GATE Center of Excellence at UAB for Lightweight Materials and Manufacturing for Automotive Technologies

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GATE
GRADUATE AUTOMOTIVE TECHNOLOGY EDUCATION

This presentation does not contain any proprietary or confidential information

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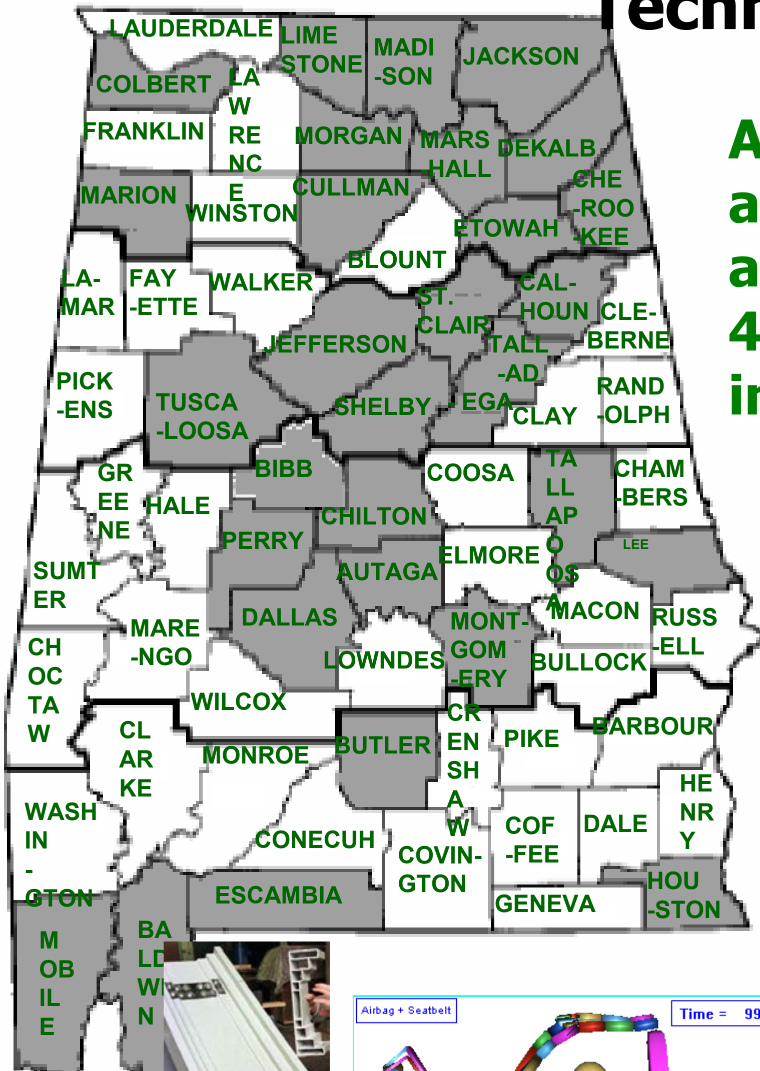
Materials Processing and Applications Development (MPAD) at UAB – The research focus is on applications development with rapid transition to industry

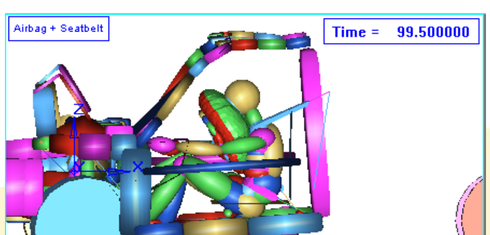
- 20,000 sq.ft of industry scale facilities
- Rapid technology transition to industry – defense, transportation, infrastructure, aerospace and marine
- Strong industry partnerships with materials suppliers, integrators and end users; more than 20 active NDA's
- Partnerships with federal & state agencies, and national labs (NSF,DOE, DOD etc)

Automotive Industry Impact in the State of Alabama – UAB DOE Graduate Automotive Technology Education (GATE)



Alabama has a rapidly growing automotive industry. Since 1993 the automotive sector has created more than 45,000 new jobs and $8 billion in capital investment in Alabama.

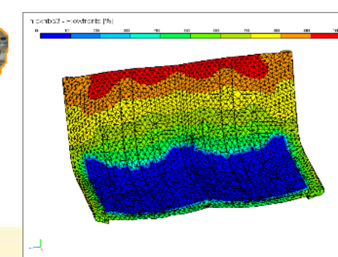
- Training students in advanced lightweight materials and manufacturing technologies.
- Design and manufacturing of future generation transportation, including automobiles, mass transit and light, medium and heavy trucks.



Modeling of crash & protective padding


High speed computational facility


Automotive castings


Process modeling

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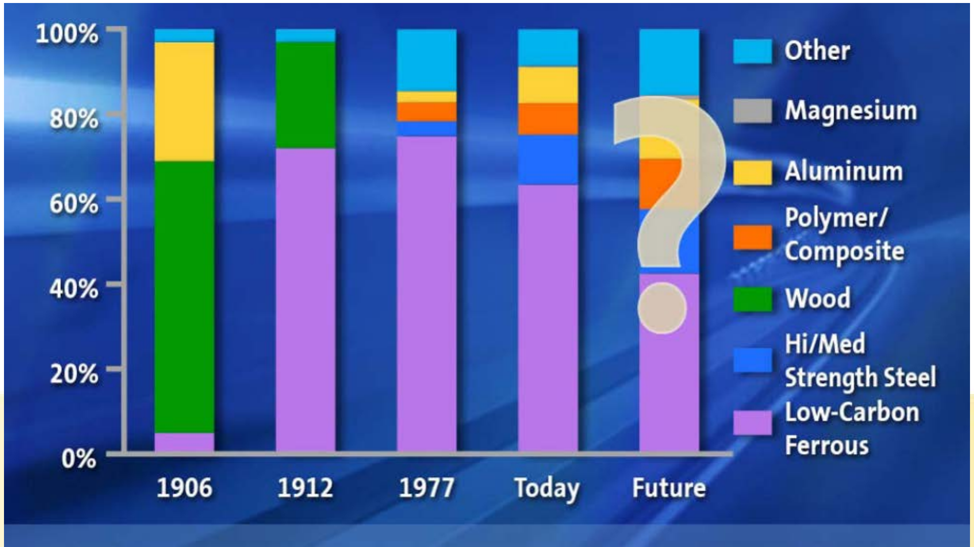
Weight reduction – Automotive, Mass Transit and Truck

- **Performance**
- **Increased 'customer value' while staying within Corporate Average Fuel Economy (CAFÉ) limits**
- **Long term increase in fuel prices**
- **6-8% (with mass compounding) increase in fuel economy for every 10% reduction in weight, everything else being the same**

DOE, Carpenter, 2008



Relevance and Goals

Overall Vehicles Technology Program Goal

- Development and validation of advanced materials and manufacturing technologies to significantly reduce automotive vehicle body and chassis weight without compromising other attributes such as safety, performance, recyclability, and cost.
- To provide a new generation of engineers and scientists with knowledge and skills in advanced automotive technologies.

DOE GATE Goal

- "To provide a new generation of engineers and scientists with knowledge and skills in advanced automotive technologies."

The UAB GATE Goals are focused on the above FCVT,VTP and GATE goals

- Train and produce graduates in lightweight automotive materials technologies
- Structure the engineering curricula to produce specialists in the automotive area
- Leverage automotive related industry in the State of Alabama
- Expose minority students to advanced technologies early in their career
- Develop innovative virtual classroom capabilities tied to real manufacturing operations
- Integrate synergistic, multi-departmental activities to produce new product and manufacturing technologies for more damage tolerant, cost-effective, and lighter automotive structures.

UAB GATE Center for Lightweight Materials and Manufacturing for Automotive and Transportation

Materials Science & Engineering/MPAD	Mechanical Engineering	Biomedical Engineering	Civil and Environmental Engineering
Lightweight Composites and Castings – Materials and Manufacturing R&D	High-fidelity modeling and simulation; predictive Engineering, material models	Crash & injury studies, Studies for protection using lightweight advanced materials	Highway crash barrier, road safety, pedestrian collisions, Transportation infrastructure

ACADEMIC PARTNERS
- Tuskegee University (Minority institution)
- Bevill State Comm. College
- Lawson State Comm. College
- Heritage Community Center

TECHNICAL AREAS FOR GATE SCHOLARS THESIS / DISSERTATIONS

Lightweight Materials & Manufacturing – Engineered Composites / Castings / Enhanced Crashworthiness
(*Basic science studies leading to Prototype/Application Development & Commercialization*)

Next Generation Carbon Fiber for Automotive &Transportation	Textile grade carbon fiber; reclaimed carbon fiber; wet laid carbon fiber; intermediate forms, effects of sizing; compounded carbon/foams; LFT injection & compression
Next Generation Renewable Materials for Automotive &Transportation	Interface treatment of biocomposites, Bioresins, Moisture uptake and prevention; Processing and blending of natural fibers with synthetic fibers
Advanced Metal Castings	Magnesium and aluminum casting; Austempered steels, Lost foam casting, In-situ X-ray analysis, predictive engineering , pressure assisted casting
Biomechanical studies / Crashworthiness modeling	Injury biomechanics, side impacts-material/body interaction on pelvis; crashworthin--ess modeling; body collision, pedestrian and child car safety studies

INDUSTRY & Other Partnership
- Automotive & Mass Transit Companies
- Economic Development Partnerhship Agency (EDPA)
- Material Suppliers & End-Users
- Alabama Manufacturers
- National Composite Center
- American Chemical Council

NATIONAL / DOE LAB Partnership
- Oak Ridge National Lab (ORNL)
- Pacific Northwest National Lab, (PNNL)
- National Transportation Research Center (NTRC)
- US Department of Agriculture (USDA)

ADVISORY BOARD
- Automotive & Heavy truck reps (Mercedes, Honda, others)
- DOE program managers_
- Material focused industry reps
- Economic Development reps

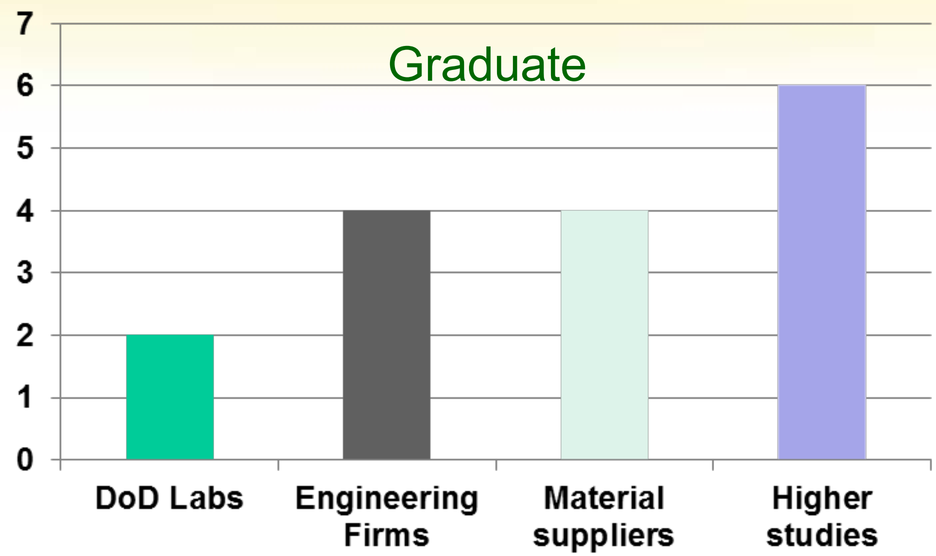
Accomplishments and Progress: GATE Directly Funded Students (2005-2011)

