RESET
Re-use of Thermoplastic Composite

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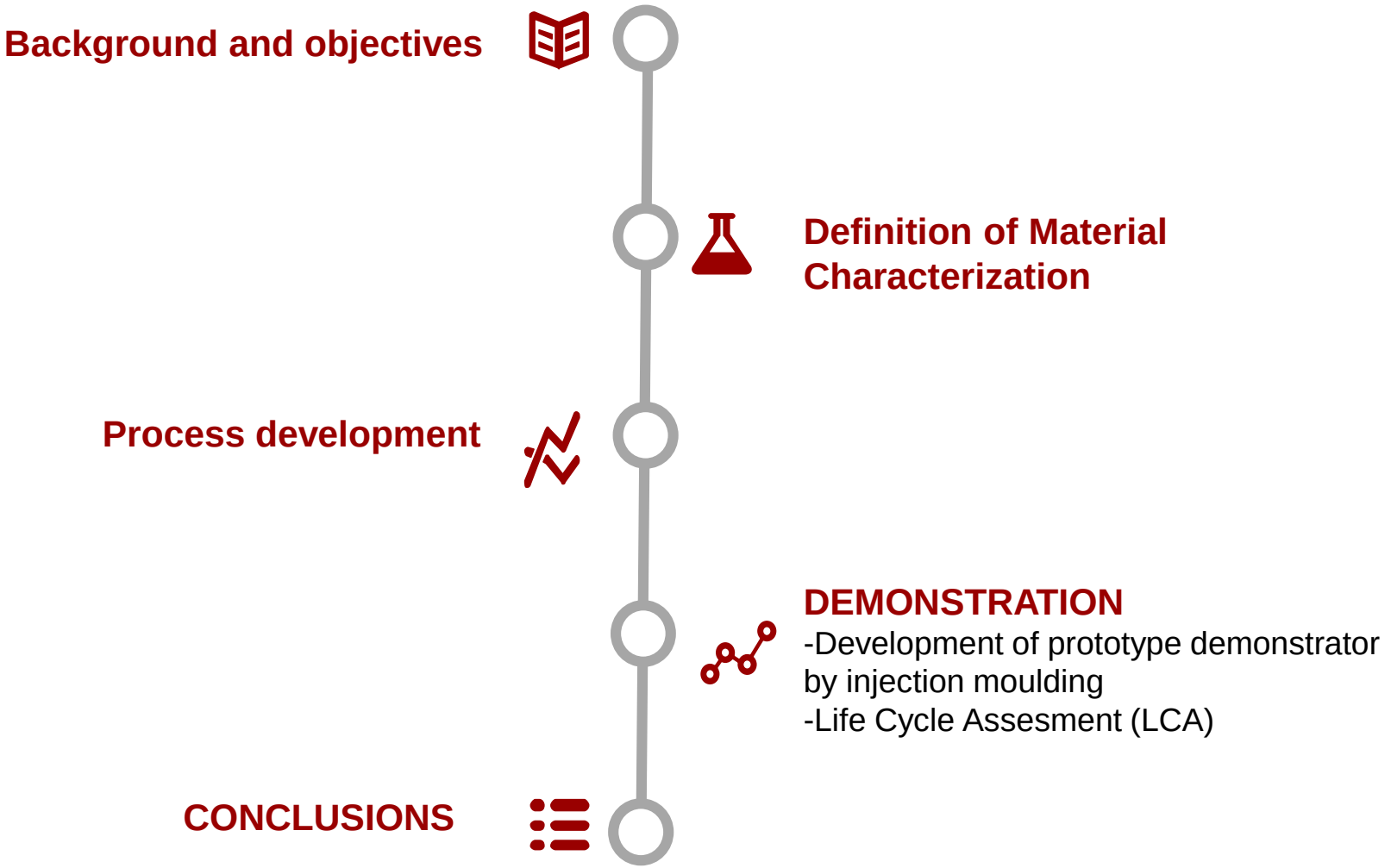
This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 686636

Outline



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Objectives

- DEVELOPMENT OF AN INNOVATIVE RECYCLING PROCESS OF THERMOPLASTICS USED IN AERONAUTIC
  - The recycled material will be used as raw material to produce new parts for aircrafts
  - Up to **70%** of recycled material will be used to produce a new family of composites materials

→ **BASED ON CRYOGENIC GRINDING PROCESS**

- COMPLETE CHARACTERIZATION OF THE NEW COMPOSITES – DEVELOPMENT OF NEW PROTOTYPES

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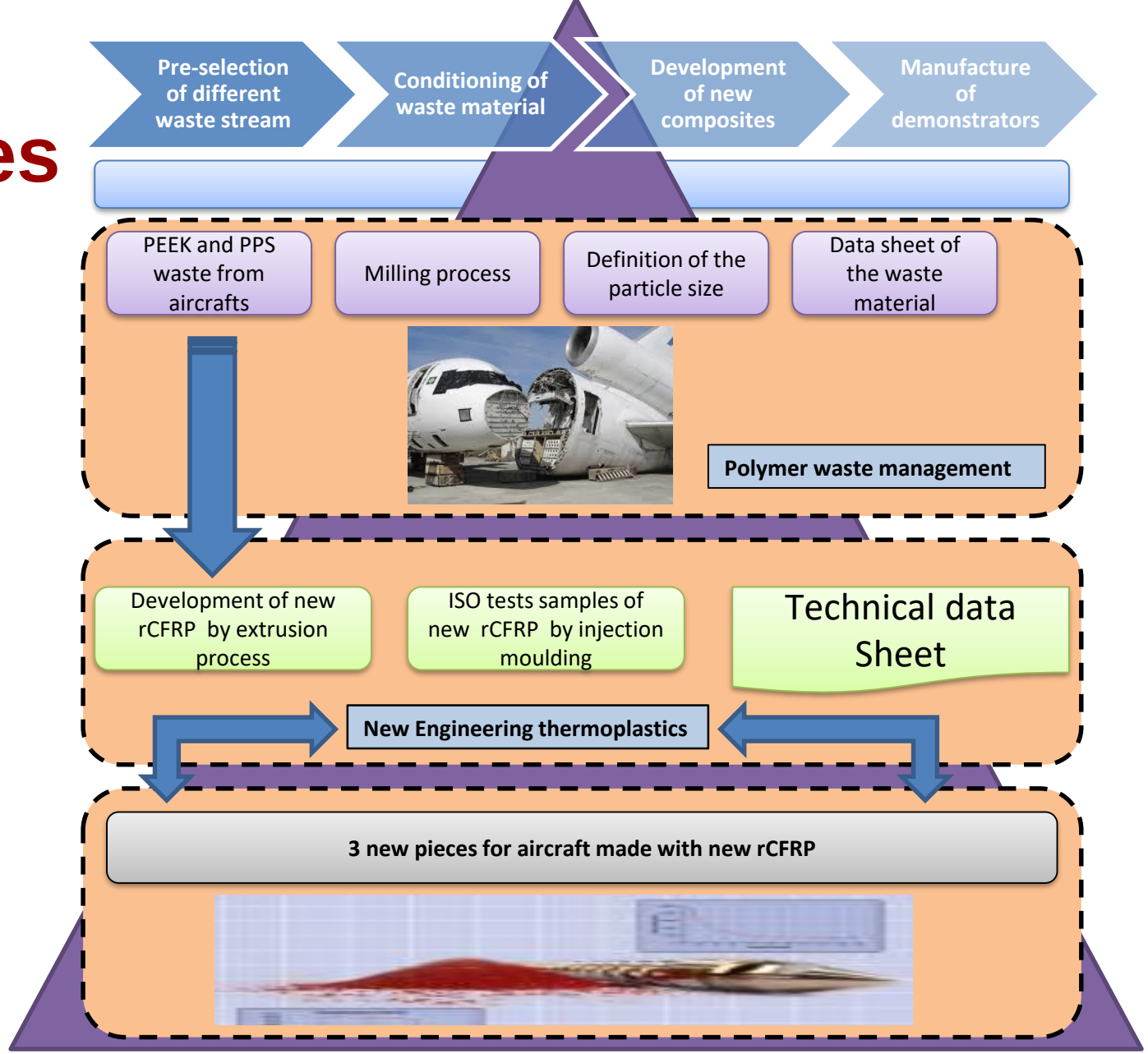
Background and objectives



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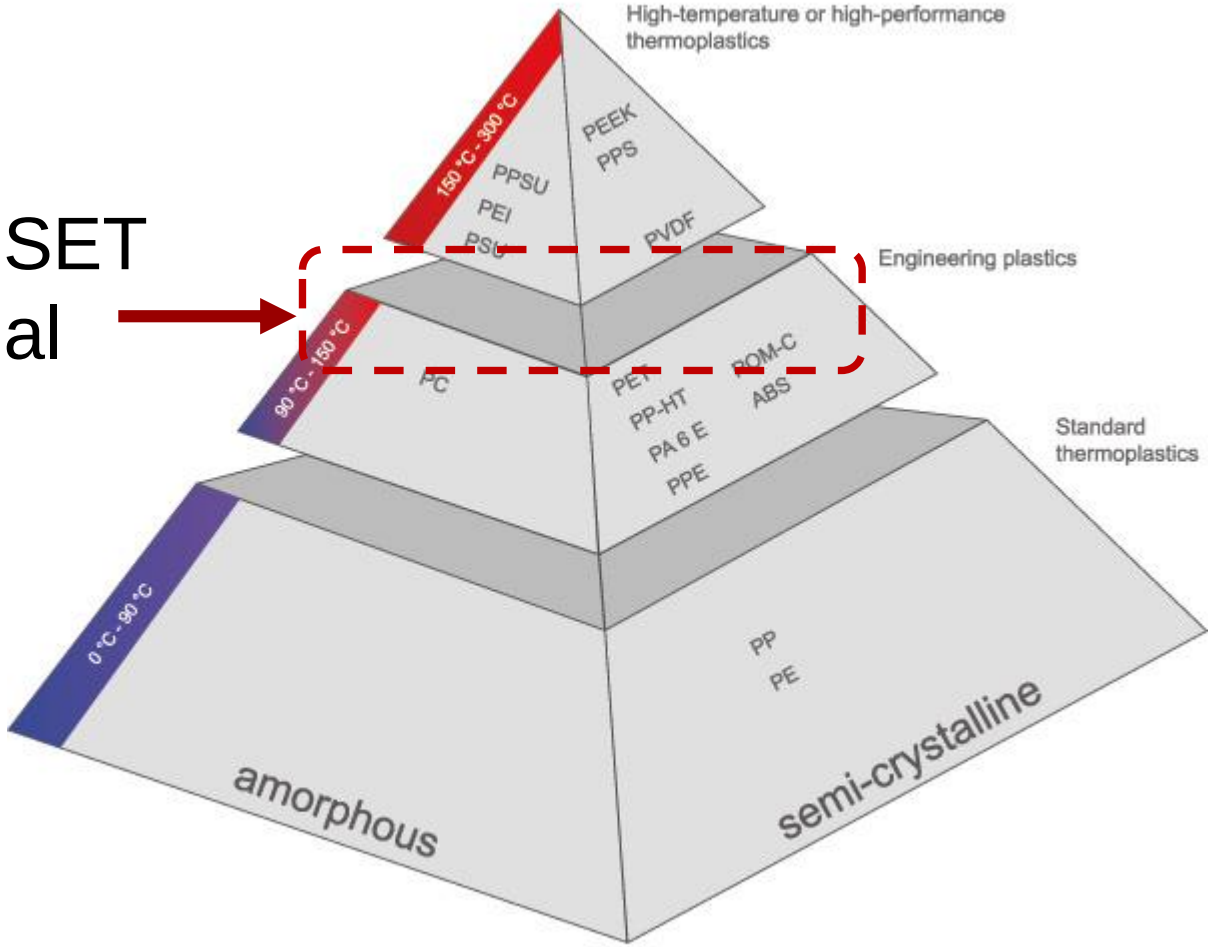
Background and objectives

Expected RESET output material



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Characterization and conditioning of the waste material

Definition of material waste

- Scrap material from part manufactures

Specification of the recycled material

- Supplier: Tencate
- Reference: Cetex PPS
- Matrix content:
- Resin content by volume 50 %
- Resin content by weight 43 %
- Mass of fabric 280 g/m²
- Mass of fabric + resin 486 g/m²
- Reinforcement architecture (fabric/tape): Carbon T300 3K 5HS

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Characterization and conditioning of the waste material

- Previous treatment of residues

The proposed strategy is the treatment of the residues through a prior conditioning by a cryogenic grinding process.

