Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts

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Project ID #
LM047

Overview

Timeline

- Start – October 2010
- Finish – September 2013
- 70% Complete

Budget

- Total project funding
  - DOE - $3,008K
  - Contractor share - $1,500K
- Funding received in FY12
  - $937K
- Funding for FY13
  - $1,000K

Barriers

- Barriers addressed
  - Cost
  - Manufacturability
  - Inadequate Supply Base

Partners

- Proterra – bus exterior panel
- IAC – automotive interiors
- MFG – Corvette body part
- ICS – Materials/process evaluation
- MIT LLC - Project lead

Objectives/Relevance

- Explore the use of virgin and reclaimed carbon fiber to produce both preforms and rollgoods for use in lower cost lightweight automotive components
  - MIT LLC's patented 3-DEP™ process for making complex net shape preforms addresses both Cost (lower material usage, less process waste and faster cycle times) and Manufacturability (fast cycle time and excellent part-to-part and within-part variation)
  - MIT LLC's development effort for producing roll goods made from carbon fiber as well as carbon fiber-thermoplastic polymer Co-DEP materials addresses the same Cost and Manufacturability barriers identified by DOE
  - The use of MIT LLC's reclaimed carbon fiber addresses both Cost as well as Inadequate Supply Base through the reuse of currently landfilled materials

Milestones

Month/Year	Milestone or Go/No-Go Decision
Sept-11	Milestone: Demonstrate Co-DEP roll goods composition(s) and manufacturing processes. Completed ahead of schedule for a broad range of Co-DEP material systems including CF/PET, CF/PE, CF/PPS and CF/NF/PP.
Jun-12	Milestone: Large 3-DEP™ machine installed and ready for shakedown and startup. Total capital needed to complete both a roll goods production line and the large 3-DEP™ machine is $5 million. Initial capital raise was only $1.5 million. Completion of the large 3-DEP™ was completed two quarters behind schedule.
Sept-12	Milestone: Shakedown and startup of large 3-DEP™ machine complete. Completed one quarter behind schedule.
Sept-12	Milestone: Overhead bracket validation at IAC complete. Behind schedule due to acceleration of Milestone 6.
Dec-12	Milestone: Rocker panel technology demonstration and validation at Proterra complete. Well ahead of schedule. Material system and processing route has been selected. Demonstration parts have been produced. Status – not commercially viable in the low volumes needed for an electric bus program.
Dec-12	Milestone: Door trim validation at IAC complete. On schedule. Commercialization likely prior to end of grant.

