GATE Center of Excellence at UAB in Lightweight Materials for Automotive Applications

Uday Vaidya (Principal Investigator) & J. Barry Andrews (Project Director)
University of Alabama at Birmingham (UAB), Birmingham, Alabama

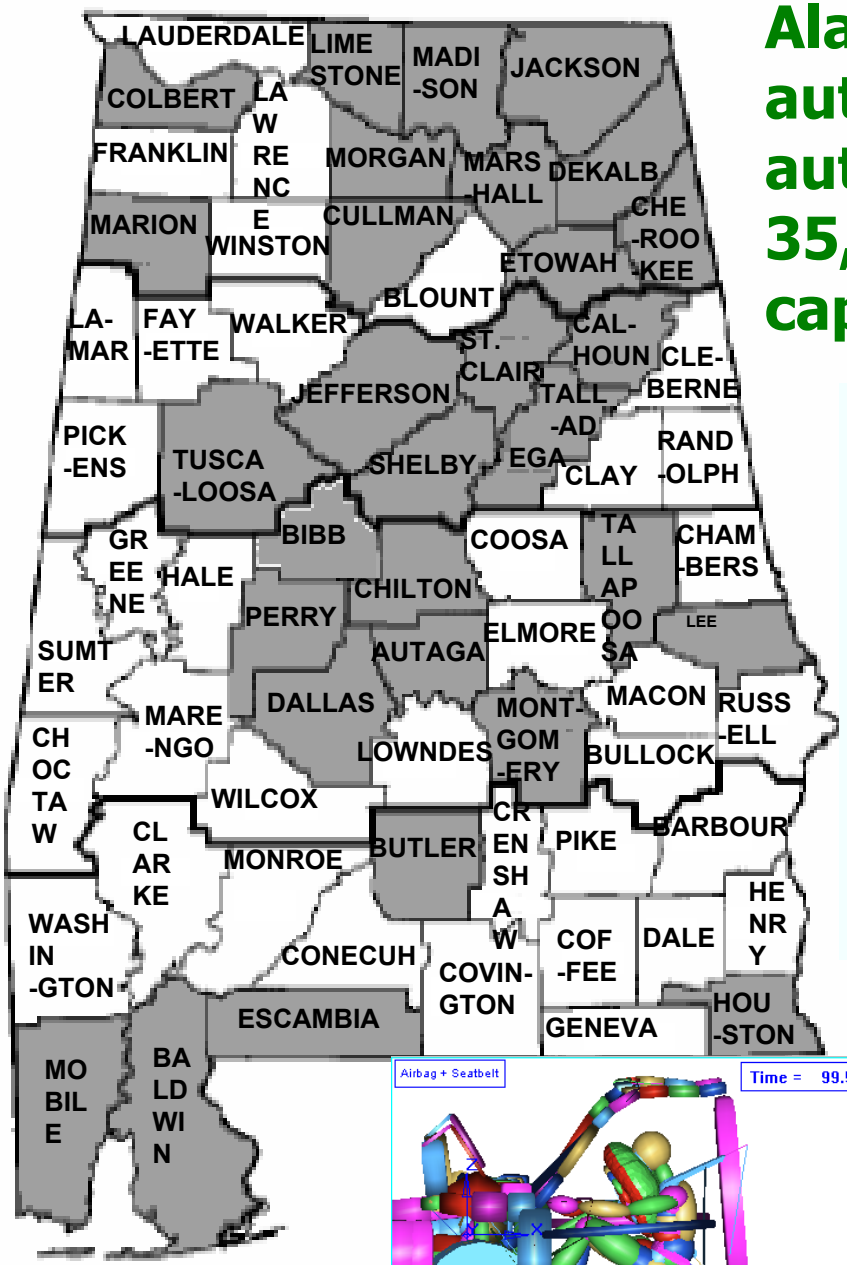
May 2009

Project ID: ti_10_vaidya
Program Manager: Dr. Samuel Taylor

This presentation does not contain any proprietary or confidential information

Automotive Industry Impact in the State of Alabama

DOE Merit Review
May 2009



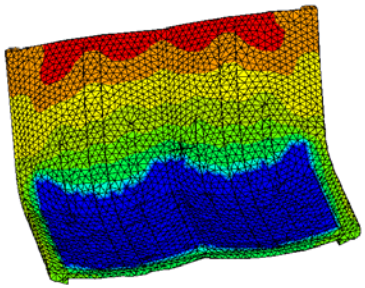
Alabama has a rapidly growing automotive industry. Since 1993 the automotive sector has created more than 35,000 new jobs and $6.4 billion in capital investment in Alabama.

The UAB GATE center is focused on training students in advanced lightweight materials and manufacturing technologies. Recent developments in low-cost composite materials and lightweight castings and fabrication technologies offer excellent potential for 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

Structure of the UAB GATE Center

UAB Materials Science & Engineering

- Advanced lightweight composite materials for vehicles
- Automotive Castings

UAB Civil & Environmental Engineering

Lightweight materials for energy absorbing guard rails and bridge repair/retrofit

UAB Biomedical Engineering

Crash & injury studies, Studies for protection using lightweight advanced materials

UAB Mechanical Engineering

High fidelity modeling & simulation of crashes, material process models and structural analysis

Miles College

- Minority institution partner
- Pipeline to UAB programs & graduate school

UAB GATE (DOE CENTER OF EXCELLENCE)

GATEWAY TO THE FUTURE
GATE
GRADUATE AUTOMOTIVE TECHNOLOGY EDUCATION

Lawson State, Calhoun & Jeff State Community College

- 2-year automotive degree
- Pipeline to UAB and automotive industry

Alabama Based Automotive Companies

- Honda, Mercedes, Hyundai, Toyota
- Plastics molders

National Labs & State

- Oak Ridge
- ALDOT

Small Businesses

- Coosa Composites
- Glasforms
- Britt & Co.
- Biomedical Co.

Outline

- Goals and Objectives
- Address Previous Review Comments
- Barriers
- Approach
- Performance Measures and Accomplishments
- Publications/Patents
- Collaborations/Interactions
- Plans for Next Fiscal Year
- Summary

Relevance and Goals

Overall FCVT 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."**

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 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 Objectives

Year 3 Objectives

- Continue to recruit GATE students and enable interdisciplinary research projects
- Consolidate the course structure and continue GATE course offerings that will enable graduate students to be trained in automotive technologies of the future
- Offer virtual classroom experience
- Coordinate and offer workshops and research training for high school, community & undergraduate students pipeline
- Hold Advisory Board meetings
- Tour industry sites

Approach to Meet Objectives (including targets)

- Support 3 graduate students/year (two supported by DOE and one cost shared by UAB) with research projects focused on automotive applications
- Support 4 undergraduates each year in automotive related research
- Develop and offer six new automotive related courses (two per year for the first three years) with the potential to impact 20 – 30 students per year
- Influence at least 30 students per year through hands-on workshops
  - Undergraduate students (promote interest in graduate studies)
  - High school students (promote interest in the automotive area)
  - Include a focus on minority students (tap into a larger workforce)
- Interact with industry through Advisory Board Memberships, tours of their facilities, collaboration through the virtual classroom concept, and interaction on research projects (including SBIRs and STTRs)

Address Previous (June 2007) Review Comments

Specific Strengths and Weaknesses (Written responses from 3 of 5 reviewers)

- **Specific Strengths**
  - "Good work in training students."
  - "This is the first year of the GATE center, and so expectations are to be tempered."
  - "Exceeded objectives in terms of number of students reached -- 200 students reached in 2.5 years."

- **Specific Weaknesses**
  - "It is not clear to me what the technical accomplishments and specific industry collaborations are."

- **Response to Weaknesses**
- *Technical contributions*
  - *Over 40 GATE research papers have been published covering both basic science and application developments in advanced materials. Topics covered include light weighting (a FreedomCAR mission), enhanced structural and functional response, and improved performance.*
  - *Specific industry collaborations are covered in the upcoming slides.*

Address Previous (June 2007) Review Comments

Specific Recommendations

- Recommendation/Comment:
- Interface with other GATE centers to see what works and what doesn't.
- Response/Action:
- We paid close attention to the sister GATE center presentations in the June 2007 & Feb 2008 review & our overall GATE fellows recruitment & training is consistent with their experiences
- Recommendation/Comment:
- UAB has a long laundry list of things to be done, but presumably not all of these are performed using the somewhat restricted budget.
- Response/Action:
- The focus of our program is in advanced lightweight materials. All participants in our multi-discipline program support the primary focus. GATE support is leveraged with automotive related funding from other sources. The technical plan and student recruitment is well-aligned with the research projects.