→

Different parameters were taken into account:
-Milling speed
-Sieve size

→

Chopped into small fragments
-Particle size up to 2,5 mm (determined by laser diffraction).

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Characterization of the conditioned PPS/CF scrap:

Fibres up to 300 µm of length

Diameter vary from 5 µm to 9 µm

- SEM:

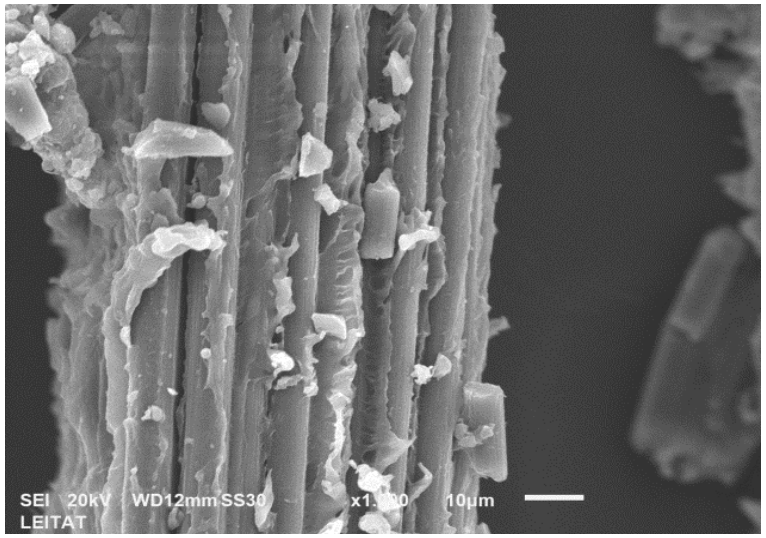

Figure 7. SEM micrographs 1000x from milled PPS scrap

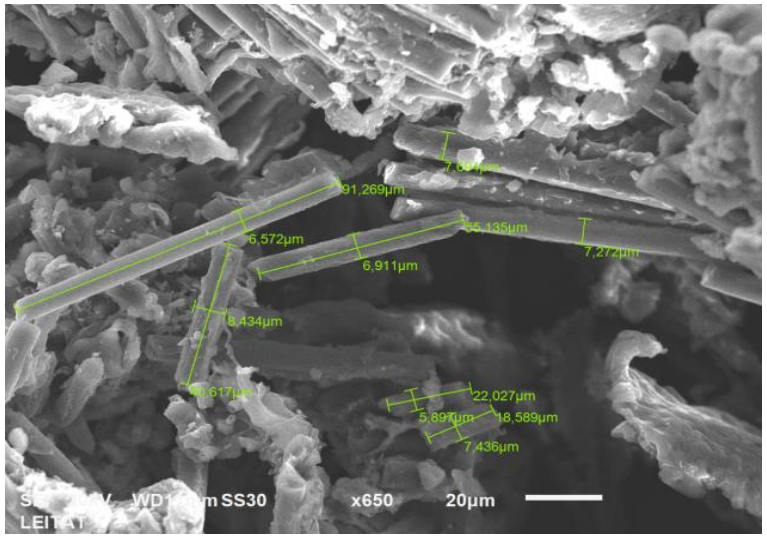

Figure 8. SEM micrographs 1000x from milled PPS scrap

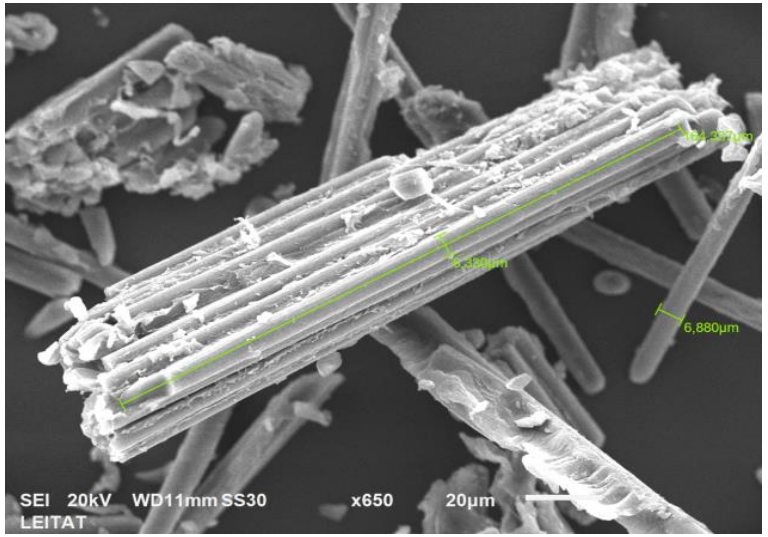

Figure 9. SEM micrographs 1000x from milled PPS scrap

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Development of a new family of composites based on PPS/CF scrap

Preparation of the new composites by means of melt extrusion

Taking into account the parameters listed below

- Extruder configuration
- Screw speed
- Temperature profile
- Residence time

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Characterization of the new family of composites based on PPS/CF scrap

- TGA

	T_{max} (°C)
PPS virgen	511
Composite 1	553
Composite 2	550
Composite 3	553

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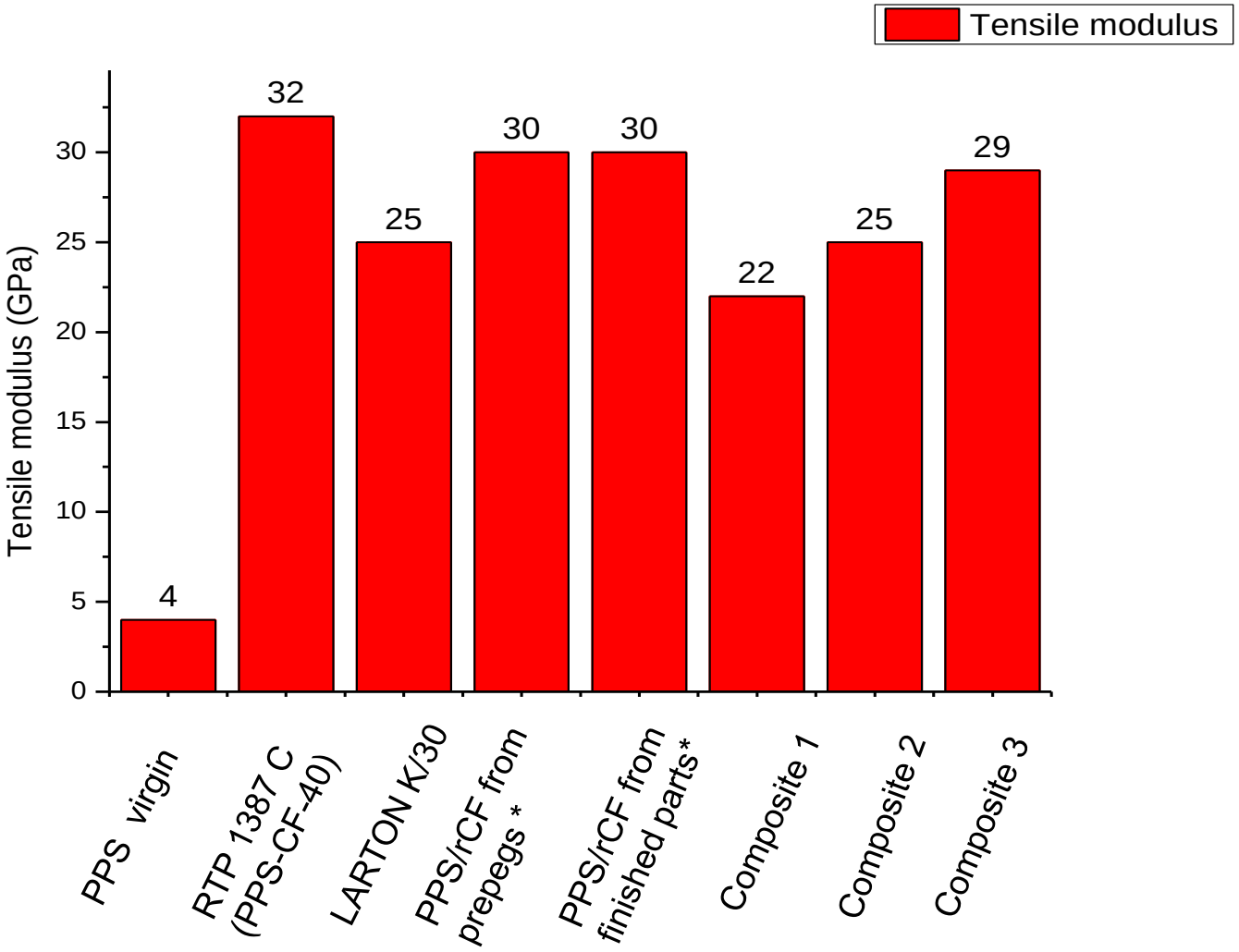
Mechanical Properties: Tensile test



Effect of the recycling Process over the mechanical Properties

Young´s modulus of the composites are comparable with the commercial countertype Larton K/30

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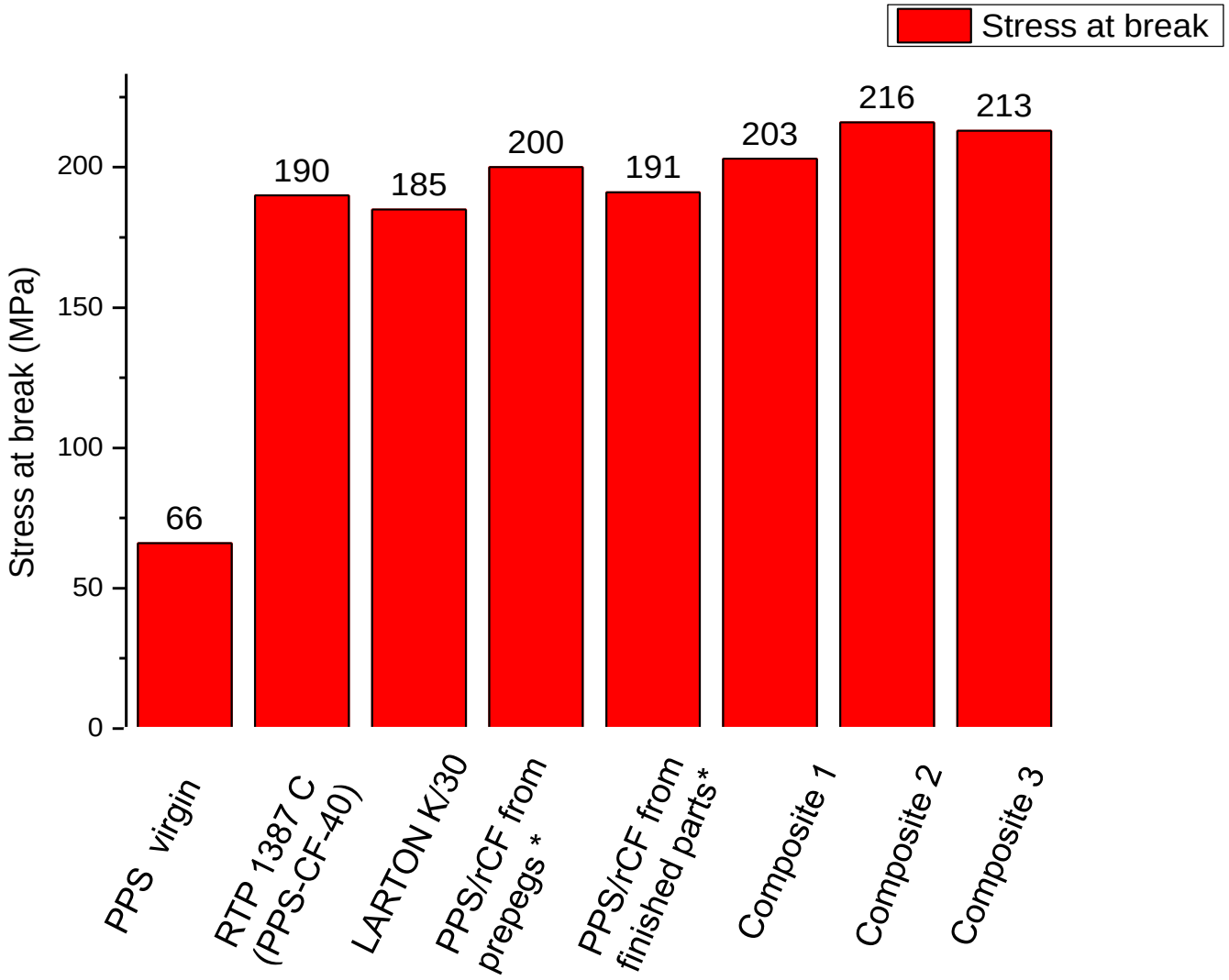
Mechanical Properties: Flexural properties



