



MAKING CARBON FIBER MORE
ACCESSIBLE TO MORE INDUSTRIES



@VartegaCFR



Vartega Post-Processing



Recycled Carbon Fiber



EasyFeed Bundles



Thermoplastic Pellets



Injection Molded Part

Applications

Additive Manufacturing / Compression Molding / Injection Molding



All parts shown using Vartega recycled carbon fiber





Project 6.20 Report and Results October 2021

Sean Kline & Andrew Maxey: Vartega

Institute for **ADVANCED**
Composites Manufacturing
INNOVATION

6.20 Closing the Loop on Automotive Carbon Fiber Prepreg Manufacturing Scrap



- **Challenge:** Carbon fiber has found limited use in automotive applications due, in large part, to the high material cost and the labor-intensive nature of typical composite manufacturing processes.
- **Approach:** Vartega Inc has developed a chemistry-based recycling process for uncured carbon fiber prepreg manufacturing scrap. Recycled carbon fiber can be made available at lower cost than virgin fiber. In addition, the discontinuous form of recycled material is suitable for higher throughput manufacturing processes such as injection molding.
- **Impact:** *Low-cost recycled carbon fiber will aid in reducing overall CFRP cost and embodied energy while substantially increasing composite recyclability and reducing the prepreg scrap waste stream. Low-cost recycled carbon fiber will be utilized in vehicle lightweighting applications to improve fuel economy and reduce emissions.*

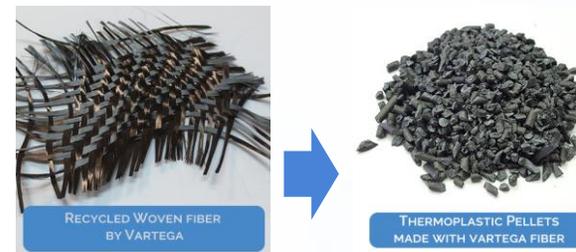
Team: Vartega, Michelman, CSM, UDRI, ORNL, UTK, MSU, with Plasan, Ford and BASF as sponsors

Technical Area: Material and Process

Type: Technical Collaboration

Budget: \$1,0447,560 (\$644,260 industry)

Status: In progress



Injection Molding of an Automotive Part



Injection molded part
(to be selected)



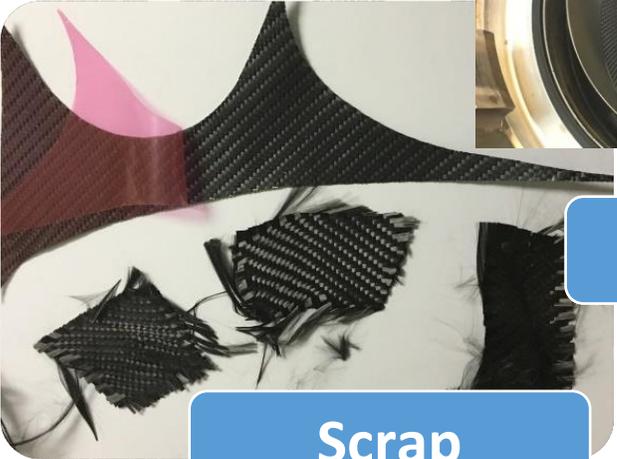
Sized and compounded



Size Reduced



Recycled



Scrap

- Recycling efficiency
- Sizing development
- Material characterization
- Compounding optimization
- Molding parameters
- Process repeatability



PLASAN
CARBON COMPOSITES



MICHELMAN[®]



MICHIGAN STATE
UNIVERSITY



THE UNIVERSITY OF
TENNESSEE
KNOXVILLE



UDRI UNIVERSITY
of DAYTON
RESEARCH
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Task 1: Recycling

