



Recovery of Carbon Fiber from Composite Aeronautic Components by Thermal Treatment at Industrial Scale

Comet Traitements

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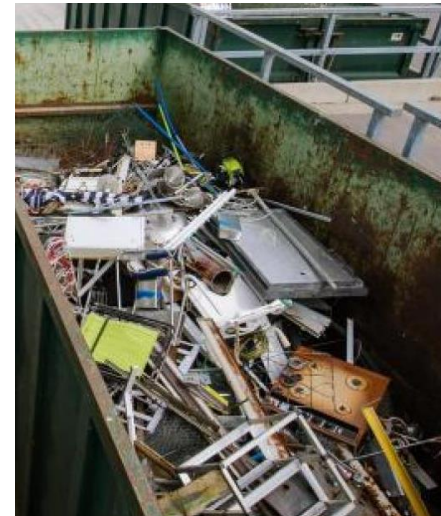


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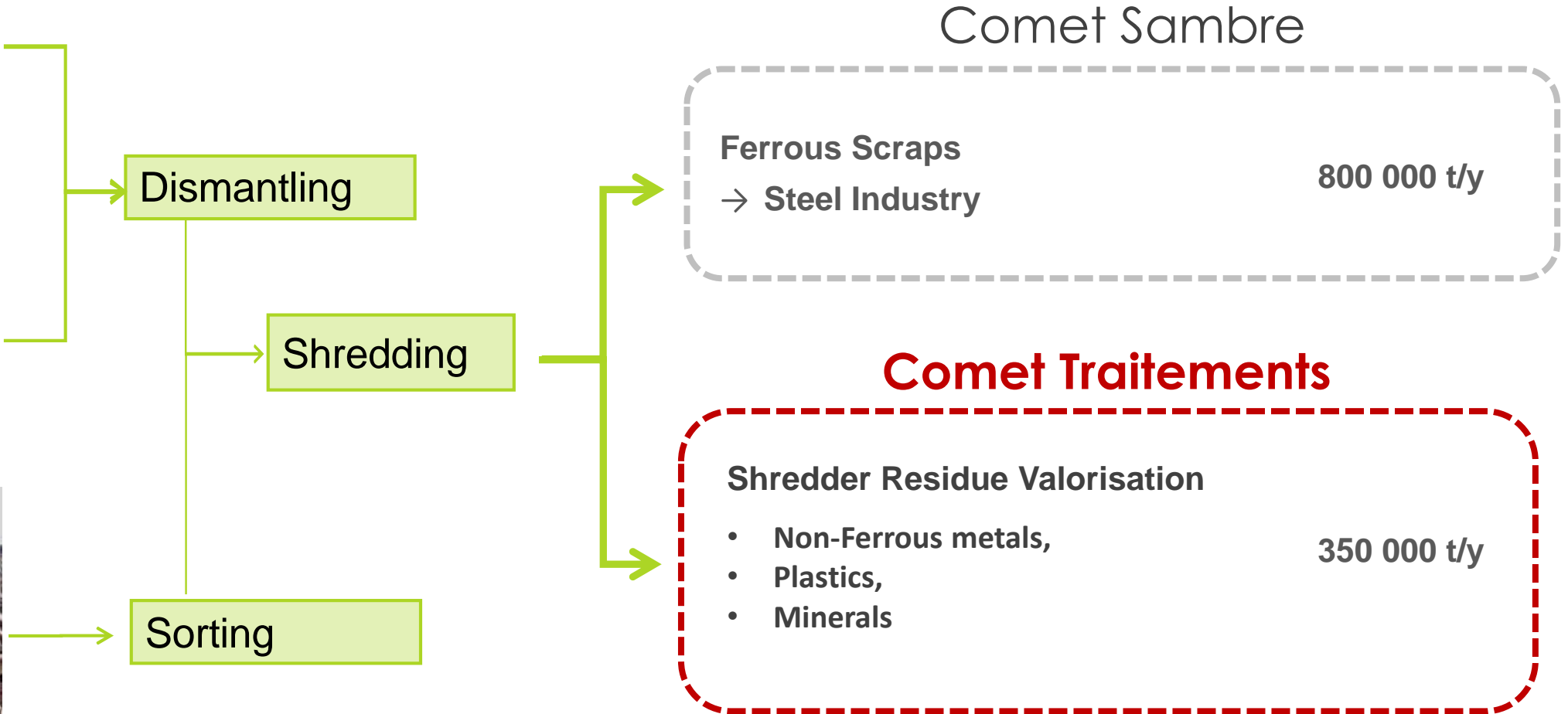
COMET GROUP / COMET TRAITEMENTS

