Deliverable D 2.3

Key Performance Parameters for coupons manufacturing & upcycling processes

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Document Control Information		
Title	*Key Performance Parameters for coupons manufacturing & upcycling processes*	
Scope / purpose of deliverable	*The Deliverable displays and summarizes the results and outcomes generated within the work package 2 on the developed upcycling processes and key performance parameters from the produced coupons made of metal and CFRP*	
Expected outcomes / contribution to impact	*In this report, the mechanical, chemical and microstructural properties of coupons manufactured based on the developed recycling approaches are summarized and explained. In addition to the comparison with reference material, the data and processes also serve as input for the design and manufacturing of the demonstrator in WP5.*	
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Date	**Version**	***Change/Comment***
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TABLE OF CONTENTS

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PUBLISHABLE SUMMARY

In SUSTAINair, up- and recycling processes and approaches were developed and investigated for metal and composite material manufacturing in order to contribute to greater sustainability in aviation and thus towards circular aviation. Different routes for up- and recycling various materials and processes were chosen and tested. On the metal side a Laser Powder Bed Fusion (LPBF) setup was modified so that titanium powder can be reused. Furthermore, novel aluminium alloys (wrought and cast alloys) were developed and produced via High Pressure Die Casting (HPDC; cast alloys) and complex geometry extrusion (wrought alloys) to overcome current limitations and make recycling with other waste streams possible. On the CFRP side processes for thermoset and thermoplastic composites were developed using production waste material.

The Deliverable D2.3 *Key Performance Parameters for coupons manufacturing & upcycling processes* summarizes the results and outcomes generated on upcycling processes. Key performance parameters from the produced coupons made of metal and CFRP are displayed. The following conclusions can be drawn:

Novel aluminium alloys: pathways were explored to align alloy compositions of automotive aluminium waste streams and those of aviation EoL structures, while also adding impurity tolerance against elements like iron. Novel alloy design strategies were developed for both cast and wrought materials, the former exploiting the novel concept of multi-element nanoeutectics, the latter blending metallurgic strategies (like eutectics) from cast alloys into automotive based wrought designs.

In both cases, the approach was successful. Nanoeutectic intrinsic refinement in complex compositions could be shown to be a universal feature of these compositions, and a final alloy design could be achieved that is capable of blending automotive (Al-Mg-Si) waste streams with aerospace 7xxx (Zn-based) grades at high ratios. KPIs could be exceeded with respect to performance, achieving mechanical strength levels close to aerospace grade structural alloys.

The same approach could successfully be applied to a wrought EN AW 6082 basis, incorporating significantly enhanced fractions of impurity elements and relevant fractions of Zn while exhibiting an increase in performance against the commercial State of the Art of more than 40%. KPIs were not fully achieved in strength, yet elongation could be displayed to meet even at high recycling element contents.

Titanium powder reuse: While standard operating of the LPBF machine generally leads to a slow degradation of the Ti6Al4V powder over several build processes, particularly when running the platform temperature at 200 °C or even above 400 °C, the implementation of an additional gas purification system to filter residual O_2, N_2 and humidity, substantially slowed the aging or degradation of the powder. Similar materials properties were measured for virgin and reused powder specimens. Due to the build-platform position dependence of the samples, also differences in porosities, mechanical and chemical deviations were detected that were not related to the oxygen uptake.

Upcycling process for thermoplastic composite: A process was developed for the manufacturing of 2nd life material with a limited content of 1st life material. Production waste was shredded into smaller particles and the resulting laminate material delivered relatively good mechanical performance: 47% and 86% of the performance for respectively flexural strength and modulus of 1st life material was regained for the UD-tape based CF/LM-PAEK material and for the fabric-based CF/PPS material it was even 60%

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and 91%. For the tensile properties the results were lower as expected with tensile stress of 23% and 34% for CF/LM-PAEK and PPS respectively compared to the 1st life material.

Possible applications would be parts mainly loaded in bending. Using the additional benefit of the flowable core material, thickness variations in the parts can be easily obtained, allowing for weight optimization. In this way, not only the cost but also the weight for selected 2nd life material applications could be lower than when using 1st life material.

Upcycling process for thermoset composite: A promising manufacturing process using FRP snippets in a pressing process was developed. A parameter study for different process parameters was carried out. Using destructive test methods, a most promising process parameter was identified. The characteristic strength values of the recyclate material reached up to 20 % of the nominal characteristic values of the original material. Optimizing the process for a uniform snippet orientation within the laminate would enable higher strength values and qualify the technology for applications with higher structural requirements.

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