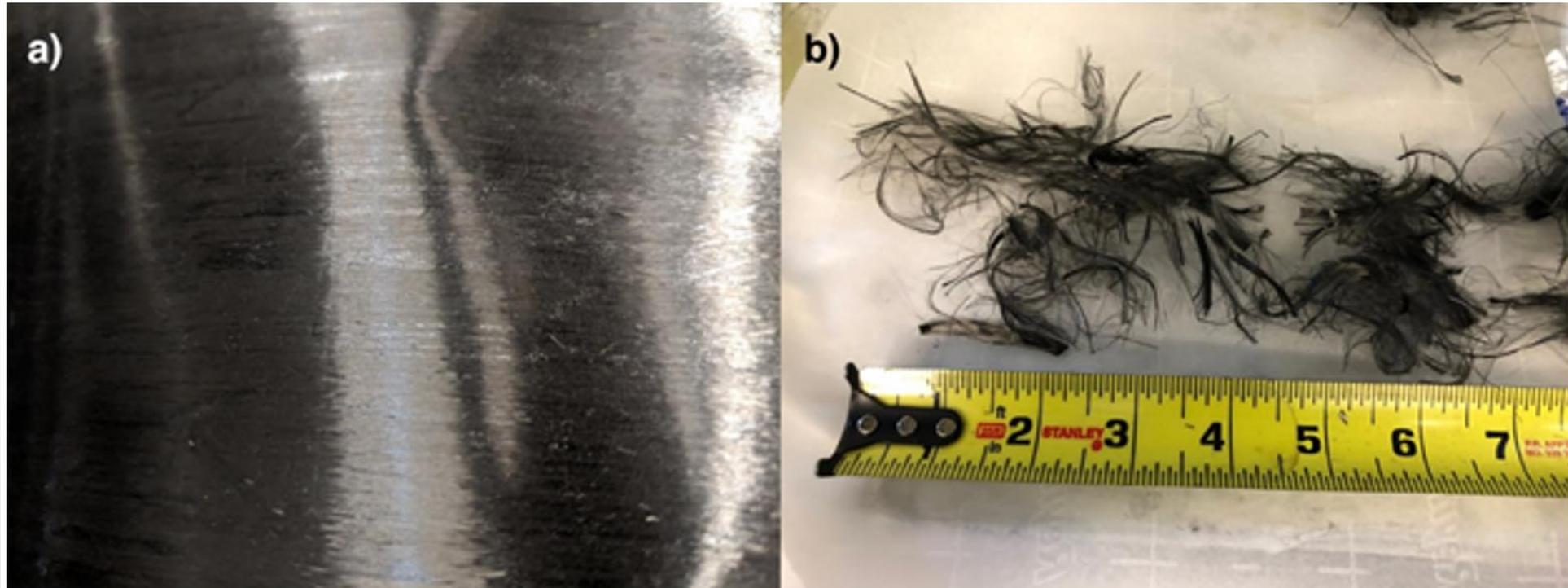
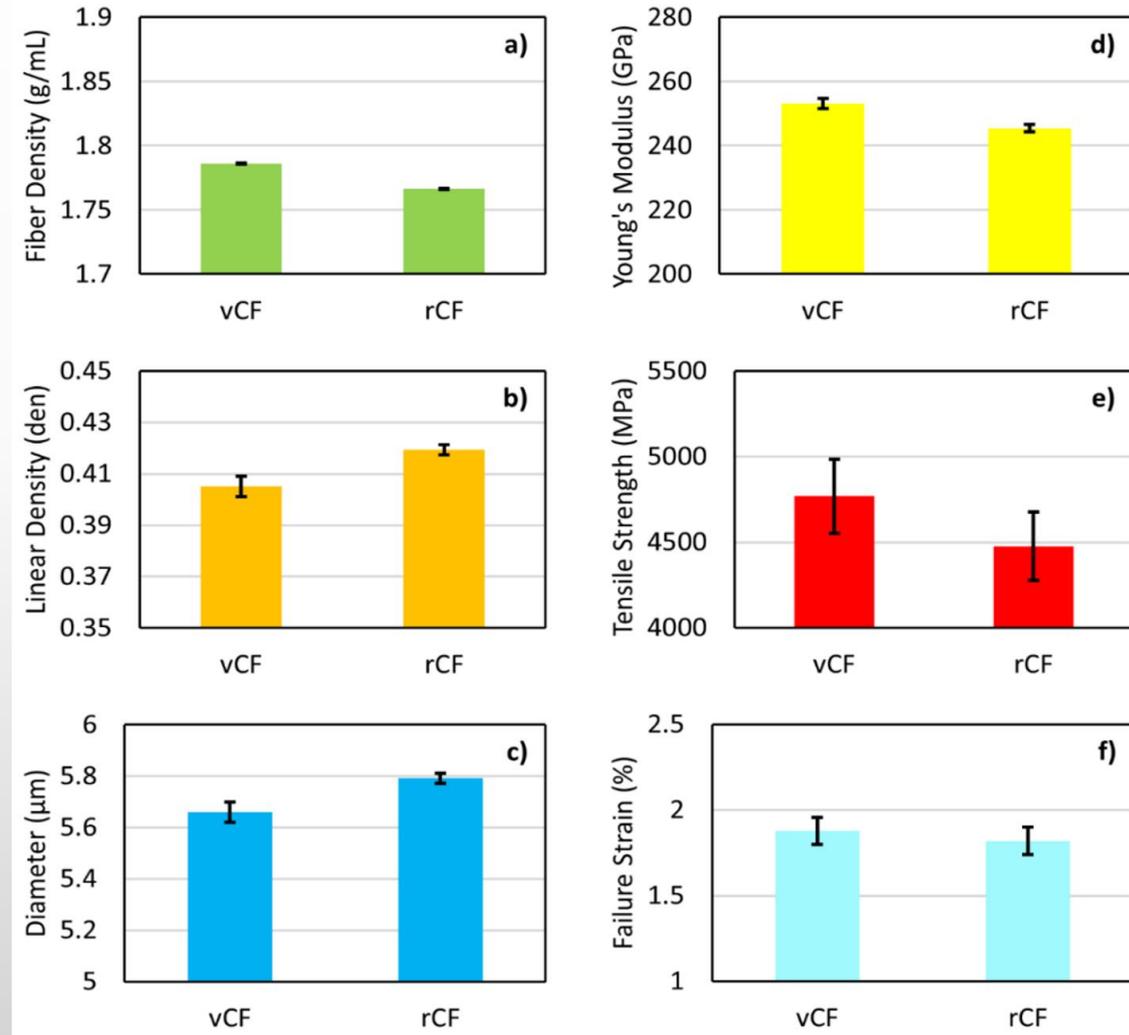