COMET GROUP :

- ❑ Family group mainly located in Belgium & France
- ❑ 500 staff, 500 M€ Turnover
- ❑ 2 shredding sites, Charleroi (3.000 CV) and Mons (7.000 CV)
- ❑ 1.200.000 to/y of Wastes – 800.000 to/y metallic



OVERVIEW OF ACTIVITIES





NEW FEEDSTOCKS



RECOVERY of CARBON FIBERS from AERONAUTICS COMPOSITES

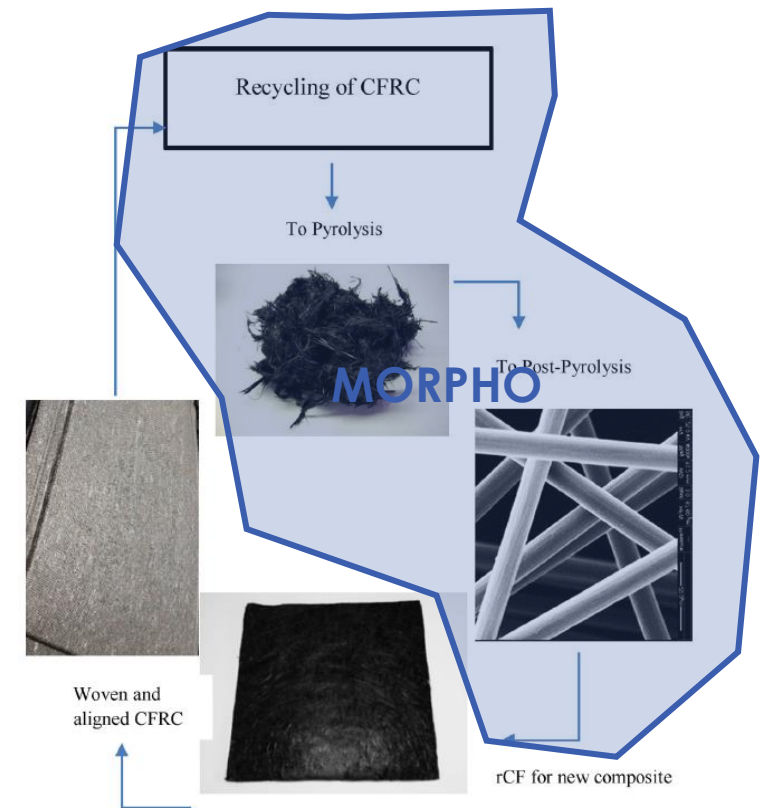
Objectives

- Recover CF from CFRP : remove the resin without affecting the CF
- Assess the feasibility of the process on Comet semi-industrial pyrolysis plant (Phoenix)

2 Steps

1) **Pyrolysis** (absence of air) : 450...600°C

2) **Oxidation** using air : 500...600 °C



Comet's semi-industrial plant

- Pyrolysis technology developed initially for organic shredder residues and adapted to Plastic Composite Materials in MORPHO



