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End of life assessment of Demonstrator B2 "Low weight green metallic fuselage panels" including physical dismantling and recycling

Final Report (M1-M18)

"Attachment 1 - Publishable Summary"

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Author: Fundación GAIKER-IK4 (Spain)
Contributors: IK4-LORTEK (Spain), IK4-AZTERLAN (Spain)

Project Coordinator: Fundación GAIKER (Spain)
Topic Manager: Dassault Aviation (France)

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1. PUBLISHABLE SUMMARY

The SENTRY Project comprised the dismantling, recycling and environmental assessment of the End of Life (EoL) phase of the "B2 Demonstrator" panels, a subcomponent of "low weight metallic fuselage section", which has been manufactured within the Eco-Design for Airframe (EDA) activity in the Clean Sky (CS) programme. The SENTRY Project has assessed the current EoL management practices, based mainly on a size reduction step, where the output is a mix of the alloys included in the panel, a drying step of the metal scraps to remove the moisture and a remelting process to produce secondary raw materials.

The proposed new EoL procedures have been tested with a panel dismantling experiment at AELS facility, an accredited EoL aircraft manager, where parts have been identified, separated, sorted and shredded in order to satisfy input specifications of metal smelters that recycle them. The separated metallic fractions (once decoated and dried) have been processed in a bench scale melting facility and the produced metallic alloys characterised in order to validate their close loop recycling as better alternative than the downgrading practice. During dismantling and recycling activities, materials and energy flows, emissions and waste generation have been inventoried in order to complete the Life Cycle Assessment (LCA) of the EoL of the "B2 Demonstrator" panels that have been compared with the one of a reference panel. The final results have been the definition of the new EoL schemes for the "B2 Demonstrator" panels manufactured by Dassault Aviation (Panel B) and IAI (Panel A). The assessment of the environmental aspects related to the new EoL scenarios has allowed the identification of those activities with a strong environmental impact and the definition of ecodesign solutions to optimize potential reuse/recycling of metallic materials.

Within the SENTRY Project, a new EoL scenario, able to recover high quality aluminium alloys by promoting proper and efficient sorting techniques that avoid the down-cycling, has been defined and demonstrated. Considering the results of the chemical assays completed on the recovered aluminium alloys and the validation from Constellium, as global aluminium products manufacturer, it can be stated that they exhibit a maximum reuse potential since, due to the absence of contamination, they can be considered as first quality materials and therefore directly introduced again in the aeronautic sector.

In particular and focusing in the chemical composition results, it is shown that in all the cases the recovered aluminium alloys fulfil the specifications, containing percentages of the most critical elements below the maximum limits (Si <0.04 wt%, Fe <0.06 wt%, Na <0.001 wt% and Ca <0.002 wt%). Regarding metal losses originated during the bench scale remelting process, and paying special attention to the valuable and volatile elements in the alloys (Ag, Li and Mg) it could be confirmed that the Ag content did not vary. The Li losses were about 7.6-11.2% for those alloys with initial Li contents in the range 0.8-1.8 wt%. The Mg losses were 20-36% for the alloys with initial Mg contents in the range 0.31-0.40 wt% and 0-2.4% for the ones in the ranges 1.37-1.82 wt% and over 4.5 wt%.

From the environmental point of view, when the market value of recyclable scraps relative to primary material was considered in the LCA, determining the product-specific degree of quality loss and the appropriate EoL credit, the impacts derived from the new EoL scenario were, in almost all impact categories, lower than the impacts derived from the current EoL. However, in a holistic approach, overall impacts throughout the entire life cycle of a product must be considered, meaning that impacts arising in the manufacturing, use and EoL phases should be regarded.

Finally, it is essential to add that all collected data from B2 Demonstrator and Reference Panels have been exchanged with the EDA Activity to be incorporated in the EDA LCA database, contributing thus with valuable and detailed LCA data on aeronautic components that can be applicable for the analysis of other parts.

Description of work

It was completed an exhaustive assessment of dismantling practices applied to EoL metallic fuselage panels and recycling procedures applied to light aluminium, alloys including their decoating, that was considered the preliminary step. As result four EoL scenarios, current for Reference Panel and new for Reference and "B2 Demonstrators" Panel A and B, were defined, see Figure 1 and Figure 2.