Figure 1: (a) Prepreg before recycling and (b) dry fiber after recycling

Task 1: Single Fiber Testing



Task 1: Data



Table 1: Mechanical property comparisons between compounded rCF and commercial material.

Mechanical Property	Specifications		Test Data (averages) †		Standard Deviation	
	BASF [22]	Ford [23]	BASF A3WC8 (baseline)	UDRI HBF-37	BASF A3WC8 (baseline)	UDRI HBF-37
Tensile Strength (MPa)	295	245	269	298	7.85	9.12
Tensile Modulus (GPa)	38.1	30	36.3	33.2	1.59	2.56
Impact Strength [kJ/m²]	11	6.5	9.57	8.39	0.446	0.399

† Type 5A specimens used from ISO 527-2

Task 1: SEM

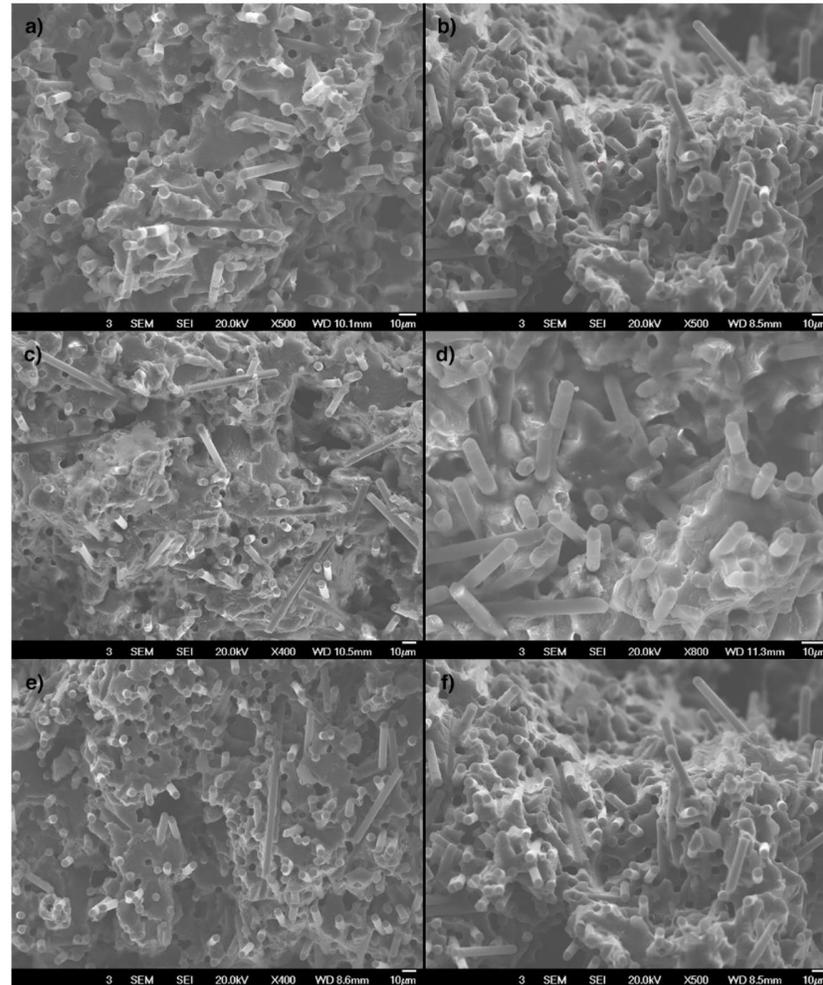


Figure 3: SEM images of (a, b) BASF vCF, (c, d) A-02 rCF, and (e, f) A-05 rCF fracture surfaces.

