Two-Session-Clustering Workshop

2021.03.03. | SESSION 2: Lightweight materials with enhanced thermal properties

Presenter:
Tamas TURCSAN

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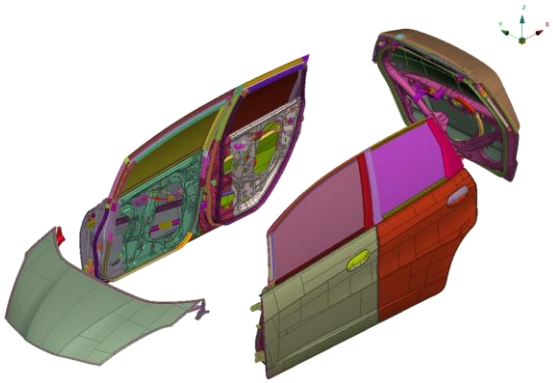
Lightweight materials with enhanced thermal properties
OBJECTIVES

- Drive range extension (~25%)
- Lighter body structure
  - Minimizing energy loss from
    - acceleration,
    - non-recuperable kinetic energy
  - Compensating additional features (PCM, etc.)
  - Seats: -10 % (from ~40 kg)
  - Doors, trunk lid, engine hood: -20 % (from ~80 kg)
- Better thermal performance, minimizing energy consumption
  - In cabin heating/cooling
  - Better insulation (20% energy for heating/cooling)
  - Lower thermal inertia (-5% energy for heating/cooling)



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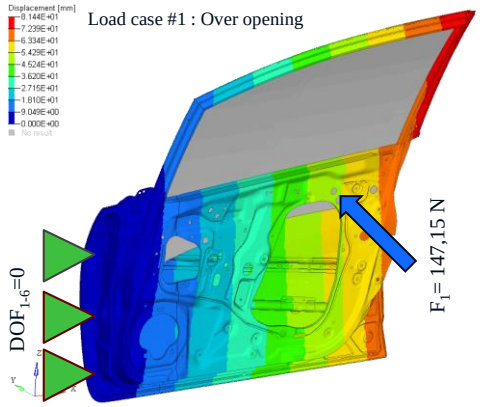
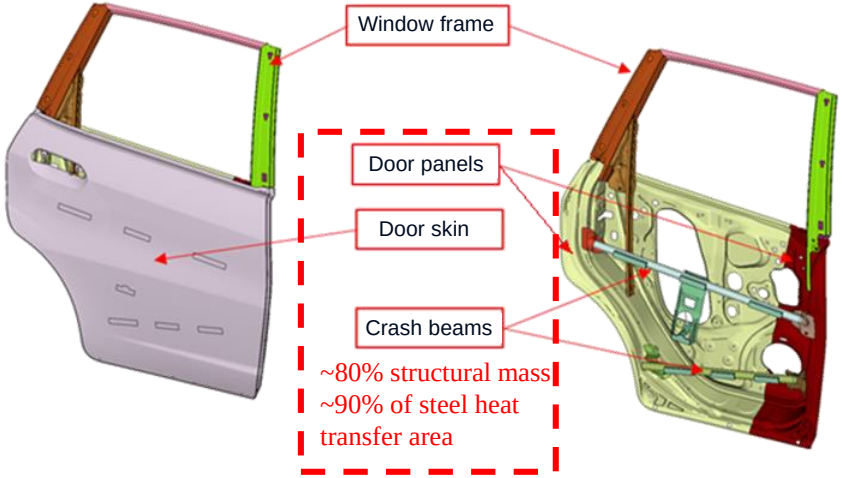
Lightweight materials with enhanced thermal properties
APPROACH

- Side doors, trunk lid, egngine hood
- Using hybrid foam and composites
  - Lower density, better thermal perf.
  - Great energy absorbance
- FEM of original structures
  - Static load cases (by HONDA)
  - Side crash of doors (FMVSS 214)
- Material testing and redesign
  - FEM of the new structure
  - Optimizing the design
  - Stiffness-mass-insulation trade-offs





