**DISACOP**

Disassembly of Eco-Designed Helicopter Demonstrators

**State of the art – Background**

The state of the art manufacturing of high-performance helicopter structures with carbon-fiber reinforced polymers (CFRP) is actually based on the use of thermoset prepregs, which generally cause high manufacturing costs [1]. Furthermore, the molecular structure of thermoset resins is characterized by strong chemical crosslinks which cannot be untied after the final curing cycle. Subsequent manufacturing steps such as fusion bonding, thermoforming or even recycling are consequently not possible.

Thermoplastic matrices for fiber reinforced polymers have become very popular. So-called thermoplastic composite materials (TPC) offer great potential regarding weldability, thermofomability and recyclability when compared to thermosets. Furthermore, their storage life is not restricted and they are known for their excellent toughness and chemical stability [1]. TPCs have therefore acquired a rising relevance for aerospace structures in the past years [2–4], which is why manufacturers and suppliers have also increased their research activities on the fusion bonding of TPCs [5–7].

Disacop focuses on integral TPC helicopter structures. In the case of metal shell constructions, the subcomponents (stiffener and skin) are usually joined with the help of bolts and rivets. These enable the disassembly of the structures in the case of damage or for recycling purposes. Despite the advantage of a possible disassembly, mechanical fastening techniques require a large amount of additional weight. With the use of TPCs, subcomponents can be directly welded, enabling an additional weight reduction. In the case of aerospace structures, subcomponents should still be separable. In the best case scenario, both components stay intact after the separation process and can be reused as subcomponents if these are not damaged.

Different recycling strategies exist, which can be classified according to their environmental benefit (Figure 1). Only the disassembly of the structure in its single components enables a correctly sorted manipulation of the different materials according to their degradation or damage state.

**Fig. 1: Overview of different recycling strategies and their environmental impact**

The most environmental friendly recycling strategy is given by the “reuse” method, since already manufactured components can be completely reprocessed in other assemblies. In order to ensure the reusability of the components, these have to be undamaged after the disassembly process, whereas in the best case scenario, both components are intact.

**Objectives**

In comparison to state of the art thermoset prepreg components that are bonded by means of thermoset adhesive or mechanical fastening, the Disacop approach opens the way to the top two recycling strategies shown in Fig. 1. Components are joined by means of fusion bonding techniques, hence taking fully advantage that the welded joint can approach the same mechanical properties as the adherents [1]. The inclusion of a generic “bonding and separation layer” (see Fig.2) enables on top the disassembly. Component and material recycling of damaged or out of life assemblies and components are subsequently made possible. Enormous economic and environmental benefits are expected.

**Description of work**

Disacop is divided into four work packages, which are described further below.

In WP1 a literature review and evaluation of different heating methods for the fusion bonding of TPCs is done. These are analysed regarding their applicability for debonding. First tests are also performed on coupon level, in order to demonstrate the debonding process. This WP will reveal the most suitable
heating method for the disassembly of fusion bonded TPC structures.

The main work package, WP2, focuses on the best component separation method obtained from WP1. The heating mechanism is investigated in detail. One focus is the heat distribution inside the components, so that only the bonding zone of the assembled parts is heated. In relation to the heating method, the impacts of the component separation on the design stage and manufacturing steps can be defined. Moreover, the implications of the debonding process are investigated. The material properties are characterized by mechanical tests before and after the component separation. These tests include most commonly tension tests and micrographs, performed on never joined specimens as well as on disassembled specimens. All investigations of WP2 are performed on coupon level.

WP3 focuses on applying the developed separation scenario on demonstrators which are manufactured by the industrial partners.

Finally, the main aspect of WP4 is to collect and provide all necessary data for a life cycle assessment including life cycle cost analysis. The data will be investigated throughout the whole project in coordination with the industrial partners.

Expected results

Disacop’s approach will contribute to utilize the well-known environmental advantages of thermoplastic composites over composites with thermoset matrices. Large amounts of waste can be avoided by separating damaged components from intact components of a TPC structure. Also the process itself will be very environmentally-friendly. Only local heating of the joining zone will be necessary to separate and re-join the components. This promises not only minimal implications on the components and their properties but also minimal energy consumption of the process. The joining and separation steps of thermoplastics are mostly driven by physical behaviour. Thermosets do need chemical reactions of often toxic components instead. Due to the possibility to rework structures with assembly faults, waste during the initial manufacturing can be avoided as well.

Fig. 2.1: Step 1a: Manufacturing of TPC Part A

Fig. 2.2: Step 1b: Manufacturing of TPC Part B

Fig. 2.3: Step 1c: Manufacturing of joining and separation layer

Fig. 2.4: Step 2: Fusion bonding of Part A and Part B with joining and separation layer

Fig. 2.5: Step 3: Component separation after heating

Fig. 2: Generic bonding and separation layer
**Project Summary**

**Acronym:** Disacop  
**Name of proposal:** Disassembly of Eco-Designed Helicopter Demonstrators  
**Technical domain:** Joining Technologies  
**Involved ITD** Green Rotorcraft

**Grant Agreement:** 323420  
**Instrument:** Clean Sky  
**Total Cost:** 199,970.40€  
**Clean Sky contribution:** 149,977.00€  
**Call:** JTI-CS-2012-01-GRC-06-006  
**Starting date:** November 2012  
**Ending date:** October 2014  
**Duration:** 24 Months

**Coordinator contact details:** Elisabeth Ladstaetter  
Institute for Carbon Composites  
Boltzmannstr. 15  
85748 Garching  
+49 (0)89 289 15088  
ladstaetter@lcc.mw.tum.de

**Project Officer:** Sébastien Dubois  
sebastien.dubois@cleansky.eu

**Participating members**  
TECHNISCHE UNIVERSITAET Muenchen DE  
POLMER COMPETENCE CENTER LEOBEN AT  
QPOINT COMPOSITES GMBH DE