Task 1: XCT

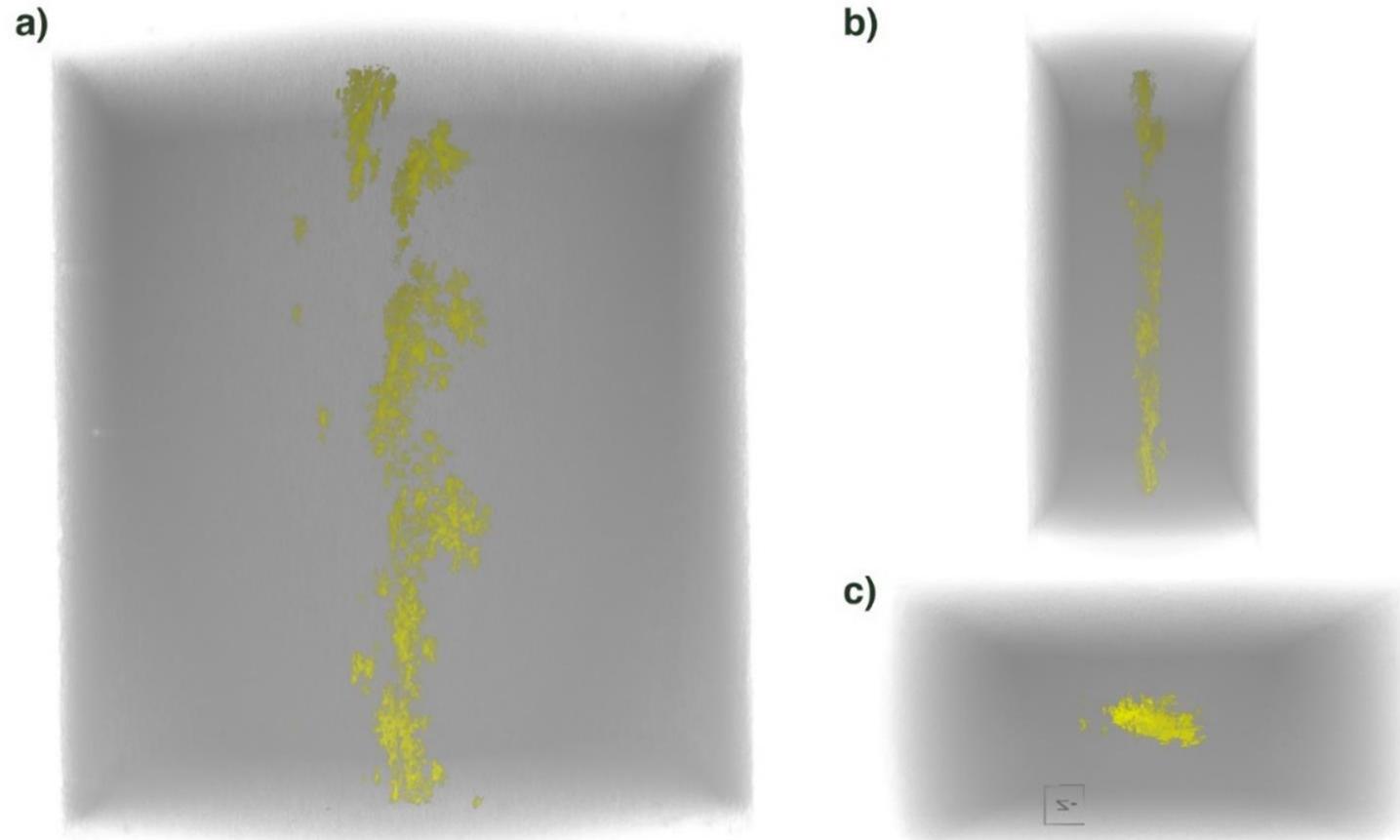


Figure 4: Voids detected by XCT in the rCF HBF-37_14 sample with (a) front, (b) side, and (c) top views.

