Deliverable 4.3

Report on joining & repair strategies for recyclable materials

Due Date:	31st December 2023
Submission Date:	22nd December 2023
Dissemination Level:	PUBLIC (PU)
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Project acronym: SUSTAINair	**Project Number**: 101006952
Start date of project: 1 January 2021	**Project duration**: 42 months (June 2024)

Document Control Information	
Title	*Test results for joining and repair*
Scope / purpose of deliverable	*This report describes the obtained test results and associated overall quality of the different joints and joining and repair techniques, applied on the material combinations under research. Metal-to-metal, metal-to-composite and composite-to-composite material combinations are analyzed for different type of metal and composite materials, both first life and (recycled) second life materials. Different online monitoring systems for composite welding are explored with focus on improving quality of the monitoring.*
Expected outcomes / contribution to impact	*The differences between the obtained results for material combinations and joining and repair techniques under research are summarized. Also the differences between first and (recycled) second life materials and the effect on the overall quality of the joint become clear.*
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Reviewer(s)	*All partners*
Dissemination level (select one, as in DoA)	☐ **CO** Confidential (please provide Published Summary) ☒ **PU** Public
Target audience	*List target audience & stakeholder groups.*
Approved by	☒ AIT-LKR (COO) ☐ NLR ☐ DLR ☐ JR ☐ JKU ☐ TUD ☐ ACIR ☐ INOCON ☐ INVENT ☐ DTC ☐ RTDS
IPRs underlined	*TBD*
Datasets underlined	*TBD*

Date	Version	*Change/Comment*
21.12.2023	V1	*First draft with content outline*

CONTENTS

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1. PUBLISHABLE SUMMARY

This deliverable, which will form the public deliverable of D4.1 and D4.2 (both confidential), can only be made after officially finishing D4.1 and D4.2. This D4.3 will therefore be made and submitted in the beginning of 2024. For reasons of dissemination, the SUSTAINair consortium is aiming for a public report that will also be transformed to a more accessible format for broader communication of the outcomes of WP4.

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2. INTRODUCTION

Topics/questions to address, from other deliverables:

1. D1.1, p8, Figure 3: What ratio in use of materials to be expected for future aircraft? For example, what is the ratio achieved for the X-57 Maxwell? Important to better feedback on the impact the project could have.
2. D1.1, p.9, Figure 5: "The aircraft design has become more and more efficient, and it has been reached only working at the same time to the three main components of a design: shape, materials and processing". WP4 is about the last component processing.
3. D1.1, p. 9, par. 1.3: "Weight saving through increased specific strength and stiffness is a major driver for the choice/development of materials in aeronautics". So can we compare in SUSTAINair how the strength/stiffness over weight ratio is per realised joint?
4. D1.1, p. 9, par. 1.3: "A crucial issue (…) is affordability". Are we addressing this in the project?
5. D1.1, p. 11, Figure 7: The approximate energy associated with the production of one kilogram of material for composites seems to be much better than for metals. But production process is impacting this, for example making metal with die casting will require another level of energy than making metal with 3D printing I assume. Can we get the differences from the LCA in T2.6?
6. D1.1, p. 12, par. 1.5: "Generally, rivets are used where shear strength properties are required". Can we somehow characterise this type of joint as well, to refer to when we compare joints?
7. D1.1, p. 12, par. 1.5: "Bonded joints can be designed such that the adhesive sustains loads greater than the strength of the parent material and do not exhibit failure due to fatigue loading". Can this be used as a reference as well in WP4?
8. D1.1, p. 22, par. 3.3: "These flakes are filled in a compression mould over an area of 350x350 mm2 in an unordered manner". Will these samples also characterised in WP2? Is this somehow impacting the resulting strength of the joint?
9. D1.1, p. 24, par. 4.1: What is the definition of joint efficiencies (JE)? Can this definition also be used for other materials than metal?
10. D1.1, p. 24, par. 4.1: Joining and disassembling technologies distinguished and therefore to be addressed as part of the WP4 work:
    a. Increased weldability of aluminium alloys by chemical tailoring
    b. Laser welding of metallic components, aluminium and/or titanium?
    c. Adhesive bonding of thermoset composites
    d. Welding of thermoplastic composites
    e. Joining of thermoset/thermoplastics
    f. SHM methods:
        i. Electromechanical impedance method, piezoelectric transducer
        ii. Ultrasonic guided waves
11. D1.2, p. 5, Figure 1: Can we consider the welded end-result from WP4 as elements? It might be good to refer to this figure in WP4 deliverable as well.

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12. D1.2, p. 9, par. 3.1: "The recycled composite laminates in SUSTAINair could show a higher degree of heterogeneity than their first life counterparts on micro-, meso-, and macroscale. Hence, it should be expected that the specimen geometry has a larger influence on the strength of second life composite laminates. This issue is overcome by the standard procedure of cutting samples from a plate of sufficient size. The increaded heterogeneity due to manufacturing is then implicitly accounted for as a larger scatter in the test results due to the higher variance between the specimens. Therefore, coupon tests designed for first life composites are also suitable for second life FRPs."
13. D1.2, p. 11, par. 3.1.2: "The second life core material is made out of mechanically scrapped laminates with relatively large dimensions of the particles compared to the coupon width. Therefore also coupons with a double with will be tested to investigate the effect of the coupon size on the test results".
    a. How is that related to point 12? Doesn't look consistent.
    b. Will these characterisation tests for wider coupons actually take place?
14. D1.2, p. 16, par. 3.2.1: "In both cases (i.e. for laser welding metal joints wrought/die-casting), butt joint welding geometries are applied as they resemble the most likely application configuration in future aeronautic structures, …". These achieved strength results cannot be used in WP4 to compare with pure composite or hybrid join (SLS-)strength, I guess.
15. D1.3 questions to be added

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3. RESULTS: METALS

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4. RESULTS: COMPOSITE WITH METAL

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5. RESULTS: COMPOSITES

6. ADVICE TO THE INDUSTRY

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7. CONCLUSIONS

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8. APPENDIX

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