Effect of the recycling Process over the mechanical Properties

Enhancement in stress at break

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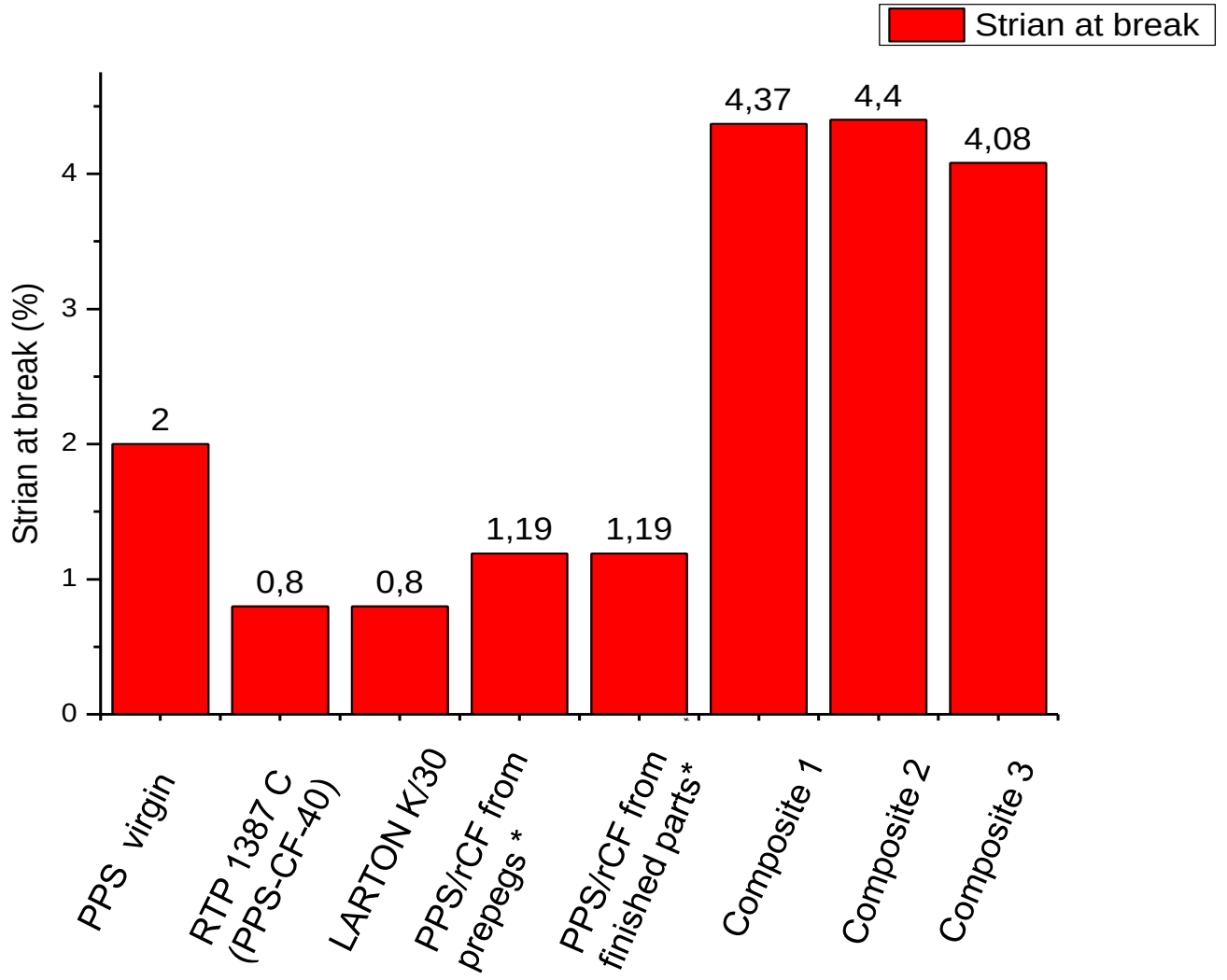
Mechanical Properties: Tensile test



Effect of the recycling Process over the mechanical Properties

Enhancement in strain at break

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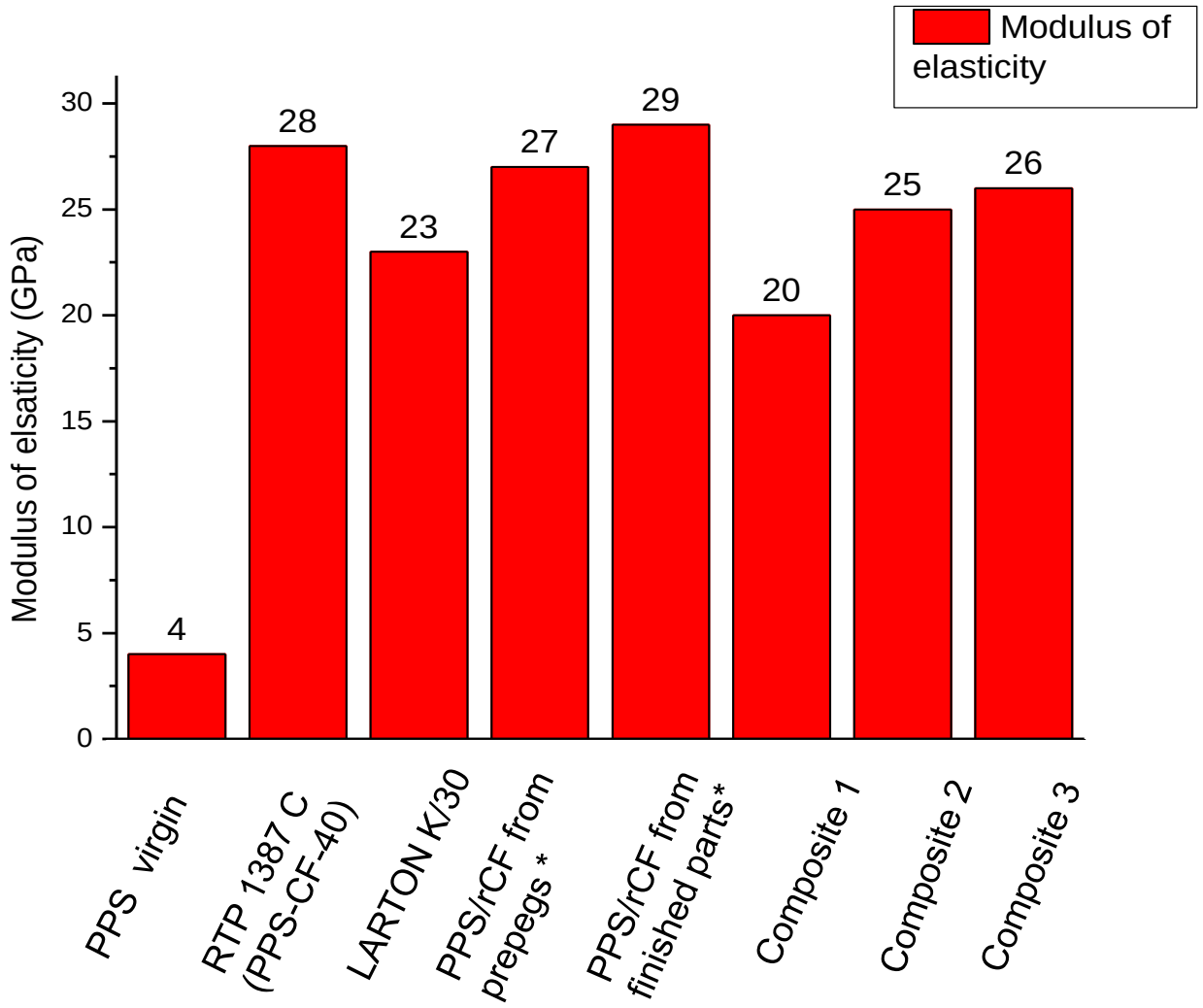
Mechanical Properties: Tensile test



Effect of the recycling Process over the mechanical Properties

Elasticity´s modulus of the composites are comparable with the commercial countertype Larton K/30

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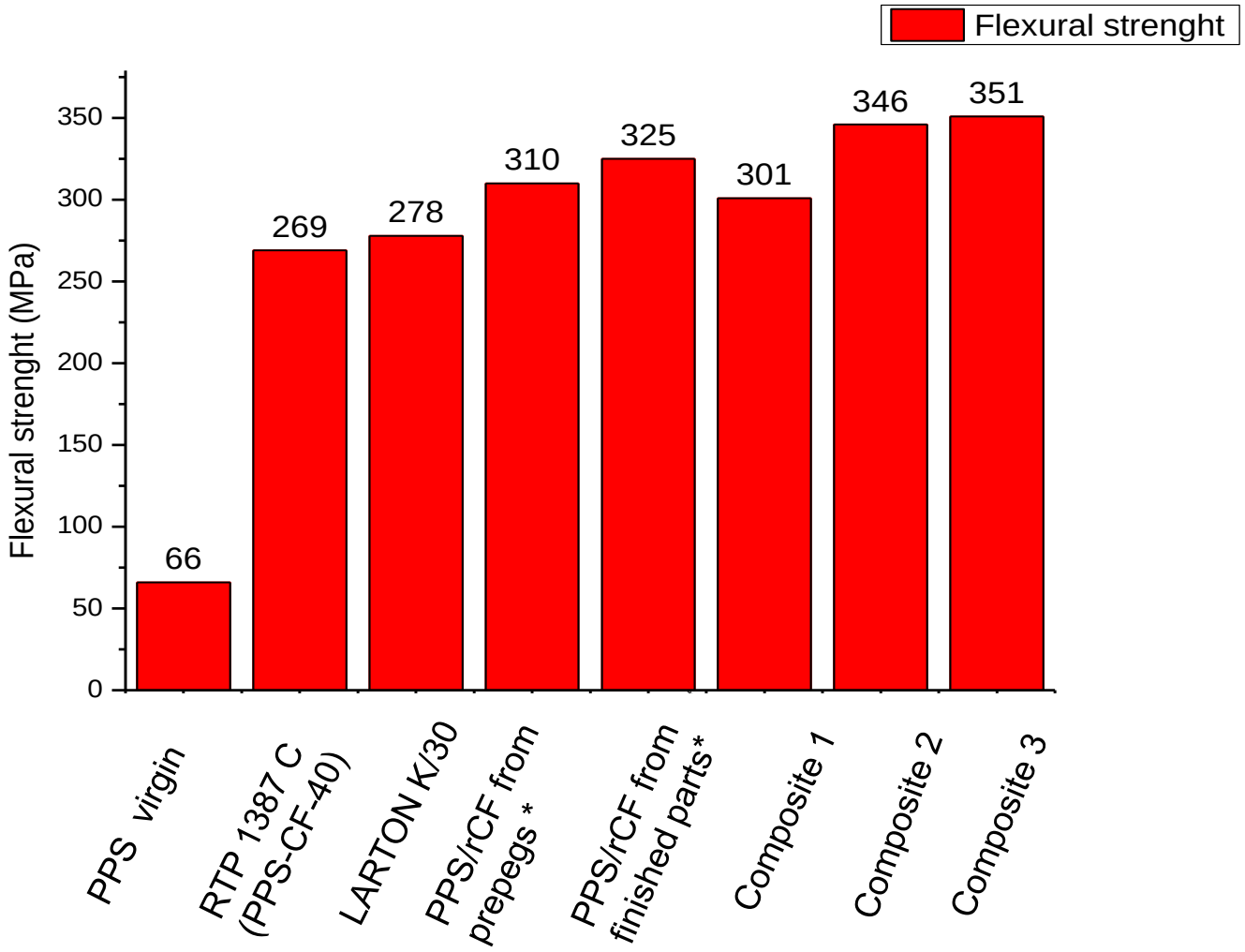
Mechanical Properties: Flexural properties