Address Previous (June 2007) Review Comments

Specific Recommendations

- Recommendation/Comment:
- If students leaves GATE after 1.5 years, is their future research oriented to the DOE efficiency & materials goals?
- Response/Action:
- Absolutely. The GATE student's thesis/dissertation is well-defined prior to them coming off of GATE funding after the allowed time period.
- Recommendation/Comment:
- If not, should GATE support fewer for longer, to focus on these areas? This is for consideration, not a firm recommendation.
- Response/Action:
- Our initial model was designed to maximize the number of students trained. However, we have determined that longer duration student support may be desirable for research areas with limited funding. We have revised our approach for specific cases.
- Recommendation/Comment:
- Good direct exchange between the students and ORNL.
- Response/Action:
- The ORNL interaction has expanded (explained in a future slide).

Accomplishments and Progress: GATE Directly Funded Students, 2008-09 (Ahead of target)

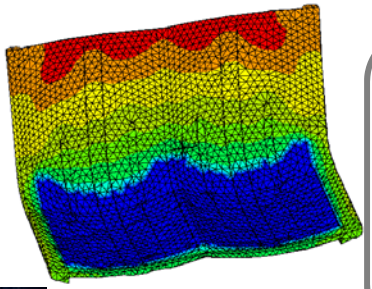
	Student Name	Department and Standing	Thesis / Research
1	Carol Ochoa	Materials Science & Engineering, PhD	Finite element analysis and modeling of thermoplastic composites
2	Amol Vaidya*	Civil & Environmental Engineering, PhD	Sandwich construction for crashworthiness of automotive applications
3	Lakshya Deka *	Materials Science & Engineering, PhD	LS-DYNA modeling of dynamic behavior of thermoplastic composites
4	Michael Magrini*^	Materials Science & Engineering, MS	Impact response of long fiber and laminated thermoplastic composite materials
5	Lina Herrera Estrada	Materials Science & Engineering, MS	Banana Fiber Composites for automotive applications
6	Satya Vaddi*	Materials Science & Engineering, MS	Fire behavior of thermoplastic composites
1	Danila Kaliberov	Junior, Materials Science & Engineering	Vibration testing of long fiber thermoplastic composites
2	V. Ameya*	Senior, Spain Park High School	Fiber length measurements of LFTs
3	Hadeel Abdelmajeed	Senior, Materials Science & Engineering	Thermoforming processing of laminated composites
4	Walter Malone*	Senior, Materials Science & Engineering	Sandwich panel construction for automotive floor boards
5	Victor Long	Junior, Materials Science & Engineering	Compression after impact of layered materials
6	Saptarshi Vichare	Junior, Mechanical Engineering	Carbon fiber thermoplastic impregnation
7	David Sexton	Junior, Materials Science & Engineering	Carbon fiber thermoplastic impregnation
8	Sueda Baldwin	Senior, Materials Science & Engineering	Long fiber thermoplastic fiber orientation studies
9	Benjamin Rice	Senior, Rhodes College, Memphis (Summer 08)	Compression after impact of E-glass/vinyl ester composites
10	Khongor Jaamiyana	Senior, Colorado State Univ (Summer 08)	Low velocity impact response of Carbon SMC

*graduated in 2008 reporting period , ^continued as MS student

Accomplishments and Progress: GATE Directly Funded Students (2006-2008)

	Student Name	Department and Standing	Thesis / Research
1	Mohammed Shohel	Civil and Environmental Engineering, PhD (Graduated, Dec 06)	Resin infusion processing of laminated composites
2	Carol Ochoa	Materials Science & Engineering, PhD	Finite element analysis and modeling of thermoplastic composites
3	Balaji Venkatachari	Mechanical Engineering, PhD	Simulation of flow fields in automotive bodies
4	Amol Vaidya	Civil & Environmental Engineering, PhD	Sandwich construction for crashworthiness of automotive applications
5	Lakshya Deka	Materials Science & Engineering, PhD	LS-DYNA modeling of dynamic behavior of thermoplastic composites
6	Satya Vaddi	Materials Science & Engineering, MS	Fire behavior of thermoplastic composites
7	Felipe Pira	Materials Science & Engineering, MS	Process Modeling of Thermoplastic Composites
8	Leigh Hudson	Materials Science & Engineering, MS	Pultrusion of thermoplastic composite elements
1	Malina Panda	Senior, Materials Science & Engineering (Graduated, May 07)	Development of hot-melt impregnated materials
2	Daniel Kaliberov	Junior, Materials Science & Engineering	Vibration testing of long fiber thermoplastic composites
3	Michael Magrini	Senior, Materials Science & Engineering	Impact response of long fiber and laminated thermoplastic composite materials
4	Michael Entz	Senior, Materials Engineering	Impact analysis of laminated composites
5	V. Ameya	Senior, Spain Park High School	Fiber length measurements of LFTs
6	Hadeel Abdelmajeed	Senior, Materials Science & Engineering	Thermoforming processing of laminated composites
7	Walter Malone	Sophomore, Materials Science & Engineering	Sandwich panel construction for automotive floor boards
8	Victor Long	Sophomore, Materials Science & Engg.	Compression after impact of layered materials
9	Sueda Baldwin	Junior, Materials Science & Engg.	Long fiber thermoplastic fiber orientation studies