Task 1: FVF & Angle

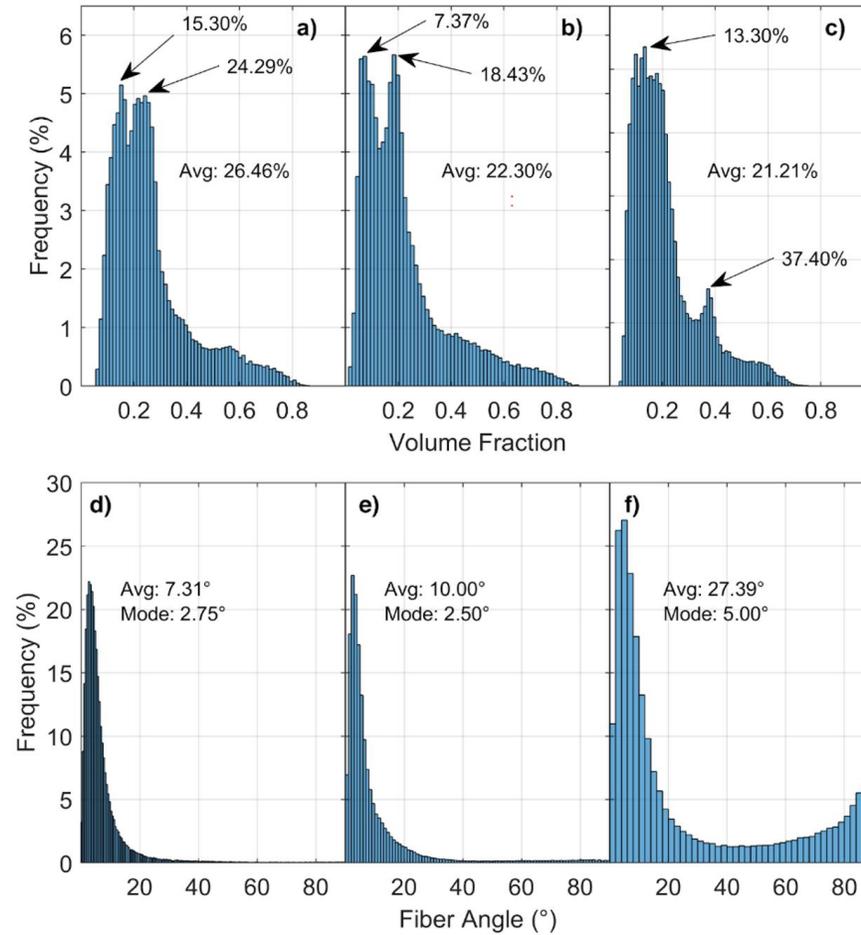


Figure 5: FVF and angular orientation measurements of (a, d) A3WC8-BASF, (b, e) HBF-37_10, and (c, f) HBF-37_14 samples, respectively, from XCT image analysis.

Task 2 & 3: Data



Table 2: Mechanical property results for Task 2 and Task 3 material

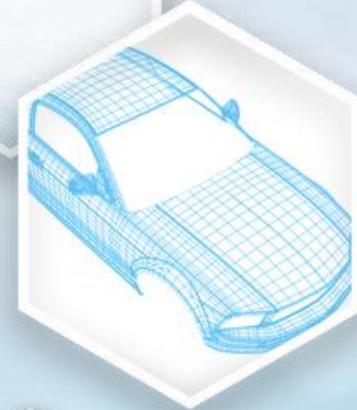
Mechanical Property	Specifications		Test Data (averages) †		Standard Deviation	
	BASF [22]	Ford [23]	Task 2 mat'l	Task 3 mat'l	Task 2 mat'l	Task 3 mat'l
Tensile Strength (MPa)	295	245	220	309	4.96	8.68
Tensile Modulus (GPa)	38.1	30	29.2	35.3	2.464	2.132
Impact Strength [kJ/m²]	11	6.5	6.52	12.3	0.166	0.642

† ISO 527-2 Type 1A tensile and ISO 197-2 Type D impact specimens used

Vartega 6.20 status

Seat back molding:

