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Green rotorcraft - GRC6.3.5

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Call for Proposal title	**Recycling of Metallic Materials from Rotorcraft Transmissions**
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Company	AgustaWestland	

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1 EXECUTIVE SUMMARY

In the 7th Framework Program of the Directorate General of the European Commission, the CLEANSKY JTI has been established to Foster cooperation between European Companies in the Aerospace and Aviation Sector.

The CLEANSKY Green Rotorcraft aims to improve the environmental impact of the components in aeronautic and air transport sectors, with focus on Rotary Wings Manned Vehicles.

REMART Project, in context of the CLEAN SKY JTI - Green Rotorcraft addresses the issue of Recycling of metallic materials from rotorcraft transmissions.

The transmission system transfers power from the engine to the main rotor, tail rotor and others accessories. The most important components of the transmission system are the main rotor transmission, tail rotor drive system, clutch and freewheeling unit. Helicopter transmission system (HTS) are normally lubricated and cooled with its own oil supply.

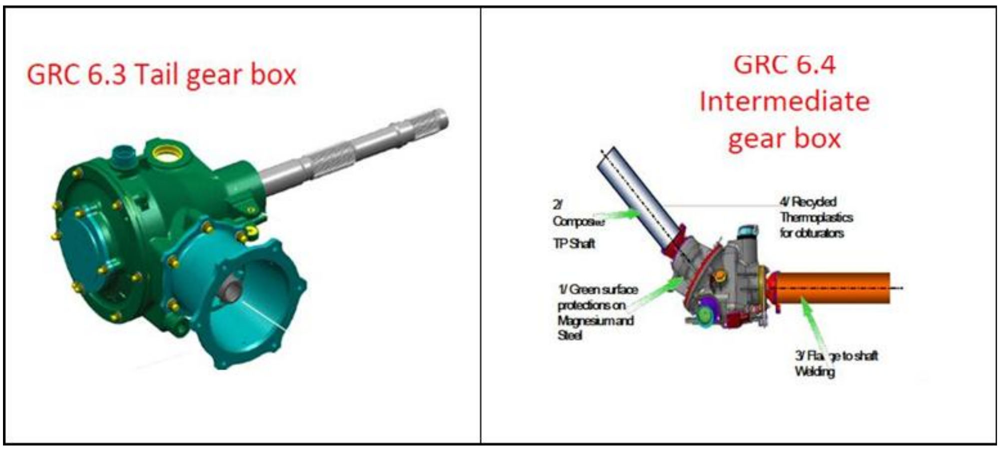

Figure 1 Tail gear box & Intermediate gear box

The components of the transmission system have a finite live, and they have to be recycled. There are several methods to remove coatings. Some of them are less harmful to the environment and workers than others.

The project deals with the analysis and validation of the main recycling processes as well as the design of recycling protocols to return the components of the helicopter power transmissions to the Material's Market, as secondary Raw Material, efficiently, profitably and environmentally sustainably.

The activities of the REMART project were developed by a consortium led by the CIDAUT Foundation (Spain), together with ITRB (Cyprus), CIDETEC (Spain) and PBLH International Consulting (Belgium) in close communication with the Topic Managers AGUSTAWESTLAND and AIRBUS HELICOPTERS.

2 PROJECT OBJECTIVES

The project didn't develop new technologies for recycling the components of the helicopter transmission systems. The main innovation achieved was to **optimize** the use of **existing recycling technologies** and the design of an efficient and environmental recycling protocol to each piece or set of pieces of the HTS.

The key to achieve this goal was to **make a quantifiable and precise assessment** of all the recycling processes. These recycling procedures have been evaluated under two kinds of parameters: economic and environmental. All the recycling processes involved and its parameters have been used to make a **spreadsheet**. This tool will allow engineers to optimize the recycling of each component of HTS and will be an interesting innovation of our project proposal.

Another distinguishing aspect of the project is that the parameters analyzed and the spreadsheet obtained were prepared in a manner that it may be used **in conjunction with other engineering**

environmental tools applied in the Design for Recycling in Product Development Process, such us **LCA** (life cycle assessment), carbon footprint, **LCE** (life cycle engineering and **DfE** (design for environment).