Methodology

Characterization of vCF

Lab-scale trials

In glassware and tubular oven

Pyrolysis and oxidation trials

Characterizations of rCF and comparison with vCF

Semi-industrial trials

Adapt the reactor to be able to pyrolyze CFRP

Pyrolysis and oxidation trials based on best parameters from lab-scale trials

Characterizations of rCF and comparison with vCF and rCF from lab-tests



Iterative process
to identify the best
operating
parameters

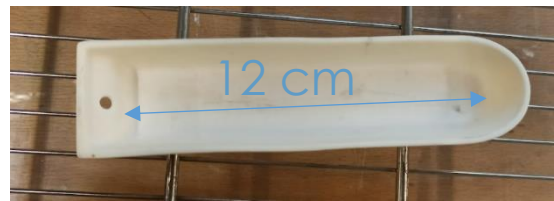
Methodology

500 mL



CFRP 1x1x1 cm
Glassware

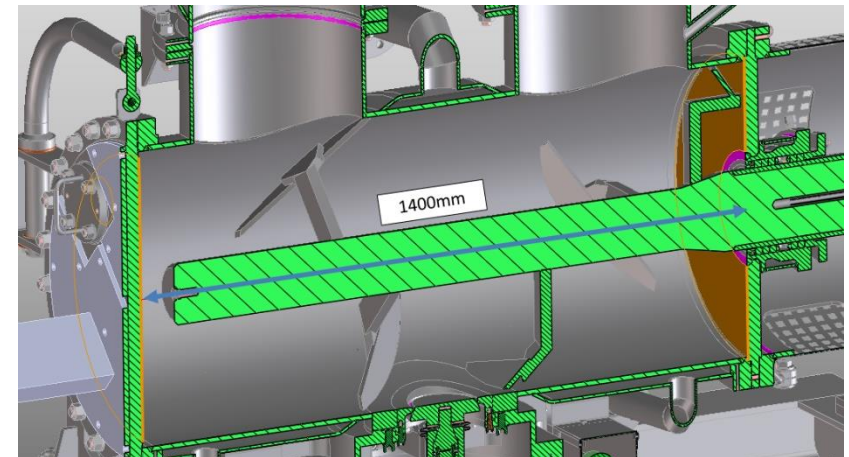
Heating zone : 20 cm



CFRP 11x2x1 cm
Tubular Oven



Pyrolyser : 400 L



CFRP 200 kg Pyrolyser

Lab-scale – Pyrolysis & Oxidation

- Performed tests in Glassware



PR520 IM7 Cube after pyrolysis

Pyrolysis: 2h @500°C Oxidation : /
6h @500°C

- Performed tests in Tubular Oven



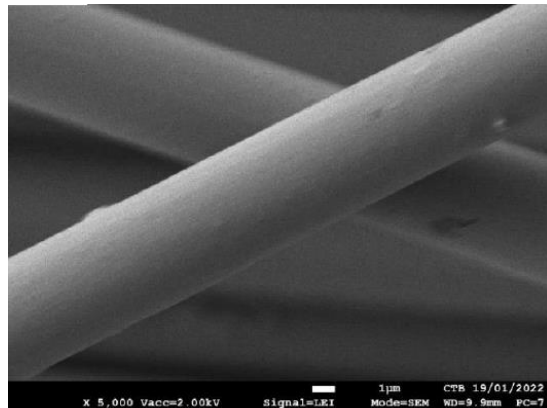
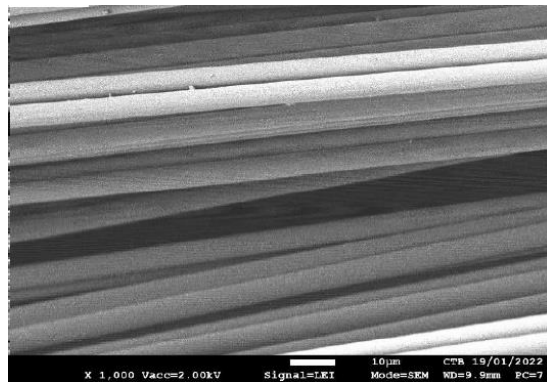
PR520 IM7 after pyrolysis after pyrolysis + oxidation