Effect of the recycling Process over the mechanical Properties

Enhancement in flexural strength

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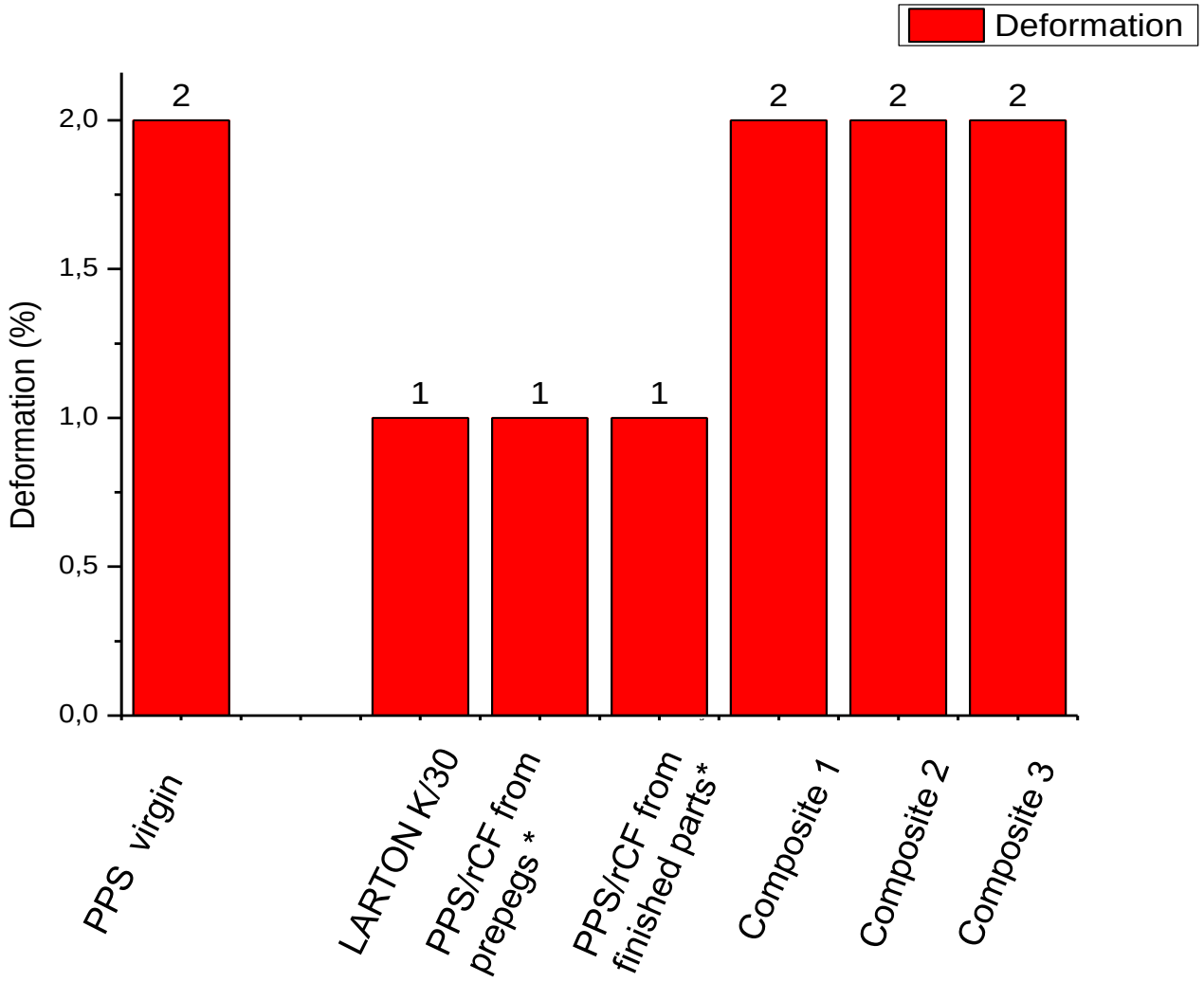
Mechanical Properties: Flexural properties



Effect of the recycling Process over the mechanical Properties

Enhancement in deformation

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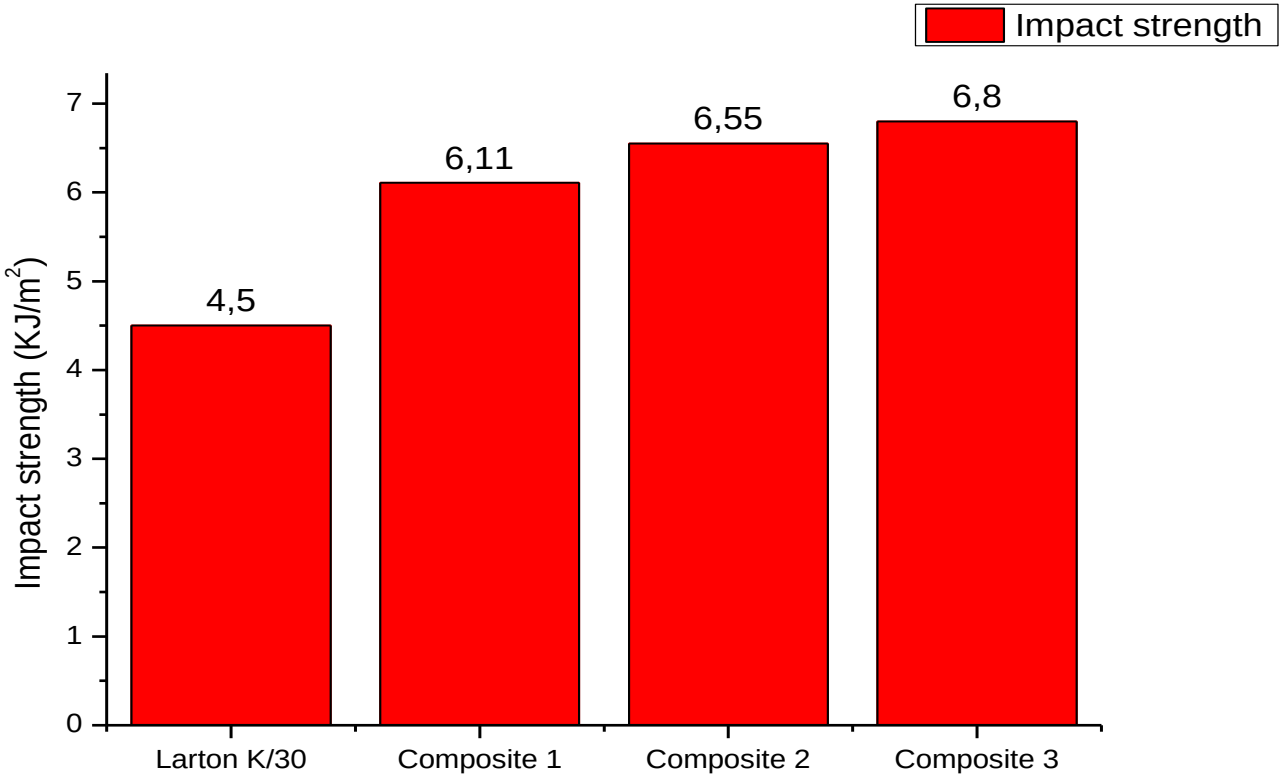
Mechanical Properties: Tensile test



Effect of the recycling Process over the mechanical Properties

Enhancement in the impact strength

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Determination of burning behaviour of interior materials.

According to the formula; B = (s / t) x 60

Specimens	*s* – Burnt distance (mm)	*t* – Elapsed time (s)	*B* – Burning rate (mm/min)
#1	0	0	0
#2	0	0	0
#3	0	0	0
#4	0	0	0
#5	0	0	0
Mean value	---	---	0

-Composite 1

-Composite 2

-Composite 3

Classification of the material : DNI (does not ignite)

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Demonstration

Name of the piece:	Bracket
Volume of the piece:	65 cm3
Nominal thickness	10 / 6 / 5,5 / 3 mm
Projected area:	71,1 cm2
Inyectora prevista:	60 Tn

Thermoplastic bracket

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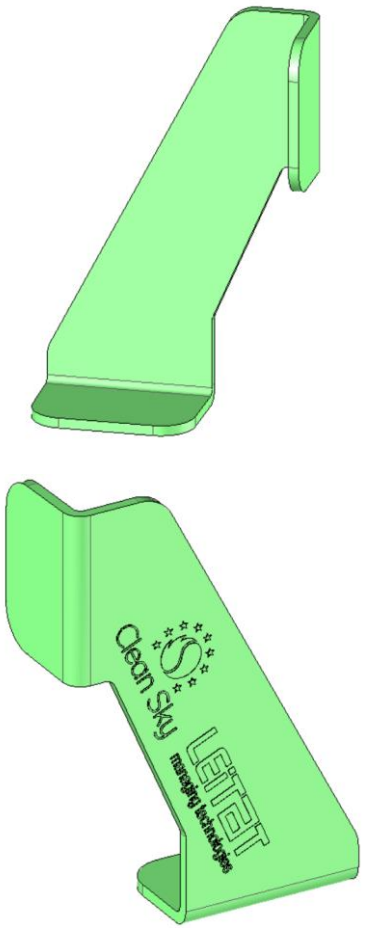
Demonstration

Name of the piece:	Thermoplastic cleat
Volume of the piece:	22,3 cm3
Nominal thickness	3 mm
Projected area:	51,1 cm2
Inyectora prevista:	40 Tn