Model	Partname	Image	Material	Process	Recycling Methods	Economic Parameters					Environmental Parameters				European Directives and Regulations		Quality Parameters		
						Cicle Time	Maintenance Cost	Labour Cost	Waste Management Cost	Electric Consumption	Recycling Rate	Waste Generated	Carbon Footprint	Water Footprint	REACH	RoSH	Morphology of the Surface	Chemical Composition	Roughness Measurement
MODEL 1	Part 1	Pic. 1	Mat1	DISMANTLING	NO	-	-	23.7 €/h	3 €/kg	0.1 kwh	-	0.1 kg	-	-	YES	YES	-	-	-
				STRIPPING	Shot blasting	0.2 h	1 kg	23,7 €/h	0.01 €/kg	2,3 kwh	0.1 %	1 kg	0.01 kg	0.01 L			SEM	EDX	Profilemeter
					Grinding	0.1 h	2 kg	23,7 €/h	0.1 €/kg	0,35 kwh	0.3 %	0.1 kg	0.05 kg	0.02 L					
					Vibratory finishing	0.3 h	0.1 €/kg	23,7 €/h	0.2 €/kg	1,1 kwh	0.5 %	0.2 kg	0.09 kg	0.1 L					
					Chemical stripping	0.6 h	0.2 €/kg	23,7 €/h	1 €/kg	0.2 kwh	0.4 %	3 kg	0.1 kg	0.2 L					
				TRANSFORMATION	Remelting	0.5 h		23,7 €/h		34 kwh									

Figure 2 Spreadsheet for HTS parts

3 WORK PERFORMED AND ACHIEVEMENTS

A complete survey of the market surrounding the recycling of the Helicopter transmission system (HTS) has been developed, with the goal of tailoring the recycling processes to the HTS components.

According to the kind of HTS pieces, the main processes that could be applied to the components of gearboxes are:

- **Dismantling** - Riveted and Bolted joints, Welds, Glued joints.
- **Stripping -** Mechanical stripping (shot blasting, machining, grinding, vibratory finishing), Chemical stripping (chemical immersion stripping: acidic immersion stripping, alkaline cyanide immersion stripping, alkaline non-cyanide immersion stripping), Thermal stripping.
- **Remelting** – Cupola, Electric arc, Induction, Reverberatory and Crucible furnaces

In any case, until the end of the project it will not be known which of the processes are necessary and appropriate.

Then a survey of gearbox components has been made and it has been performed a relationship cross-table, linking each piece of the HTS with all the processes that can be employed in its recycling process.

In order to carry out the cross-table, the different pieces of the HTS have been analysed, studying the material compositions and the specific coatings; once completed this analysis, it has been chosen those technologies that could be employed in the recycling of the parts of HTS and with all this information it has been made the cross-table.

It has been necessary to describe the main parameters to be analysed in each of the processes involved in the recycling of HTS; after such analysis, it has been concluded that the main parameters to take into account for the comparison of HTS recycling processes are the following:

- **Economic Parameters**: Cycle time, Maintenance costs, Labour cost, Waste management, Electric consumption.
- **Environmental Parameters**: Recycling Rate Wasted generated, Carbon footprint, Water footprint and European directives.

- **Quality Parameters**: Morphology, Chemical composition, Roughness.

For the selection of the recycling protocols for each piece, in order to have a good comparison, the protocols have been divided into two groups, according to the nature of the stripping phase: mechanical stripping (Fig. 3) and chemical stripping (Fig. 4) are some of the protocols used for a specific material.