Pyrolysis: 2h @500°C Oxidation : 0 min @500°C
6h @500°C 30 min @500°C
 60 min @500°C

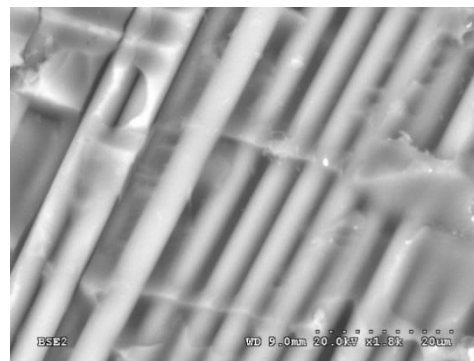
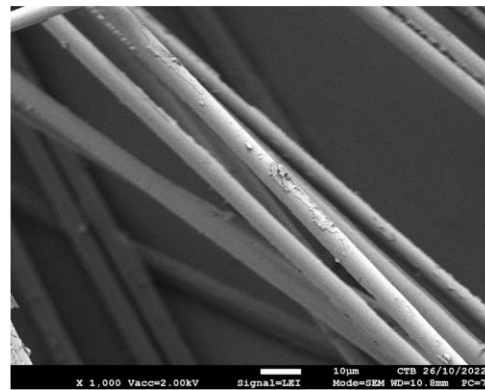
+ Mass Balance

Lab Scale - Characterisation (SEM)

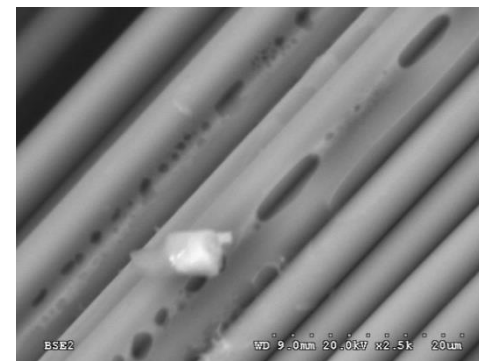
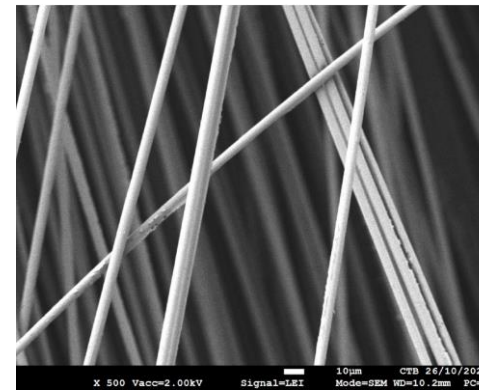
vCF



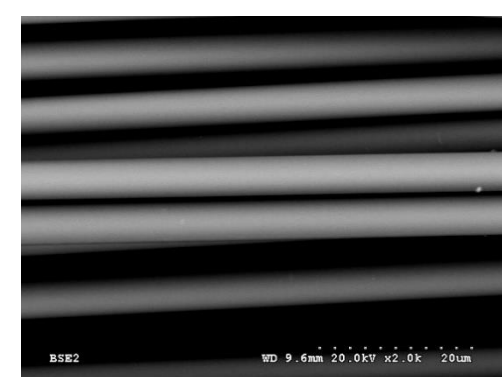
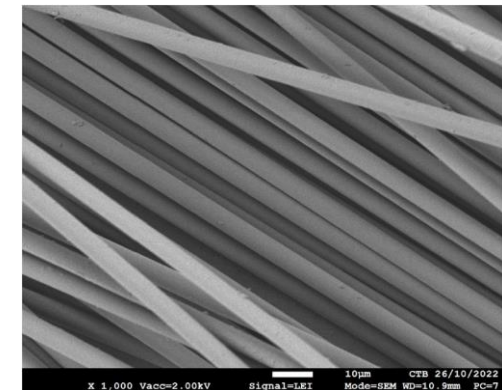
rCF
P-500°C
O-500°C 0 min



rCF
P-500°C
O-500°C 30 min



rCF
P-500°C
O-500°C 60 min



Lab Scale - Characterisation

(MECHANICAL PROPERTIES)