Technical Accomplishments



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

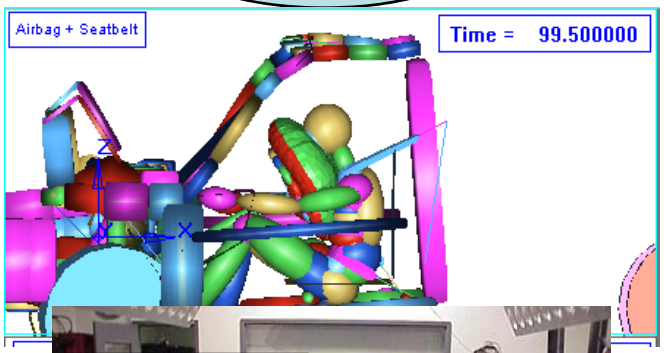
Advanced Composites Technologies

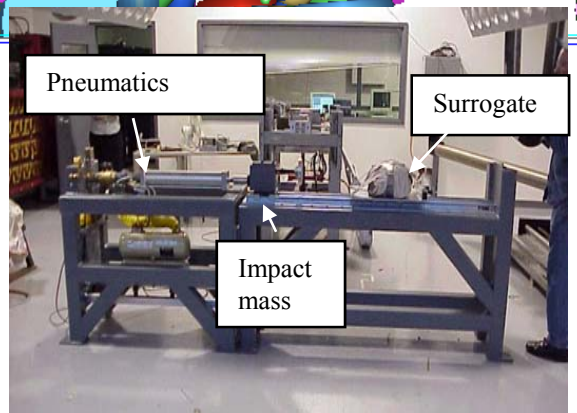
Advanced Metal Casting Technologies

Automotive castings

Advanced materials for automotive safety

High fidelity computations for crashworthiness studies



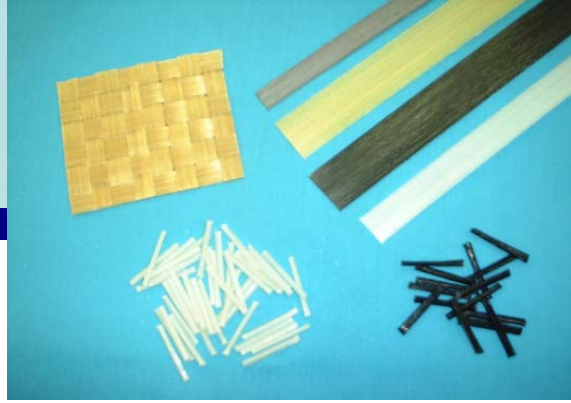


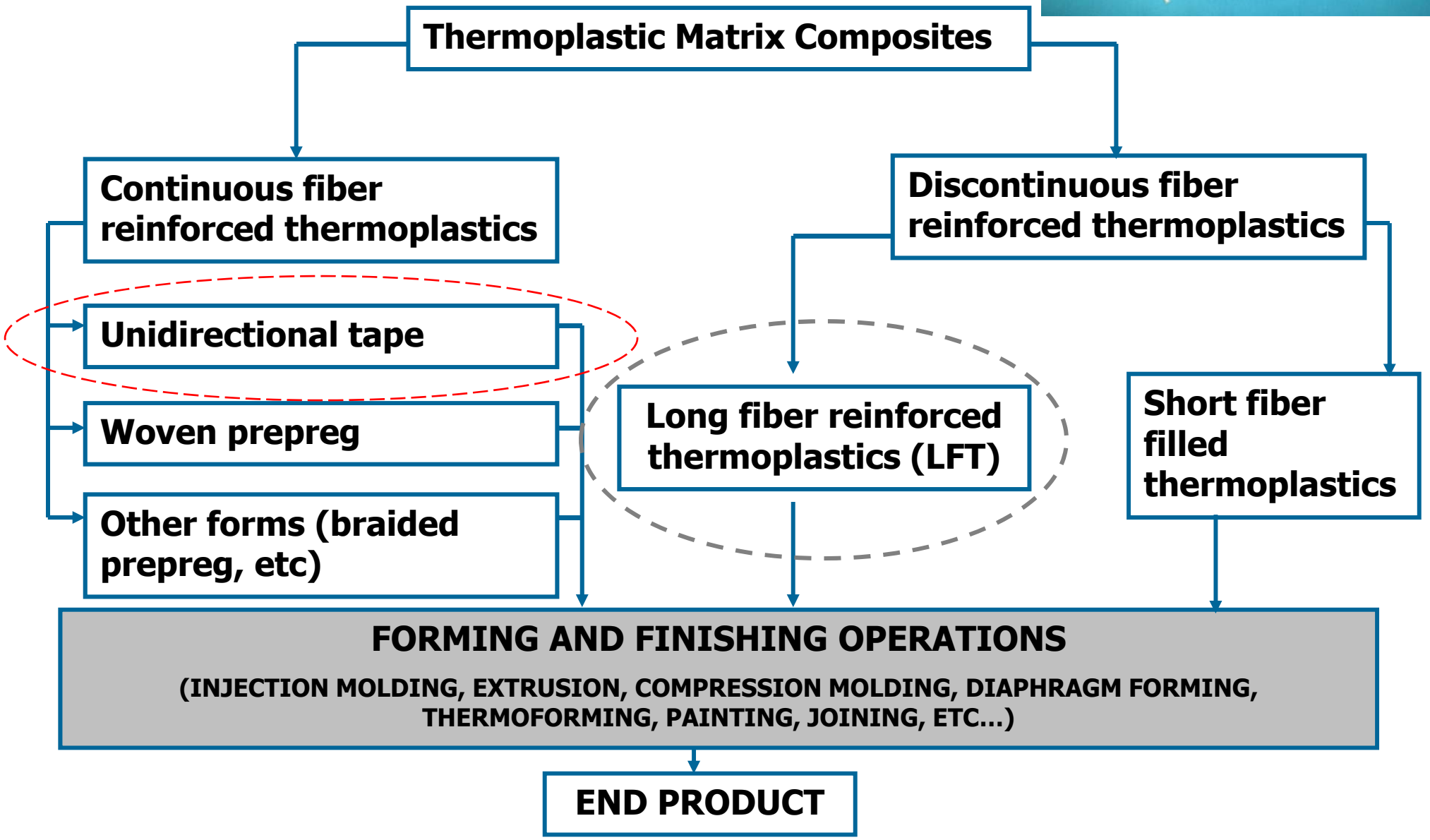
Lightweight materials for highway safety

Technical Accomplishments

- 40%-60% weight reduction, and ~40% cost-savings featuring energy-efficient composites in DOE relevant mass transit and automotive applications (examples included).
- Carbon fiber impregnation with thermoplastic polymers research expanded.
- Integration of natural fiber composites and nanostructured biocomposites development for vehicle applications
- Strong industry collaboration with GATE research aligned with US industry base and strong DOE relevance.
- Technical publications (see list) by GATE fellows in – long fiber rheology, natural fiber composites, biomechanics/ crashworthiness, fiber/matrix interface studies, multifunctional materials, real time X-ray for castings inspection, innovation in process methods
- Lost foam casting developed to minimize material porosity
- Advances made in thermoplastic extrusion-compression, pultrusion and forming techniques applicable to materials for safe highway barriers and energy-efficient automotive structures

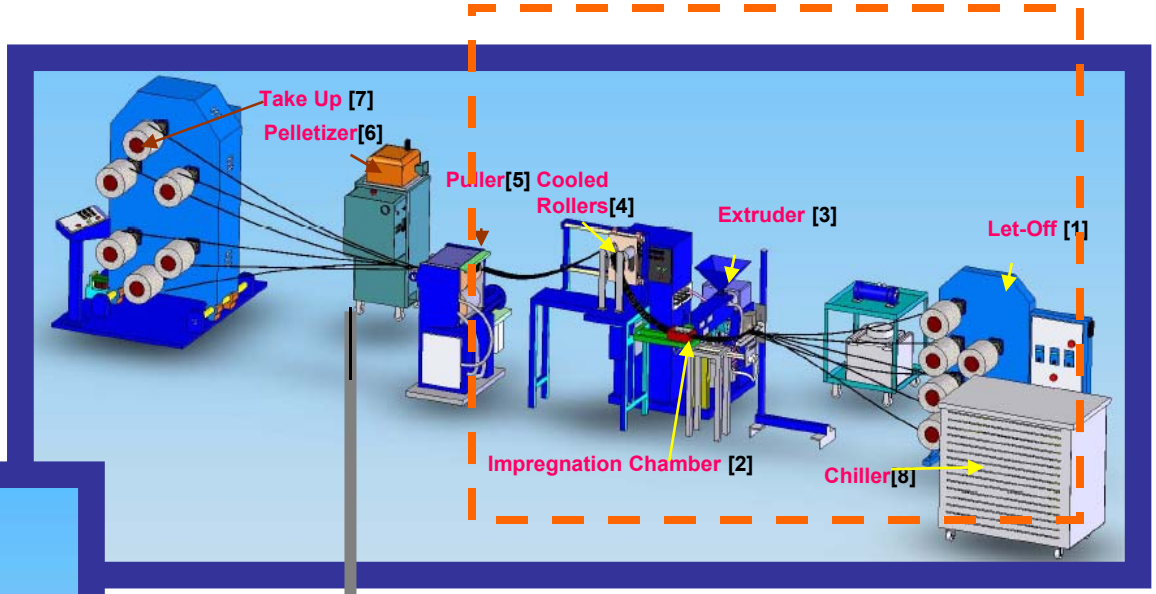
Materials Forms for Thermoplastic Composites Manufacturing

