part of fuse link. Using a silicone FIRESTOP reduce the length of fuse link for more than 30% and weight for more than 20% in comparison to other technical solutions.

The process of application of the silicone on the melting element in the production is relatively complicated and time consuming (application on the melting element, drying, curing, control).

The challenge is to find a suitable technical (replacement for FIRESTOP silicone or another additive to quartz sand (like boric acid)) and find technological equivalent to the existing process, which will be simpler and will reduce production costs.

Existing technical solution with FIRESTOP silicon is patented in EU (Pat. Nr.EP 14 835 723.9)

Objectives:

- Finding a technical and technological equivalent for the existing FIRESTOP silicone.
- Significantly reduce costs of material used and production process (for more than 50%).

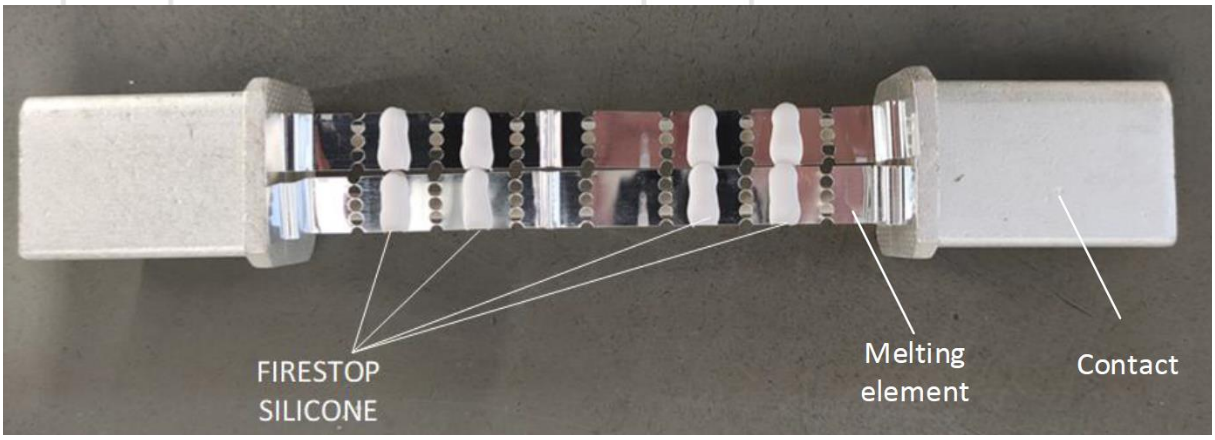


Figure: Example of fuse link

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BUILDING

Polymer-based composites

47_BUILD_PBC_LoCaBaFi

TITLE: Low Carbon dioxide emitting Basalt fibre production for composite material

Description Carbon fiber reinforced polymers (CFRP) have a negative environmental impact due to the fossil-based manufacturing process of the carbon fibers, and the inefficient waste recovery at the end-of-life phase. The concept of the LoCaBaFi includes several approaches that will achieve a substantial reduction of CO_2 emission of at least 30 % in the life cycle assessment of basalt fiber reinforced polymer (BFRP) and reinforced ceramics (BFRC).