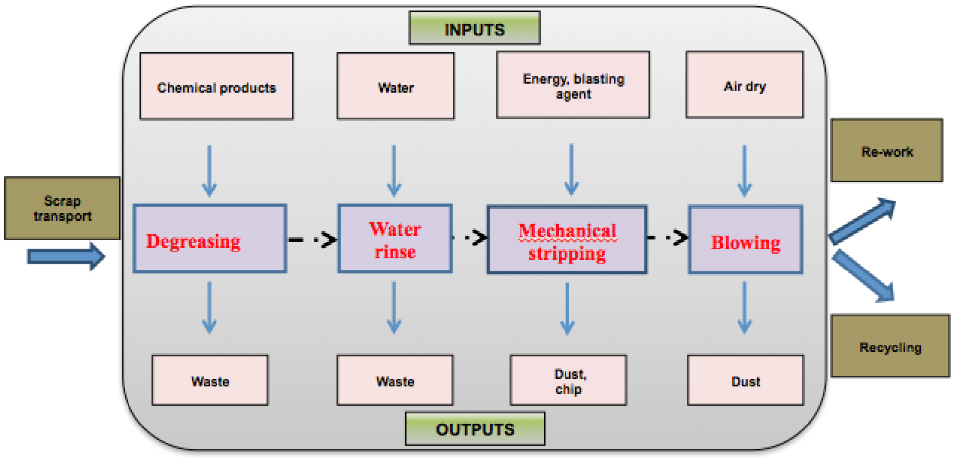

Figure 3 Recycling protocol for mechanical stripping

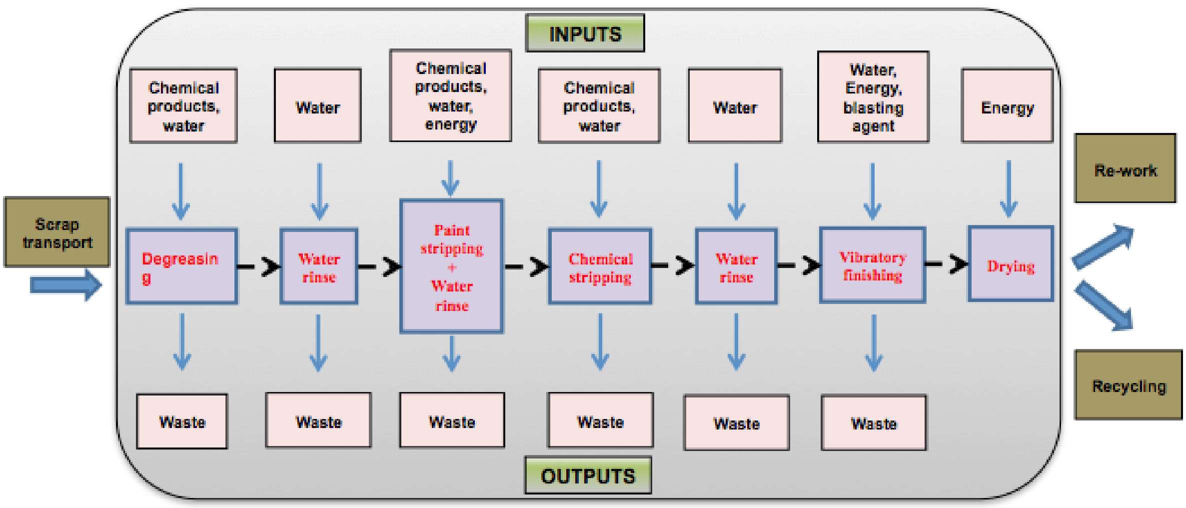

Figure 4 Recycling protocol for chemical stripping

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At this point, it has been possible to design a spreadsheet which to obtain that allows obtaining better recycling methodologies for the different parts of the HTS.

Model	Partname	Image	Material	Process	Recycling Methods	Economic Parameters					Environmental Parameters						Quality Parameters		
						Cicle Time	Maintenance Cost	Labour Cost	Waste Management Cost	Electric Consumption	Recycling Rate	Waste Generated	Carbon Footprint	Water Footprint	European Directives and Regulations		Morphology of the Surface	Chemical Composition	Roughness Measurement
															REACH	RoSH			
MODEL 1	Part 1	Pic. 1	Mat1	DISMANTLING	NO	-	-	23.7 €/h	3 €/kg	0.1 kwh	-	0.1 kg	-	-	YES	YES	-	-	-
				STRIPPING	Shot blasting	0.2 h	1 kg	23,7 €/h	0.01 €/kg	2,3 kwh	0.1 %	1 kg	0.01 kg	0.01 L			SEM	EDX	Profilemeter
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					Chemical stripping	0.6 h	0.2 €/kg	23,7 €/h	1 €/kg	0.2 kwh	0.4 %	3 kg	0.1 kg	0.2 L					
				TRANSFORMATION	Remelting	0.5 h		23,7 €/h		34 kwh									

Table 1 Spreadsheet for HTS parts

The next step was the experimental testing phase with the execution of the recycling protocols through two demonstrators. It Is in this phase that the quality of the results was checked for the final study, like in the following example with the results of the stripping (chemical and mechanical) of a coated aluminum specimen.