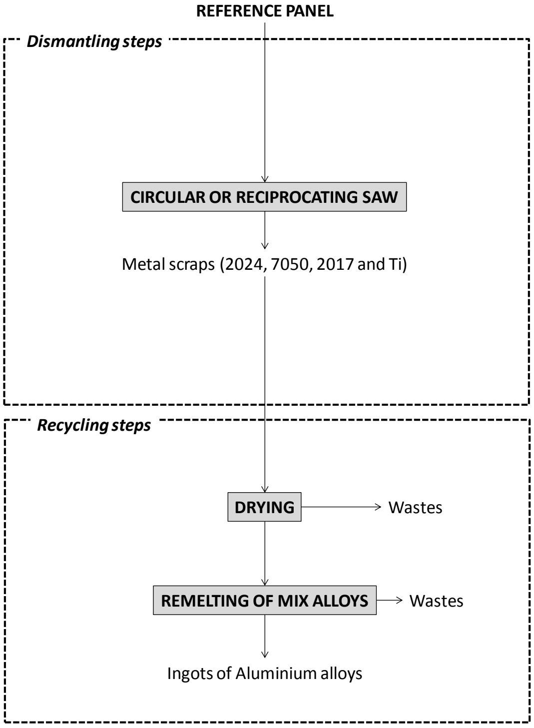

Figure 1. Current EoL scenario for the Reference Panel

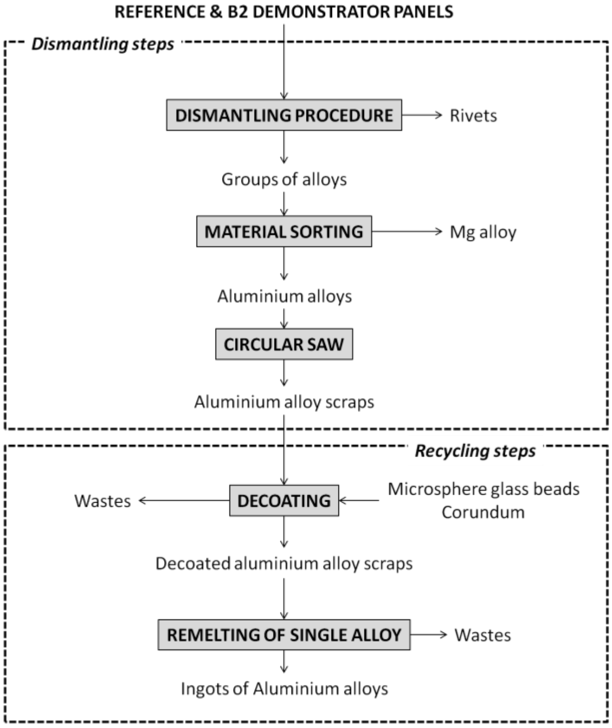

Figure 2. New EoL scenario demonstrated for the Reference and the "B2 Demonstrator" A and B Panels

Once defined the dismantling and recycling practices, the environmental assessment of current EoL for the Reference Panel was modelled. The definition of the LCA framework and the setting of the boundaries of the current EoL were achieved. The environmental indicators were calculated to set a baseline scenario and to quantify the environmental impacts in the eleven categories recommended by the impact assessment methods. The unit operations of the current EoL practices with a strong environmental impact were identified.

The new EoL scenarios defined for the Reference and "B2 Demonstrator" Panel A and B were tested in demonstrations including a dismantling of panels and a classification by alloy type, Figure 2 top. The classified parts were shredded and the light aluminium alloys recycled after being decoated, dried and remelted, Figure 2 bottom. A collection of data was done, gathering information about equipments or tools used, operation times, consumptions, input and output materials and waste generated. A characterization of the light aluminium alloys by chemical and metallographic analysis was carried out to check the presence of undesired phases, inclusions/oxides and alloy quality in terms of element composition.