Approach / Strategy

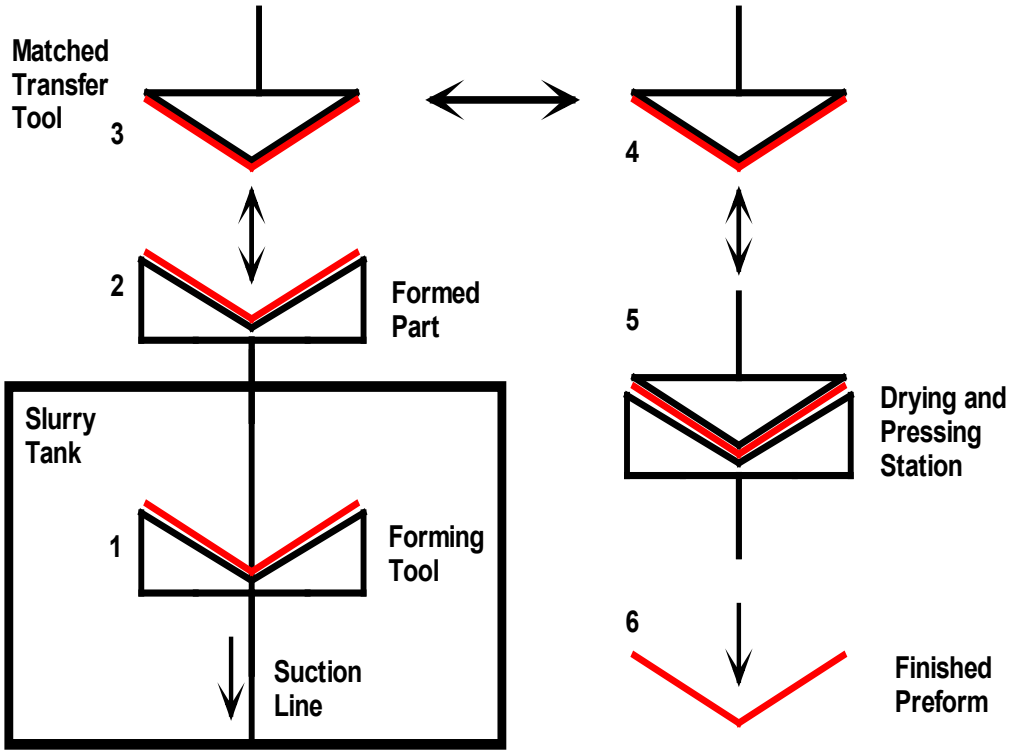


Figure 1.Schematic of traditional fiber slurry molding process.

(1) Fibers deposited on porous forming tool. (2) Formed part partially dried by vacuum. (3) Matched transfer tool picks up part from forming tool. (4) Partially dried part transferred to drying station. (5) Part dried using vacuum-assisted heating. (6) Finished preform.

Approach / Strategy

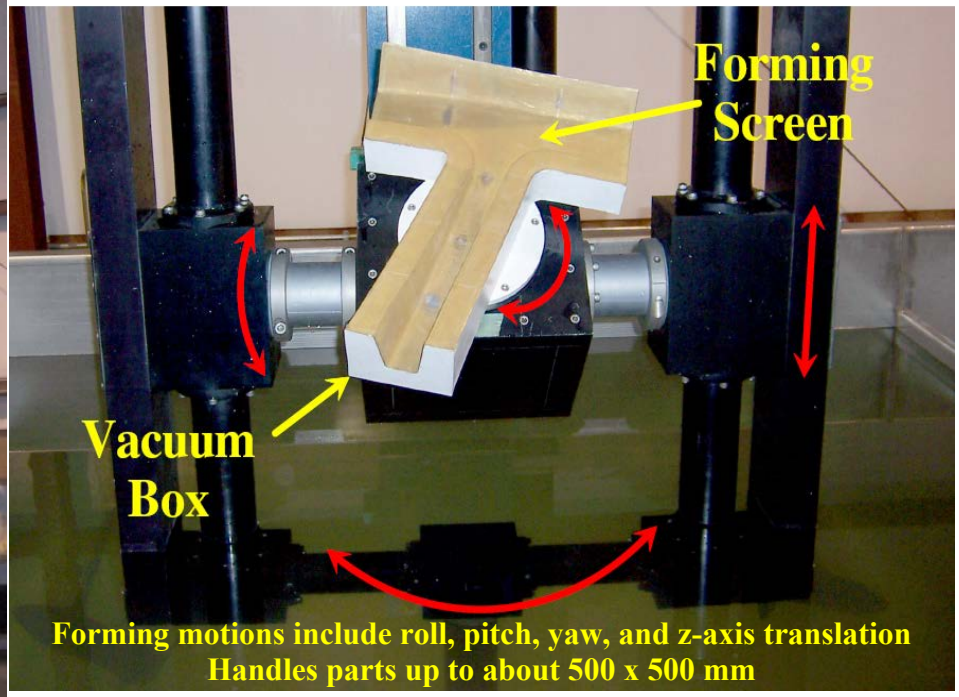


Figure 2. (A) Overview of the 20-foot tall, pilot-scale 3-DEP™ machine. (B) Detail of the forming head of the 3-DEP™ machine showing the forming screen for an automotive "B-pillar" (used in the Phase I project) and the four degrees-of-freedom (roll, pitch, yaw, and z-translation) that provide the unique forming capability of the 3-DEP™ technology.