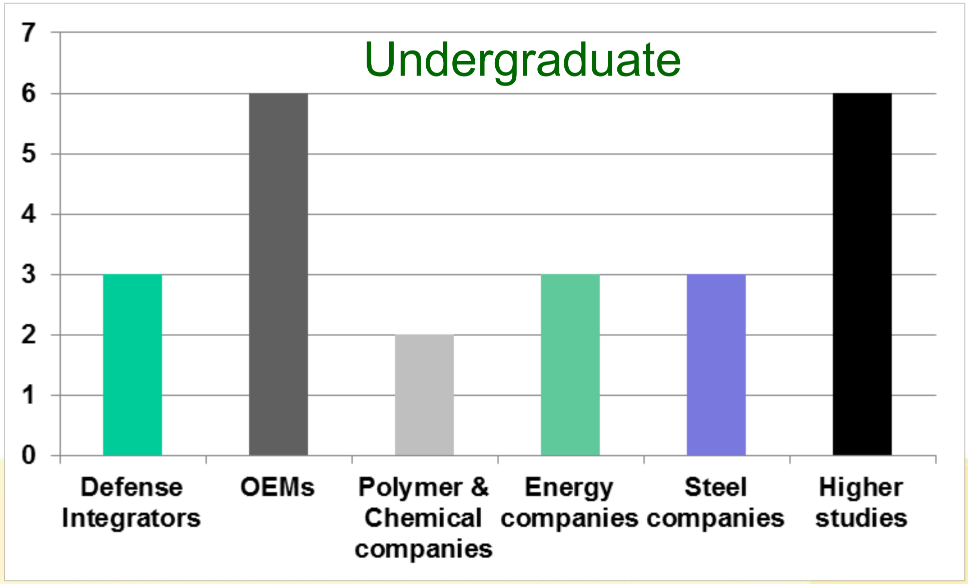
	GATE SCHOLAR	WHERE PLACED	GATE Thesis / Dissertation
1	Mohammed Shohel	KBR, Houston, (CEE, PhD ‘06)	Resin infusion processing of laminated composites
2	Carol Ochoa	Fenner Belts, Pennsylvania (MSE, PhD ’09)	Finite element analysis and modeling of thermoplastic composites
3	Balaji Venkatachari	CFDRC, Huntsville (ME, PhD’ 09)	Simulation of flow fields in automotive bodies
4	Amol Kant	Owens Corning (CEE, PhD ’09)	Sandwich construction for crashworthiness of automotive applications
5	Lakshya Deka	Whirlpool (MSE, PhD ‘06)	LS-DYNA modeling of of thermoplastic composites
6	Satya Vaddi	Technical Fiber Products (MSE, MS’09)	Fire behavior of thermoplastic composites
7	Felipe Pira	Airbus (MSE, MS’07)	Process Modeling of Thermoplastic Composites
8	Leigh Hudson	Toray Carbon Fibers (MSE, MS’09)	Pultrusion of thermoplastic composite elements
9	Lina Herrera-Estrada	Pursuing PhD at GA Tech (MSE, MS’ 09)	Banana Fiber Composites for automotive applications
10	Danila Kaliberov	Pursuing PhD, UAB (MSE, MS’ 10)	Threaded long fiber thermoplastic composites
11	Michael Magrini	Tyndall Air Force Base (MSE, MS’11)	Impact response of long fiber and laminated thermoplastic composite materials
12	Melike Dizbay-Onat	Interdisciplinary Engineering, Pursuing PhD, UAB, Graduation Dec 2014	Carbon footprint reduction and emission absorpbtion activated carbon composites
13	Aaron Siegel	Jacobs Engineering (MSE, MS’ 12)	Energy absorbing compounded thermoplastic foams for enhanced crashworthiness
14	Peter Barfknecht	MSE, Pursuing PhD (UAB, Dec 2014)	Carbon fiber sizing and liquid molding of reactive thermoplastics
15	Nsiande Mfala	Pursuing PhD, Tuskegee University (MSE, BS’ 2010)	Nanostructured kenaf and banana fiber thermoplastic composites for automotive applications
16	Benjamin Geiger-Willis	MSE. Pursuing PhD 2015	High strain rate impact of thermoplastic composites and foams for crashworthiness

GATE fellows to date (2006-present)

23 graduate students (9 MS + 14 PhD)
- Partially or fully funded by DOE GATE
- Research dissertation/thesis focus on GATE topics
- Peer-reviewed research publications & papers

25 undergraduate students
- Work study students serve as pipeline for graduate program & GATE fellows
- Experiential learning
- 6 transitioned from undergraduate to become GATE scholars
- Participate in poster competitions and undergraduate research forums





GATE Directly Funded Students (2011-2012)

GATE – Graduate scholars

	GATE Scholar	Department and Standing	GATE Thesis / Research
1	Melike Dizbay-Onat	Interdisciplinary Engineering, Pursuing PhD	Carbon footprint reduction and emission absorption by natural fiber composites
2	Danila Kaliberov	Materials Science & Engineering, Pursuing PhD	Threaded long fiber thermoplastic composites
3	Alejandra Constante	Materials Science & Engineering, PhD	Natural fiber composites for automotive applications
4	Khongor Jaamiyana	Materials Science & Engineering, PhD	Modeling of thermoplastic pultrusion for truck frames
5	Hicham Ghossein	Interdisciplinary Engineering, PhD	Nanofiber sizing and carbon fiber integration
6	Theresa Bayush	Materials Science & Engineering, PhD	Natural fiber composites

GATE Team for Industry Support

Alejandra Constante, Theresa Bayush, Arabi Hassen, Samuel Jasper, Danila Kaliberov, Benjamin Willis, Qiuishi Wang, Ranae Wright, Peter Barfknecht,

GATE – Undergraduate scholars pipeline

	GATE Scholar	Department and Standing	GATE Research
1	William Warriner	Materials Science & Engineering, Junior	Extrusion-compression molding of long fiber thermoplastics
2	Ranae Wright	Materials Science & Engineering, Pursuing PhD, Junior	Sandwich composites with high damping and energy absorption capabilities
3	Raymond C. Solomon	Mechanical Engineering, Sophomore	Carbon fiber orientation evaluation in long fiber plaques
4	Emily Willis	Collaborating High School, Hoover High	Pull-out strength of screws from thermoplastic composite plates

GATE: Undergraduate Student Pipeline

1	Malina Panda	Ford (MSE, BS' 07)	Development of hot-melt impregnated materials
2	Daniel Kaliberov	Pursuing PhD UAB (MSE, Dec 2014)	Vibration testing of long fiber thermoplastic composites
3	Michael Entz	Pursing PhD, NC State University (BS, ME'08)	Impact analysis of laminated composites
5	V. Ameya	Eastman Chemicals (BS, CE'12)	Self reinforced polypropylene studies
6	Hadeel Abdelmajeed	BAE Systems (MSE, BS' 09)	Thermoforming processing of laminated composites
7	Walter Malone	Hanna Steels (MSE, BS'09)	Sandwich panel construction for automotive floor boards
8	Victor Long	Raytheon (MSE, BS'09)	Compression after impact of layered materials
9	David Sexton	Southern Company (MSE, BS'08)	Carbon fiber thermoplastic impregnation
10	Saptarshi Vichare	KBR Houston (BS, 08)	Carbon fiber thermoplastic impregnation
11	Benjamin Rice	Carnegie Mellon (Grad school) (MSE, BS'08)	Compression after impact of E-glass/vinyl ester composites
12	Khongor Jaamiyana	UAB MS 2013/ Intern at Owens Corning	Low velocity impact response of Carbon SMC
13	Alex Johnson	GM (CE'12)	Carbon fiber impregnation and characterization
14	Krishane Suresh	Hyundai, Dec' 12	Long fiber thermoplastics processing
15	Amber Williams	Jefferson County Baccelaureate	Pultruded composites characterization
16	Anshul Bansal	Alabama School of Fine Arts	Fuel cell demo and composite bipolar plates
17	Sueda Baldwin	GE (BS' 08)	Long fiber thermoplastic fiber orientation studies
18	William Warner	Honda of America, Dec'12	Nondestructive evaluation of defects in sandwich composites
19	Theresa Bayush	UAB Pursuing MS; Graduating Summer 13	Nanonstructured banana fibers thermoplastic composites for automotive applications
20	Benjamin Geiger-Willis	UAB Pursuing PhD, December 2015	Split Hopkinson Pressure Bar for high strain rate impact testing of materials
21	Daniel Creamer	Hannah Steel (BS, November 2012)	Lost foam casting

GATE course – Series A and B being developed as part of the 5-year plan

GATE A series courses*

(*Developed in the 2005-10 GATE period*)

- Composite Design and Manufacturing Technologies for Automotive Applications **Process Modeling and Simulation for Lightweight Materials**
- **Optimized Lightweight Material Designs for Prevention of Crash-Related Injuries**
- **Mechanical Characterization and Performance Evaluation of Advanced Lightweight Materials;**
- **Advanced Composite Mechanics**
- **Nano materials for Automotive Applications.**
- **Process Quality Engineering**
- **Nondestructive Testing & Evaluation**

GATE B series courses**

(*New courses*)

- **Carbon Fiber Technologies for Automotive**
- **Sustainable/Renewable Materials and Processing Technologies for Automotive**
- **Predictive Engineering – Integrated Process Modeling and Design in Composites & Castings**
- **Materials by Design for Heavy Trucks and Mass Transit**
- **Materials and Design for Fuel Cell and Hybrid Vehicles**
- **Modeling and Simulation for Crashworthiness**

*,** ***A GATE scholar takes at least 6 courses of the above 14. The GATE A and GATE B series courses and GATE certificate option will be make available to the industry participants as well.***

Accomplishments and Progress: GATE Courses Developed & Offered

GATE COURSES

- ☑ MSE 635/735: Advanced Composite Mechanics (Offered twice)
- ☑ MSE 634/734: Design & Mfing Technologies for Automotive Applications (Offered twice)
- ☑ MSE 667/767: Process Modeling and Simulation for Lightweight Materials (Offered twice)
- ☑ MSE 490/590: Nanomaterials for Automotive Applications (Offered twice)
- ☑ ME/MSE/CEE 690/790A: Mechanical Characterization & Performance Evaluation of Advanced Lightweight Materials (Offered twice)
- ☑ BME/MSE/CE: Optimized Lightweight Materials for Improved Protection (Summer 2011)
- ☑ MSE 433/533 Nondestructive Evaluation (Offered twice)
- ☑ MSE 614/714 Process Quality Engineering

AUTOMOTIVE CERTIFICATE (GATE Graduate Fellows)

"Automotive Certificate" issued at the department level for GATE graduate fellows who have met the requirements for a graduate degree

1. Taken at least 4 GATE courses
2. Completed a research project tied to the automotive or transportation area

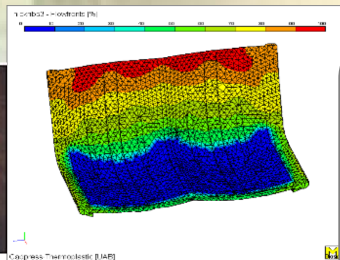
AUTOMOTIVE CERTIFICATE (Undergraduate GATE fellows)

A participation certificate is issued to undergraduate students who participate in GATE projects or work on senior design related to automotive projects.

Technical Accomplishments

Advanced Composites Technologies

Advanced Metal Casting Technologies



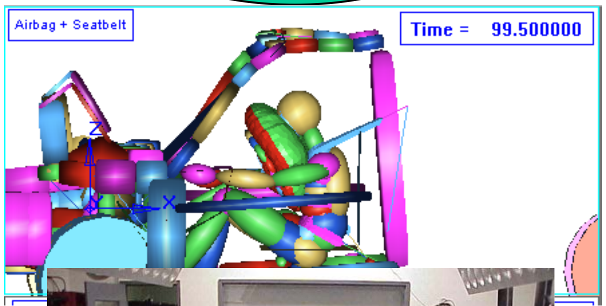
Basic science.
Design, analysis
and applications
For energy efficient
lightweight material

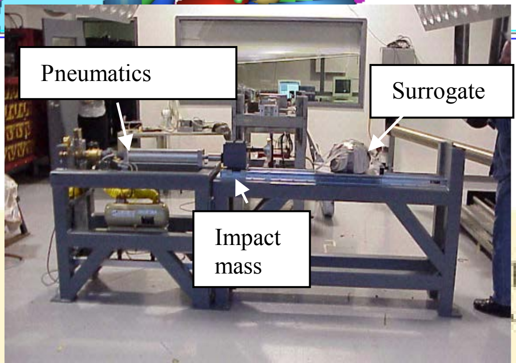
Automotive castings

Advanced materials for automotive safety

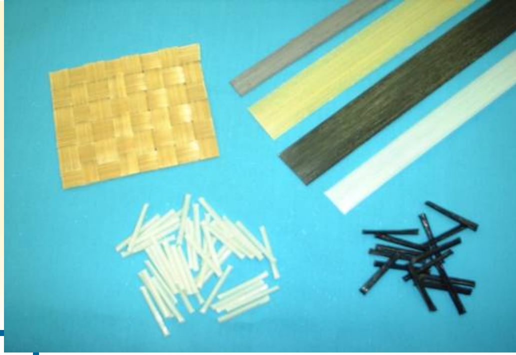
High fidelity computations for crashworthiness studies

Lightweight materials for highway safety





Materials Forms for Advanced Composites Manufacturing



Thermoplastic Matrix Composites

- **Continuous fiber reinforced thermoplastics**
  - Unidirectional tape
  - Woven prepreg
  - Other forms (braided prepreg, etc)
- **Discontinuous fiber reinforced thermoplastics**
  - Long fiber reinforced thermoplastics (LFT)
  - Short fiber filled thermoplastics