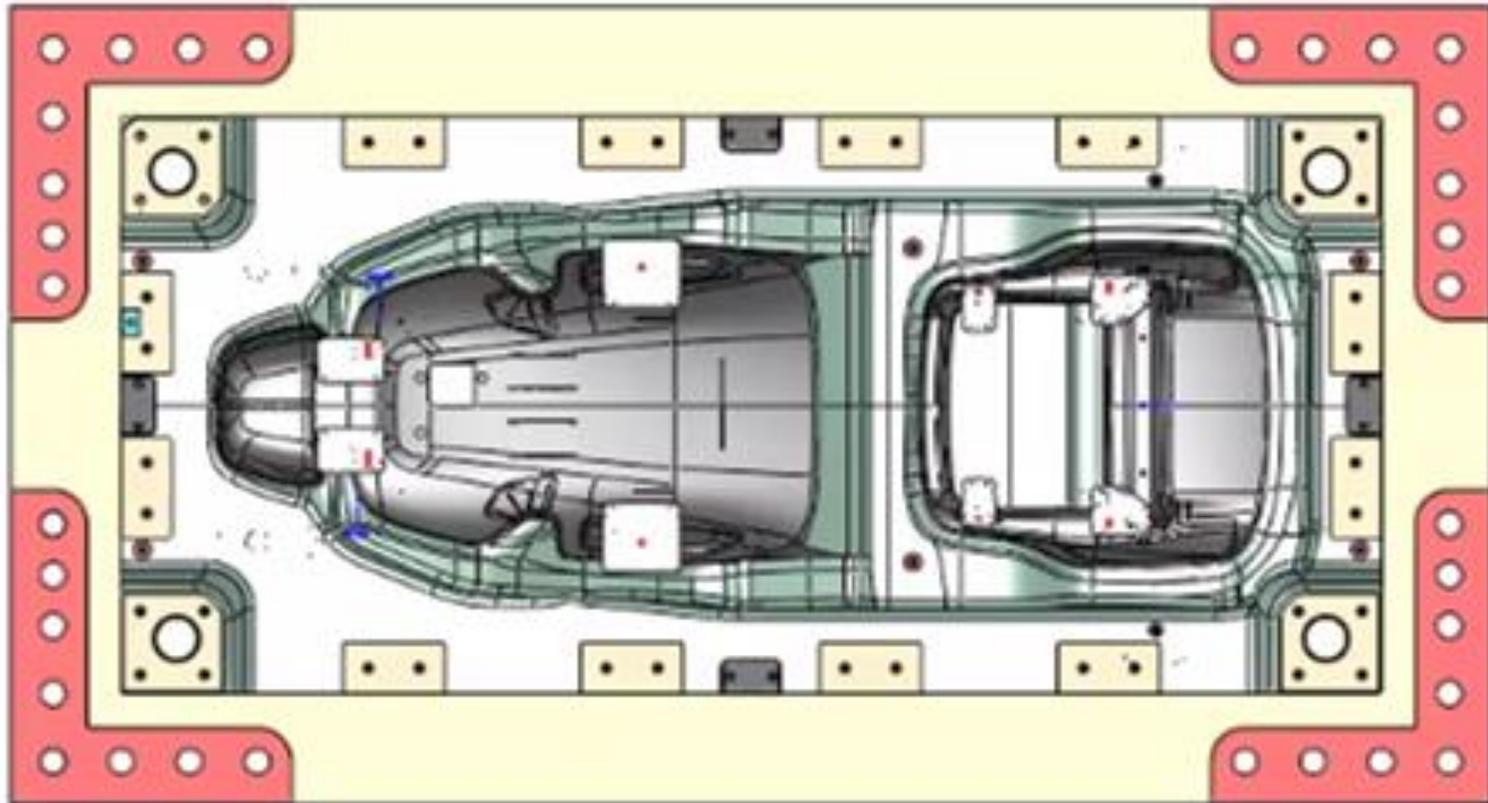
Interim status July 15, 2021



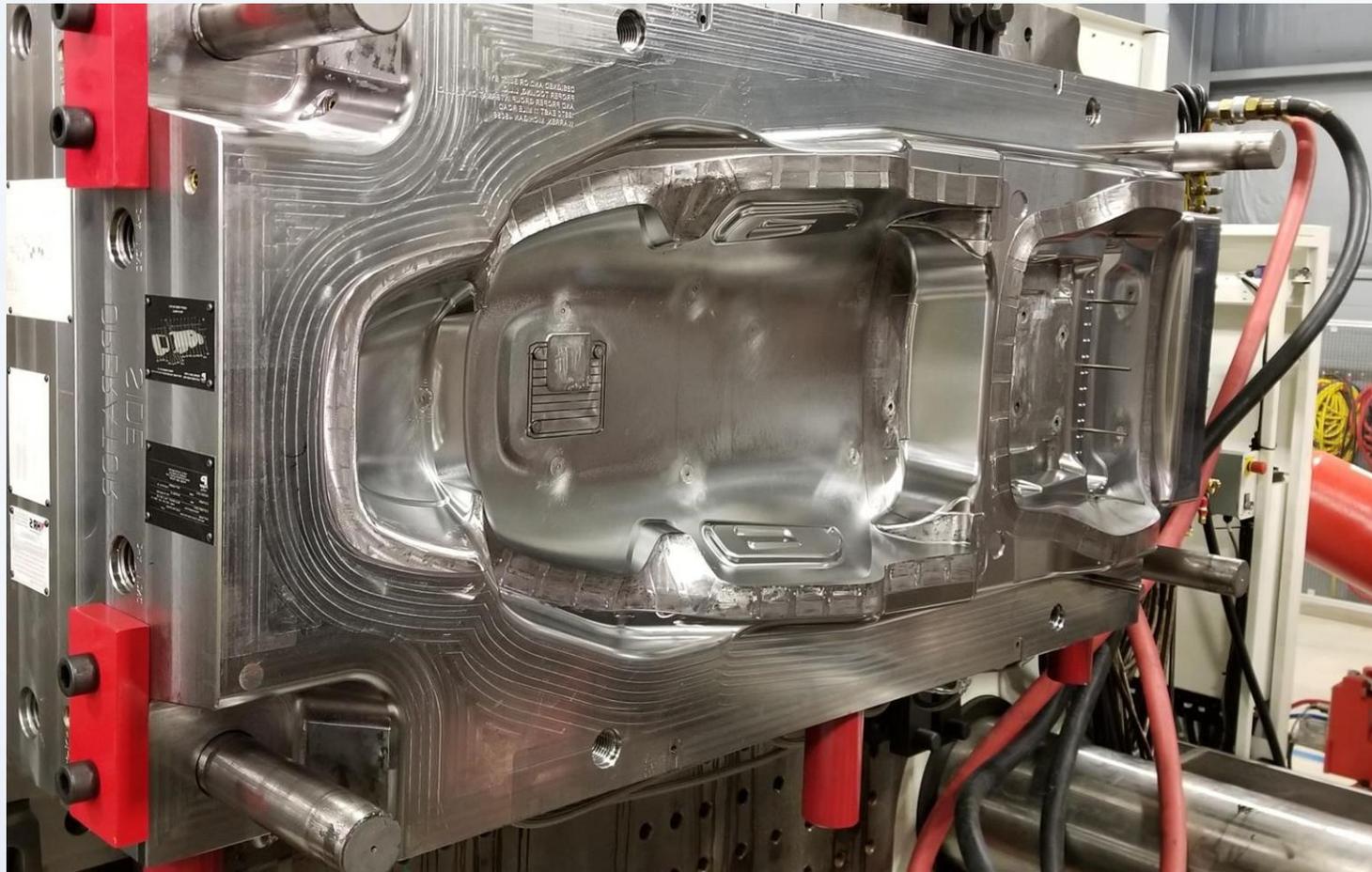
Background

- Saturn Fender Tool utilized for previous moldings
 - Traditional dual gate, cold drop, hot runner design
 - Previous moldings on this tool
- IACMI project 3.9 seatback tool utilized for last Vartega 6.20 molding
 - Seat back / pan – dual cavity design
 - Molded features – ribs, clips, attachment holes
 - Structural geometry
 - Complex tool
 - 14 SVGs
 - Hot runners, hot drops, cooled tips
 - Tool history
 - Designed / verified for 50% GI / PA 6
 - Tooling bought off & ran two other times
 - Tool designed to accommodate long fiber inserts (not utilized in this study)
 - Due to EoAT supply / tooling vendor issues, molding conducted at Proper Mold