Approach / Strategy

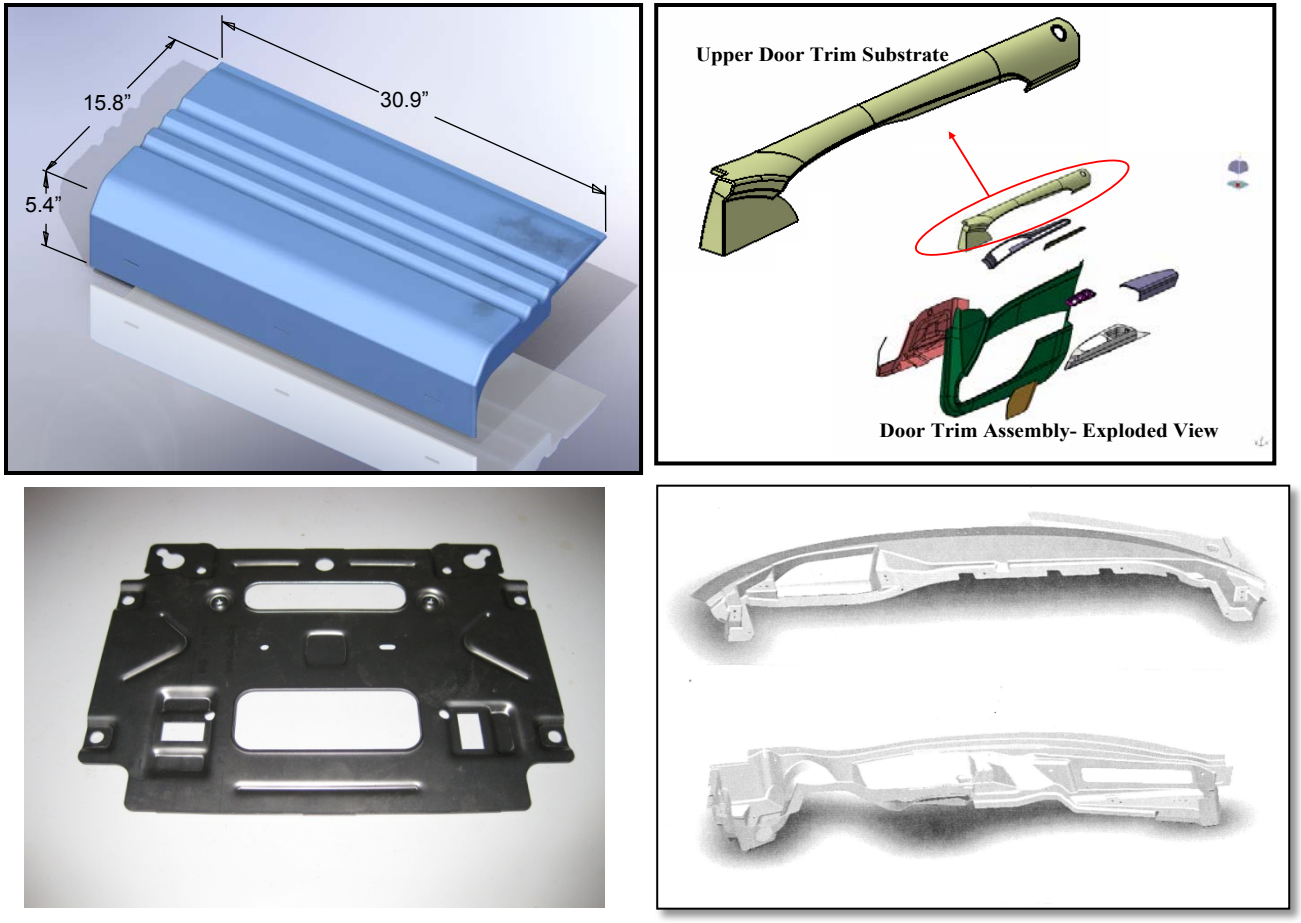


Figure 3. Overview of the automotive and bus components we plan to fabricate during the Phase III project. (A) side rocker panel for an electric bus - Proterra; (B) upper door trim substrate for the Ford Fusion/Mercury Milan - IAC; (C) overhead bracket for Chrysler Minivan - IAC; (D) upper and lower plenum for the Corvette - MFG.

