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 challenges. 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.



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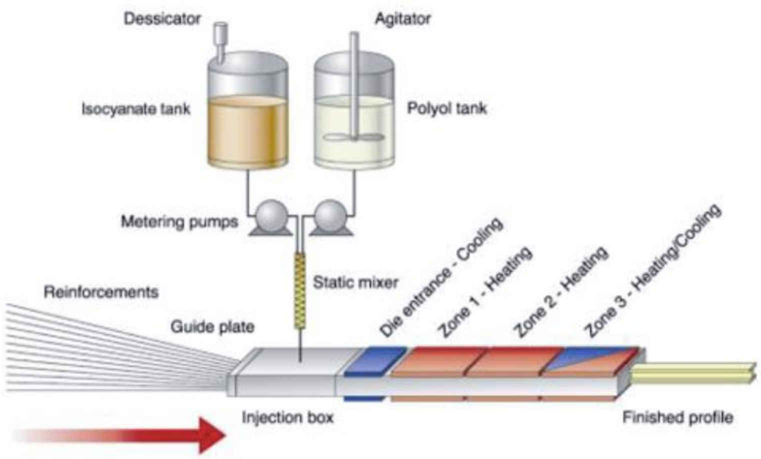
43_ENER_PBC_SimulOpt

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.

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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.

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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.

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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%),
- Connects to the ceramic tube and will not cause deviation or cracks,

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- 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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