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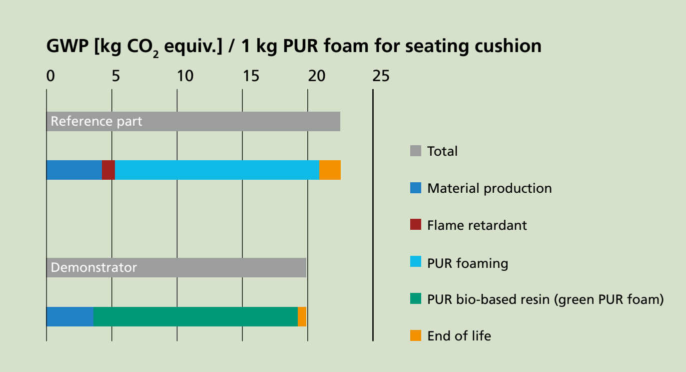
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT



FRAUNHOFER ICT
CLEAN SKY RESEARCH TOPICS

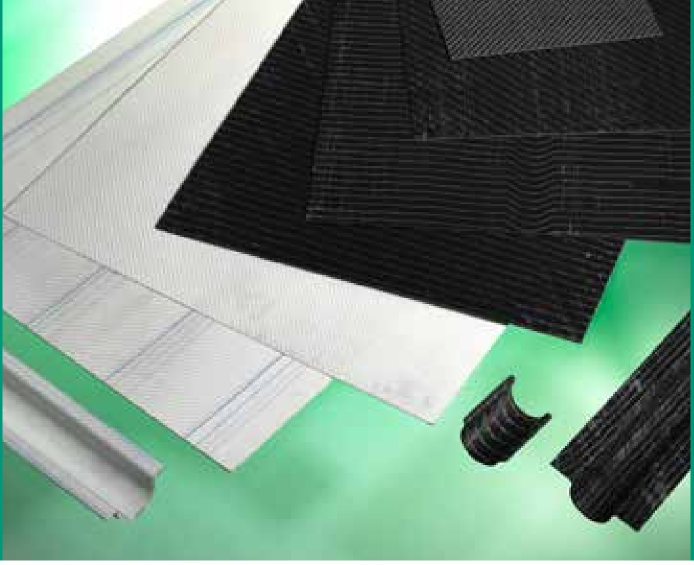
Industry and politics require information on the nature and extent of environmental impacts at each life cycle stage. To tackle this challenge, the European Commission and the aviation industry have launched the CLEAN SKY INITIATIVE with its continuation in the Clean Sky 2 (CS2) Work Program.

In CS2, eco DESIGN is a transverse activity: this offers the possibility for an optimal implementation of Life Cycle Assessment (LCA). The combination in a holistic transverse activity within CS2 means that eco DESIGN will be a part of every integrated technology demonstrator. This is an essential step, since airplanes are complex product systems depending on different supply chains, high grade and specific materials as well as specially customized processing technologies for their part production.

The results from the selection, processing and recycling of environmentally sound materials will be combined to generate a tool enabling the implementation of a green product life cycle for the aeroplanes of the future.

TECHNICAL RESEARCH TOPICS

- Development of environmentally friendly composites with improved behavior in terms of environmental impacts and recyclability
- Development of new surface treatments with improved corrosion behavior, and nano-porous adhesion layers
- Extended use of renewable resources in the aircraft industry
- Innovative and effective polymer flame retardants
- Development of new manufacturing technologies and improvement of current ones to decrease resource consumption and reduce emissions
- Identification and maturation of end-of-life options for aircraft dismantling and re-use



HYBRID SEATING STRUCTURE

In large passenger aircraft several hundred aircraft seats ensure the comfort and safety of the passengers. These seats are replaced several times over the lifetime of an aircraft. Aircrafts seats are thus a major component in all passenger aircraft, and fast disassembling and dismantling are needed to recycle all parts of the seating structures.