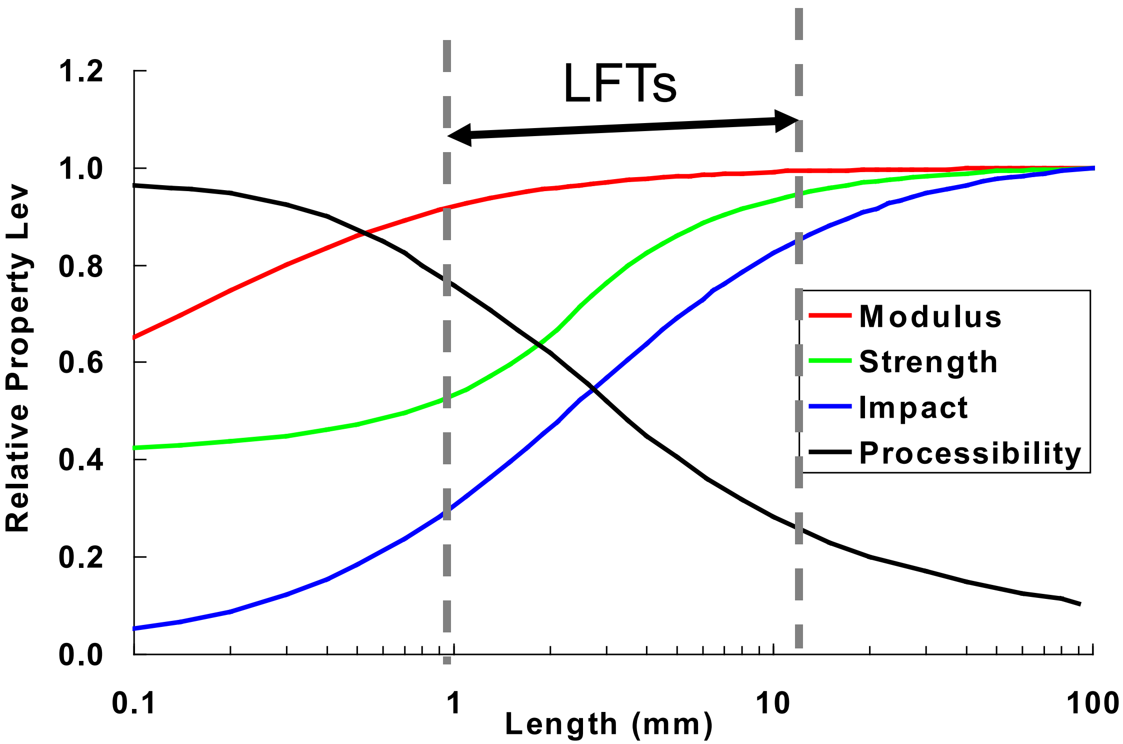
FORMING AND FINISHING OPERATIONS

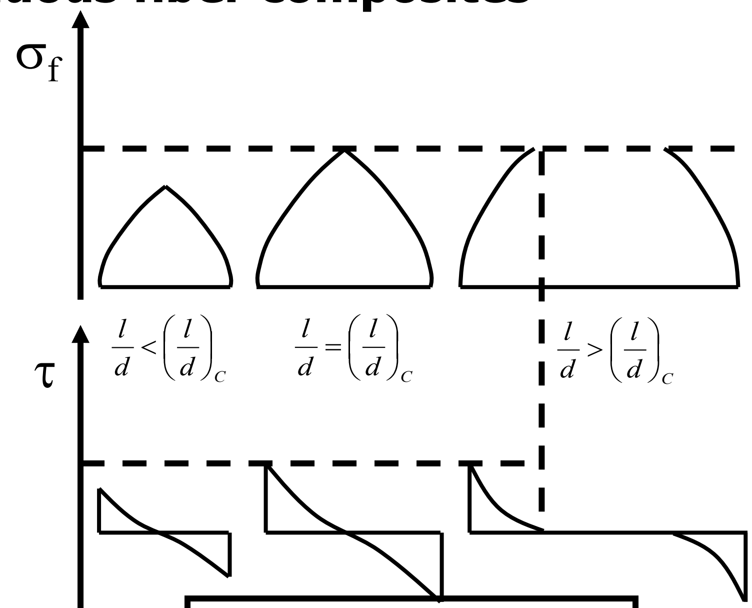
(FIBER INJECTION MOLDING, EXTRUSION, COMPRESSION MOLDING, PULTRUSION, DIAPHRAGM FORMING, THERMOFORMING, ETC…)

END PRODUCT

Long Fiber Thermoplastics (LFT)

Superior mechanical properties in comparison to short fiber composites (higher modulus, higher impact properties, higher tensile strength); elastic properties ~70-90% that of continuous fiber composites



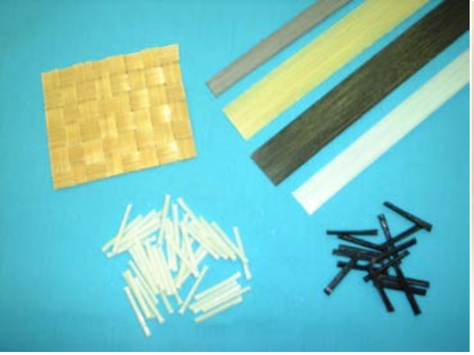


Critical length to diameter ratio:

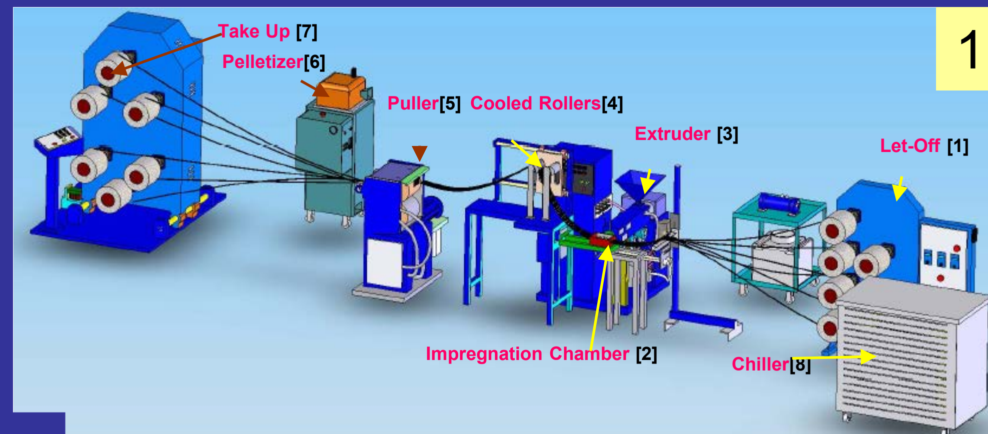
$$\left(\frac{l}{d}\right)_c = \frac{\sigma_{max}}{2\tau}$$

Source: J. Thomason and M.A. Vlug

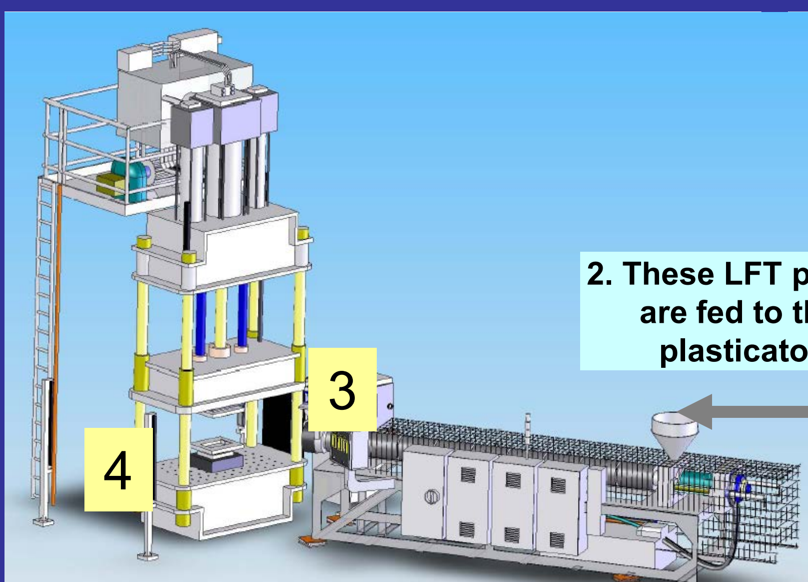
Long Fiber Thermoplastic (LFT) Composites Processing Technology



3. The polymer in the LFT pellets melts to produce a molten fiber-filled charge that is then compression molded.



1. Hot-Melt Impregnation: Dry fibers are impregnated with extruded thermoplastic polymer in a die. The rod material is chopped into long fiber pellets (of 0.5" to 1" fiber lengths)



2. These LFT pellets are fed to the plasticator

Representative molded part

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Compounding Micro-Sphere Pellets

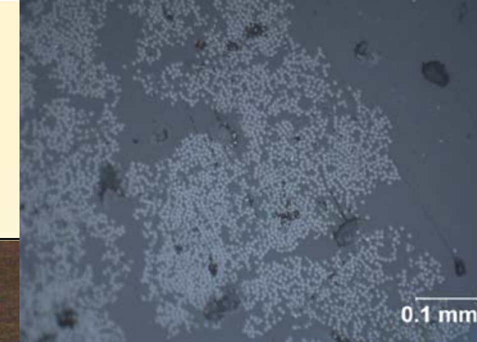
Twin Screw Extruder

Puller & Pelletizer

Main Resin Feeder

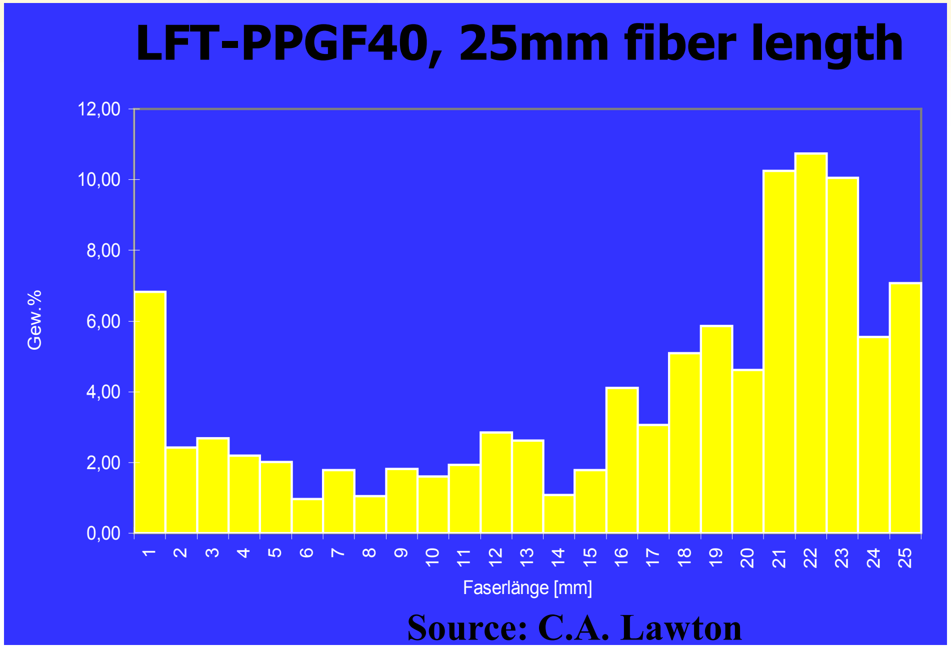
Material Transitions

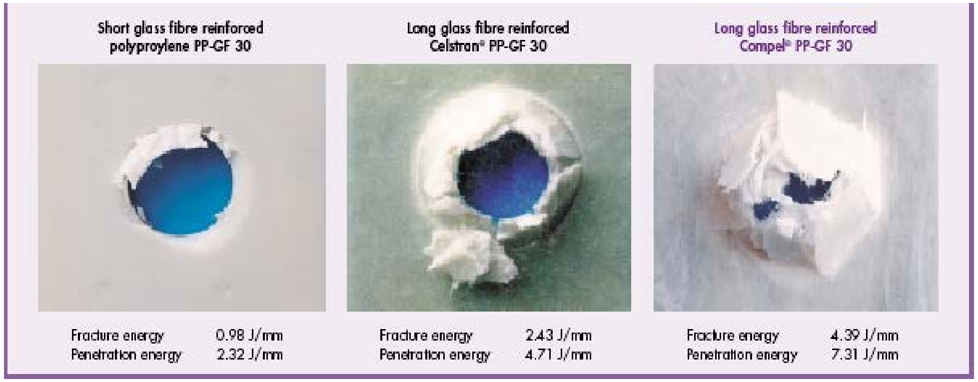
Pellets



Charge / Shot

Fiber Lengths Preserved





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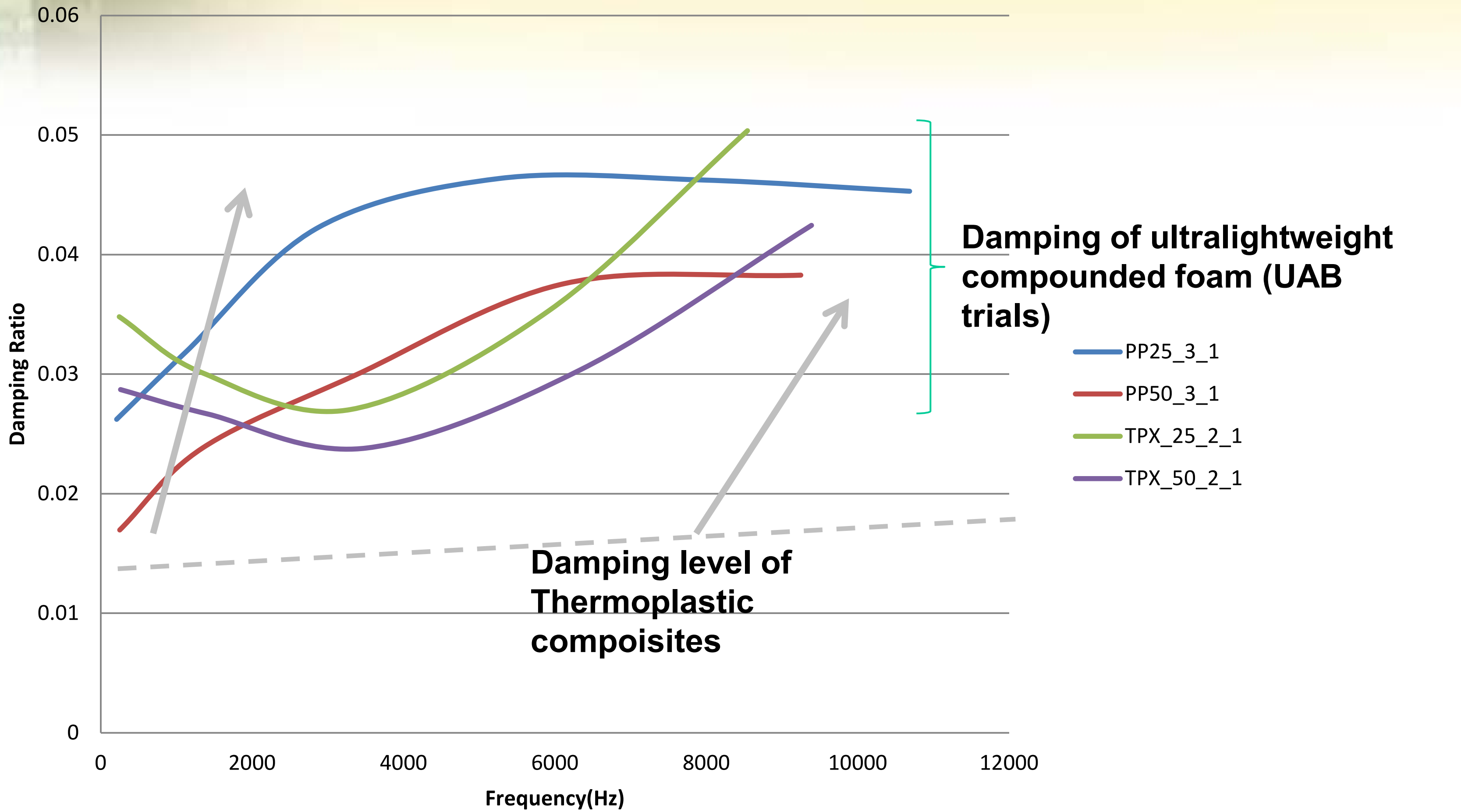
Source: Ticona