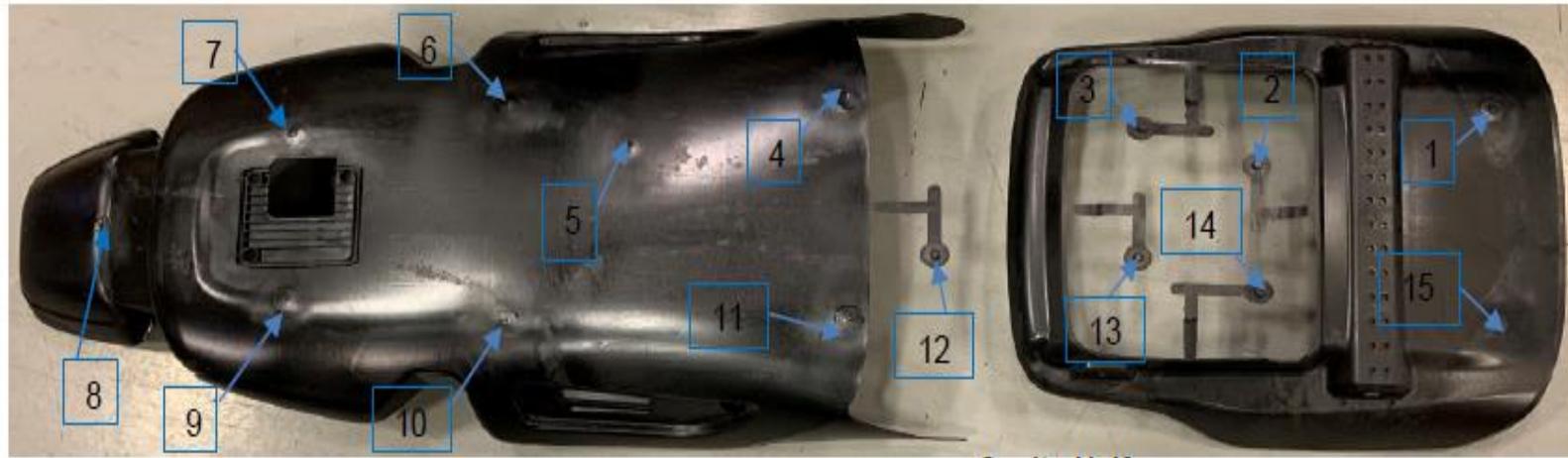
Tooling



Tool photo (shown at SuRF)



Tooling Valve Gate locations



Sequential valve gate (SVG) locations
** part shown from another material run

A3WC8 Seat pan



A3WC8 seatpans



A3WC8 seatback



Notes / Remarks from Molding



- A3WC7 – first material ran due to qty of material (+750 lbs)
- Due to high thermal conductivity of CF, had problems freezing in gates
- One cavity would run (seatback), then pan would freeze off, then alternate
- Complete parts were retained, partial fill parts were discarded
- Initial molding condition
 - 550, 585, 600, then 625F
- Due to the design of the hot runner system, 40% CF fill is just out of the process capability for this tool
- Part surface quality was good for 40% CF fill
- Material would run well with different hot runner system modification

Acknowledgements



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 - Kenneth Kort
 - Ravi Deo



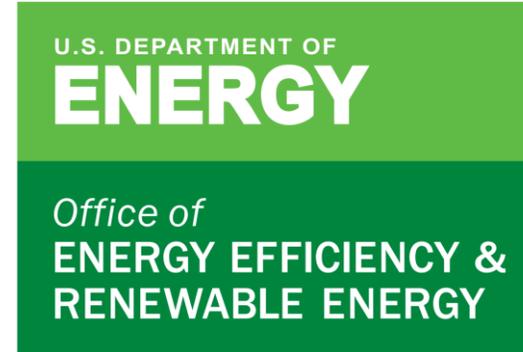
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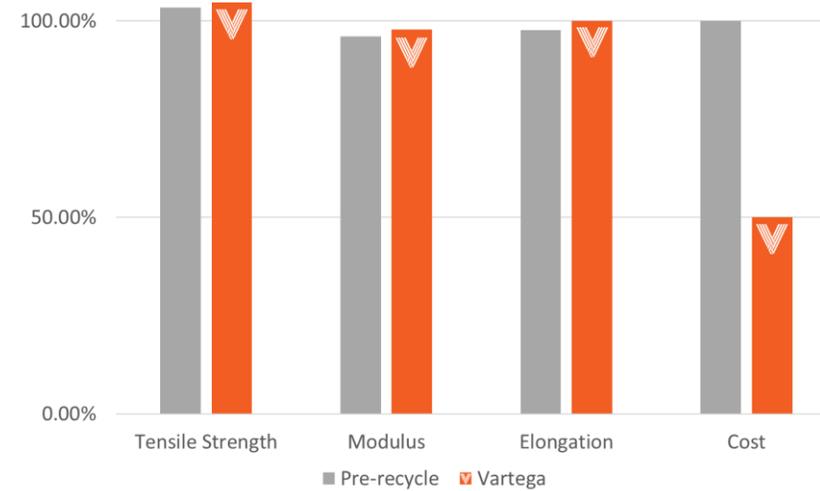


Acknowledgements, cont.



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Stop by CAMX Booth Q58 to get another tire lever and complete your set



Mechanical Property	Test Data (averages)	
	40% SM rCF/PA66	40% IM rCF/PA66
Tensile Strength (MPa)	220	309
Tensile Modulus (GPa)	29.2	35.3
Impact Strength [kJ/m ²]	6.5	12.3

Sponsored in part by:





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