Thermoplastic cleat

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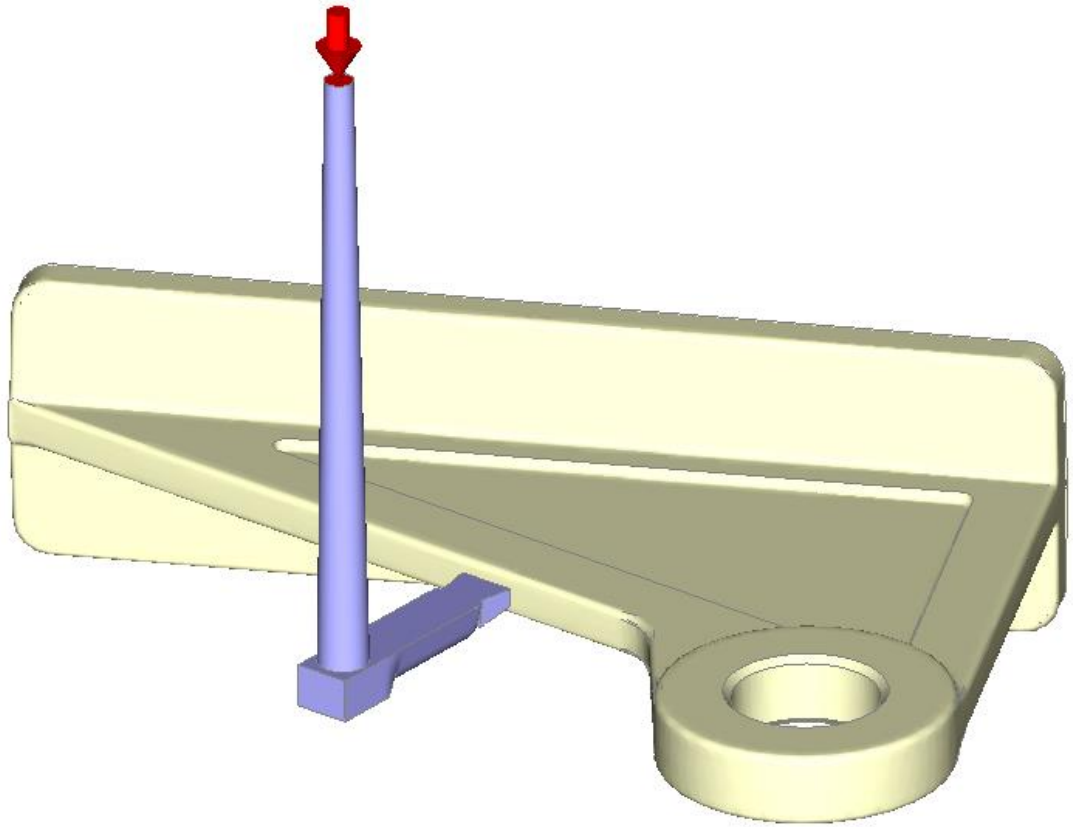
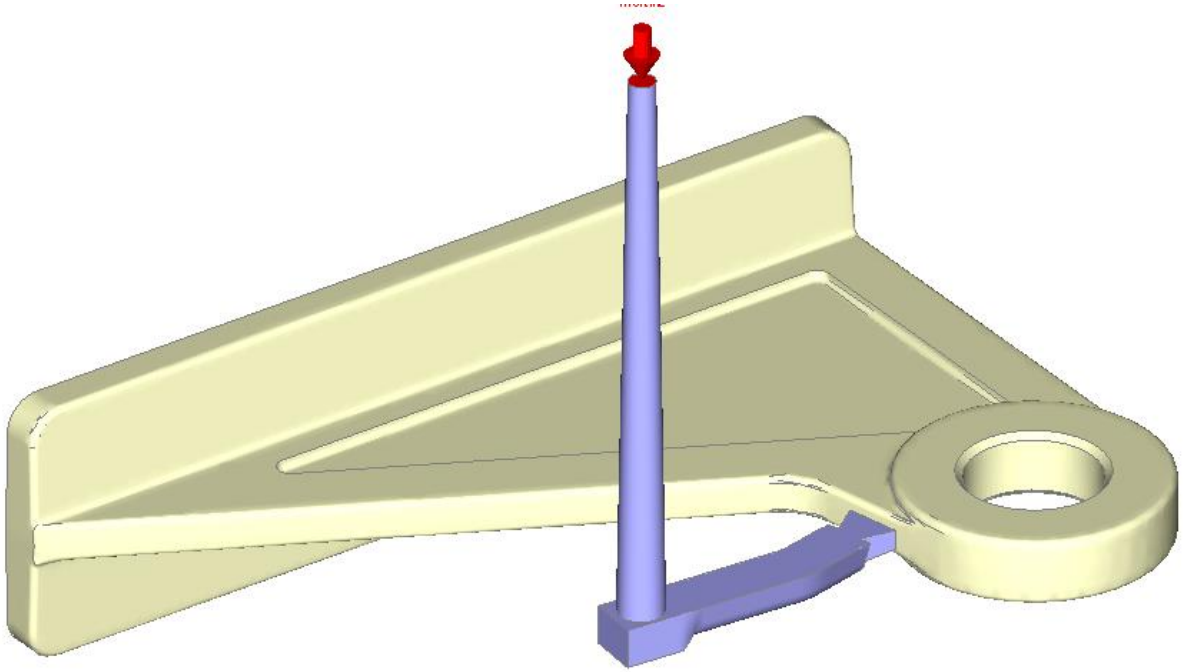
Demonstration

BRACKET: study of the position of the injection point

Case 1:



Case 2:



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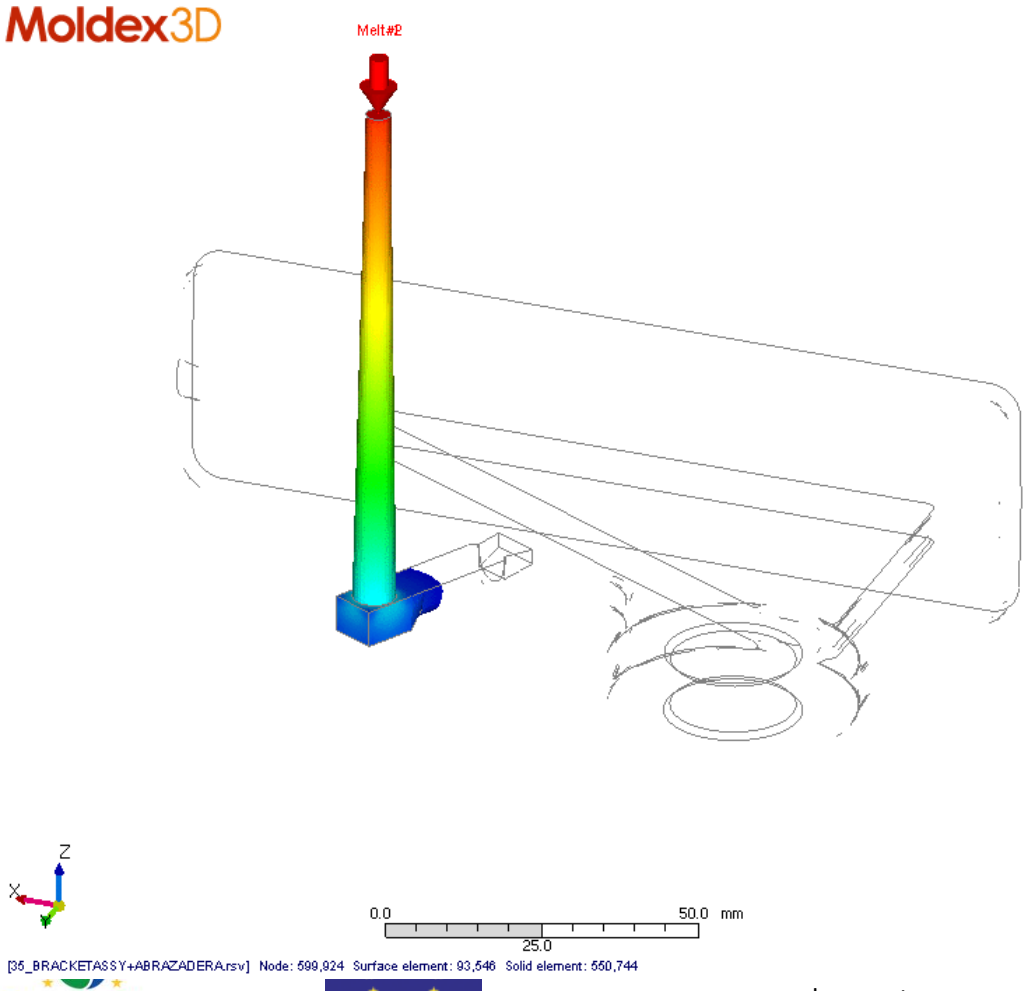

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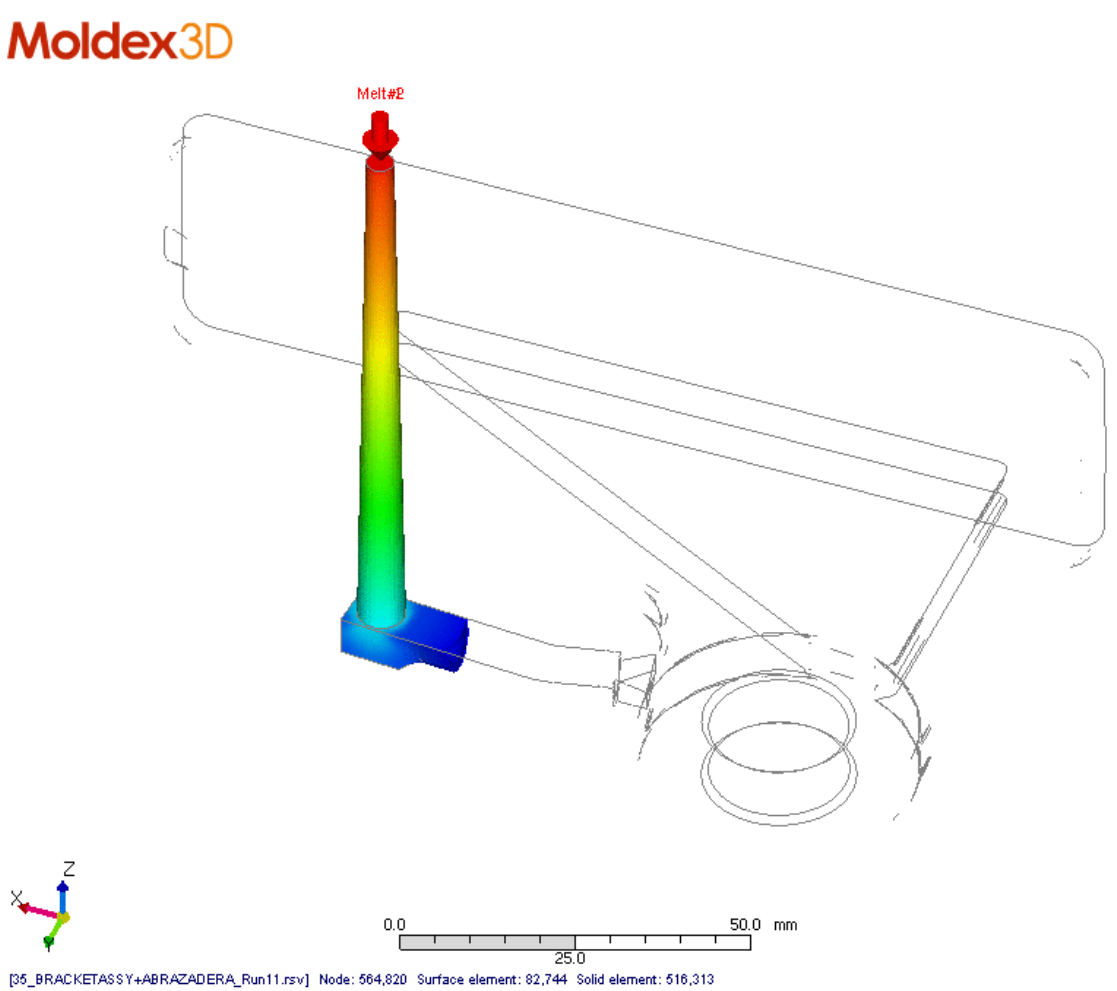

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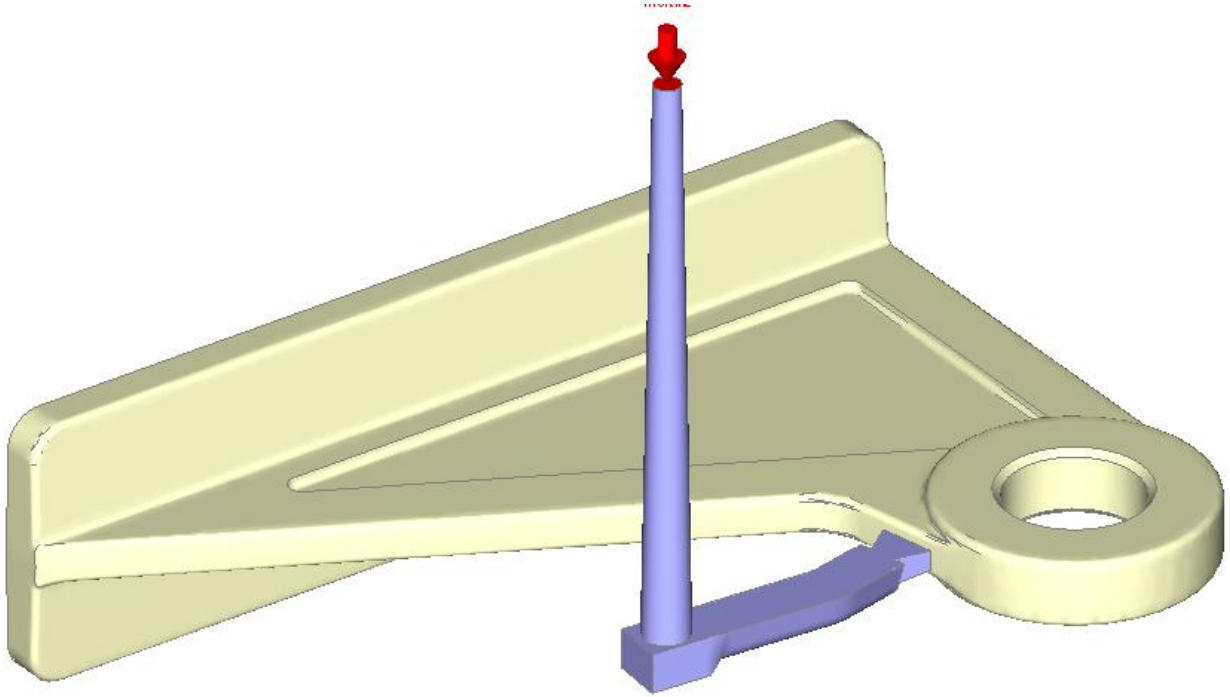
:he Clea programme under grant agreement No 686636