Damping enhancement possibilities by ultra lightweight compounded foam



Significant enhancement of damping capacity by the compounded foam materials. While we are in the process of quantifying between the variants, all variants show multifold increase in damping, therefore promise for enhanced crashworthiness in automotive applications

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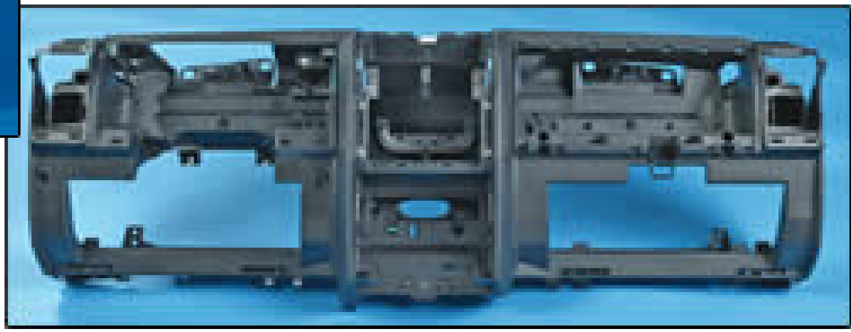
Thermoplastic Composites in Automotive & Mass transit


Injection-molded concentric slave cylinder used in the automotive industry


Headliner of the 2007 Honda Acura MDX


Long glass/PP structural duct : 2007 Dodge Nitro SUV


All-terrain vehicle (ATV) footwell

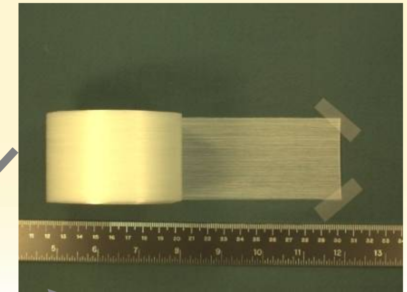

Brake sensor housing for the automotive industry

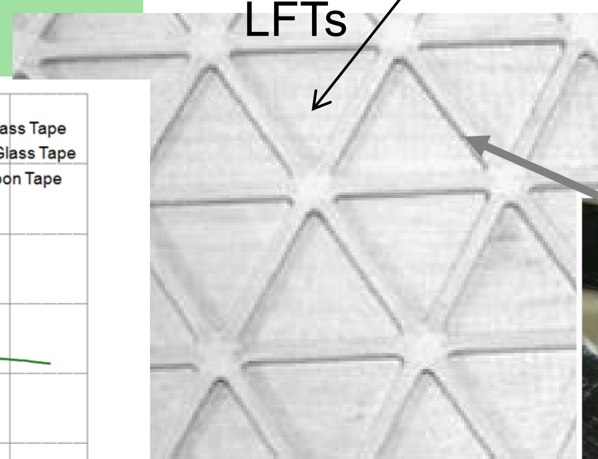

Wiper pivot housing used in automotive industry

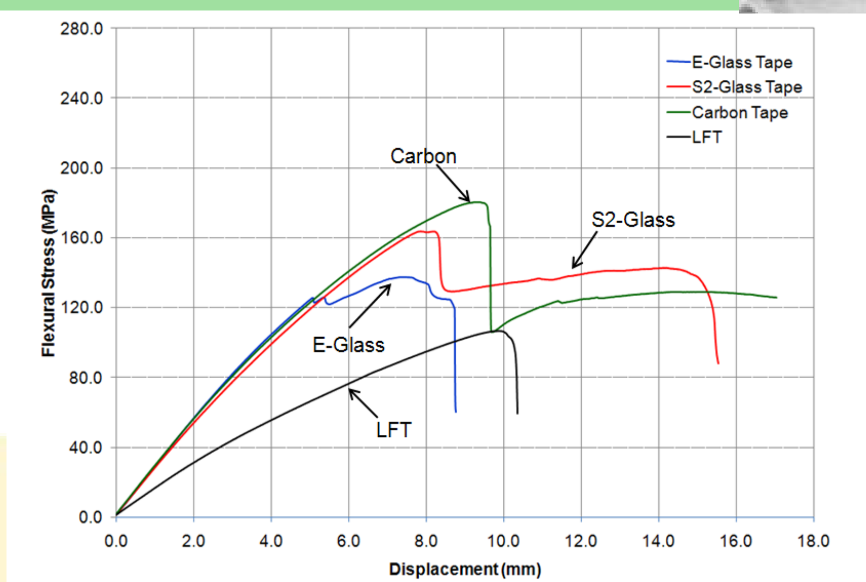
Source: Ticona

LFT Co-molded with Continuous Thermoplastic Tapes

- Co-molding LFT with pre-consolidated / continuous reinforced tape
- Local reinforcements
  - Replace traditional rib structures
  - Local tailored strength & stiffness
  - Functional integration
- Parameters influencing final properties
  - Processing
  - Bonding interface
  - Stiffness of the materials
  - Thickness ratio



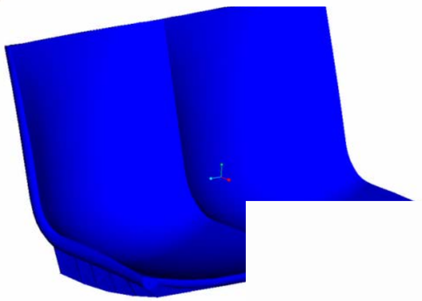




Polymer Composites, In-print, Jan 2013

Composites for Mass Transit Bus

AC Roof Cover



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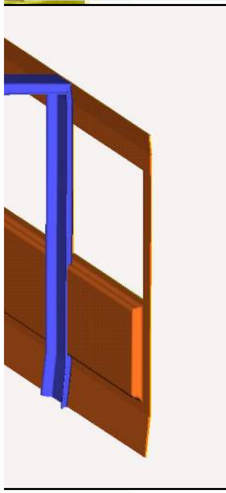

Body
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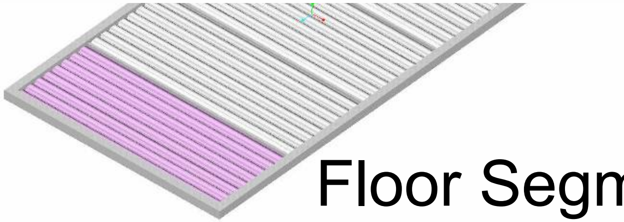
Battery Access Door



Floor Segment

GATE - Industry Leverage

GATE
GATEWAY TO THE FUTURE
GRADUATE AUTOMOTIVE TECHNOLOGY EDUCATION

MIT RCF
REENGINEERED CARBON FIBER

eSpin

PPG

NSF

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

OWENS CORNING

ZOLTEK

Composites Innovation Centre

TORAY

SIOUX
Manufacturing Corporation

DAIMLER
Daimler Trucks North America

HONDA
Honda of America Mfg., Inc.

NABI INC.

FTA U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL TRANSIT ADMINISTRATION

HYUNDAI

National Composites Center

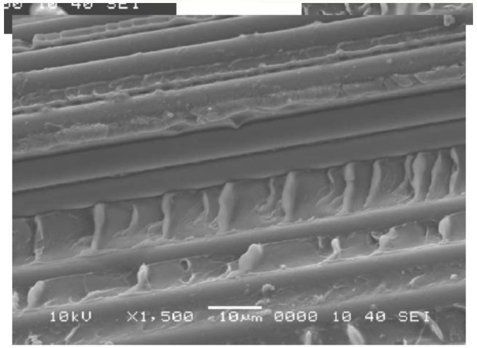
MacDon

Great Dane

polystrand

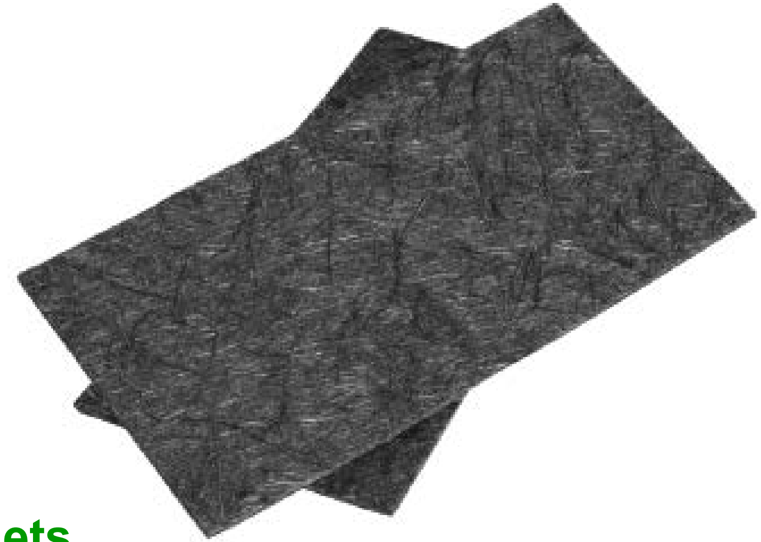
Laurel BioComposite, LLC
Clean. Green. Renewable

Representative Material Forms

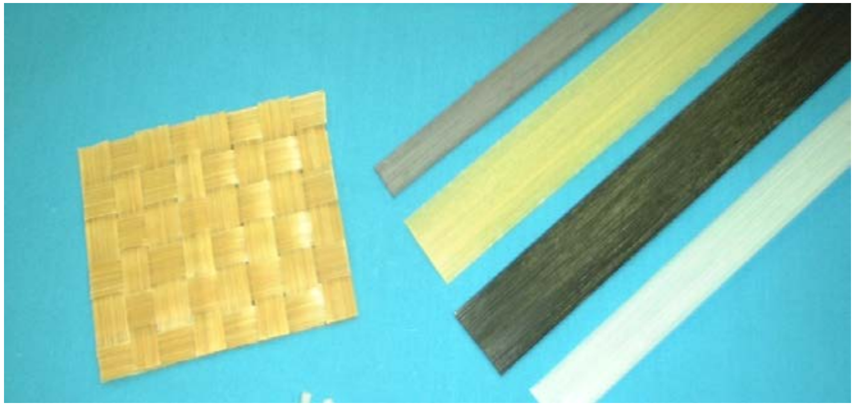


Intimate wet-out

Simple blends, hot-melt pellets



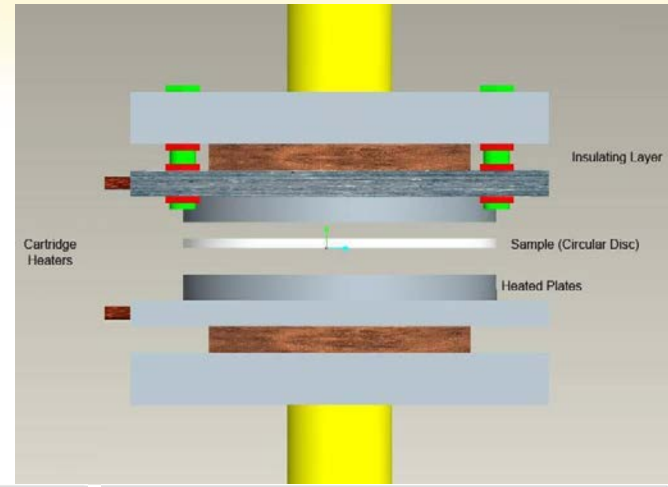
Wet-laid or roll bonded

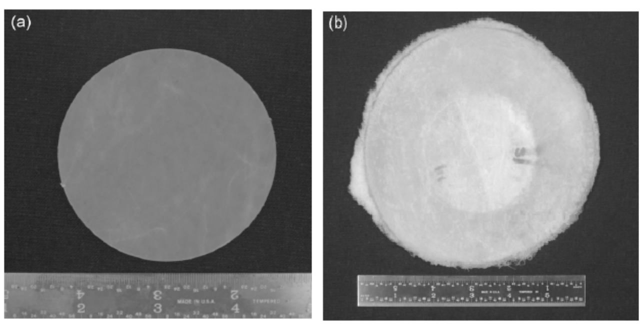


Tapes, Woven Fabrics

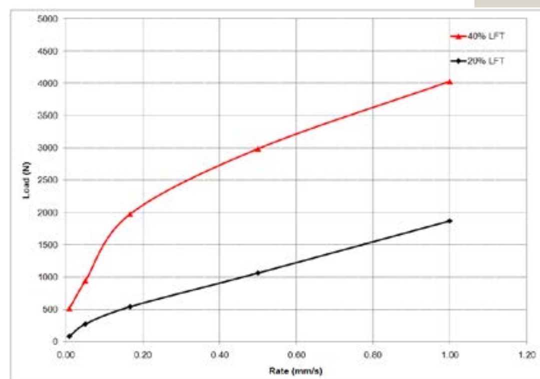
Rheological test methods for fiber filled suspensions – Long fiber thermoplastic compression molding

