Cost-Effective Weight Reduction with Multi-Material Composites

Automotive Lightweight Materials USA 2021
Agenda

• Intro to WEAV3D®

• Overview of WEAV3D process and Rebar for Plastics® design methodology

• Background on hybrid length-scale materials

• FEA Case Study
  • Effects of alignment of reinforcement fibers
  • FEA model validation
  • Effects of lattice positioning

• Summary
About WEAV3D

Technology invented

2014

WEAV3D founded out of Georgia Tech

2017

Headquartered in metro-Atlanta, Georgia

TODAY

In R&D and commercialization funding

$2.5M+
Rebar for Plastics®
Process Overview

THERMOPLASTIC PREPREG TAPE
Commercially Sourced

WEAV3D Process

LIGHTWEIGHT STRUCTURAL COMPOSITE PART

INJECTION MOLDING
- Overmold Tool
- Lattice

COMPRESSION MOLDING
- D-LFT, SMC or BMC
- Lattice

THERMOFORMING
- Thermoplastic Sheet
- Lattice

LATTICE WEAVING & CONSOLIDATION

WEAV3D Product

TRIMMED COMPOSITE LATTICE

Standard Molding Processes
Why Composite Lattice?

**Handleable**
- Woven and welded at interlace for stability
- Sheet or roll format

**Formable**
- Reheat/reform
- Form in mold
- Colamination

**Tunable**
- Locally optimized:
  - Lattice density
  - Tape material

*Strategic* use of UD tapes in lattice provides a cost-effective and adaptable solution
### WEAV3D Applications & Value Proposition

<table>
<thead>
<tr>
<th>Example Application</th>
<th>Structural Metal Substitution</th>
<th>Structuralizing Molded Plastics</th>
<th>Composite Optimization</th>
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<td>Interior Panels</td>
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<td>SMC Covers</td>
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<td>Weight Reduction</td>
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<td>Upcycling of Recycled Reinforcements</td>
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<td>Expanded Use of Natural Fillers</td>
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Why Hybrid Materials?

Ref: Thomason (2002, 2005)
Why Hybrid Materials?

Independently tunable modulus, strength, and impact

Stress Concentration of Lattice Reinforcement

Lattice concentrates stress away from molded plastic.
Application Area

- Automotive interior panel, replacing long glass reinforced PP and metallic stiffeners

Problem Statement

- Develop a 2mm thick lattice reinforced plastic panel that can achieve an equivalent flexural stiffness of between 10 and 45 GPa with superior economics to magnesium

Design Approach

- Design – mold panels – validate – optimize

In Partnership with:

[Logos of Clemson Composites Center, Covestro, and DSM]
### Materials

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<tr>
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<th>UD Tape for Lattice</th>
<th>Overmolded Plastic</th>
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<tbody>
<tr>
<td><strong>Design 1</strong></td>
<td>Maezio® Composite Carbon Fiber (PC CF)</td>
<td>Bayblend® T85 XF (PC+ABS)</td>
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<tr>
<td><strong>Design 2</strong></td>
<td>UDea™ Akuron® K20HG60 (PA6 GF60)</td>
<td>Bayblend® T88 GF-10 (PC+SAN GF10)</td>
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<tr>
<td><strong>Design 3</strong></td>
<td>UDea™ Akuron® K20HC50 (PA6 CF60)</td>
<td>Akuron® K224-HG6 (PA6 GF30)</td>
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Experimental vs. FEA

Major Load Axis

Short Fibers Aligned with Load
Short Fibers Aligned Randomly
Short Fibers Aligned Across Load

Decreasing Stiffness and Strength
FEA Validation

- Samples simulated for short fibers aligned with load axis and aligned across load axis
- Flexural and tensile sample produced for each design
- Plaque samples were all fabricated with short fibers aligned across the load axis (worst-case)

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<th>Error Range</th>
<th>Average Error</th>
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<tr>
<td>Flexural Modulus</td>
<td>-14% to +6%</td>
<td>-4.4%</td>
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<tr>
<td>Tensile Modulus</td>
<td>-26% to +10%</td>
<td>-6.1%</td>
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Single vs. Double Sided Panels

Neutral Axis

\[ I = \frac{bh^3}{12} + Ad^2 \]
Single vs. Double Sided Panels

Neutral Axis

\[ I = \frac{bh^3}{12} + Ad^2 \]
Single vs. Double Sided Panels

Neutral Axis

\[ I = \frac{bh^3}{12} + Ad^2 \]

Double sided designs yield better performance for the same material cost
Lattice panels are 20-34% lighter than magnesium panels of same size.
Summary

- WEAV3D’s Rebar for Plastics® design approach combines a continuous fiber lattice with short fiber or unreinforced molded plastics to achieve cost-efficient structural performance.
- FEA simulation must take into account molded plastic fiber alignment.
- Stiffness improvements are most significant when lattice can be applied to opposite part surfaces.
- Carbon reinforced lattices can provide superior performance at the same or lower cost than glass reinforced lattices in some application areas.
WEAV3D is partnering with OEM and Automotive Tier suppliers to support automotive product development.

To learn more, get in touch with us at info@weav3d.com.
Appendix
Smarter than Steel™ Hybrid Material Lattices

Enable Smart Structures

Power

Data

Thermal

WEAV3D lattices can combine structural reinforcement with transmission materials
WEAV3D Engagement Model

Collaborative Design

Application Scoping

FEA Simulation

Proof of Concept

Part Selection

Part Optimization and Prototyping
WEAV3D Intellectual Property Overview

**BACKGROUND IP**
- Licensed from Georgia Tech
- Composite Lattice
- 2 Forming Methods
- 3 Machines
- Trade Secrets

1 issued patent, 2 applications in prosecution

**WEAV3D IP STRATEGY**
- Machine Improvements
- Design Software
- Lattice Placement Tooling
- Trade Secrets
- Lattice Applications
- Trademarks

New patent applications filed 12/2019 and 3/17/2020
WEAV3D® and Rebar for Plastics® are registered trademarks
WEAV3D Full-Scale Pilot Machine

Patent-pending customizable lattices and lattice forming process