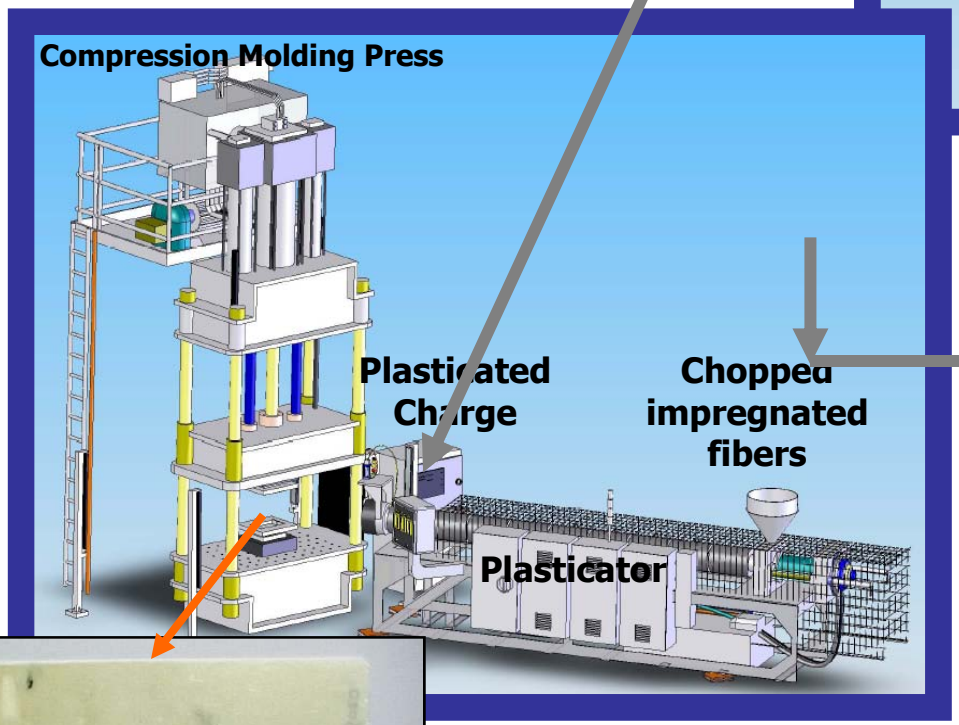




Hot Melt Impregnation & Extrusion-Compression Molding

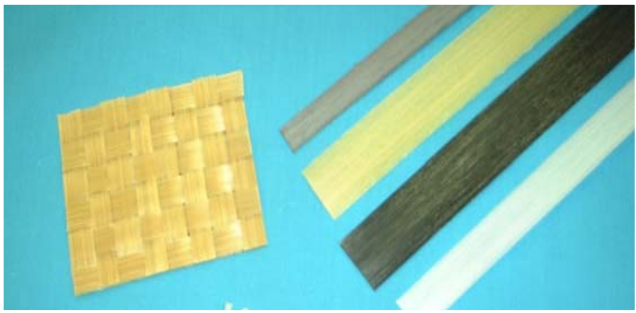
Charge / Shot

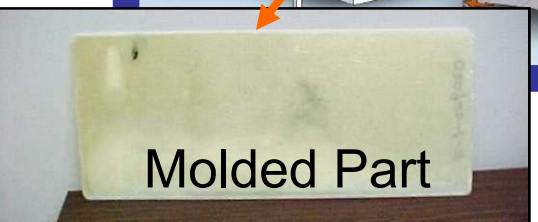




LFT Pellets

Tape & Fabric





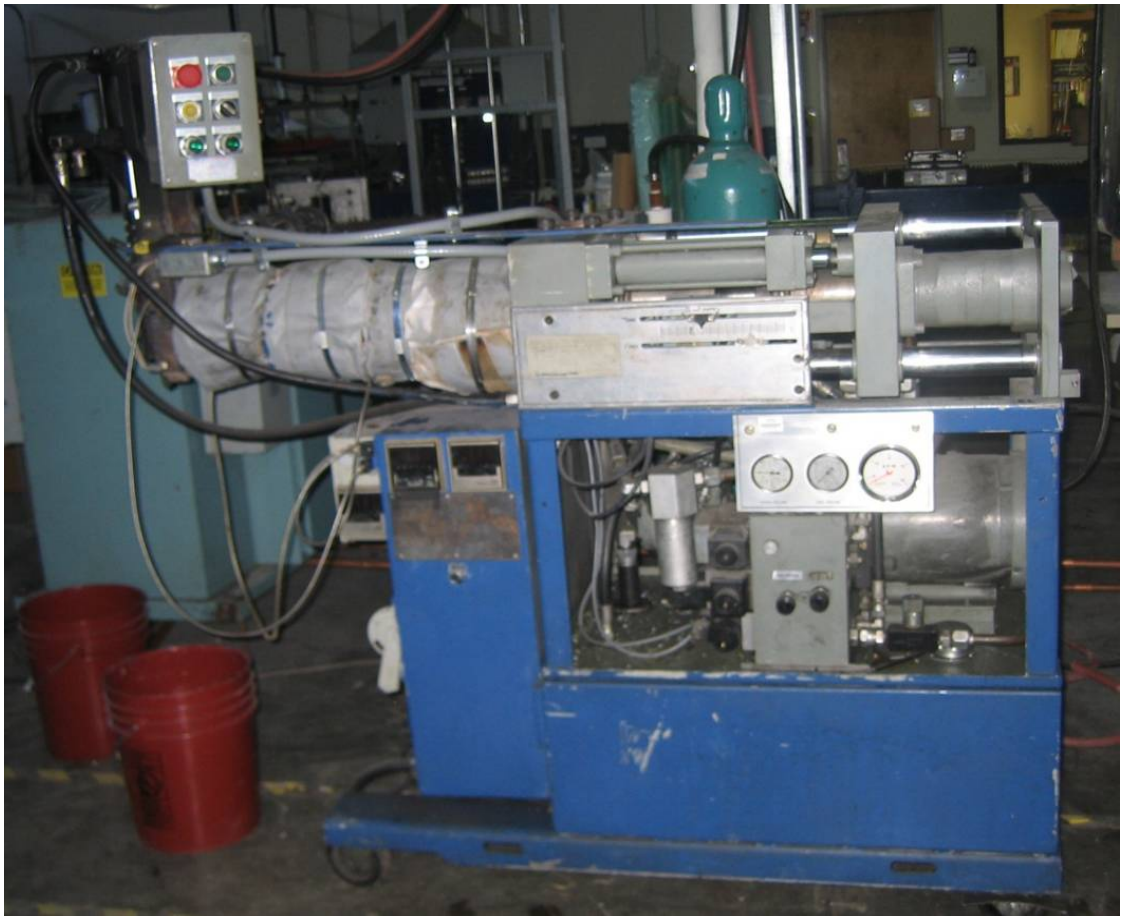
Carbon Fiber Thermoplastic Impregnation Studies

- Carbon fiber has promise for significant weight reduction in vehicles provided cost can be reduced.
- There are very limited carbon fiber sizing options for thermoplastic polymers.
- Carbon fiber sizing is generally proprietary from industry.
- Work has been initiated by GATE fellows to impregnate PAN and textile grade carbon fiber with thermoplastic polymers (Work aligned & coordinated for DOE ORNL interest based on discussions with Dave Warren & Bob Norris, ORNL)
- Successfully impregnated Polypropylene and Polyamide thermoplastics on carbon fibers sized for epoxy, vinyl ester and unsized PAN fibers. Impregnation quality is excellent; physical, static & dynamic mechanical property evaluations are underway.
- These material options can be used by the automotive and transportation industry in number of broad good applications for exterior and interior structural panels.

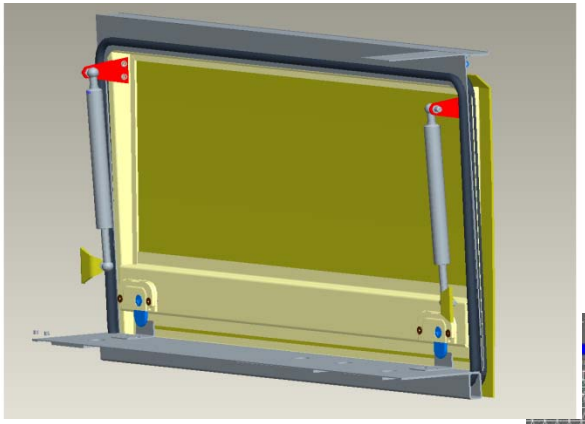
New Addition: 300 Metric Ton Fast Acting Compression Molding Press & Plasticator