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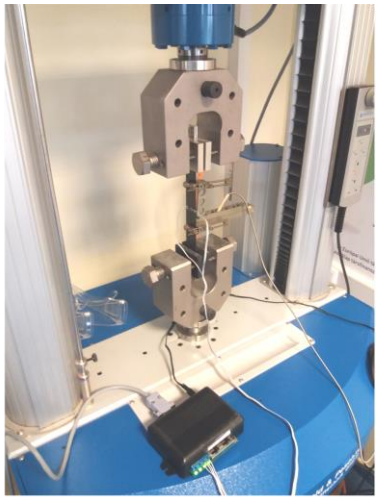
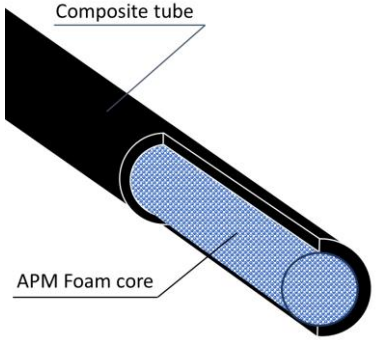
Lightweight materials with enhanced thermal properties
APPROACH

- Material selection
  - CFRP – Carbon Reinforced Polymer
  - Tensile strength of 500-1500 MPa
  - Density of 1.4-1.6 g/cm^3
  - Thermal conductivity 5 W/(m K)
  - Crash beams filled with APM
  - In-house test result based simulations
- Manufacturing
  - Cost effective prototyping
    - Minimizing tooling cost
    - For small series
  - Upscalable technologies
    - For larger series
    - Up to 10,000 unit/year





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Lightweight materials with enhanced thermal properties
RESULTS

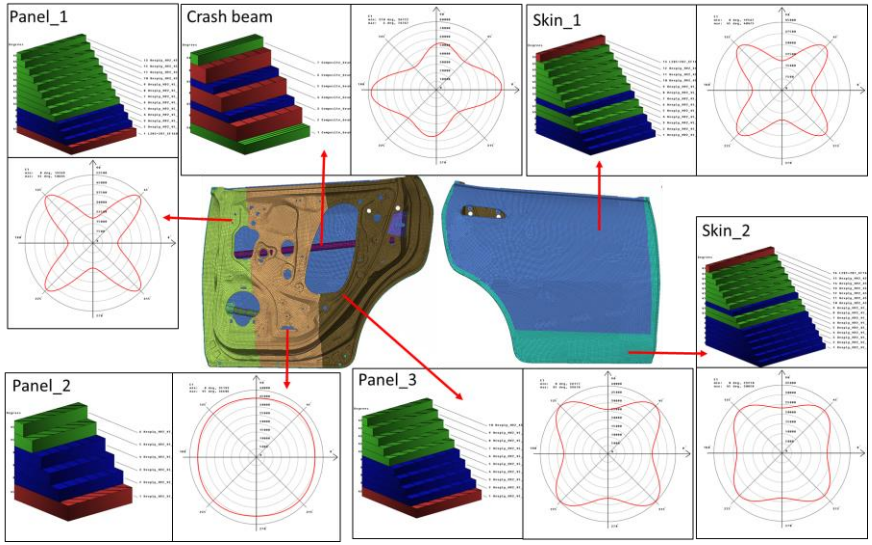
- Measured weight loss

Part	Baseline weight [kg]	Global weight red. [%]	Weight red. with new glazing [%]
Front Side Door	21.43	21.56	31.23
Rear Side Door	14.12	22.98	24.89
Engine Hood	3.67	27.20	N/A
Tailgate	15.53	22.91	28.13
	AVG	**23.66**	**28.08**