The aircraft industry will face massive challenges in the coming years. Despite the fact that air traffic is responsible for less than two percent of global CO_2 emissions, the industry is forced to reduce fuel consumption and emissions. For example, each kilogram of weight reduction in all A320 aircrafts worldwide results in a reduction of fuel consumption of about 0.7 million liters per year. High production rates for future aircraft require effective production methods and a high degree of integration of different components and functions.

Hybrid materials and structures offer the potential for meeting both key challenges. However, the recycling of the materials after use has not yet been satisfactorily resolved. To reduce the environmental footprint of the aircraft it is also necessary to develop a dismantling concept for hybrid materials and structures, and in addition to develop efficient manufacturing processes with a high degree of function integration. The key to achieving the objectives is the design and development of a hybrid seating structure consisting of different types of polyurethane (soft and hard), fibers to reinforce the structure only where it is necessary and metal inserts as connecting or functional elements.

RENEWABLE RESOURCES

The use of natural material sources in technical applications is a key research field of Fraunhofer ICT. Sugar, starch, or lignin are used as building blocks to synthesize thermoplastic or thermosetting resins. Polymer synthesis processes are available in lab and pilot scale, along with the appropriate analytics for chemical and mechanical characterization of the products.

FLAME RETARDANTS

The substitution of halogen flame retardants using aluminum or phosphorous compounds has been under research for years, starting with reactive flame retardants in polyurethanes. These reactive components have been synthesized and tested at Fraunhofer ICT. For qualification, several standardized small-scale burner tests are available, along with flue gas characterization.

END-OF-LIFE OPTIONS

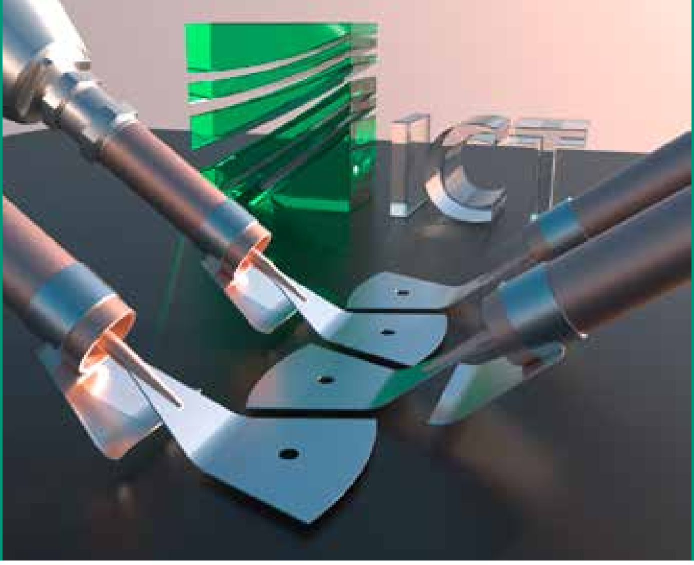
Since more than a decade Fraunhofer ICT has operated the center of excellence "LOOP", providing solutions both for production scrap and end-of-life products and materials. Once the reusable parts have been identified and dismantled from the aircraft, the remaining materials must be processed to generate the maximum added value. To this end, Fraunhofer ICT offers numerous in-house processes for the grinding, sieving and sorting of composite materials on a pilot scale. Moreover, pyrolysis and solvolysis processes are available to separate and to recover miscellaneous materials, along with characterization and analysis tools.

BIRD TOOL

The results from the end-of-life activities are integrated into a tool called BIRD (Base tool to Implement Recycling information in aircraft Design). BIRD enables the designer to consider recycling in aircraft design by comparing material combinations of aircraft parts in terms of economic feasibility, dismantling and recycling.

SUPPORT FOR THE SOCIO-ECONOMIC DERIVATIVE

The socio-economic derivative (SED) is a key performance indicator (KPI) for the assessment of technologies developed in CS2. Article 2a of the CS2 regulation with its parent chapter III of societal challenges in Decision 2013/743/EU sets out life cycle impacts, smart green design and competitiveness benefits from the scientific/R&D activities and impacts along the supply chain. The greenhouse gas reduction goal cited in article 2b is also a criterion for assessment and is a part of the SED. In CS1 the eco DESIGN ITD demonstrators were assessed through eco-statements implementing LCA and TRL. CS2 broadens the assessment methodology to include more environmental indicators including water and other natural resources, material and knowledge flows, jobs and skills and new services in the aviation sector. It also provides a structure



for design guidance for CS2 technologies and for the assessment of the future social impacts and competitiveness of the European aviation sector. The SED structure is made up of four groups of factors.

