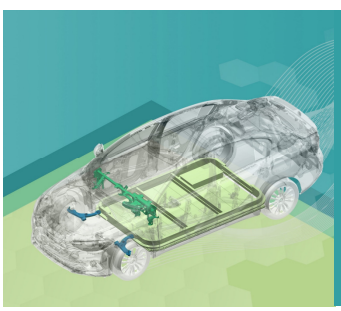

PARAMETRIZATION OF THERMOPLASTIC RESIN TRANSFER MOLDING (T-RTM) PROCESS USING NON-CRIMP FABRIC REINFORCE AND INNOVATIVE THERMOPLASTIC RESIN

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1. MOTIVATION

The present study focuses on the development of innovative and affordable solutions for automotive industry. Vehicle electrification has increased the already critical requirements of weight reduction for ICE vehicles, since an EV can add 250kg to the total weight of a vehicle as compared to the internal combustion models. CFRP materials appear to be one of the most promising candidates to achieve lightening targets. In spite of this, industry is still reluctant to adopt these materials, and takt times are one of the cornerstones for sectors where mass production is needed. The novel development of resin chemistries appear to be a game changer. Hence enabling the development of novel manufacturing routes such as TP-RTM

TP-RTM exhibits a promising balance of structural properties and cycle times. However, due to the novelty of the manufacturing process a few technological challenges are still present for the full deployment of this technology.

2. CASE STUDY

The present study deals with the process window adjustment at the lab scale for the development an automotive component currently developed in metallic materials. In this sense a suspension arm development has been identified as a potential candidate for TP-RTM implementation.

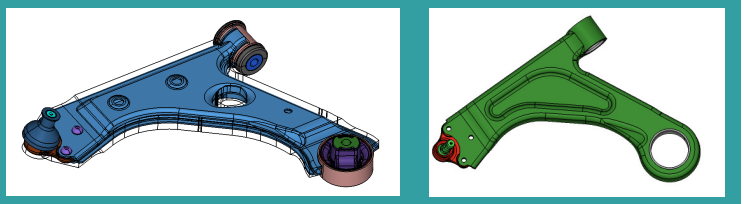


Figure 1. Suspension Control Arm (benchmark product left and newly developed design right)

3. EXPERIMENTAL PROCEDURE

MATERIALS

- **RESIN:** C195 Elium (R) , ARKEMA
- **INITIATOR;** 16 Perkadox, NOURYON
- **REINFORCEMENT;** UD- NCF, 200 gsm, G. ANGELONI with T700S Fiber from Toray

EQUIPMENT

- **1K RTM INJECTION SYSTEM,** ISOJET
- **T CONTROL UNIT**, REGOPLAS
- **MOULD:** 2D moulds of a range of thicknessess

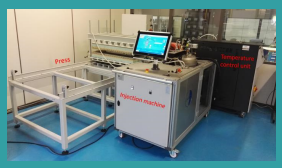
Curing cycle optimization

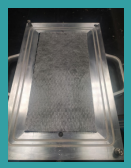
↓

RTM Process window adjustment

↓

Material card development





Stiffness	Resistance
E_1: Young's Modulus direction 1 (0°)	X: Tensile strength direction 1 (0°)
υ_{12}: Poisson' Coefficient	Y: Tensile strength direction 2 (90°)
E_2: Young's Modulus direction 2 (90°)	X': Compression strength direction 1 (0°)
G_{12}: Shear modulus	Y': Compression strength direction 2 (90°)
	S: Shear resistance

Figure 2. (left to right hand side) Isojet injection and press equipment, mold and tests performed in order to develop the material card.

RESIN CHARACTERIZATION

Injection processing temperature was chosen as a compromise of a number of factors.

- Rheological properties
- Gel time & permeability

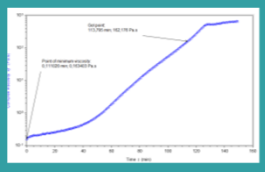


Figure 3. Thermogram at 25°C of Elium with 2phr Pekadox 16.

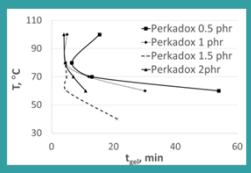


*Figure 4. Curing simulation studies (*deviations were found at T higher than 100 °C due to evaporation)*

Curing cycle was optimized both at small scale (i.e. Cure simulator) and validated afterfwards during coupon's manufacturing.

Sample	Curing T, °C	Curing t, min	T_g, °C	ΔH, J/g	Degree of cure, %
ELIUM® C195 + 2phr Perkadox	80	15	110	43.42	85.4
		20	105	33.36	88.8
		25	118	18.66	93.7
		30	114	13.72	95.4

Table 1. Cure degree of small components.

4. RESULTS

TP-RTM was adjusted by studying the influence of the injection pressure on the porostiy and impregnation quality while keeping it as short as possible in order to meet the targets of automotive sector.

In order to assist the process FBGs sensors where placed on different locations within the mould and stacking

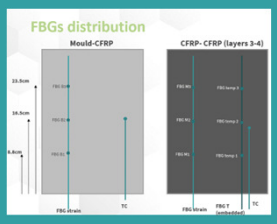
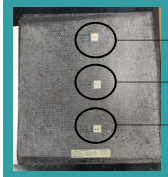
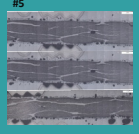


Figure 5. FBGs and distributed FOS





# Trial	Porosity (%)		
	Resin inlet	Middle	Resin Outlet
#2	7	6	15
#3	7	15	14
#4	5	6	8
#5	-	2	5
#6	5	7	2

Figure 6. Porosity studies by means of MO.

	χ_{t1}, MPa	E_{t1}, GPa	u_{12}
AVG	1552.17	102.47	0.35
SD	68.25	3.51	0.04
	χ_{t1}, MPa	E_{t2}, GPa	
AVG	15.57	6.59	
SD	1.60	0.41	
	τ_{12}, MPa	G_{12}, GPa	
AVG	50.39	4.20	
SD	0.53	0.20	
	χ_{c1}, MPa	E_{c1}, GPa	
AVG	210.29	117.15	
SD	10.31	22.12	
	χ_{c2}, Mpa	E_{c2}, Gpa	
AVG	112.82	8.25	
SD	3.92	0.19	

Table 2. Material card developed.

Figure 7. Details of specimens after testing

Figure 8. Post-mortem analysis with special focus on the fiber matrix interface by means of SEM.

5. CONCUSIONS AND FUTURE WORK

TP-RTM shows promising results in terms of productivity due to the shortest curing cycles needed as compared as traditional thermoset resins (i.e. Reduction of up to 60%)

The obtained mechanical properties are lower than intially expected due to possibiliy resin- sizing compatibilites. Several alterantatives are at present under evaluation.

Even then a weight reduction of 40% has been obtained in the novel component. The experimental validation is at present ongoing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006888.