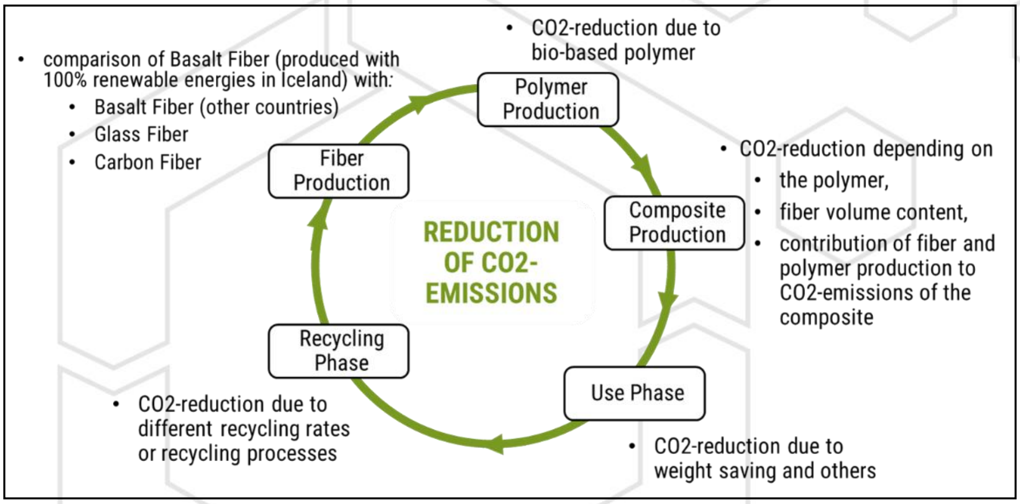

Figure: Potential for reduction of CO_2 emissions.

Iceland is a world leader in using renewable energies summing to over 99% of its total electricity consumption. Iceland has also plentiful of natural basalt resources from which basalt fibers (BF) can be produced using renewable energies. Nowadays, raw basalt rock is mainly mined in Russia, Ukraine and Georgia. The long transportation distance to Europe and the use of fossil-based energy to produce the fibers accounts for a negative environmental impact. Additionally, a risk of time-to-market shortage could become possible upon changes in political partnerships or due to political conflicts.

The matrix of the lightweight BFRP developed in this project will be made of a 100 % bio-based thermosetting polymer or CO_2 neutral Geopolymers for BFRC compared with concrete leading to a further reduction in CO_2 emission. Concerning environmental impact, BF is a natural material, eco-friendly, non-toxic and can be easily processed and recycled. Regarding mechanical properties, BF bridge the gap between glass and carbon fibers and offer the advantage of cost effectiveness, resistance to elevated temperatures and to chemical environments.

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The outcome of the project of reducing the CO_2 emission has an enormous positive environmental impact and has a direct positive impact on the society. Additionally, it contributes to the goal of reaching a circular industrial value chain and a resilient Europe.

Scope of the challenge

The aim of the LoCaBaFi challenge is to develop a low CO_2 footprint FRP / FRC made of BFs of natural raw materials reinforcing a fully bio-based thermosetting polymer and or Geopolymer. This sustainable BFRP / BFRC paves the way to a substantial reduction in CO_2 emission of lightweight composites and to support the effort of the EU to combat global warming. The concept of the project is based upon the following approach combinations to achieve this exceptional contribution of CO_2 reduction:

I. Mining natural basalt in Iceland

Iceland is an important source of natural basalt and lava rock originating from the volcanic activity over the past thousands of years. Additionally, basalt and lava rock are continuously formed due to the frequent volcanic activity encountered in the region. These natural resources could then be used as an alternative to currently used sources coming from remote countries (e.g. Russia, Ukraine and Georgia), ensuring resilience, economic flexibility and a shorter time-to-market for European lightweight producers.

II. Fiber production using renewable energy

Iceland generates over 99 % of its electricity production using hydropower and geothermal power. Producing the BFs using renewable energy, instead of using the energy-intensive fossil-based manufacturing process, reduces dramatically the emission of CO_2 upon production of the fibers. As fiber production accounts for an intensive energy consumption process, this will be an immensely beneficial to circular economy of lightweight composites.

III. Melt-Spinning prototype machine

One of the project partners will build a prototype melt-spinning machine validated to TRL 5 with a 20-50 bushings capacity and will lend / give it to another project partner for fibre spinning. The machine will be the base for an industrial up-scaling prototype plant. This introduces two important benefits: (1) reduction of CO_2 emission by the low transportation distance between the mining site and the location at which the melt-spinning plant for fiber production will be established, (2) reduction of export control regulations and reduction of EU dependency on producers of BFs from countries outside the EEA.

IV. Prepreg / semi-finished products

Semi-finished products based on commercial bio-based polymers like tubes or rods for building - reinforcement of concrete – or aerospace & aeronautics.