CA Lawton 300 T Press

Rose Plasticator

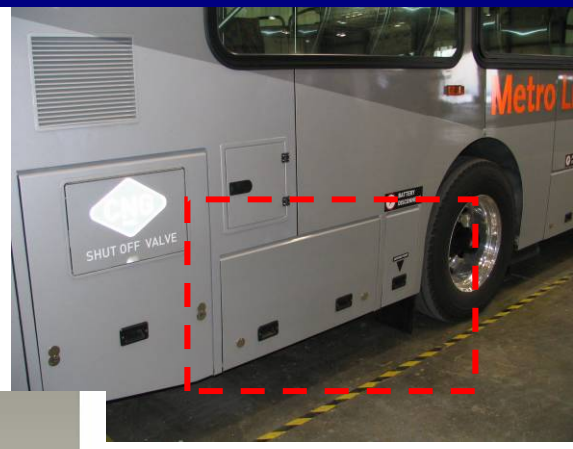


Thermoplastic Composite Materials for Transportation Applications

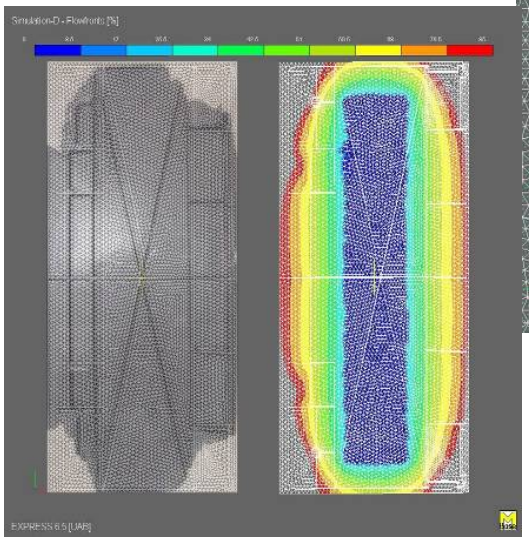


Heavy metal door

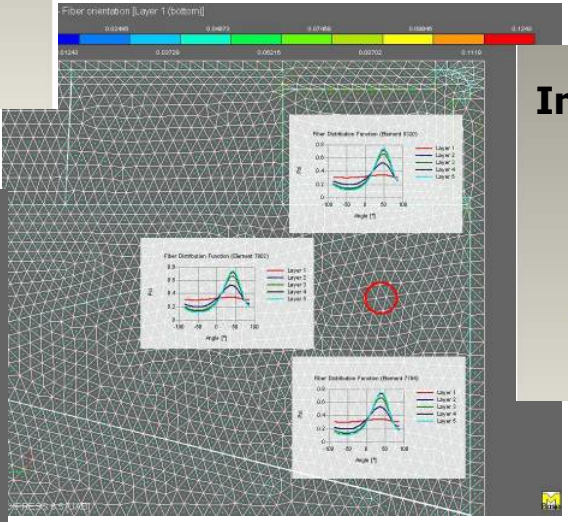
60% weight reduction & 40% cost-savings realized by replacement of metal battery door by long fiber composite

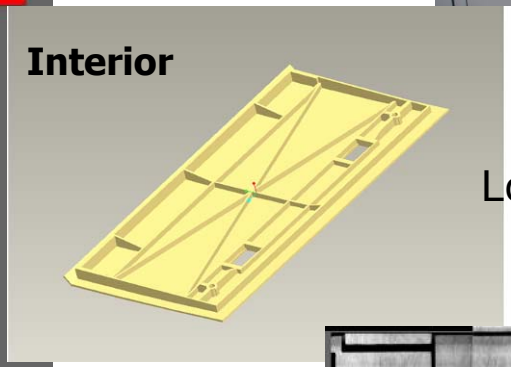


Long fiber thermoplastic door; 60% lighter



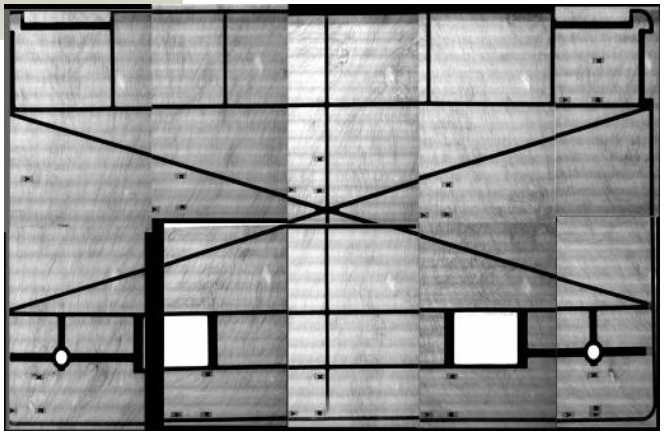
Process flow modeling of long fiber charge





Fiber orientation modeling and prediction

- ☑ IP disclosure filed
- ☑ Technology transfer
- ☑ NABI and other mass transit companies interested in implementation



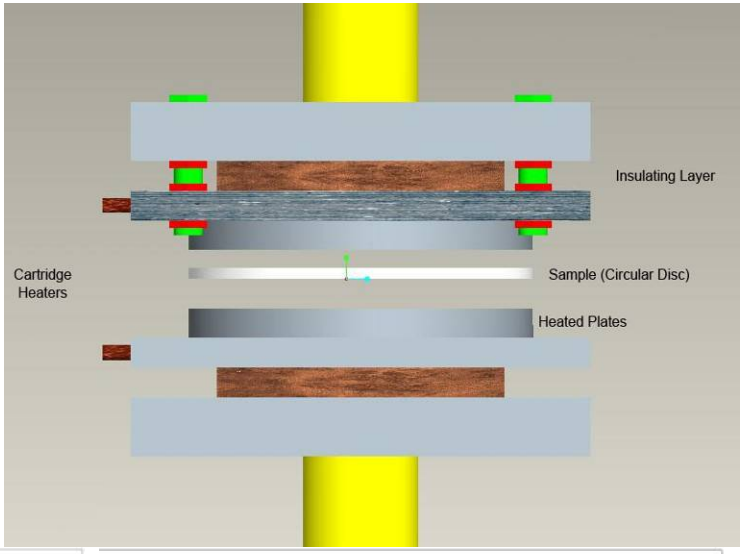
X-Ray studies to evaluate fiber orientation

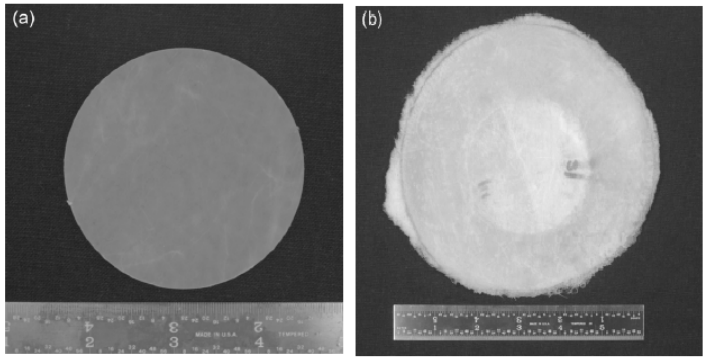
Balaji T et al., Process simulation, design and manufacturing of a long fiber thermoplastic composite for mass transit application., Composites Part A: Applied Science and Manufacturing, Volume 39, Issue 9, September 2008, Pages 1512-1521

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

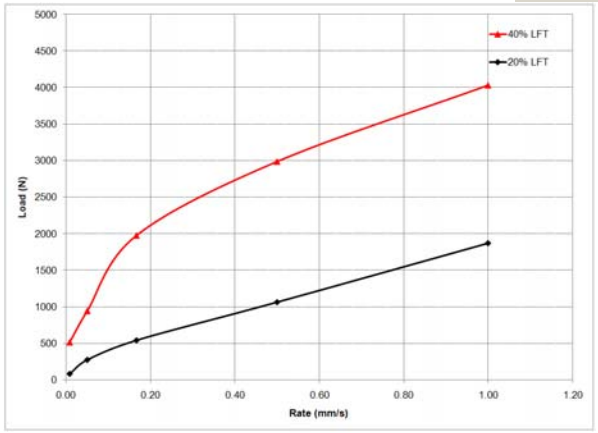
DOE Merit Review
May 2009

- 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

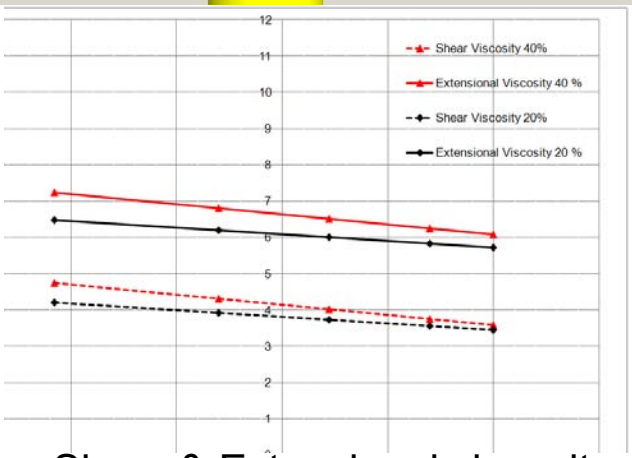




- Isotropic flow (Circular specimen remained circular under squeeze)
- Compression molding is modeled as a combination of extensional and shearing flow