Demonstration

BRACKET: study of the position of the injection point

Case 2:



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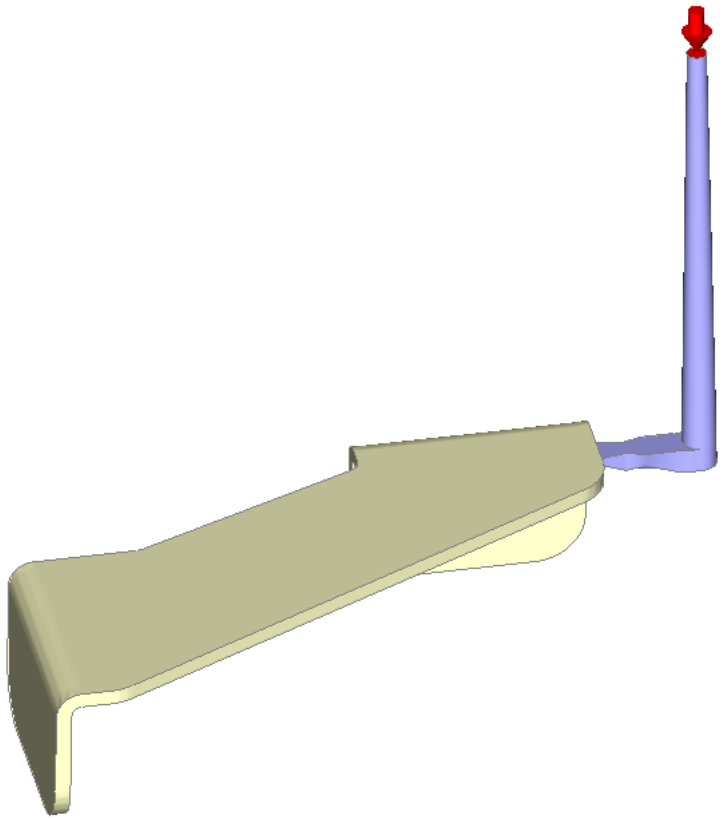

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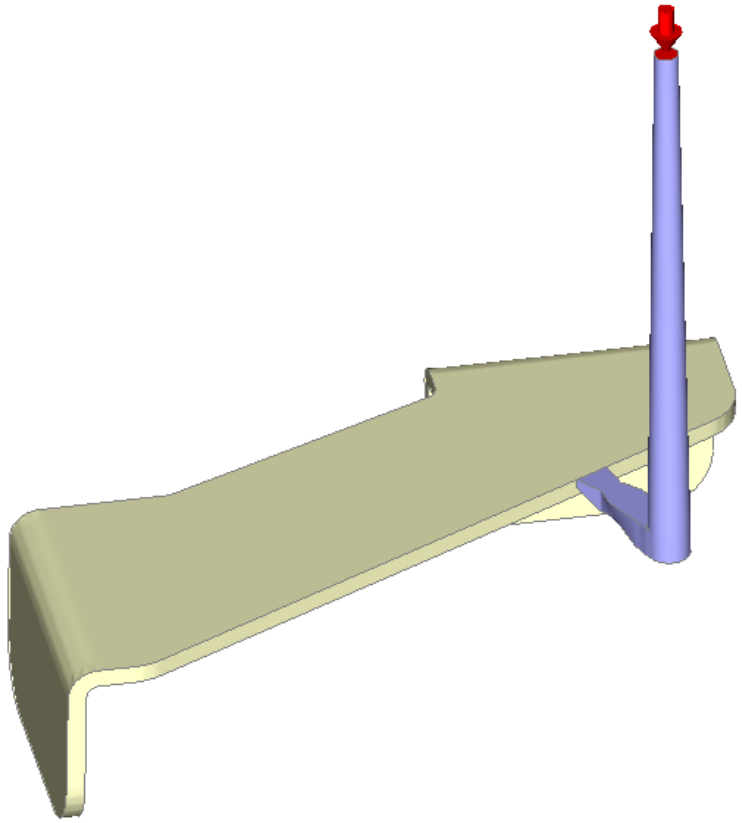

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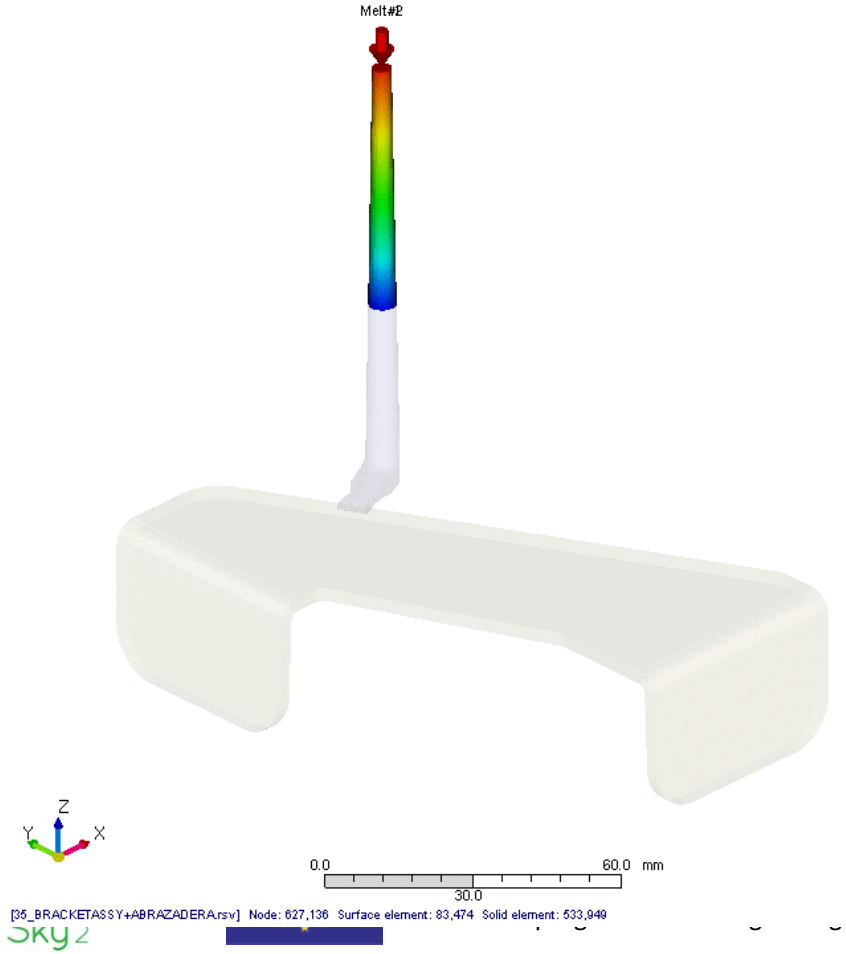

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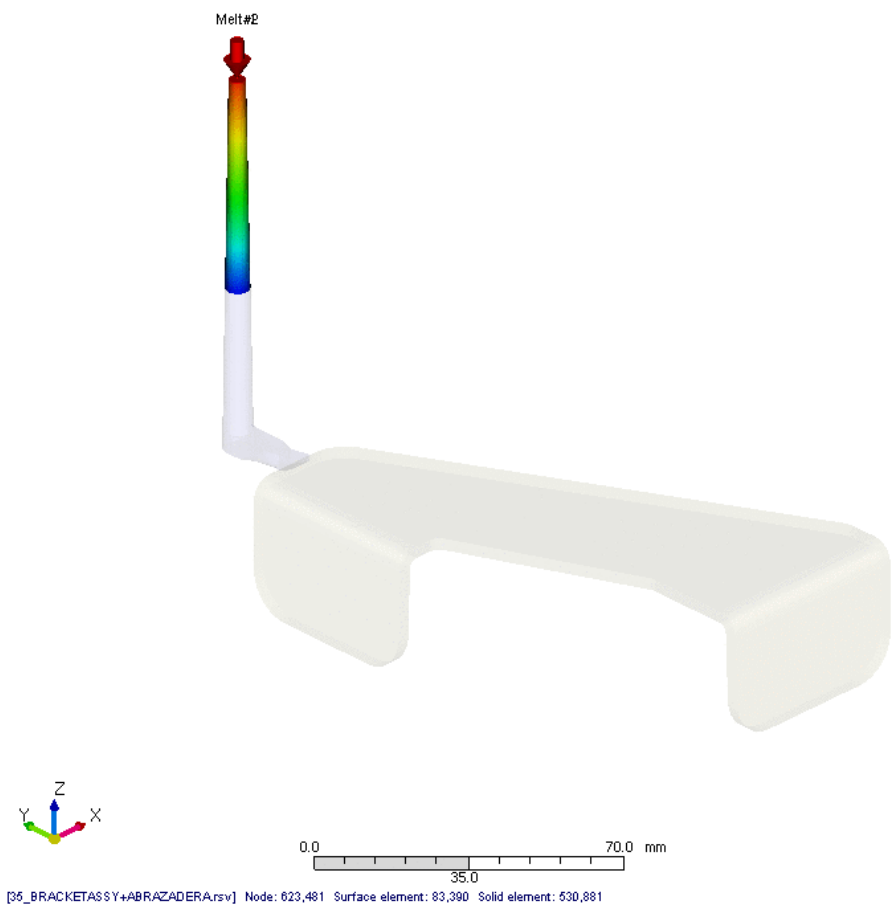

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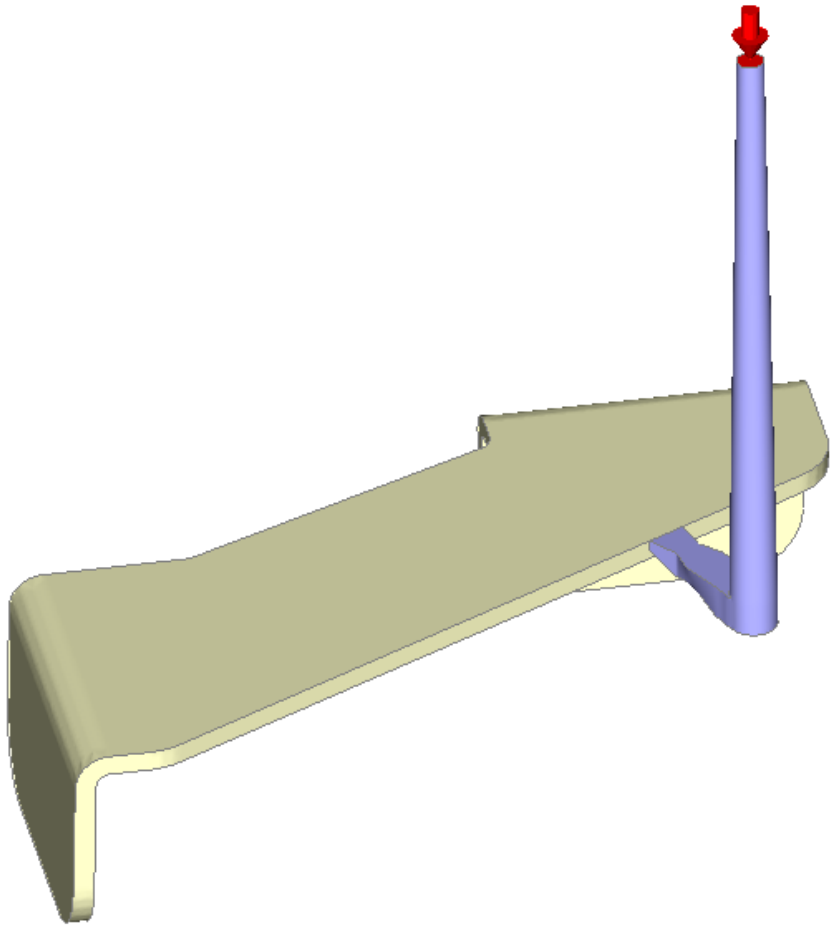
No 686636