Sample	vCF			rCF			Unit	Comment
	V3 (50 Fibres) T2124753r	StdDev	Δ	304Y023 T2309671	StdDev	Δ		
Operating Condition	Measured			P-500°C 2 hours O-500°C 30 min				
Tensile Strength	5008,9		0%	4450,7		-11%	MPa	
Tensile/Young modulus E_f	298,1		0%	264,9		-11%	Gpa	Young modulus decreases when stiffness decreases
Ultimate elongation at failure	1,68	0,34	0%	1,68		0%	%	
Force Maximum	9,83	3,17	0%	8,91		-9%	cN	
Weight/Length	0,570		0%	0,650		14%	g/m	(20 fibers average by gravimetry)
Filament diameter	5,00		0%	5,05		1%	μm	(20 fibers average by vibroscope)

→ Determination of optimum parameters

Promising results:

- Thermal treatment succeeded in recovering fiber
- Mechanical properties slightly affected (10-15%)

Upscaling lab trials in Comet's pilot



- Samples : Safran BE
- Pyrolysis : 2h @500°C
- Oxidation : /



- Samples : Safran FR
- Pyrolysis : 2h & 6h @500°C
- Oxidation @ 500°C

→ **Feasibility assessed**

Need to be more precise → optimization in Comet's industrial oven

Optimization trials

PYROLYSE				
	Référence IN	Equipment	Condition de pyrolyse	Reference rCF
1	IM7 PR520 10*10*10 (209Y001)	Glassware	P 2h - 500°C	NA
2	IM7 PR520 10*10*10 (209Y001)	Glassware	P 6h - 500°C	209Y003 (CHAR) 209Y004 (Huile) NA 209Y005 (CHAR) 209Y006 (Huile)
3	IM7 PR520 10*10*10 (209Y001)	Glassware	P 2h - 500°C	
4	IM7 PR520 20*43*110 (209Y002)	Tubular oven	P 6h - 500°C	209Y007
5				
6				
7	IM7 PR520 20*43*110 (209Y002)	Tubular oven	P 2h - 500°C	211Y021
8	IM7 PR520 20*43*110 (209Y002)	Tubular oven	P2h - 500°C (rampe Comprise)	311Y001
9	IM7 PR520 20*43*110 (209Y002)	Tubular oven	P2h - 500°C (rampe Comprise)	311Y003
10	IM7 PR520 20*43*110 (209Y002)	Carbolite Oven	P2h - 500°C (rampe Comprise)	404Y002
11	IM7 PR520 400*400*110 coupon (407Y012)	Carbolite Oven	P3h - 500°C (rampe Comprise)	407Y013
12	Safran BE Shredded - Pre Test	Mixing Oven	P2h - 500°C	
13	Safran BE Shredded - Heat Balance	Mixing Oven	P2h - 500°C	
14	IM7 PR520 20*43*110 (209Y002)	Mixing Oven	P2h - 500°C	
15	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C	230206P200
16				
17	IM7 PR520 20*43*110 (209Y002)	Static Oven	P 6h - 500°C	230220P600
18				
19	IM7 PR520 20*43*110 (209Y002)	Static Oven	Pr+80 - 500°C (rampe comprise)	230619P200 A
20				
21	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C (sans rampe)	230619P200 B
22				
23	IM7 PR520 20*43*110 (209Y002)	Static Oven	Pr+30 - 500°C	230731Pr+3000
24	IM7 PR520 20*43*110 (209Y002)	Static Oven	Pr+45 - 500°C	230801Pr+4500
25	IM7 PR520 20*43*110 (209Y002)	Static Oven	Pr+60 - 500°C	230804Pr+6000
26	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C (rampe Comprise)	23102304P2
27	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C (rampe Comprise)	23102404P2
28	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C (rampe Comprise)	231229P200
29	IM7 PR520 20*43*110 (209Y002)	Static Oven	P2h - 500°C (rampe Comprise)	240126P200
30	IM7 PR520 400*400*110 coupon (407Y012)	Static Oven	P2h - 500°C (rampe Comprise)	240202P200