- Conventional rotational & capillary rheometers do not represent the rheological behavior of fiber filled polymers adequately.
- A squeeze-flow rheology approach was developed to measure squeeze force and plate separation that represents realistic compression molding conditions of long fiber thermoplastics.
- Characterization of materials with planar fiber suspension

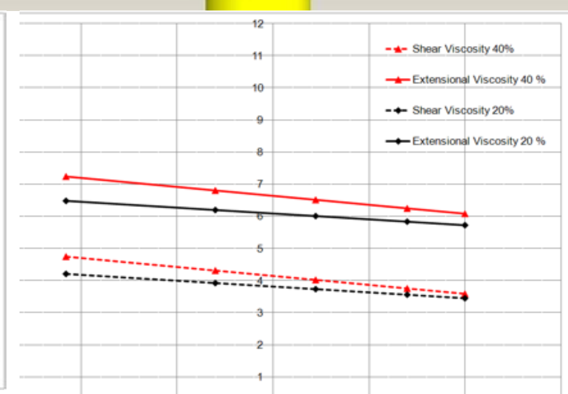




- Isotropic flow (Circular specimen remained circular under squeeze)
- Compression molding is modeled as a combination of extensional and shearing flow
- Power law Non-Newtonian Model
- Shear and extensional viscosities were determined



Load versus rate for long fiber disc specimens

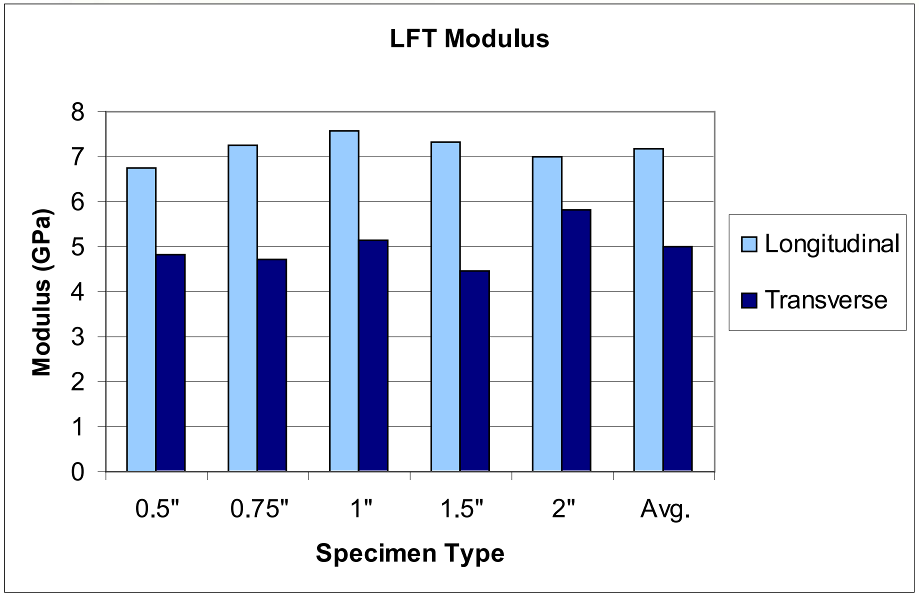


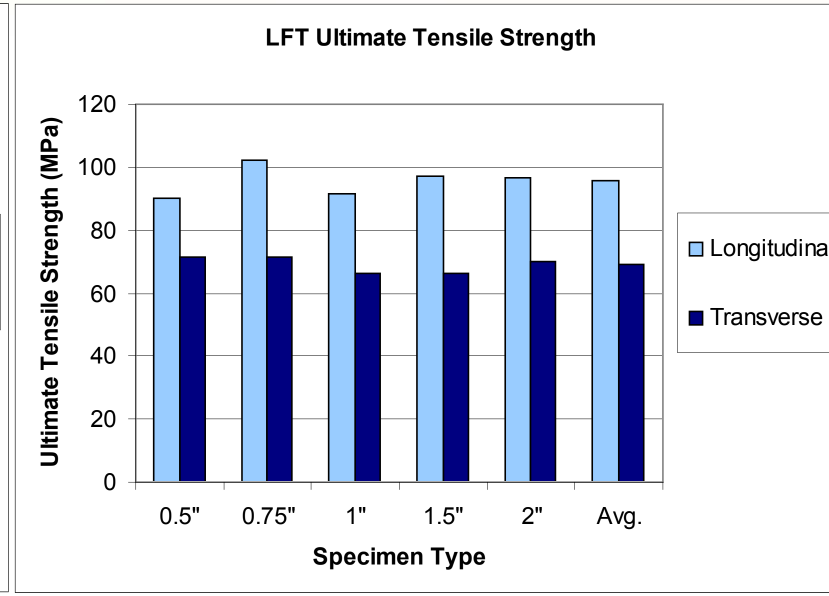
Shear & Extensional viscosity

Composites Part A: Applied Science and Manufacturing, *v 40, n 10, p 1515-1523 (2009).*

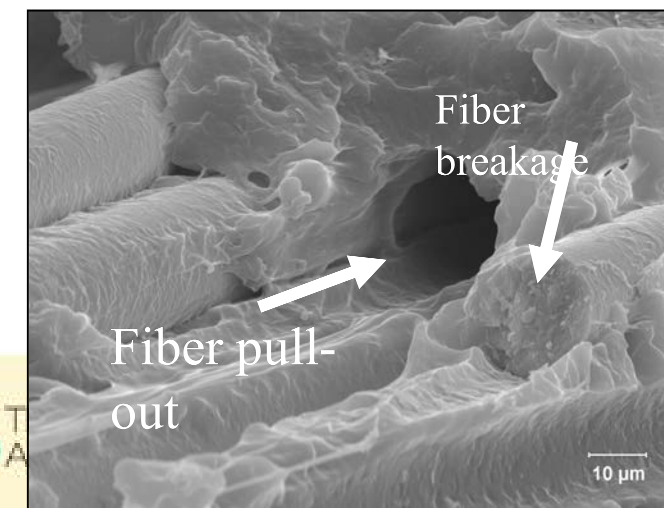
- Glass / Polypropylene - 190 °C
- Varying Fiber weight fraction of 40%, and 20%
- Constant Fiber length of ½”
- At constant mold separation of 2.30 mm

LFT Mechanical Properties – Effect of Specimen Width & Fiber Orientation



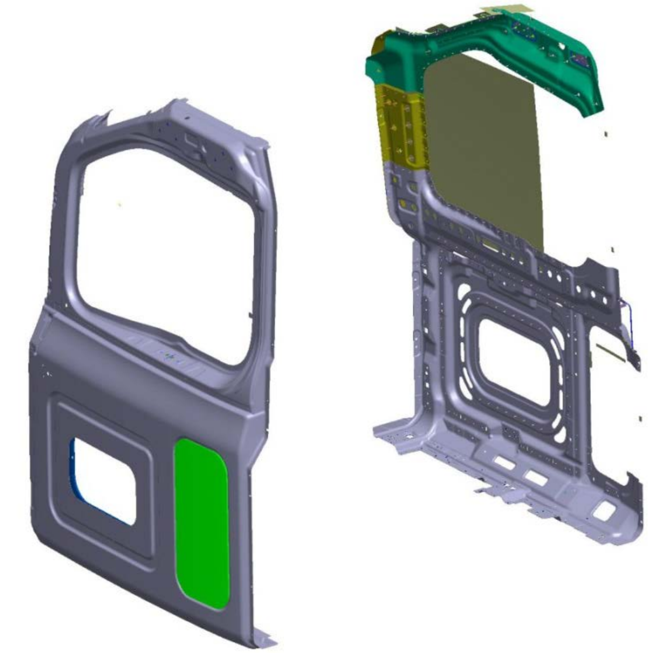


Longitudinal orientation of LFT panels showed higher modulus and UTS due to fiber alignment. Minimal effect of sample width on properties.



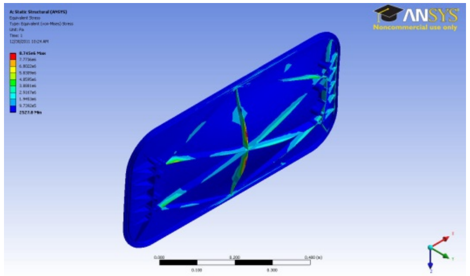
Composite Structures, 2008

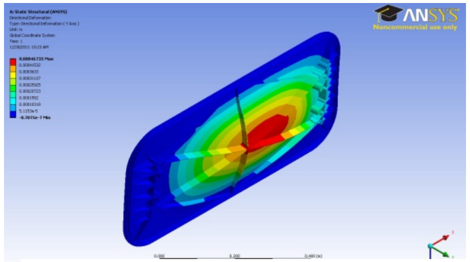
Composite Door for Truck



LFT Extrusion-compression molded part–
Material selection – Weight & performance optimization

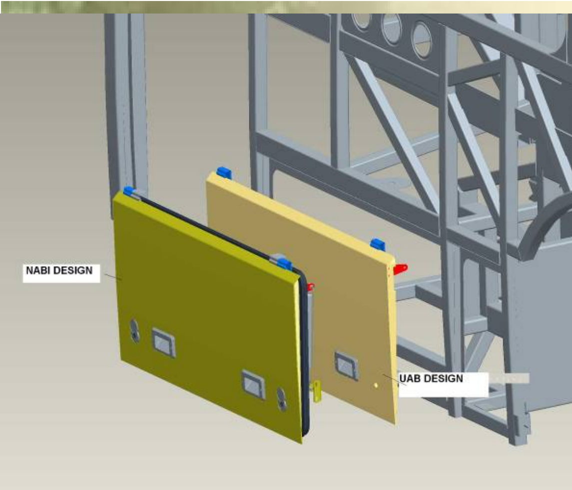
Design Variable		Material	Max deflection (mm)	Mass (kg)	Weight savings
Aluminum design (baseline)		Aluminum	0.23	2.5	--
Panel (mm)	Rib (mm)	Composite Design			
3	2	40 wt% glass-Nylon66	0.35	1.78	28.7%
4	2	40 wt% glass-Nylon66	0.33	2.19	12.5%
4	3	40 wt% glass-Nylon66	0.30	2.26	9.7%
3	2	40 wt% glass-Nylon66 + 40wt%carbon-Nylon66 hybrid	**0.23**	1.72	**31.1%**
4	2	40 wt% glass-Nylon66 + 40wt%carbon-Nylon66 hybrid	**0.21**	2.11	**15.5%**
4	3	40 wt% glass-Nylon66 + 40wt%carbon-Nylon66 hybrid	**0.19**	2.18	**12.8%**

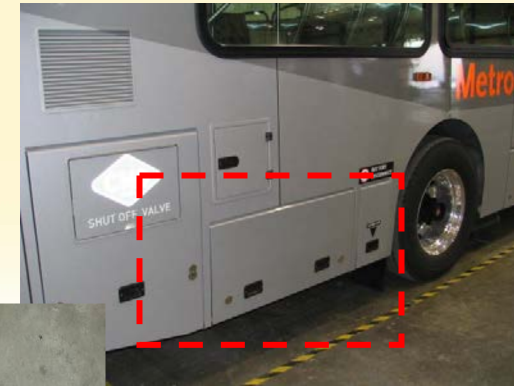


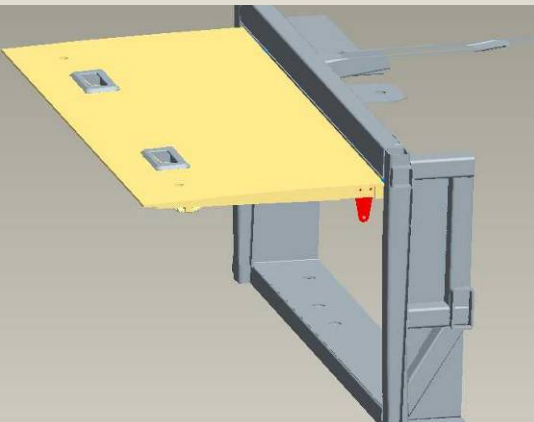


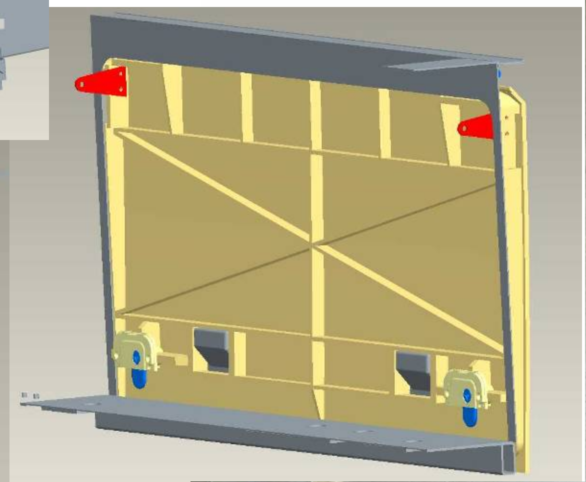
- Maximum stress: 8.7 MPa
- Max deflection: 0.47 mm
- Mass: 1.84 kg
- Weight saving: 26.4%