Demonstration

CLEAT: study of the position of the injection point

Case 2:



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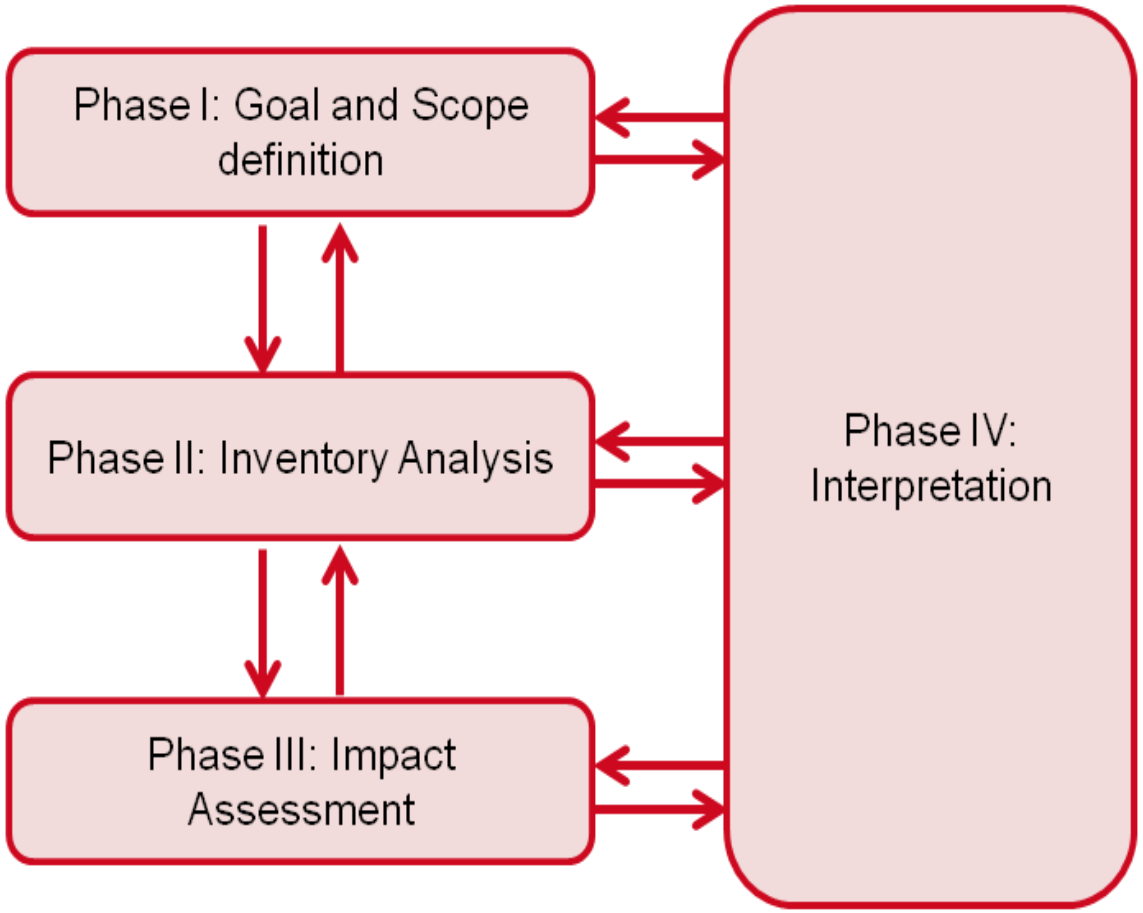
Life cycle assessment



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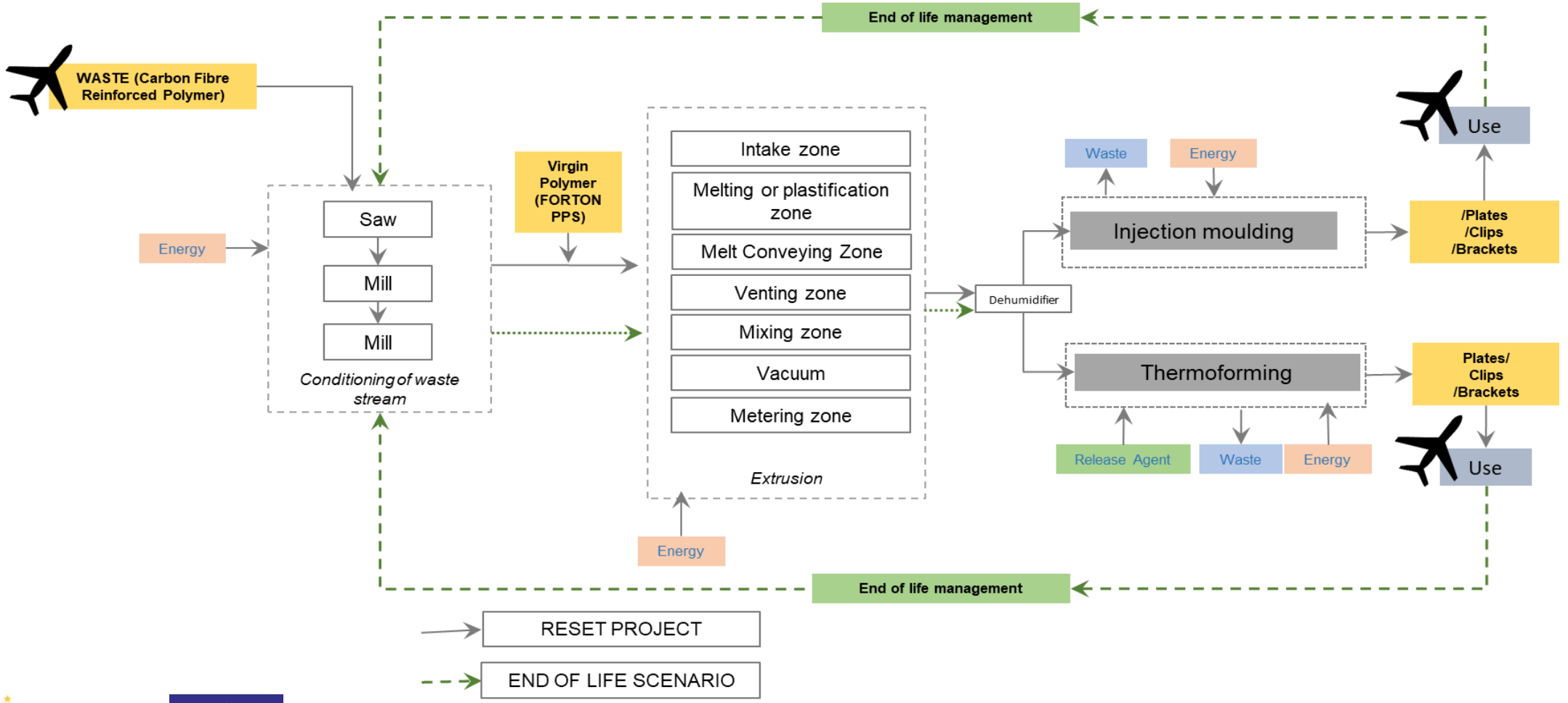
Life cycle assessment

Goal and Scope

The functional unit has been defined as **1 kg of recycled thermoplastic composite to be employed by the aircraft manufacturing industry**



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Life cycle assessment

Goal and Scope

Assumptions considered

- The transportation of waste from France and crude polymer from China has not been considered. The impact associated to the transport are very high and it doesn't let assess the specific impacts of recycling processes. The transportation of release agent which is used in the thermoforming process is neither considered because the specific origin is not known.

- The lifespan of the manufactured pieces from the recycled composite thermoplastic is unknown. For that reason, it is assumed to be the same as the lifespan of an aircraft (25 years).

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Life cycle assessment

Goal and Scope

Assumptions considered

- The two technologies have been implemented in France and in Spain but the LCA study considers that both processes have been developed in the same country (in Spain). This fact allows the comparison between the environmental performance of the recycling technologies, independent of the sustainability of the energy matrix in each country. The difference between the energy matrix in these countries causes different impacts because the source of the energy is not the same. That assumption allows comparing.

- The recycled waste contains around 40% of carbon fibres and 60% of PPS. The same percentages have been considered for PEEK analysis.

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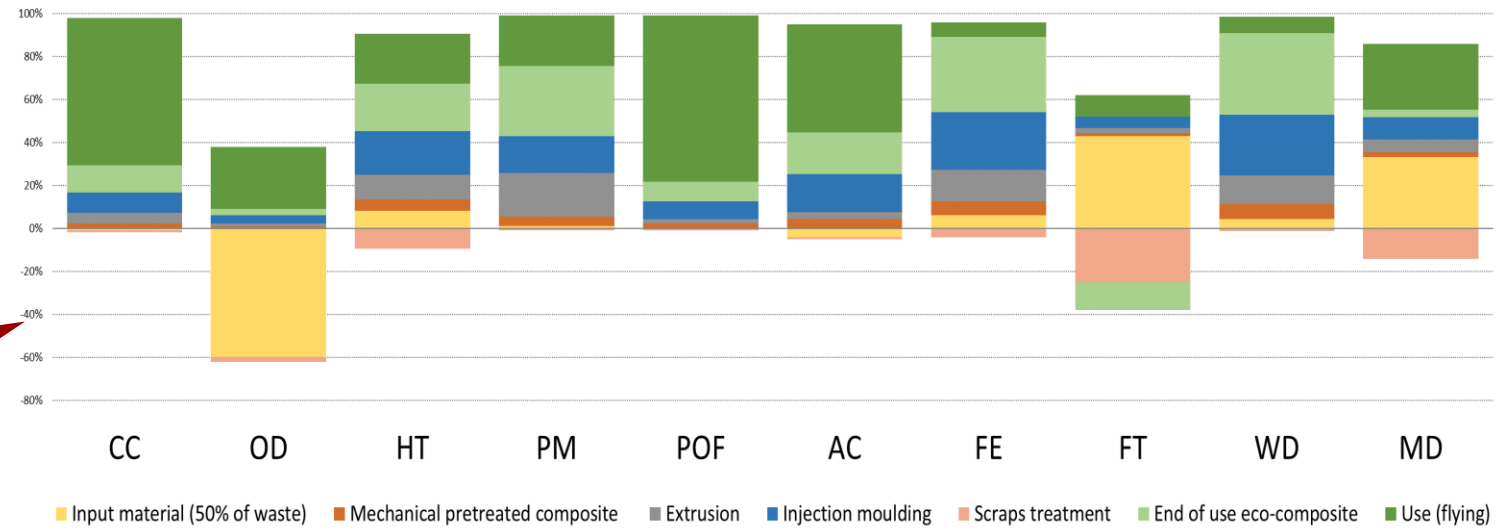
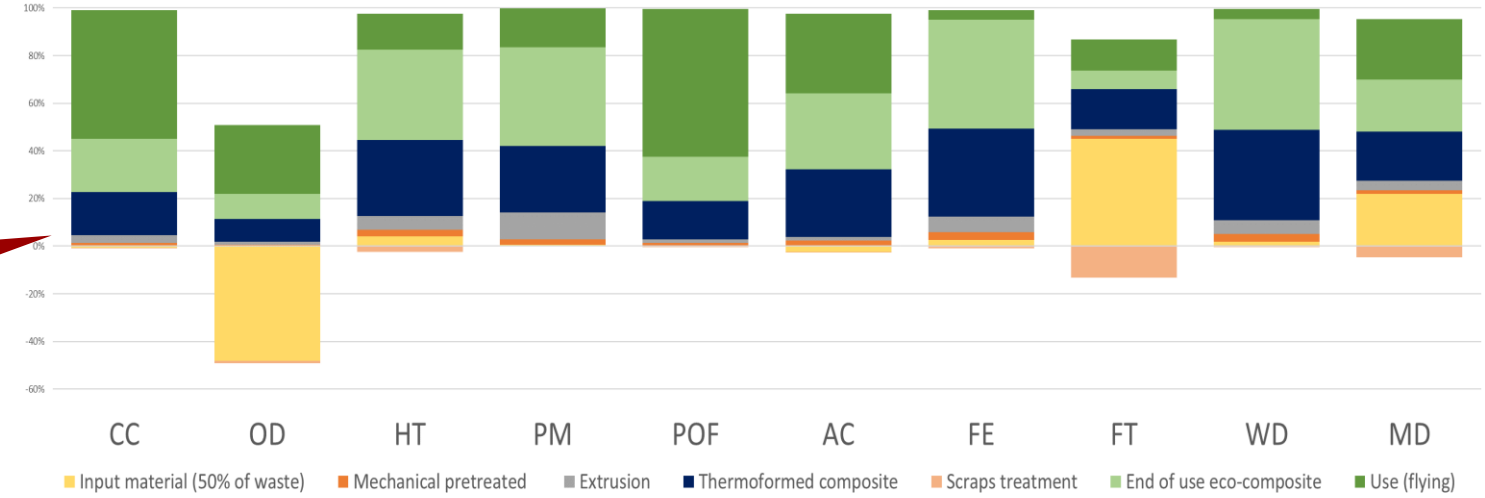
Life cycle assessment