Load versus rate for long fiber disc specimens



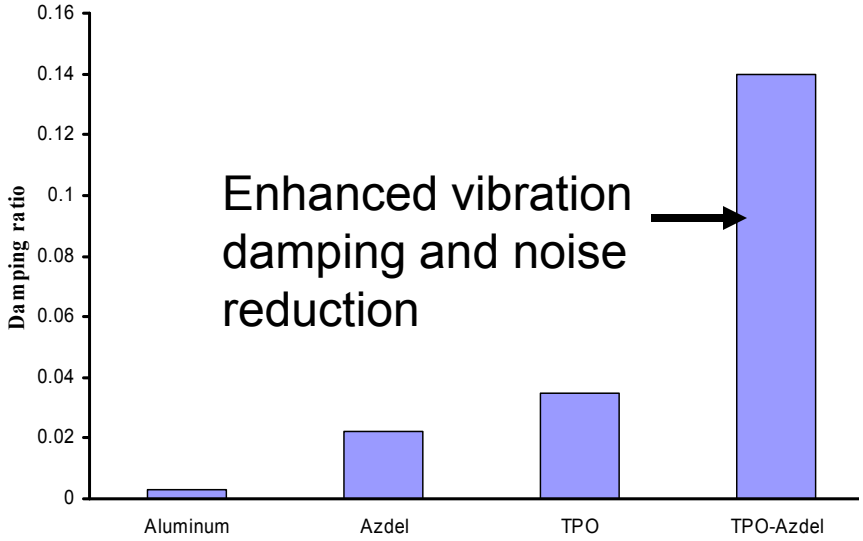
Shear & Extensional viscosity

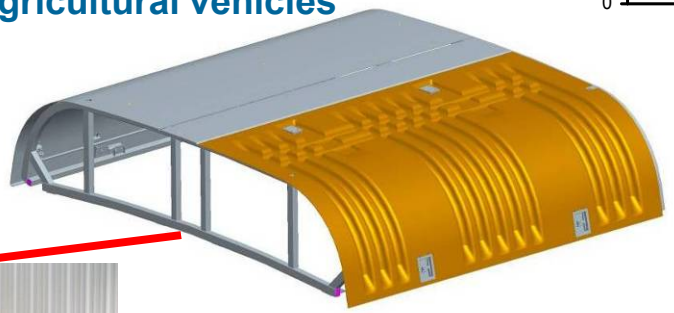
- Glass / Polypropylene - 190 °C
- Varying Fiber weight fraction of 40%, and 20%
- Constant Fiber length of ½”
- At constant mold separation of 2.30 mm

39% lighter Roof Door for Mass Transit Bus; Weight reduction - 450 lbs of roof

DOE Merit Review
May 2009

- 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 light rail, trucks and agricultural vehicles





- ☑ IP disclosure filed
- ☑ Technology transfer
- ☑ Awarded best entry at 'SPE Thermoforming Conference', Cincinnati, OH, Sep 2007.
- ☑ NABI and other bus companies interested in implementation

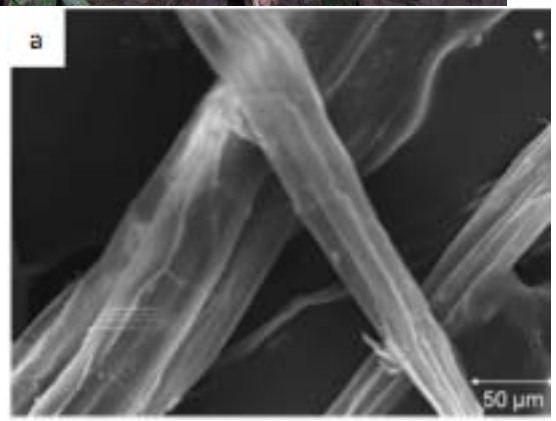
Vaidya et al., Design and development of thermoplastic composite roof door for mass transit bus., Materials & Design, Vol. 30, April 2009, Pages 983-991.

Natural Fiber Composites & Nanostructured Biocomposites for Vehicles

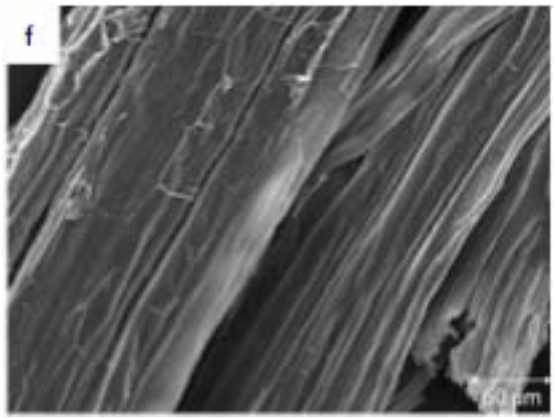
- Fibers obtained from the dried stalk of banana trees.
- These fibers are a waste product of banana cultivation.
  - Sodium Hydroxide (NaOH) treatment:

    Removes impurities from the fiber surface, Decreases moisture absorption, causes mechanical bonding and alters surface polarity

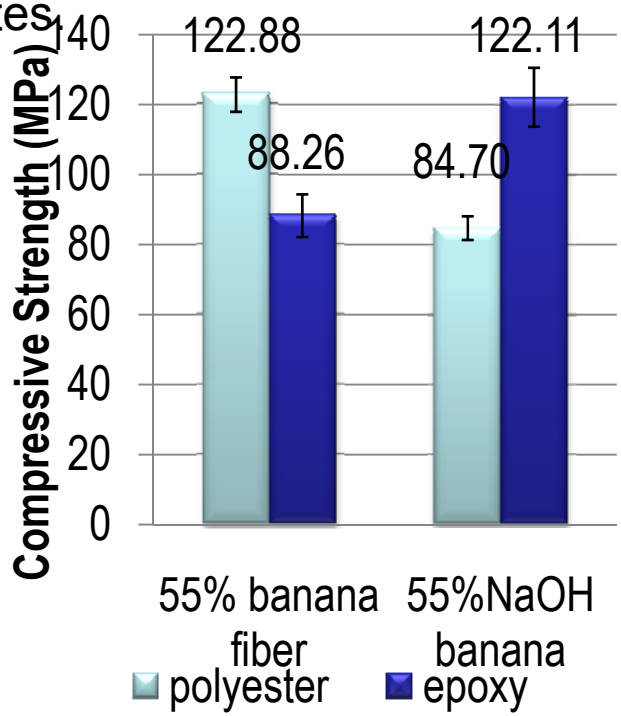
Alkali treatment enhances fiber/matrix interaction, causing a decrease in moisture absorption and higher compressive strength in banana fiber/epoxy composites



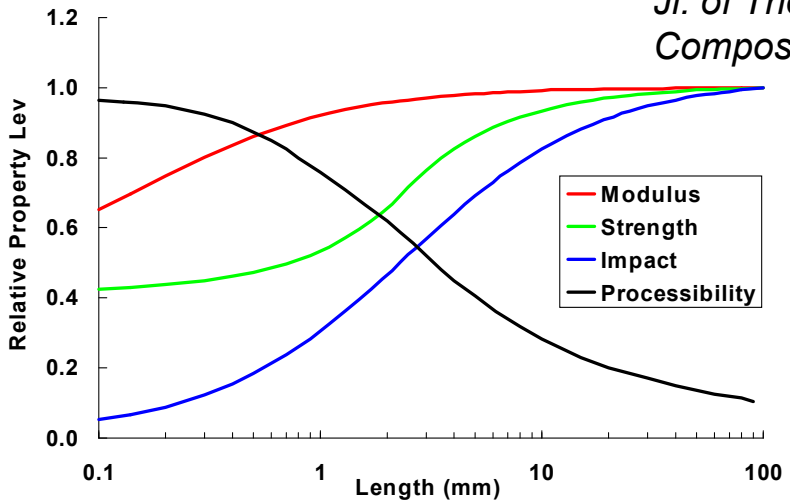
As-received



NaOH treated

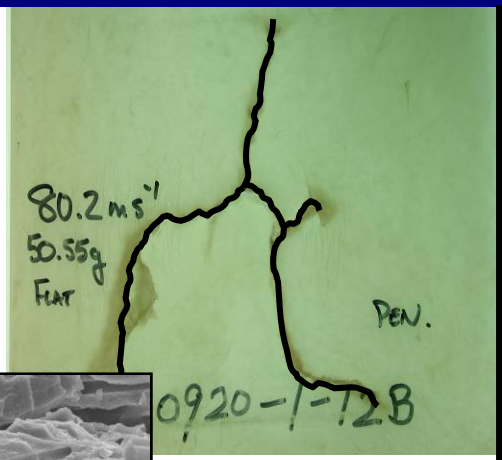


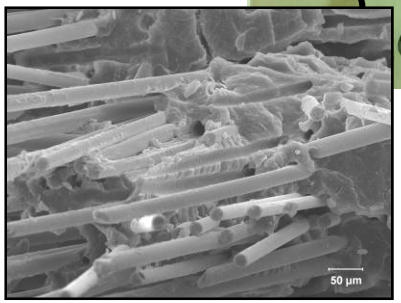
Other examples of Basic Research by GATE fellows