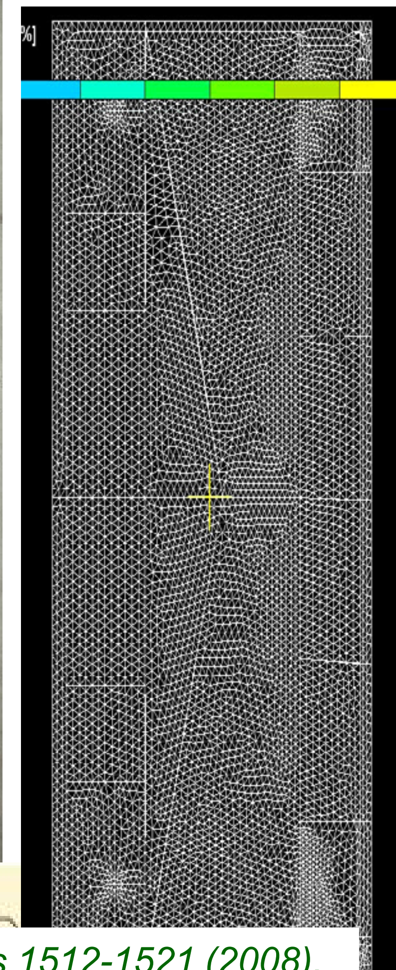
Access Doors (Passenger and Military Vehicles)

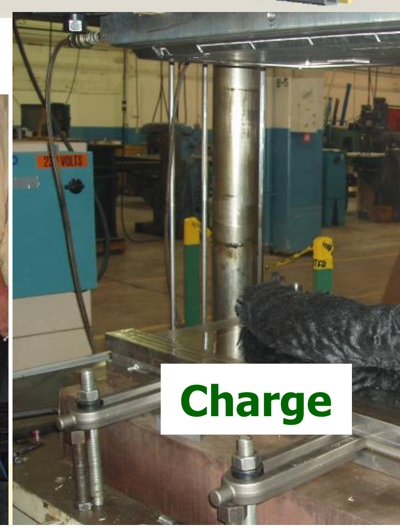










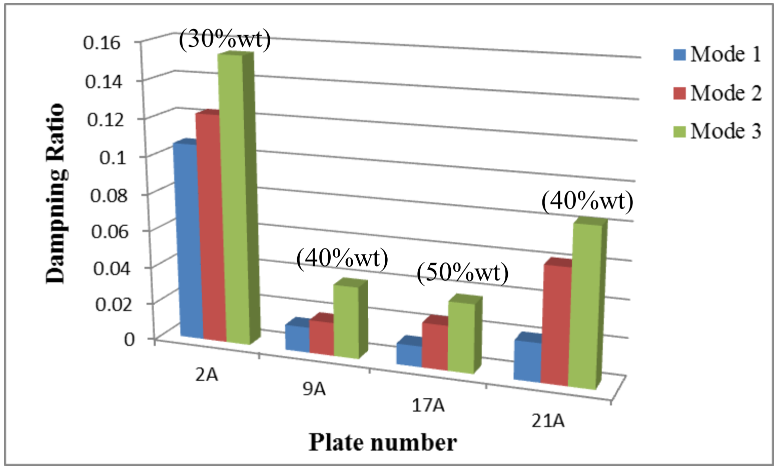


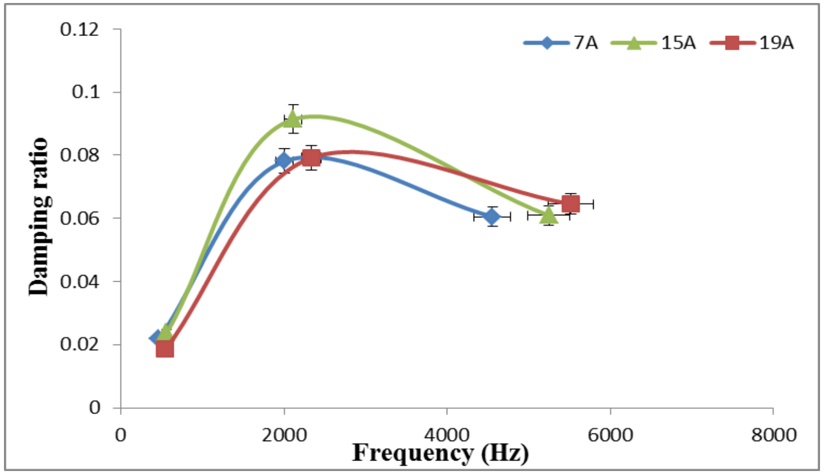
Composites Part A: Applied Science and Manufacturing, *Volume 39, Issue 9, Pages 1512-1521 (2008).*

GATE Collaboration with MIT-RCF

MIT-LLC Project Planning and Execution Document (PPED) for GATE Program at UAB

- **Project Name:** RCF-LFT: effects of fiber length, resin viscosity, and mixing
- **Project Partner:** Materials Innovation Technologies LLC, Fletcher, NC
- **Project Monitor:** Dr. Mark Janney
- **Brief Project Description:** Define the roles played by fiber length, resin viscosity, and methods of mixing in determining the mechanical properties of compression molded long fiber thermoplastic (LFT) composites made from recycled carbon fiber. Properties can be directly compared with RCF-PET Co-DEP properties form MIT-LLC DOE III project.



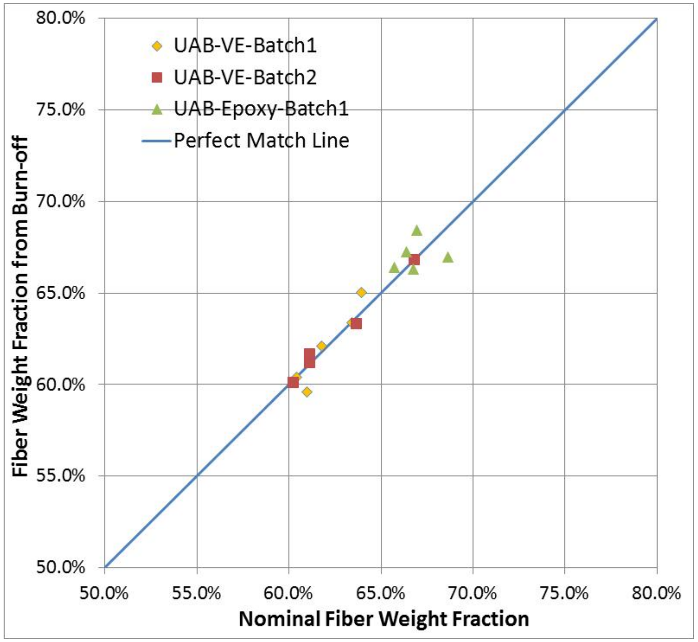


MITRCF
REENGINEERED CARBON FIBER

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

New Method for Carbon Fiber Content Determination in Carbon Fiber composites

- Carbon fiber content plays a critical role in determining the properties of composites.
- ASTM D3171 - Standard Test Methods for Constituent Content of Composite Materials is currently used for measuring carbon fiber content.
- A new burn-off method (different from the procedures specified in ASTM D3171) is developed that accurately measures the carbon fiber content (being reviewed by ASTM sub-committee).
- Non-hazardous and does not require long digestion time



Comparison between nominal and measured carbon fiber content from burn-off method

Sample	M total (g)	M carbon fiber(g)	M residual (g)	W% nominal	W% (burn-off result)	Deviation
1	2.142	1.43	1.462	66.76%	66.28%	-0.48%
2	1.971	1.32	1.385	66.97%	68.42%	1.45%
3	1.734	1.19	1.195	68.63%	66.98%	-1.65%
4	2.145	1.41	1.466	65.73%	66.38%	0.65%
5	1.747	1.16	1.208	66.40%	67.23%	0.83%
Neat Epoxy	5.367	--	0.314	--	--	--

