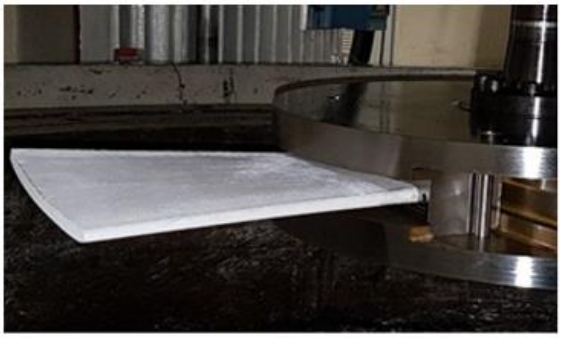
AEROSPACE & AERONAUTICS

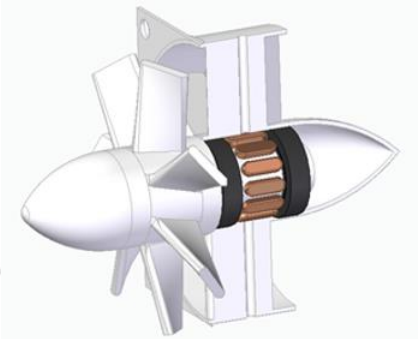
Ceramic Matrix Composites

8_A&A_CMC_CMCFan

Title: Lightweight CMC High-Temperature Fan for Aerospace Applications

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





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

The state of the art in IAD technology uses heavy gas tanks for inflation (examples include IRDT or NASA HIAD). If we demonstrate the feasibility of using hot air during re-entry for inflation, this enables the use of extremely lightweight IADs for small rocket stages and return of cargo from space.

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

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

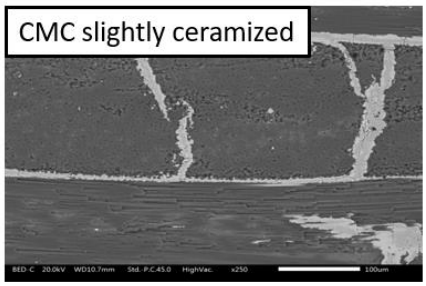
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101005435

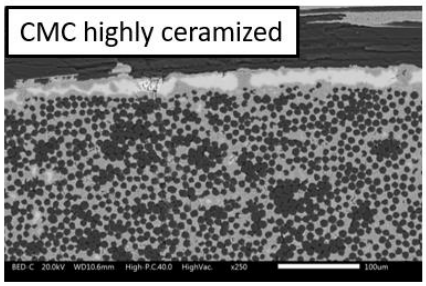
9_A&A_CMC_PrepregCMC

Title: Prepreg optimized for the Ceramic Matrix Composites production

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

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





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

Objectives of the challenge:

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

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