OXYDATION		
Référence IN	Equipment	Condition d'oxydation
NA	NA	NA
NA	NA	NA
NA	NA	NA
NA	NA	NA
NA	NA	NA
NA	NA	NA
NA	NA	NA
209Y007	Tubular oven	O 30min - 500°C
209Y007	Tubular oven	O 60min - 500°C
209Y007	Tubular oven	O 45min - 500°C
211Y021	Tubular oven	O 45min - 500°C
311Y001	Tubular oven	O 30min - 500°C
311Y003	Tubular oven	O 30min - 500°C
404Y002	Carbolite Oven	O 30min - 500°C
407Y013	Carbolite Oven	O 30min - 500°C
-	-	-
-	-	-
-	-	-
230206P200	Static Oven	-
230206P200	Static Oven	O 30min - 500°C
230220P600	Static Oven	O 45min - 500°C
230220P600	Static Oven	O 30min - 500°C
230619P200 A	Static Oven	O 30min - 500°C
230619P200 A	Static Oven	O 45min - 500°C
230619P200 B	Static Oven	O 30min - 500°C
230619P200 B	Static Oven	O 45min - 500°C
230731Pr+3000	Static Oven	O 30min - 500°C
230801Pr+4500	Static Oven	O 30min - 500°C
230804Pr+6000	Static Oven	O 30min - 500°C
23102304P2	Static Oven	O 30min - 500°C
23102404P2	Static Oven	O 30min - 500°C
-	Static Oven	O 30min - 500°C
240126P200	Static Oven	O 30min - 500°C
240202P200	Static Oven	O 30min - 500°C

30 trials

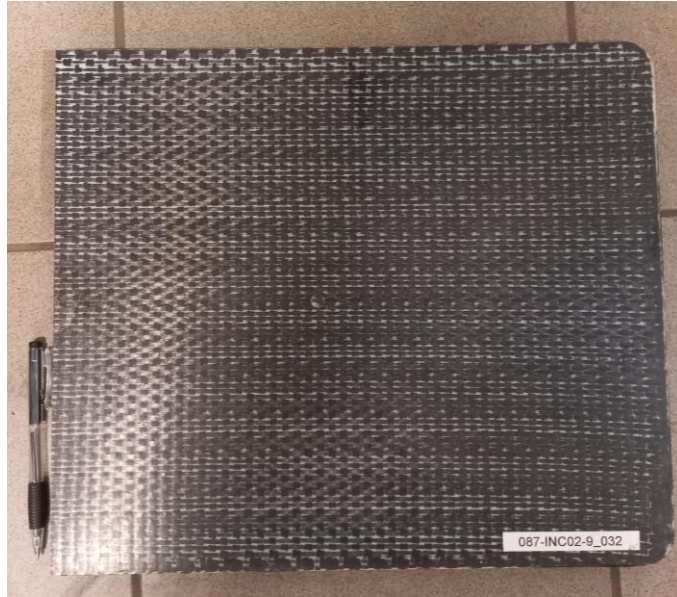
- 11 at lab scale
- 19 at pilot / oven scale