■ Life Cycle Assessment factors (LCA)

These factors are environmental impact required indicators. They provide a limited set of indicators for the assessment of improvements in the environmental performance of CS2 technologies over the baseline technologies defined in the eco-design analysis (EDAS). The LCA factors are those specified in the eco-statements delivered in CS1 including resource depletion potential (RDP) for a selected set of natural resources, and other indicators, such as global warming potential (GWP), eutrophication potential (EP), and photochemical ozone creation potential (POCP), among others.

■ Guidance factors (GF)

The guidance factors provide indicators that can be used to enable an environmental assessment as an integral part of the design process. The required indicators are:

- Renewables primary energy demand (RPED)
- Water resource demand/footprint

The indicators to be provided for the CS2 technologies are:

- Depletion of materials which are not included in the RDP, but which are necessary for the production of CS2 technologies e.g. titanium
- REACH emissions
- A product category declaration (PCR: summary of the environmental performance of the CS2 technologies)
- Material scrapping ratios from production
- Land use impact
- Biodiversity impact

■ Strategy factors (SF)

These factors are used to assess the contribution of the CS2 technologies to the market competitiveness of manufacturing companies and service providers along the value chain. The required indicators are:

- Change in the number of horizontal process steps: the change in the number of defined steps for production management for CS2 technologies along the value chain of the technology. The vertical processes of sub-components or sub-systems that are combined into the production process during the horizontal series of production steps are not considered.
- Material buy-to-fly ratios

Indicators in the category “Indicators to be provided where available for the CS2 technologies” have not been defined for strategy factors.

■ Social and economic factors (SEF)

In CS2 there will be socio-economic statements (SES) to accompany the eco-statements. The SES will report indicators for the social and economic impacts of the CS2 technologies. The CS2 social and economic factors take account of the EU eco-innovation agenda and the Flight Path 2050. This requires an assessment of the future competitiveness: market prospects and possible employment in the EU aviation industry as affected by CS2 technology developments.

The socio-economic factors will consider the whole life cycle of technologies. This includes the extraction and production of materials, the production process including the supply chain and supply chain logistics, maintenance and ground handling during the use phase and disposal or recycling at the end of life.

FRAUNHOFER ICT – ABOUT US

At Fraunhofer ICT's main site in Pfinztal, near Karlsruhe, approximately 540 employees carry out research and development work in the fields of energy, chemistry, process engineering, environmental technology, polymer technology, and explosive technology. The Project Group for New Drive Systems NAS in Karlsruhe has grown to more than 25 employees. With our support, an institution working on microsystem technology, ICT-IMM in Mainz, has become part of the Fraunhofer-Gesellschaft and currently has nearly 100 employees.

Around 73 percent of our revenues come from contract research for commercial companies as well as publicly-funded research projects. The remainder is financed through institutional funding provided by the German federal and state governments. We work on issues that will become relevant to the economy and to society in five to ten years from now.

The total area of the institute in Pfinztal has increased to 210,000 m². Our infrastructure has also been expanded. We commissioned additional pilot plants, laboratories, workshops, test stands, and offices, which means that we currently have over 27,300 m² of cutting-edge infrastructure. Pilot plants make up more than half of this area. Our high-volume pilot plants and industrial-scale equipment enables us to develop and implement new materials, processes and products up to near-industrial level. In addition, we currently have approximately 70 chemistry and physics laboratories equipped according to the latest developments in safety and energy technology, as well as all the analysis and testing procedures necessary for our fields of research.

The field of environmental simulation has been decisively shaped by the Fraunhofer ICT, which investigates the effects of environmental influences on materials and technical products. For over 40 years the institute has been the headquarters of the well-known German GUS Society for Environmental Engineering (Gesellschaft für Umweltsimulation e.V.).

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