Approach/Strategy

- Two processing routes are being explored
  - 3-DEP™ for producing preforms with 3-dimensional shape, deep molding draws or tight radii at short cycle times (1 minute)
  - Continuous roll goods for use in relatively flat final part geometries
- Two main materials routes are being explored with each of the processing routes
  - Carbon fiber (for thermoset applications)
  - Co-DEP materials containing carbon fiber and one or more thermoplastic resins co-deposited into a felt-like material
  - A variety of thermoplastic resins are being studied including PPS, PA, PP, PE and PET
- Goal is to utilize the improved properties achieved by the introduction of carbon fiber to reduce the thickness and mass of current parts

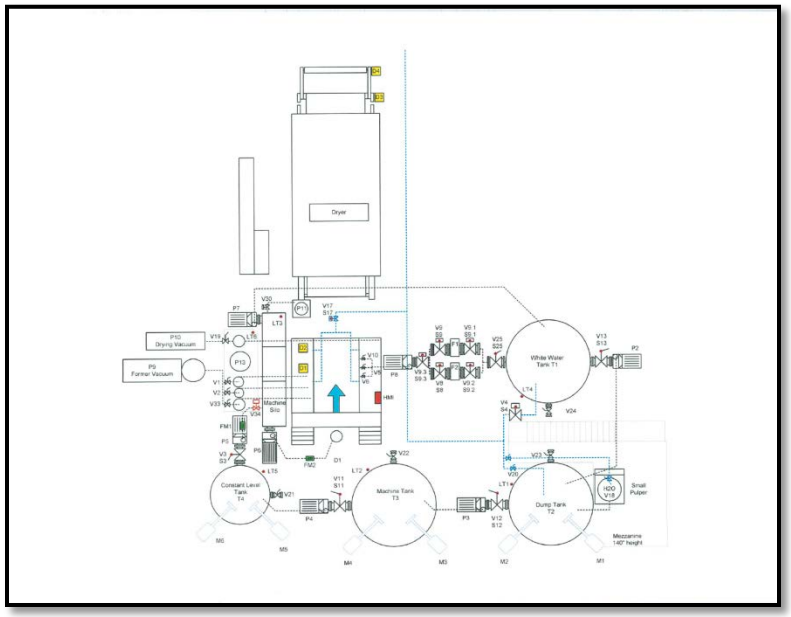
Technical Accomplishments

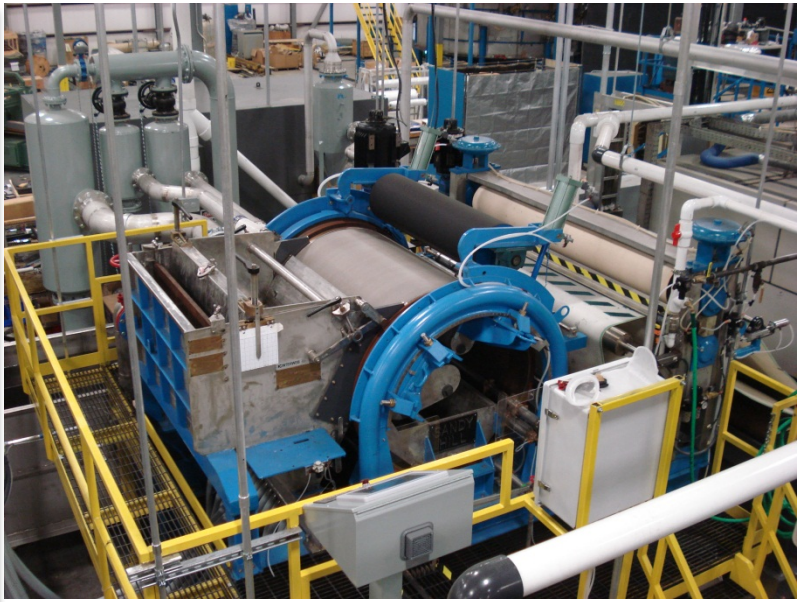
- Task 1: Roll Goods Development
  - Initial trials completed using Carbon Fiber alone along with Co-DEP rollgoods consisting of CF/PP, CF/PA and CF/PPS
  - 26” wide material made in roll form up to 200 ft. in length
  - Total length of roll goods produced to date in excess of 1 mile
  - Results were so encouraging that funding was diverted towards accelerating the design and construction of a 50” wide production roll goods machine.