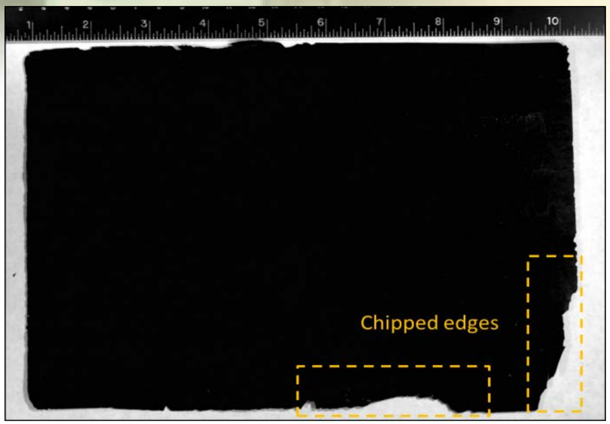
Composite sample before burn-off

Residue from composite sample after burn-off

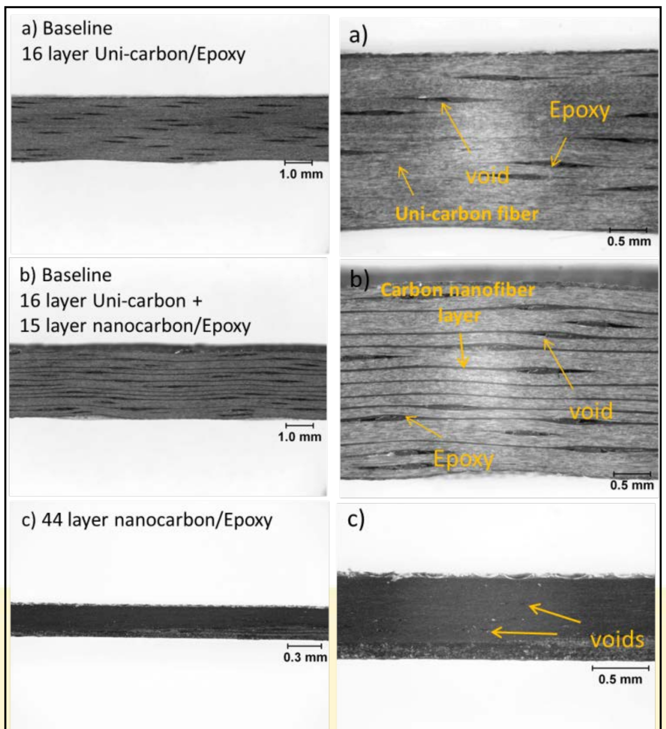
Residue from neat resin after burn-off

Continuous Large Scale Carbon Nanofibers Composites

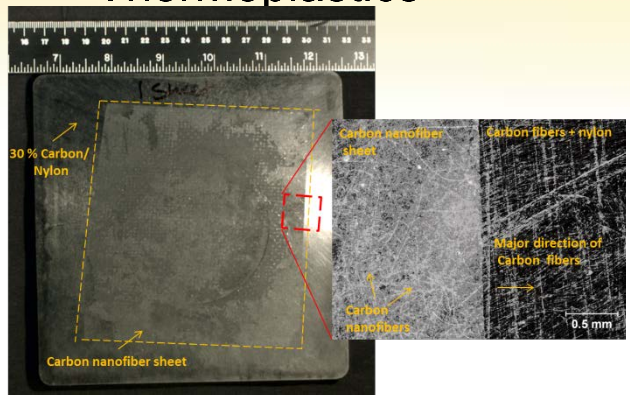
Thermosets



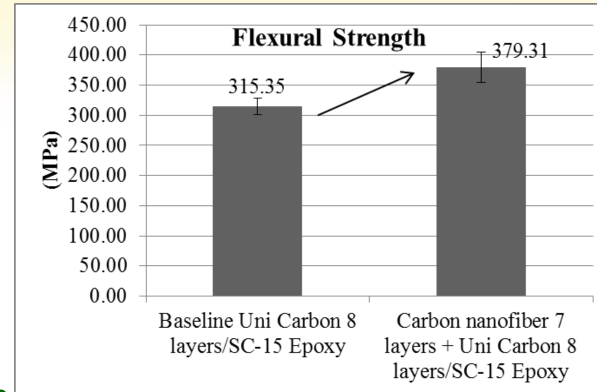
44 Layer nanocarbon/Epoxy composite

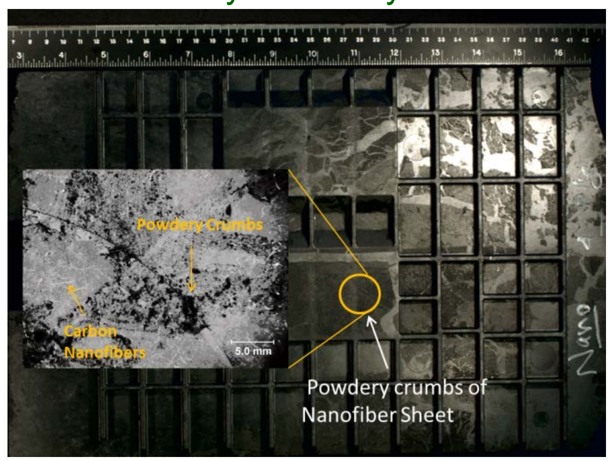


Thermoplastics

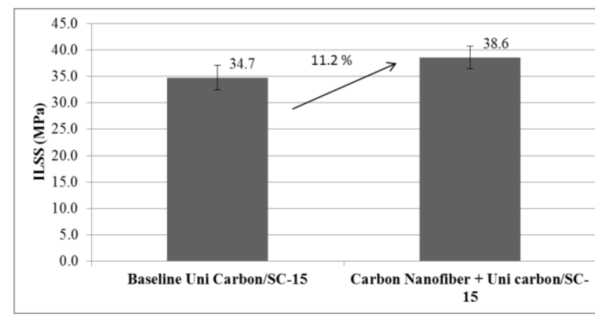


30% carbon/nylon + 1 layer nanocarbon



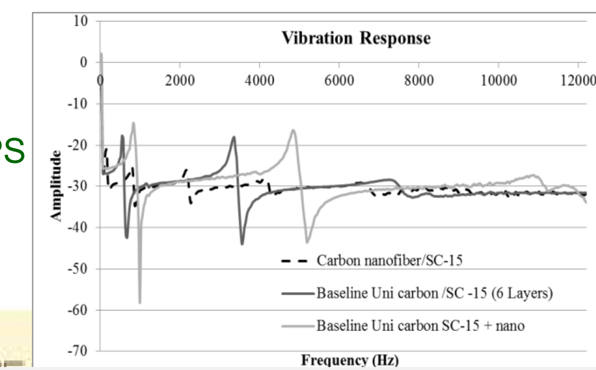


Electronic panel- recycled carbon/ PPS + 4 layers nanocarbon



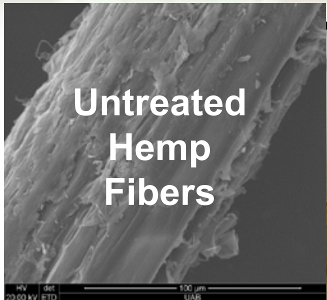
Potential added capabilities

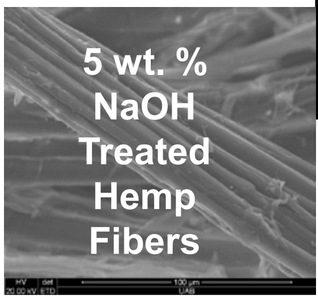
- Static charge dissipation
- Heat dissipation
- Electro magnetic shielding
- Vibration damping

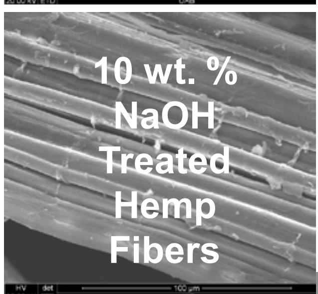


Nano carbon layers increased stiffness and damping

Compounding of Hemp Fiber/PP and Extrusion-Compression Molding







Hemp Fibers

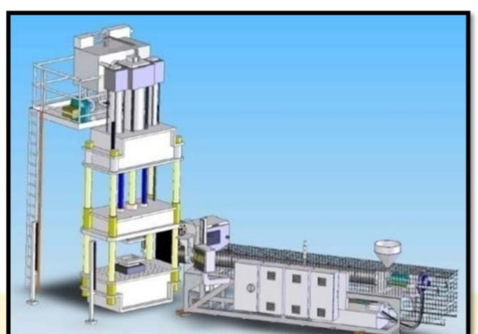
+

Polypropylene

Twin Screw Extruder

Die redesigned for minimum shear producing compounded Tape Form

Chopped tape

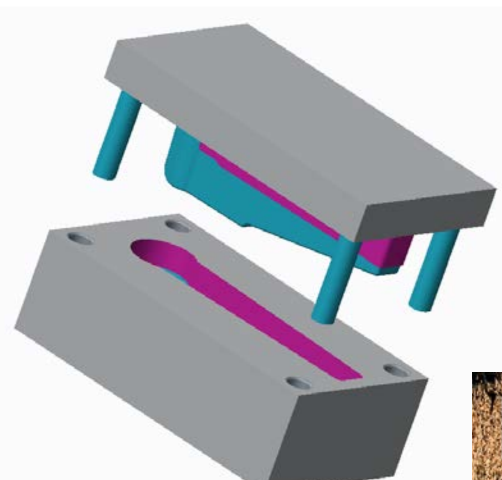


ECM Cell

6"x6" ECM plates

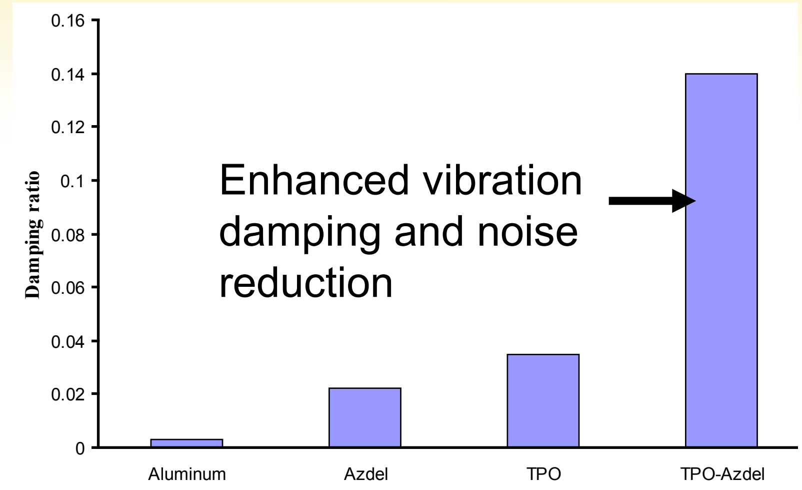
MacDon – Duct Screen Cleaner

- Develop compounding and processing parameters for achieving maximum fiber aspect ratio of hemp fiber.
- Investigate fiber treatments and coupling agents for enhanced fiber matrix interface
- Evaluate PP/hemp fiber composite for manufacture of duct screen cleaner for MacDon tractor application; mechanical testing, thermal characterization, UV stability, hydrothermal aging.
- Redesign duct screen cleaner for extrusion-compression molding (ECM).
- Design tooling for proto-typing of part / Prototype and test.
- Volume 650 parts per year.

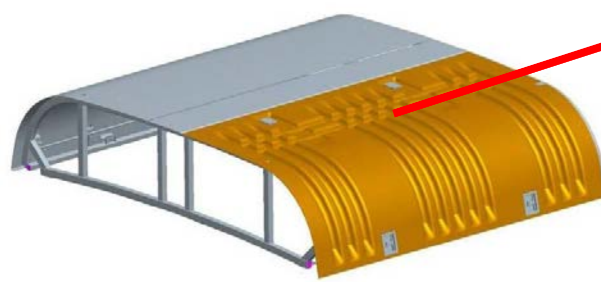


MacDon

40% lighter Roof Door for Vehicle; Weight reduction - 450 lbs



- Thermoplastic composite technology demonstrated on a large scale part; Innovative utilization of synergistic materials
- Form-fit function; including existing hardware
- 39% weight reduction & 77% less free standing deformation
- Order of magnitude improved vibration damping Lowering of Center of Gravity. The BRT bus has ~8 roof doors per segment –potential weight savings 450 lbs
- Cost effective manufacturing – reduced assembly steps
- Generic to military, light rail, trucks and other vehicles



Materials & Design, *Volume 30, Issue 4, Pages 983-991 (2009).*

Recycled Materials for Transportation

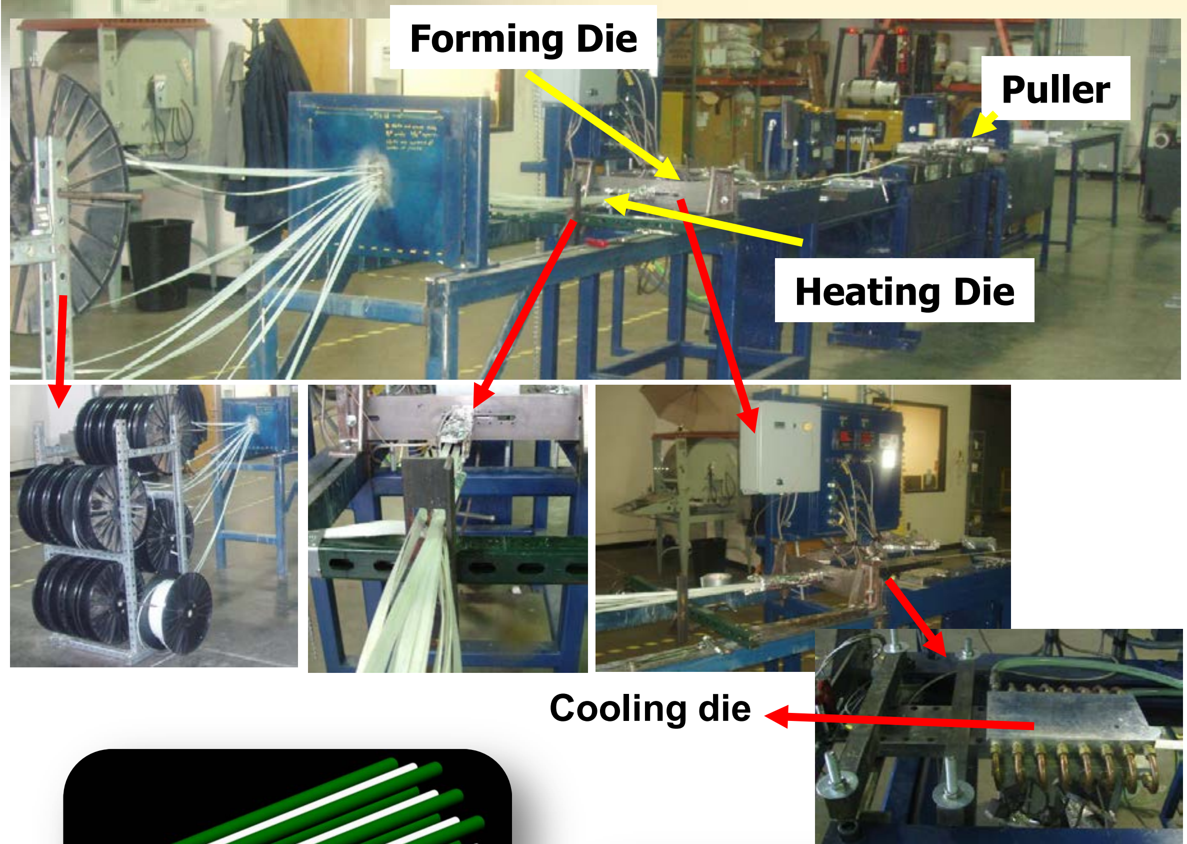
Great Dane

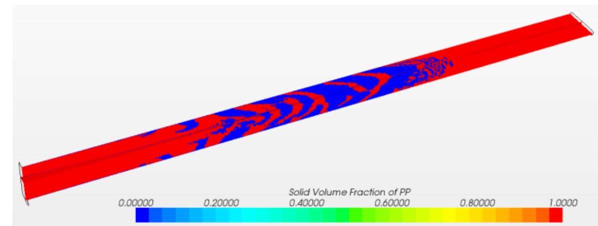
polystrand

SPE ACCE, Troy, Sep 2012

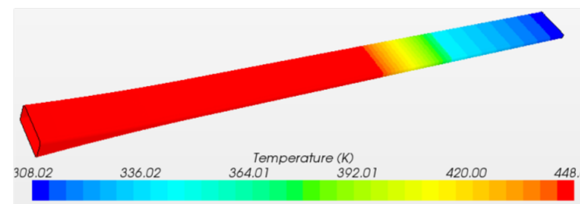
Thermoplastic Pultrusion

- Line Speed
- Temperature
- Number of Tows
- Pulling Force



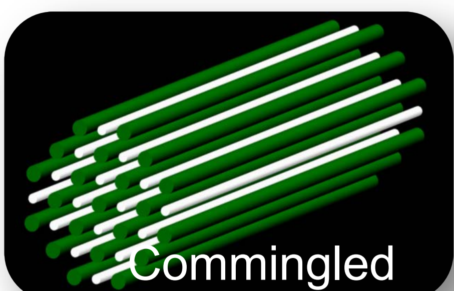


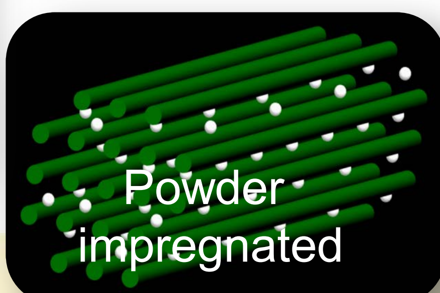
Phase change simulation at the highest pull speed and lowest die temperature.