Objectives

- A reduction of CO_2 emission of at least 30 % in the LCA of the new BFRP in comparison to commercially available CFRP and GFRP.
- Development of semi-finished products out of these new basalt fibres based on bio-based polymers.
- Development of a composite with over 50 vol.% of bio-based materials.
- Usage of 100 % renewable energy sources for manufacturing natural BFs.

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- A prototype melt-spinning machine validated to TRL 5 will be established at the main basalt-mining site.
- Reduce export control regulations, secure time to market of lightweight solutions and reduce EU dependency on producers of BFs from Russia and other countries outside the European Economic Area (EEA).

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Light Metal Alloys

24_BUILD_LMA_WAAMpipelines

TITLE: WAAM Technology for pipeline structures: improvement of the manufacturing of pipeline connections

DESCRIPTION

The challenge in question aims to improve the manufacture of metal pipeline connections. Such connections are nowadays formed using specialist parts that involve:

- waste of material (normally designed for maximum nominal pressures)
- low flexibility (difficulty in adapting to changes in plan)
- high costs
- time consumption

The proposed solution consists of using 3D metal printing technology for large parts such as Wire and Arc Additive Manufacturing (WAAM) to fabricate the connectors.

The following technological achievements will be reached during the project:

- off-site custom-made specialist parts (i.e., for intersections and changing slope)
- off-site mechanical connections for straight tubular elements (realization of a new concept of connection for conventional straight runs with the use of hybrid WAAM)
- off-site multi-material connections (exploring the possibility to use multi-material WAAM for new connectors)
- on-site connections (using mobile 3D printing solutions for WAAM)

Objectives of the project:

- Reduction of the manufacturing time
- Increase in productivity
- Waste reduction
- CO_2 reduction
- Increase in durability and efficiency of the pipeline connections

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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.

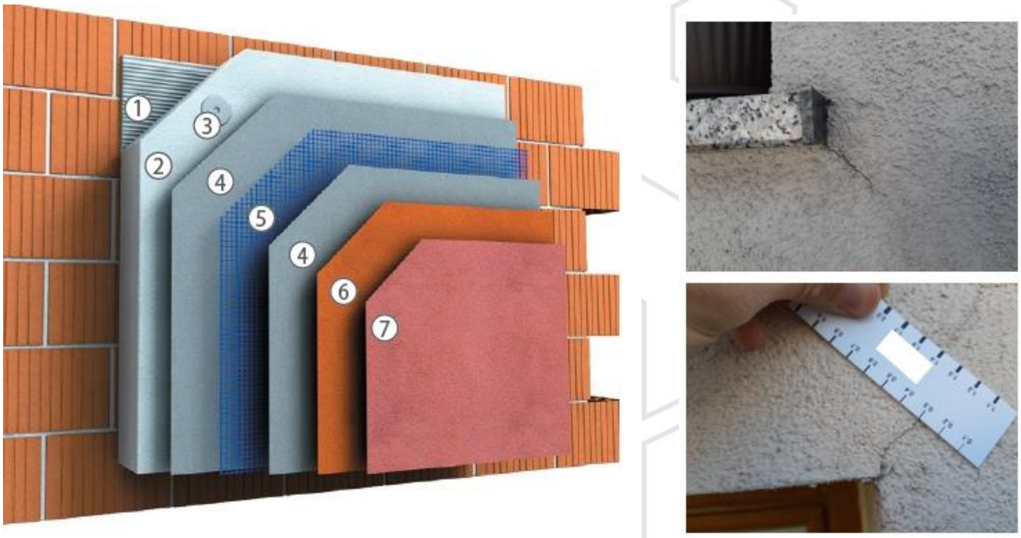

Figure: left - 1 Primer, 2 Thermal insulation, 3 Anchor, 4 Base coat, 5 Reinforcement mesh, 6 Primer, 7 Top coat; right - crack examples

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

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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, 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

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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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