Technical Accomplishments

- Task 1: Roll Goods Development
  - Thermoforming was successfully demonstrated using roll goods made of:
    - CF/PPS (commercial aircraft seatback)
    - CF/PET (Proterra Bus rocker panel)
    - CF/NF/PP (IAC door bolster/trim piece for the Ford Escape)

Technical Accomplishments





- Task 1: Roll Goods Development
  - 50” wide production roll goods line has been designed, installed and successfully commissioned.
  - Capable of producing areal basis weights from 50 to 500 gsm.
  - Cost estimates for a comparable new line from OEM’s varied between $9 million and $15 million.

Technical Accomplishments

- Task 2: Rocker Panel (Proterra Bus)
  - A wide range of Co-DEP materials have been explored including CF/PP, CF/PA, CF/PE and CF/PET.
  - CF/PET offers the best combination of properties for this specific application – cost, strength, stiffness, impact strength, abrasion resistance, paintability.
  - Prototype compression molded CF/PET parts have been produced and are being studied by the end customer.
  - 25% weight reduction has been achieved over current materials
  - Commercial viability unlikely due to low annual bus volumes

Technical Accomplishments

- Task 3: Door Trim Support (IAC)
  - Proof-of-concept compression molding trials have been completed in order to validate the development plan
  - Initial Co-DEP materials evaluation completed with several materials
  - Target material construction consists of approximately 10% reclaimed carbon fiber, 40% natural fiber and 50% polypropylene.
  - 40% weight reduction has been achieved over current material.