Results

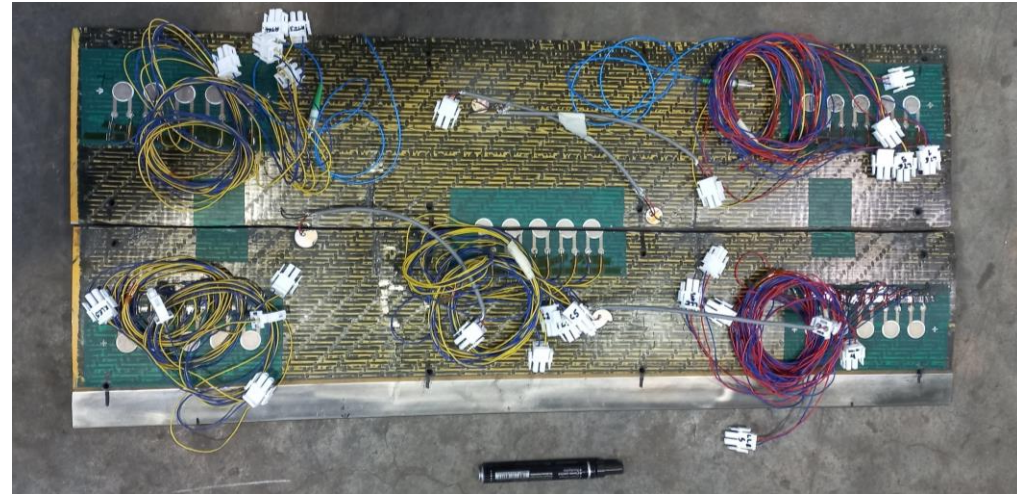
Sample	vCF			rCF			rCF			rCF			rCF			Unit
	V3 (50 Nibres) T2124753r			240126P200 P-500°C 2 hours O-500°C 30 min			230626P2030A T2315844 P-500°C 2 hours O-500°C 30 min			230626P2045A T2315843 P-500°C 2 hours O-500°C 45 min			230731Pr + 30' 030 T2319242 P-500°C r+30 min O-500°C 30 min			
	Measured	StdDev	Δ		StdDev	Δ		StdDev	Δ		StdDev	Δ		StdDev	Δ	
Tensile Strength	5008,9		0%	4601,3		-8%	4473,9		-11%	4540		-9%	4188,5		-16%	MPa
Tensile/Young modulus E_f	298,1		0%	258,5		-13%	274,5		-8%	282		-5%	253,9		-15%	Gpa
Ultimate elongation at Failure	1,68	0,34	0%	1,78	0,47	6%	1,63	0,82	-3%	1,61	0,29	-4%	1,65	0,47	-2%	%
Force Maximum	9,83	3,17	0%	9,03	2,15	-8%	8,78	3,01	-11%	8,91	1,73	-9%	8,22	2,15	-16%	cN
Weight/Length			▾	0,800		▾	0,900		▾	0,800		▾	0,900			g/m
Filament diameter				5			5			5			5			μm

Weight/Length : 20 Fibers average by gravimetry, 20 Fibers average by vibroscope

Upscaling on larger composite parts



CFRP panel



Instrumented panel (trial this week)

- Lack of homogeneity of mechanical properties observed
- Geometry aspect : to be still investigated (e.g. heating curve to avoid temperature gradient)

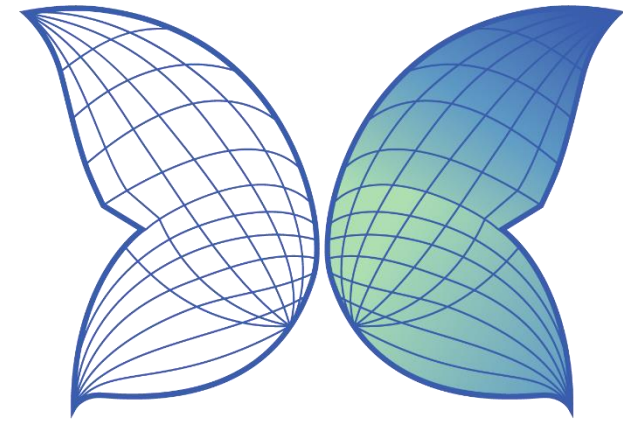
CONCLUSIONS

Promising results at lab scale & pilot (small parts)

- Thermal treatment succeeds in recovering fiber
- Mechanical properties slightly affected (10-15%)

Large composites parts & upscaling

- Results not fully transposable today
- Possible heterogeneity in real waste feedstock



morpho

Thank you!



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