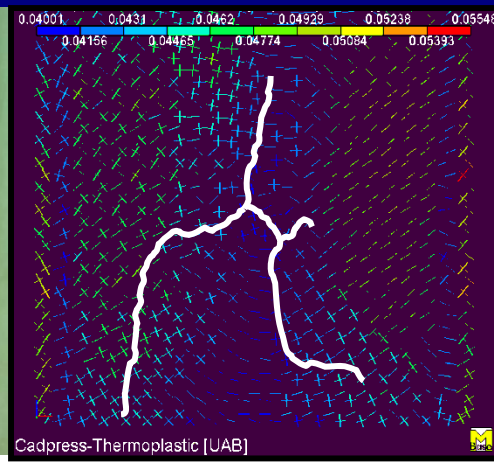


Jl. of Thermoplastic Composites, Sep 2008

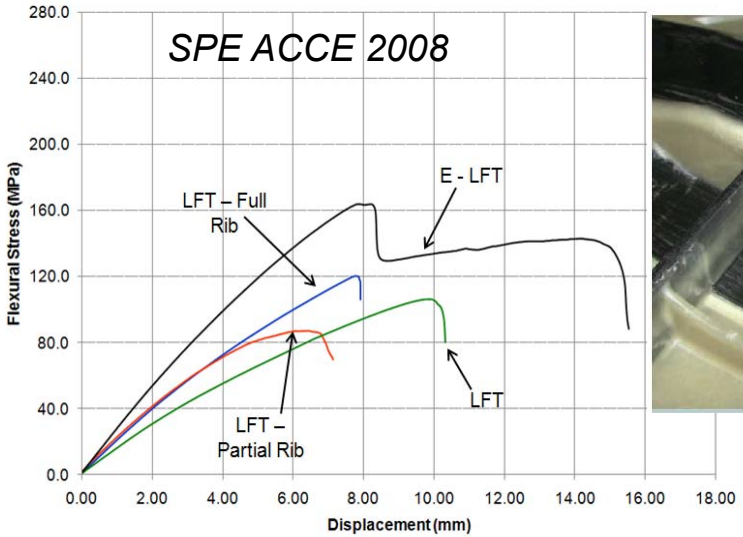
Performance and processability windows for advanced thermoplastics composites

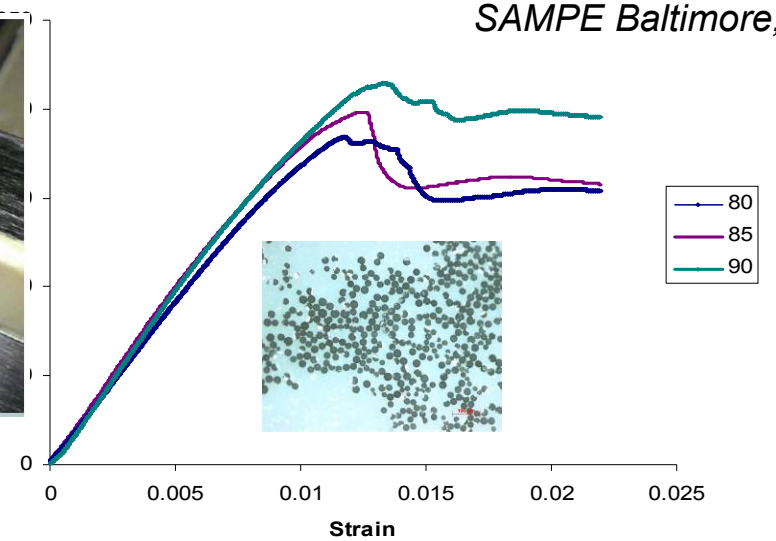






Impact /microstructure/modeling Correlations of long fiber thermoplastics



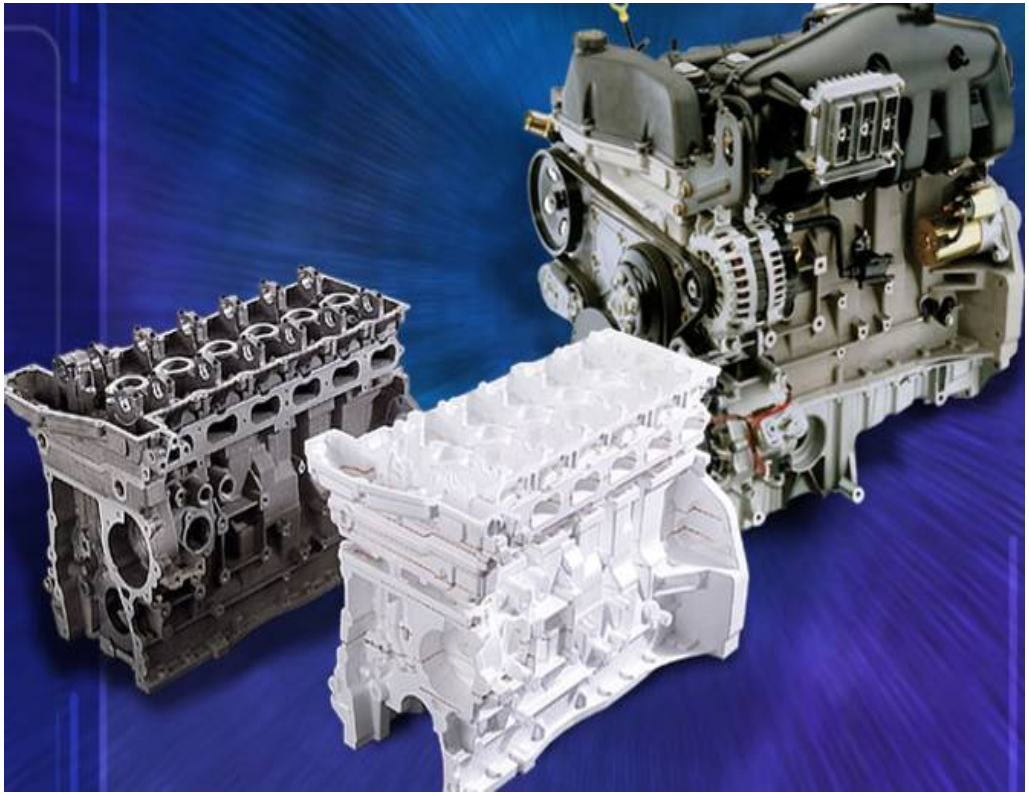


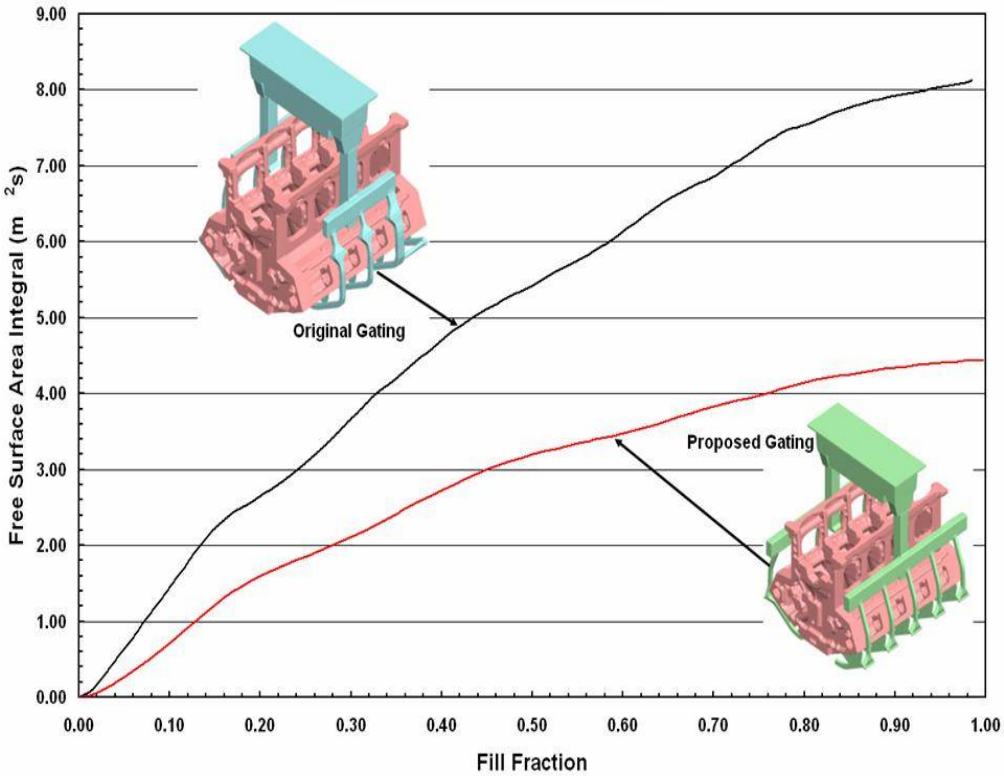
Studies with co-molded continuous tape and long fiber thermoplastics for enhanced energy absorption and crashworthiness, improved safety

Thermoplastic pultrusion process optimization of materials profiles used in structurally efficient members for transportation

Aluminum Castings for Automotive Applications

UAB has an international reputation for expertise in the evaporative pattern (lost foam) metals casting process. Federal funding and industrial partners are supporting research in complex aluminum castings





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

Recognition of Transportation and Automotive Work at UAB

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.