Figure 3. Live dismantling (upper line) of panels and live remelting of sorted aluminium alloys (bottom line)

Once products quality validated, the environmental profile of the new EoL scenarios was assessed following the same LCA methodology set for current EoL. The environmental impacts of the new EoL for the Reference and “B2 Demonstrator” Panel A and B were identified and analysed. A comparative assessment was carried out to know the environmental benefits and drawbacks of the new EoL scenario and the influence of the panel design and structure. Finally, on the basis of LCA results, ecodesign solutions were proposed.

Results

In the current EoL scenario, the Reference Panel is understood as an individual product of the whole fuselage scrapping step. The EoL is based on a size reduction, being the output a mix of scraps of the metal alloys included in the panel. This mix is remelted to produce a low value secondary material.

In the new EoL scenario, the Reference and “B2 Demonstrator” Panels A and B have been dismantled according to specific procedures. The rivets have been drilled out, the parts have been sorted by alloy composition and each part cut to reduce the size prior to recycling. The recycling has included the surface decoating by sandblasting and the remelting of each material. Mass loss during remelting has been measured and product quality characterized by chemical and metallographic analysis. The compositions of the alloying elements, in particular Li, Mg and Ag, have been compared with the nominal ones in the aluminium alloys of the studied panels.

The comparative environmental assessment concluded that:

- The use of accurate allocation methods is critical when different EoL are compared for a same product or system and when the quality and value of the recovered streams are different for each EoL. In the case of current and new EoL for Reference Panel, this turns into a penalization of the down-cycling recycling operations and a promotion of efficient sorting techniques to recover high quality aluminium alloys.
- The environmental profile of the panels is highly influenced by the energy source employed during the EoL steps, by the yield of the EoL operations, the final value of the recovered alloys and the environmental impact of the alloy manufacturing.

The SENTRY Project has led to the definition of a new EoL scenario able to allow the recovery of high quality aluminium alloys avoiding the downgrading and promotion of proper sorting techniques.

Potential impacts

The execution of the SENTRY Project has achieved two main final results. On one hand, the implementation of an efficient and value-preserving new EoL scenario has been completed which avoids the down-cycling recycling operations and drives to the recovery of high grade aluminium alloys. On the other hand, the comparative LCA which once completed has concluded that the environmental profile of the panels is highly influenced by the energy source employed during the EoL steps, by the yield of the EoL operations, the final value of the recovered alloys and the environmental impact of the alloy manufacturing. Additionally, considering these factors and with the aim of optimizing the environmental performance of the three panels at EoL phase, several eco-design solutions have been proposed such as the use of natural gas as energy source or the improvement of the remelting step to minimize the losses of alloying elements.

Despite the fact that the technical and environmental feasibility of the new EoL has been demonstrated, the expected socio-economic impacts will be associated with the industrial implementation of the new EoL in a profitable way. An initial revision pointed out that costs associated with labour for, either dismantling parts by drilling and cutting, or sorting fractions by classifying compatible materials, or conditioning particles by shredding and decoating, should be reduced. Attending to this, some of the next actions or steps should be considered:

- To carry out Life Cycle Cost (LCC) of the new EoL scenario implemented in SENTRY Project
- To assess the new EoL scenario applied to other alloys or sections of an aircraft
- To develop selective shredding processes and mainly automatic material sorting and identification methods focused on light aluminium alloys

To conclude, the true impacts of the SENTRY Project will be associated directly with the implementation of the proposed solutions by EoL aircraft managers and material recyclers. These actions will have effect on companies devoted to the manufacturing of dismantling and recycling equipment and will retrofit the aircraft manufacturers and decision makers. Besides, the implementation of selective aircraft dismantling and recycling practices, technically, economically and environmentally feasible, would contribute to raw materials and energy preservation, supporting the close loop recycling alternative instead dilution and downgrading. The amount of aeronautic grade aluminium scraps from post-consumer origin to be recycled was estimated in 60,000 t/year after considering the number of airplanes currently in service, a life span for them in the range 20-25 years and the implementation of the EoL management practices defined within the SENTRY Project. Calculations based on global aeronautic grade aluminium alloy consumptions determined that another 60,000 t/year of post industrial scraps could be generated during aircrafts manufacturing. The market value of these high grade alloys could range 1,600-1,800 €/t, double or triple than the conventional aluminium alloys.

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