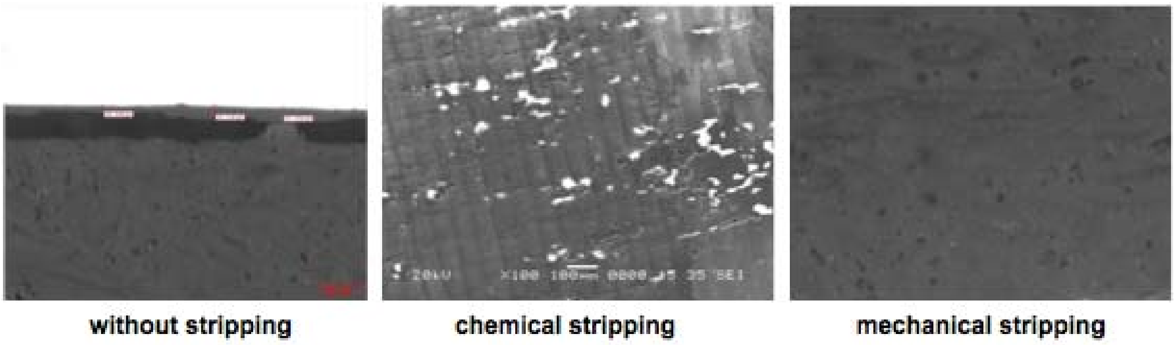

Figure 5 Coated aluminium part stripping

Finally, the experimental data collected has been entered in the spreadsheet where the program provides the best methodologies, based on two criteria:

- ✓ **Low cost**: the cheapest recycling protocol is obtained for each piece.
- ✓ **Best quality**: the best final quality for each piece.

4 IMPACT AND DISSEMINATION

The Recycling of metallic materials from rotorcraft transmissions Results are:

Reduction of Aerospace Structure and Systems Environmental Impact

The project outcomes through the improvement of the recycling process will minimize the generation of waste associated to the aerospace industry, reducing the emissions associated to the waste treatment as well as to the production of the new parts. The amount of CO2 and total air emissions are both reduced by over 90% per tonne when metals are produced by recycling rather than primary processes. Moreover, the outcomes of the project will facilitate the control and reduce the liquid waste quantity and hazardousness of the stripping process, allowing an easier treatment of the residues.

Improvement and Growth of European Industry competitiveness

The project will give a push to the aluminium recycling SMEs spread all over Europe by providing access to an innovative procedure that will allow them to modernize the process and improve its effectiveness in the waste sorting. The use of a cost effective coating stripping procedure will facilitate the sorting of the waste and smooth the use of automatic process reducing the cost of the whole recycling cycle.

The Main Advantages and Impact of Recycling of metallic materials from rotorcraft transmissions are:

Energy savings. The energy consumption per tonne of secondary aluminium or magnesium is much lower than that needed for primary aluminium or magnesium, between 85 and 90% lower.

Reduced waste disposal. The mass of solid waste generated per tonne of recycled aluminium or magnesium is 90% lower than that for primary metals. Recycling aluminium reduces hazardous waste generation by over 100 kg per tonne of metal produced.

Reduced emissions. Primary production generates both hazardous (fluorides, sulphur dioxide, etc.) and non-hazardous (carbon dioxide) emissions.

Reduced capital cost. The capital equipment used for recycling is less complex and thus less expensive than used for primary processes.

As part of the dissemination activities, a **visual identity including a logo** for NEMESIS Project was developed:

Remart

Figure 6 Remart project logo

This has been used to identify the project in the web page and other external communications.

The **project website** (`www.remartproject.com`) was designed by PBLH, to achieve the objective of promoting the dissemination of the project activities and the widespread of the non-confidential results.

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Apart from the online dissemination activities, Remart project activities and outcomes were disseminated in two events:

- The Second European **Aircraft Recycling Symposium** Stuttgart/Germany (11-12/03/ 2015)
- The Innovation forum global aerospace summit (www.aerospacesummit.com) (4-9/04/2014 in Abu Dhabi)
- The Innovation forum resoursceseffizienzkongress karlsruhe (www.ressourceneffizienzkongress.de) (24/09/2014 in Karlsruhe).