Results: 50% of waste and 50% of crude polymer

Injection moulding



Thermoforming



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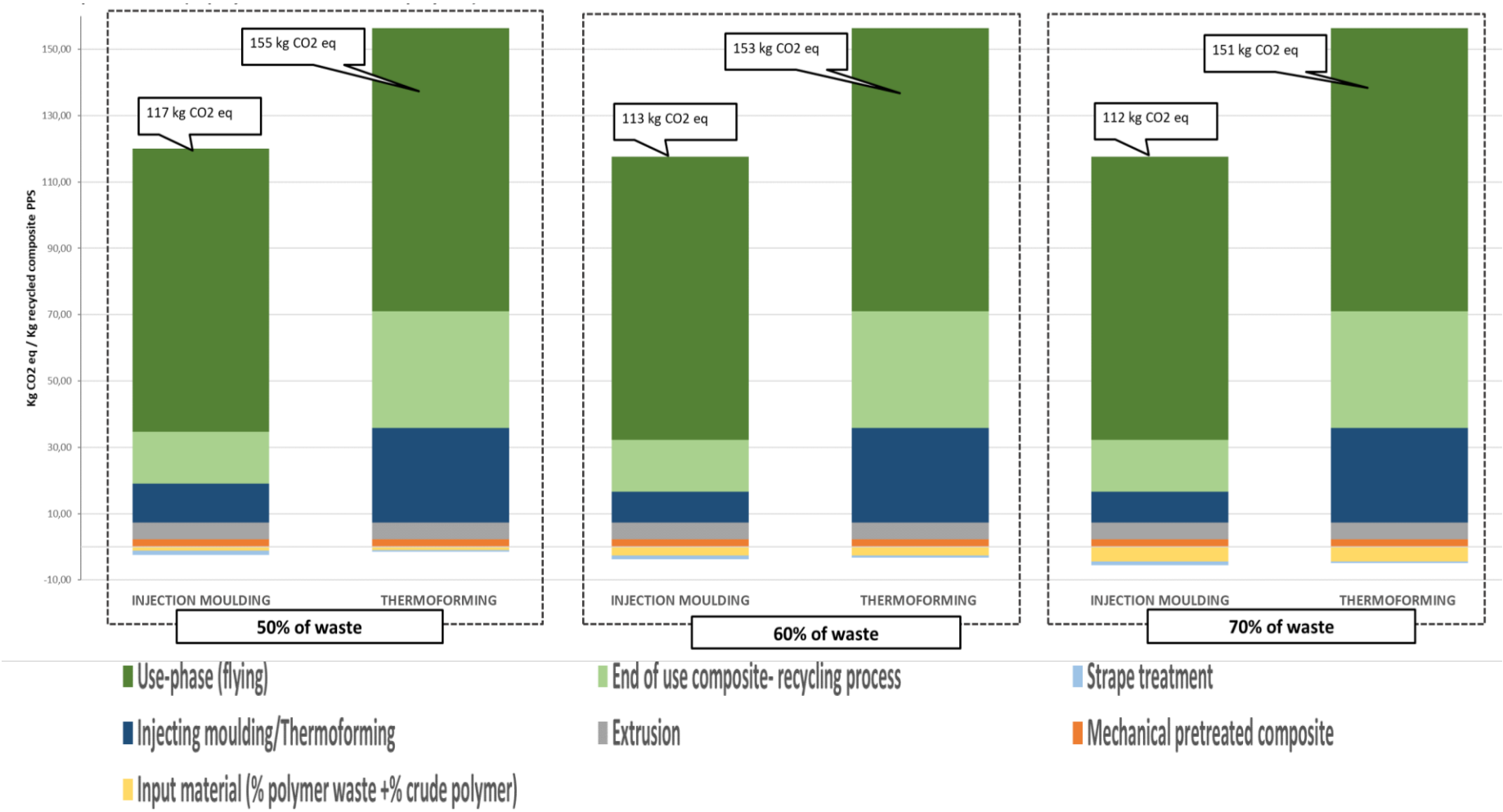
Life cycle assessment

Results: Carbon footprint related to waste contained and technology



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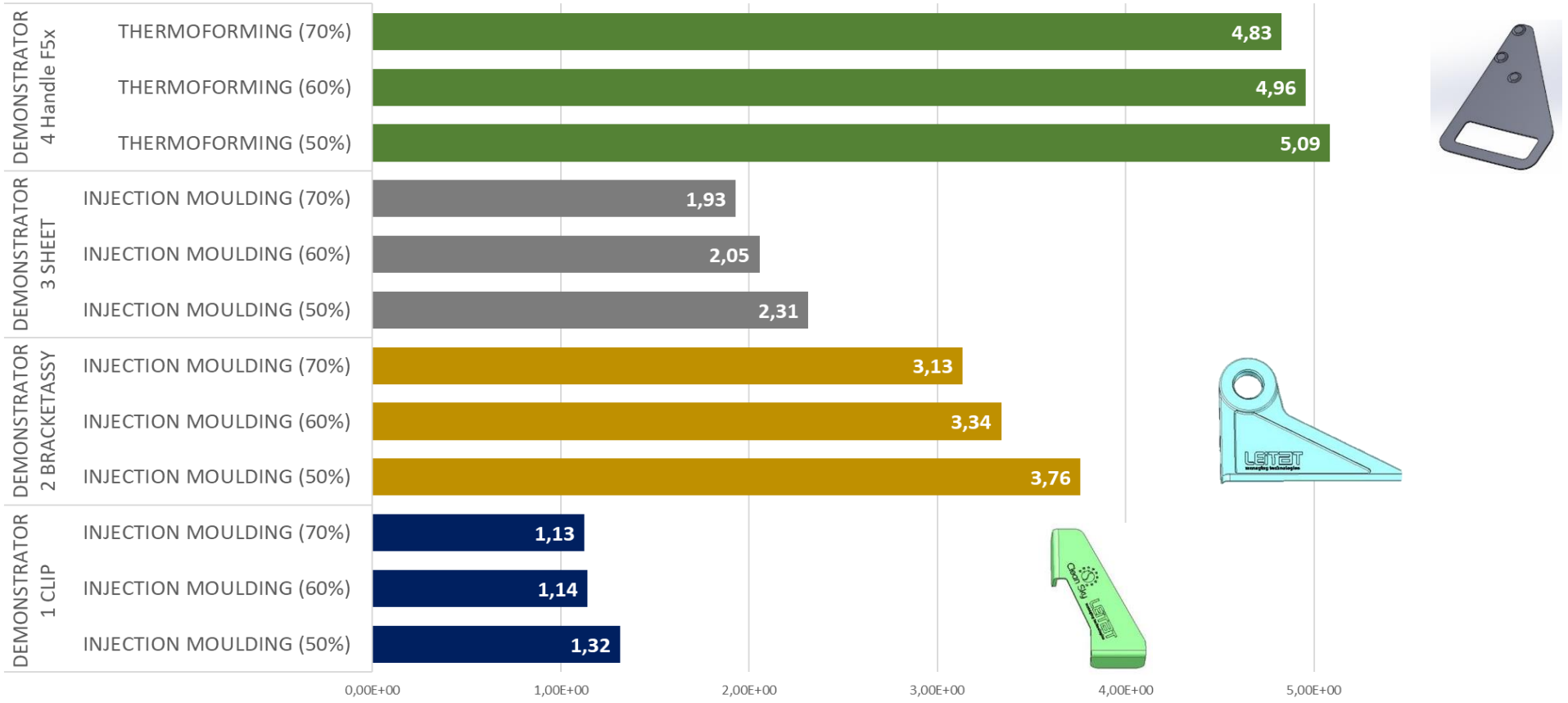
Life cycle assessment

Results: comparative of impact (Carbon Footprint) the four demonstrators



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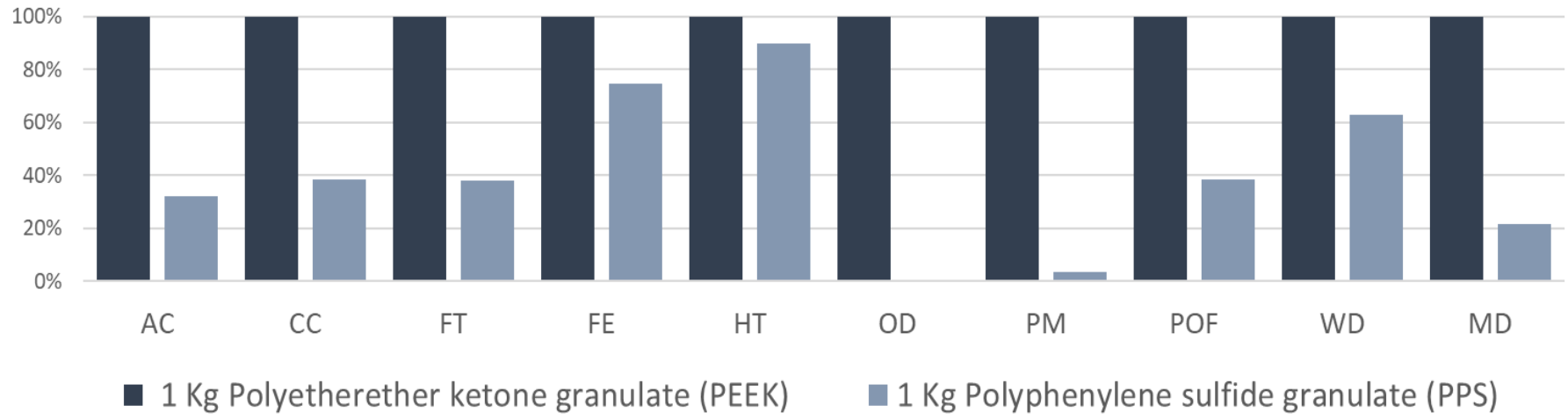
Life cycle assessment

Results: PEEK versus PPS



PEEK manufacturing process generates halogenated organic and dust (PM 2,5) emissions. On average, PPS represents around 46% less environmental impacts than PEEK.

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Conclusions

In this work, laminates of PPS and carbon fibre were recycled by means of cryogenic grinding process.
The recycled composites were compounded with virgin PPS to obtain composites up to70% of recycled material

The mechanical properties of the material are comparable with the commercial countertype and composites prepared with recycled carbon fibre

Development and characterization of prototype demonstrators by injection moulding and thermoforming

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THANKS FOR YOUR ATTENTION

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