Fluid flow simulation as a function of die temperature

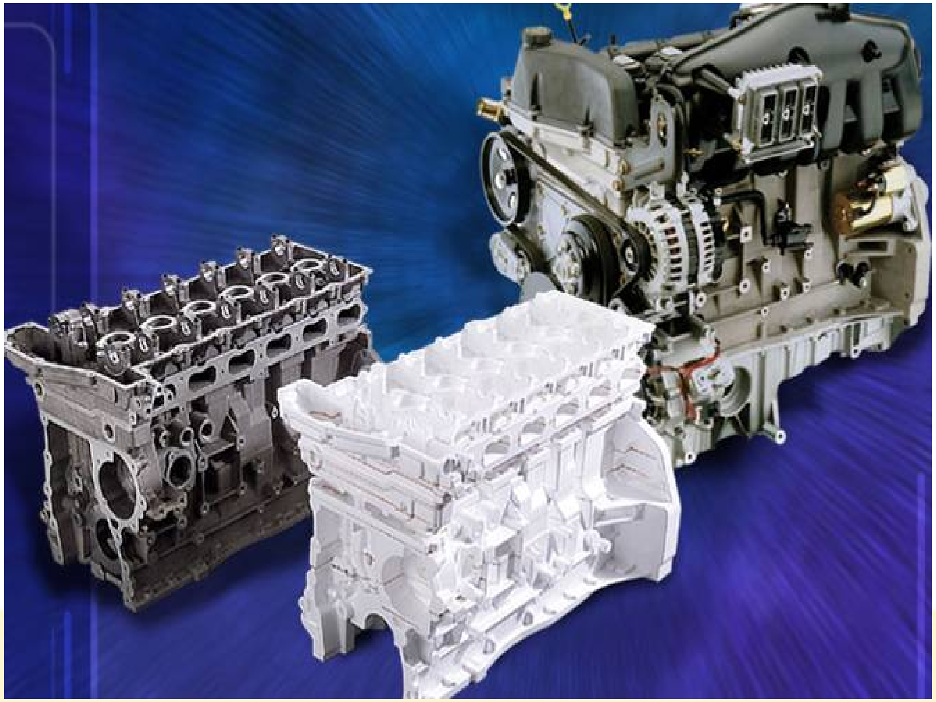
- **Hot-melt impregnated**
- **Self-reinforced**
- **Hybrids**
- **Pultruded tapes**

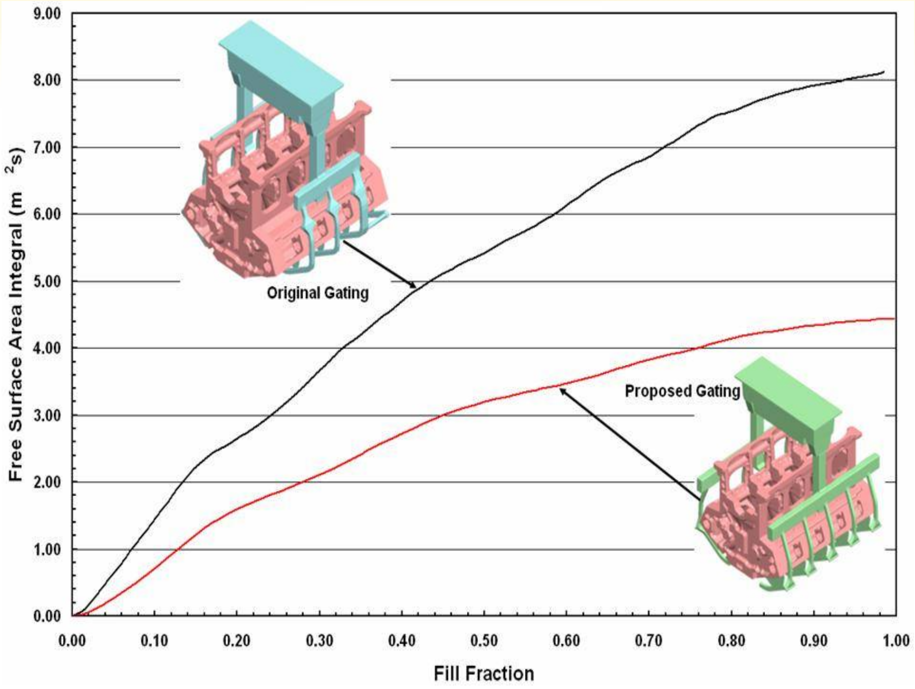




Aluminum Castings for Automotive Applications

GATE students getting experience on evaporative pattern (lost foam) metals casting process to produce complex aluminum castings



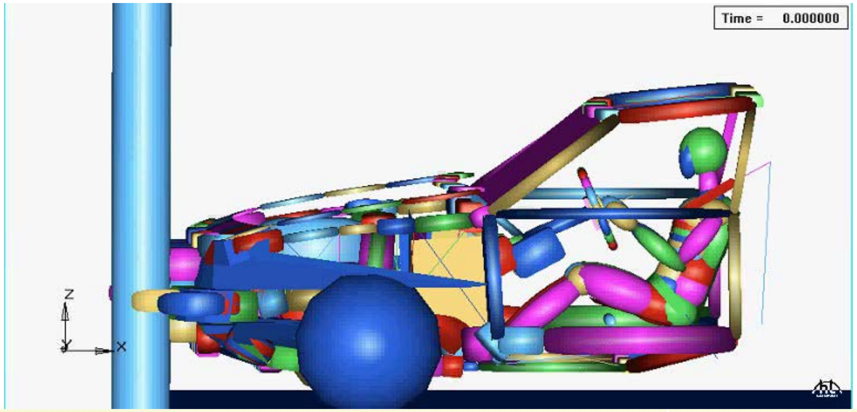


Modeling of flow during mold filling for engine block castings has led to a 45% reduction in casting defects.

Crash modeling and Injury Biomechanics

Multi-Body Dynamics

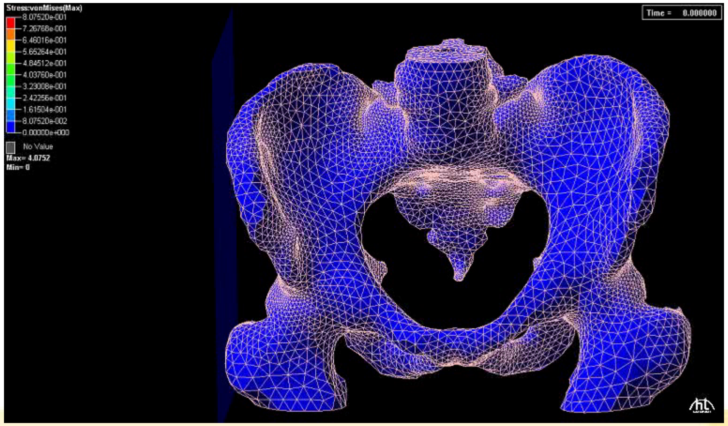
- Multi-body system comprised of rigid and/or flexible bodies
  - Joined together by kinematic joints
  - Acted on by forces
  - Systematic and efficient algorithms for governing equations of motion
- Commercial codes : MADYMO, ADAMS, DADS, etc.



MADYMO simulation :
A vehicle with dummy impact to a pole

Finite Element Methods

- Can be applied to all of engineering fields
  - Dynamic solution of structural system
  - Solve governing equilibrium equation for finite element discretized in space
  - A variety of material constitutive models
- Commercial codes : LS-DYNA, PAM-CRASH, RADIOSS, etc.



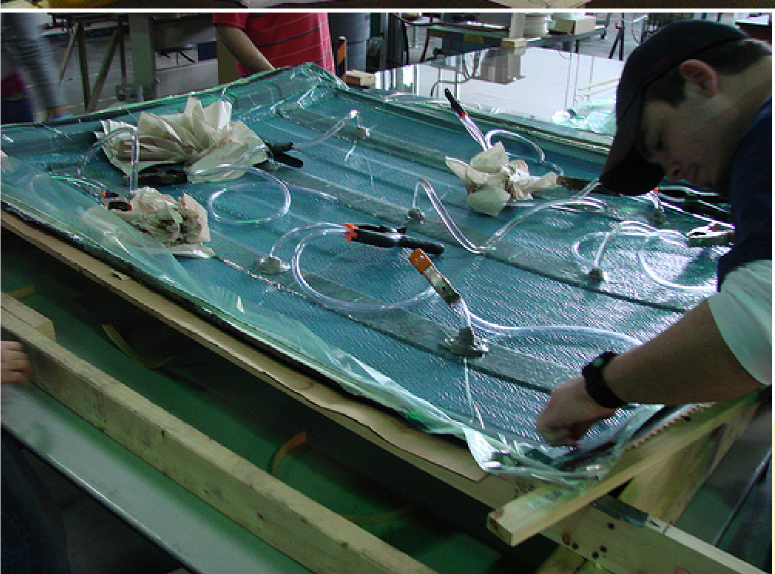
LS-DYNA simulation :
Side impact of a human pelvis

Interactions with DOE Oak Ridge National Laboratory (ORNL) and Professional Societies

- Visits to ORNL – Presentation at Southern Policy Board meeting – May 31, 2012 at ORNL
- Student use of facility through Oak Ridge University User Agreements
- Southeastern Automotive Alliance Consortium – UAB partner with Oak Ridge and National Transportation Research Center (NTRC)
- Utilization of high rate testing capability at Oak Ridge for material property evaluation at high strain rates
- ORNL talks at Alabama Composites Conference, June 2013.
- SPE Automotive Composites Conference – Organizing Committee
- SAMPE – Aerospace Composites with Automotive Efficiency workshop, SAMPE Wichita

Automotive OEM interactions

Body in-white (Honda of America, Lincoln, Alabama plant)



GATE senior design students – Zack Snyder, Rosemary Sacris, John McKinney and Hadeel Abdelmajeed

GATE students working on Industrial scale facilities - Training

Theresa Bayush (MS candidate) and Melike Onat (PhD candidate) working on natural fiber extrusion

Alejandra Constante (PhD candidate) and Samuel Jasper (PhD candidate) working on composite beams

Lightweighting Vehicles

inside manufacturing

THERMOPLASTIC COMPOSITES LIGHTEN TRANSIT BUS

Low-pressure forming processes and low-density, long fiber-reinforced thermoplastic come together to cut weight of aluminum transit bus roof air conditioning door by 40 percent.

Composites material suppliers and molders have spent many years developing and producing lightweight components for automobiles and heavy trucks, aimed at improving fuel efficiency and cost. During this period, much less attention has been devoted to mass transit applications for composites. But that is changing, as transit equipment manufacturers and governments recognize the opportunities to reduce fuel consumption and road wear, particularly for buses.

North American Bus Industries' (NABI) 60-BRT is a common articulated bus for public transport in major cities. A number of the auxiliary systems, including the air conditioning, are housed on the roof of the bus under access doors similar to that trialed in the UAB/NCC project.

Transit authorities in New Jersey, for example, have requested bids for new buses that weigh 5,000 lb/2,270 kg less than current models in use, says Uday Vaidya, director of the Engineering Plastics and Composites Laboratory at the University of Alabama at Birmingham (UAB). Vaidya and his colleagues Sellvum Pillay and Haibin Ning, in collaboration with the National Composite Center (NCC, Kettering, Ohio) and other partners, have recently completed a five-year effort, funded by the U.S. Department of Transportation, to demonstrate how buses can be made lighter using composites.

A key entity in the contracted effort was North American Bus Industries Inc. (NABI, Anniston, Ala.), a major producer of heavy-duty diesel, compressed natural gas (CNG), liquefied natural gas (LNG) and hybrid electrically powered buses. NABI offers standard-floor and low-floor transit buses, including 60-ft/18.2m articulated versions. In 2001, NABI also offered the first bus with an all-composite body (see "Learn More," p. 47).

For this program, NABI provided the platforms from which the UAB/NCC team selected components for its series of demonstrations. In the program's first four years, composite bus seats, floor and frame sections, body panels and a battery box door were produced. For the culminating project, an aluminum door/cover for the roof-mounted air conditioning system was selected for conversion. The net result is an innovative hybrid: an unreinforced thermoplastic outer skin, made using low-cost thermoforming technology, backed with a structural, low-density thermoplastic composite inner panel produced by low-pressure compression molding. The finished product meets or exceeds all requirements for fit, form and function, exhibiting greater stiffness, improved vibration damping and a mass reduction of nearly 40 percent compared to the aluminum production part.

INITIAL TRIAL WITH UNREINFORCED TPO

The air conditioning cover doors on the NABI 60-BRT (see "Learn More") are part of a series of rooftop doors that give access to the heating, ventilation and air conditioning (HVAC) equipment. Other doors provide access to natural gas tanks and other systems. The existing production door is approximately 4 ft wide and 6 ft long (1.22m by 1.83m). Weighing 46.2 lb/21 kg, the door

- Lightweight Materials – *Composites Technology Magazine*
- *JEC Composites* magazine, Europe

ALABAMA COMPOSITES CONFERENCE (ACC 2013)

June 18-20, 2013

Engineered Composites Revolutionize–

Defense, Power, Energy, Transportation, Infrastructure & Emerging Applications

Alys Stephens Center, Birmingham, Alabama

www.uab.edu/composites/acc2013

June 19-20th – Main Conference
- 30 Invited talks
- 40 exhibitors
- 50 student posters

June 18th - 3 workshops
- Managing corrosion with FRP
- Design and modeling of composites
- Recycling and green technologies

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Summary of Progress towards GATE Goals and Objectives (Sep 2011-May 2013)

- ✓ Support 3 graduate students/year - 5 *graduate students have been supported in current GATE cycle*
- ✓ Support 4 undergraduates each year – 6 *undergraduates have been in current GATE cycle*
- ✓ Develop and offer two new automotive related courses per year to impact 20 to 30 students per year – *7 GATE courses have been developed with a total enrollment of 130 students; Frontiers of Automotive Materials was developed in Summer 2012*
- ✓ Influence at least 30 students per year through hands-on workshops – *to date 60+ students have participated in the GATE Workshops*
- ✓ DOE relevant Industry collaborations– *various industry collaborations have been developed and case studies presented in this brief.*
- ✓ GATE scholars are being employed in advanced materials and manufacturing fields.

Summary

- Selective insertion of cost-effective, lighter, high performing, mass produced composite parts for automotive and transportation.
- Next generation work-force development
- Materials and process innovations
- Applications developed ready for commercialization.
- The applications developed are generic for marine, aerospace, medium/heavy vehicles and energy sector.