- Calculated thermal conductivity

Part	Composite surface [m^2]	Steel surface [m^2]	Thermal conductivity decrement [%]
Front Side Door	0.74	0.06	84.9
Rear Side Door	0.60	0.08	81.0
Tailgate	0.80	0.00	91.8
		AVG	**85.9**

- Calculated thermal inertia, doors
  - -80% for targeted str. elements
  - Up to -40% for global door



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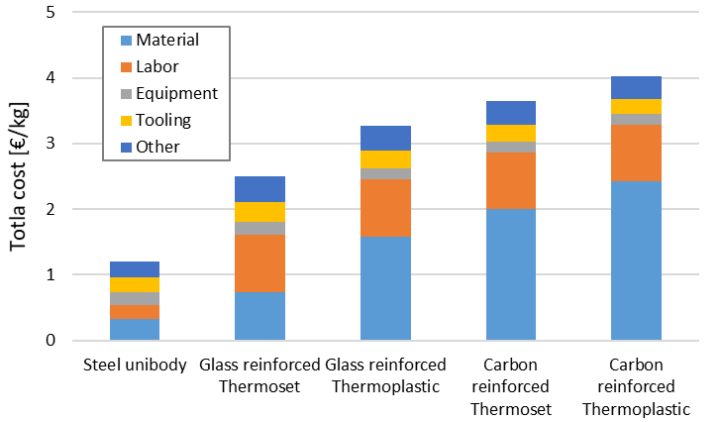
Lightweight materials with enhanced thermal properties
RESULTS

- ## Manufacturing costs

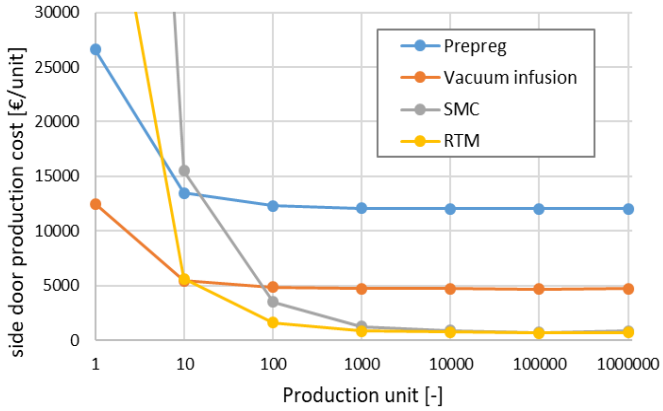
Manufacturing method	Quality, precision, repetitiveness	Tooling Cost	Part per year [unit]*
Hand lay-up (vacuum assisted)	+	€	100-200
Vacuum injection (infusion)	++	€€	300-500
Prepreg + Vacuum bag	+++	€€€	100-200
Prepreg +Autoclave	+++++	€€€€€	100-200
Composite Pressing (SMC)	+++++	€€€	10,000-50,000
RTM	+++++	€€€	1,000-5,000
T-RTM	+++++	€€€€	10,000-50,000

*estimation, mediums size and complexity carbon CFRP part



- ## Specific costs

Material	Cost [€/kg]	Density [kg/m3]	Specific strength [kNm/kg]	Embodied energy [MJ/kg]	Specific strength /Embodied energy [kNm/MJ]
Steel	0.4 - 0.6	7800	38	45	0.84
Aluminum	0.7 - 1.6	2600	130	227	0.57
Composite SMC	1.5 - 1.9	1200	150-400	33-226	1.77-4.55
Composite RTM	2.6 - 4.8	1200-1600	150-400	33-226	1.77-4.55



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Presenter

Tamas TURCSAN
eCon Engineering
www.econengineering.com
e-mail: tamas.turcsan@econengineering.com

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Get in touch with the QUIET consortium!

www.quiet-project.eu

Project Coordination:
Dragan SIMIC (AIT Austrian Institute of Technology GmbH | www.ait.ac.at)
e-mail: dragan.simic@ait.ac.at

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