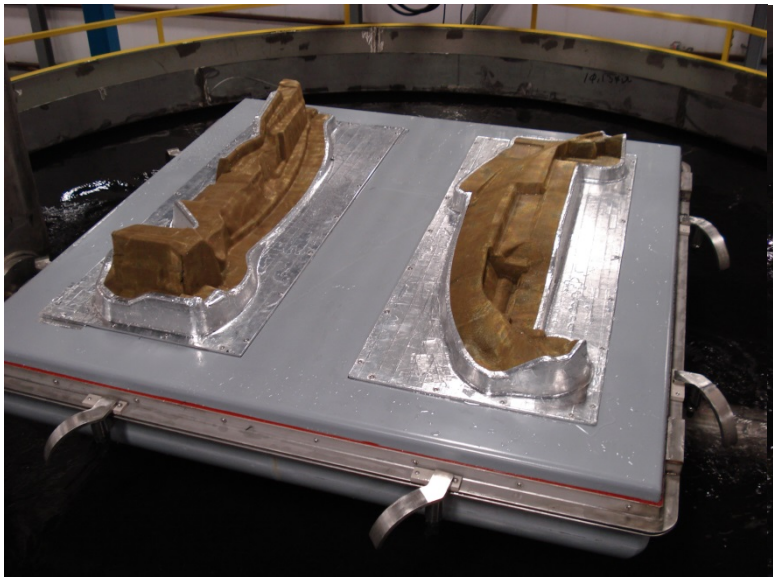
Technical Accomplishments

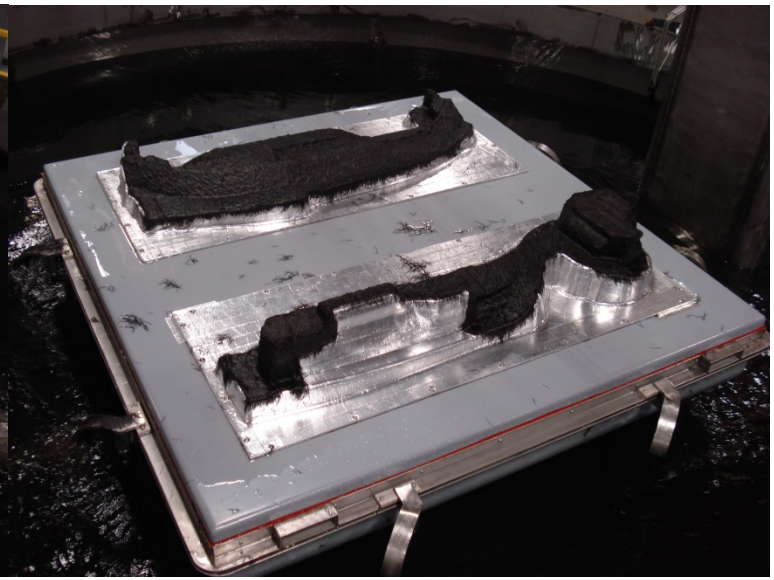
- Task 3: Door Trim Support (IAC)
  - Full construction validation testing of several final candidate material systems on the Ford Escape upper door trim piece has been completed.
  - Goal is a cost-neutral replacement at a 40% weight reduction.
  - Currently doing final material/process optimization.
  - Run-at rate testing on the production tooling will commence soon.
  - Commercialization likely prior to end of grant (October 2013).

Technical Accomplishments

- Task 5: Large 3-DEP™ Machine – Build, Install, Shakedown
  - Equipment layout and infrastructure was completed ahead of schedule and on budget.
  - Main stainless steel forming tank was fabricated and installed ahead of schedule.
  - Machine design, construction bids and initial fabrication was completed ahead of schedule.
  - Final construction was completed two quarters behind schedule due to a shortage of capital funding.

Technical Accomplishments





- Task 6: Upper Plenum and Lower Plenum for Corvette
  - Resin, carbon fiber volume fraction, molded part thickness and molding process validation completed on time.
  - 3-DEP™ preforming tools for both Upper and Lower Plenums completed on time and on budget.
  - Initial 3-DEP™ preforms were successfully produced for both Upper and Lower Plenum preforms.
  - Initial parts were molded using vinyl ester resin and 25% carbon fiber resulting in a weight savings of one pound per part.
  - Commercialization probable in 2014.

Technical Accomplishments

- Task 6: Upper Plenum and Lower Plenum for Corvette
  - Process Demonstration (2:31)

Collaborations

- Partners
  - **Proterra Bus** (Industry): lightweight structures for use on their electric/hybrid bus
  - **International Automotive Components (IAC)** (Industry): lightweight interior components for a variety of automotive OEMs
  - **Molded Fiber Glass (MFG)** (Industry): lightweight automotive parts for GM/Corvette
  - **Innovative Composite Solutions (ICS)** (Industry): molding process evaluations
  - **University of Alabama at Birmingham (UAB)** (Academic): materials property testing

Future Work

- Continue development of the roll goods manufacturing process with and emphasis on process cost reduction and machine throughput.
- Continue to investigate a variety of pre-consolidation techniques for both roll goods and 3-DEP™ applications.
- Continue to explore heated and cooled tooling for compression molding applications.
- Commercialize automotive interior Co-DEP material system at Ford, GM, Nissan or Toyota.
- Complete Computational Fluid Dynamics (CFD) study of our patented 3-DEP™ process.
- Produce large parts (up to six feet by six feet) and multiple parts on our large 3-DEP™ machine.
- Expand potential parts suitable for our roll goods and 3-DEP™ processes.

Summary

- The project focuses on commercialization of lightweight composites for the transportation industry
  - Necessary for meeting upcoming CAFE and Supertruck requirements
- Our approach utilizes thermoplastic and thermoset materials reinforced with reclaimed carbon and other structural fibers with the goal of decreasing existing part thickness and mass by 30 – 50%.
- We are on or ahead of schedule in all areas except for the metal bracket replacement application for automotive interiors.
- Compression molding trials have produced excellent looking parts with good mechanical properties and commercialization looks promising.
- Market pull for lightweight parts for the transportation industry has been increasing since project inception and several new potential partners have expressed interest in expanding our scope of work.