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.

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 Selvum 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.

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

- UAB featured in front page article on Lightweight Materials Technologies – *Composites Technology Magazine*
- Featured in *JEC Composites* magazine, Europe

Accomplishments and Progress: New Courses Developed & Planned (on schedule, 60 students)

GATE COURSES

- ☑ MSE 635/735: Advanced Composite Mechanics
- ☑ MSE 634/734: Design and Manufacturing Technologies for Automotive Applications
- ☑ MSE 667/767: Process Modeling and Simulation for Lightweight Materials
- ☑ MSE 490/590: Nanomaterials for Automotive Applications
- ☑ ME/MSE/CEE: Mechanical Characterization & Performance Evaluation of Advanced Lightweight Materials
- BME/MSE/CE: Optimized Lightweight Material Designs for Improved Protection

AUTOMOTIVE CERTIFICATE (GATE Graduate Fellows)

"Automotive Certificate" issued at the department level for GATE graduate fellows who have

1. Met the requirements for a graduate degree
2. Taken at least 4 GATE courses
3. 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.

Car and Driver "One Lap of America"

- GATE students develop carbon fiber parts for Honda of America (HOA)
- HOA races the ***Honda Odyssey*** in the ***One Lap of America*** competition.

UAB GATE students developed the Carbon Fiber Hood for the Honda Odyssey Van

Carbon Fiber Hood assembled weight – 8 lbs

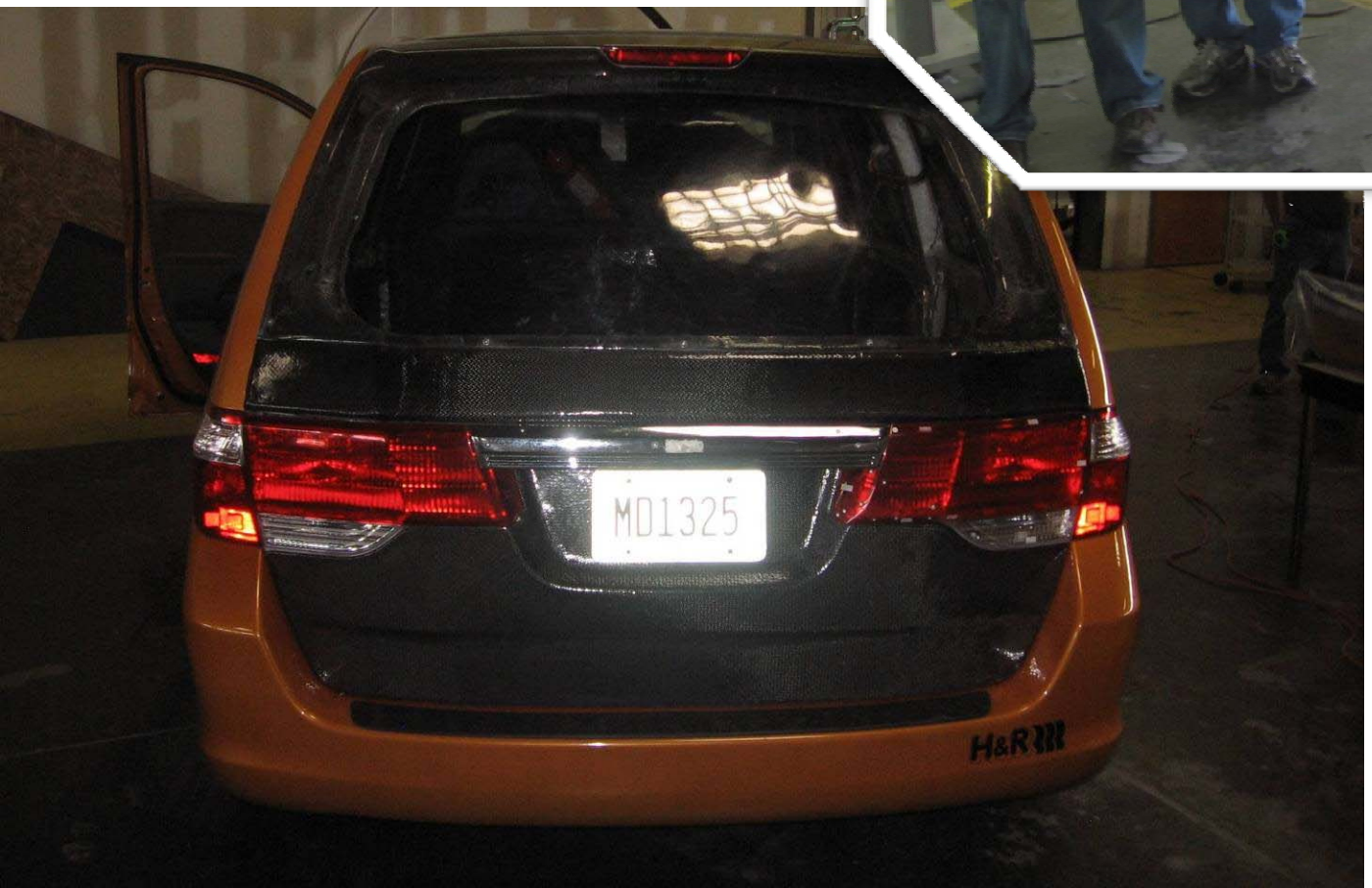
The metal hood weighs – 28 lbs

Carbon Fiber Hood Development

GATE students Hadeel Abdejmajeed, Danila Kaliberov, Walter Malone, K. Balaji & Michael Magrini working on the carbon fiber hood fabrication

Carbon Fiber Tailgate

GATE students Walter Malone & K.Balaji working on the tailgate assembly

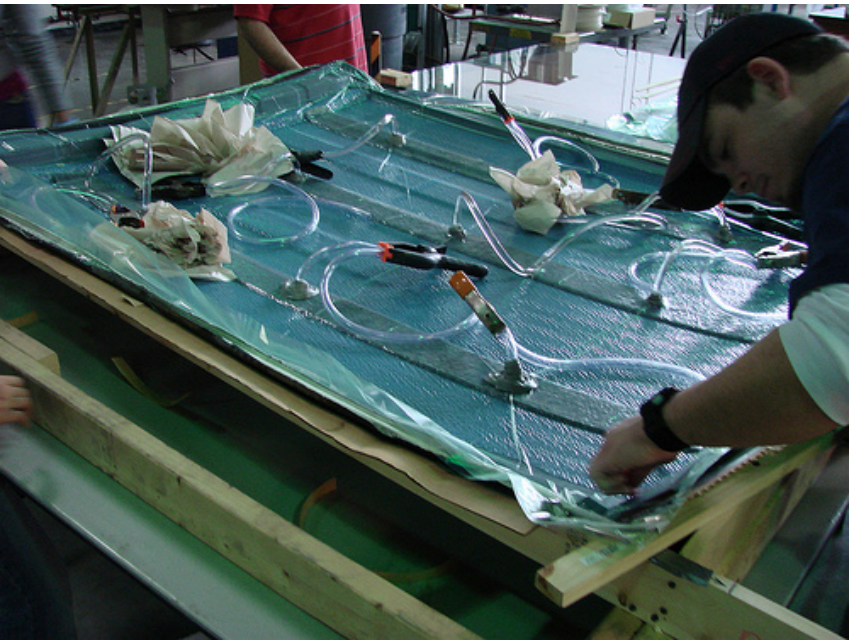


Carbon Fiber Tailgate assembled weight - 44 lbs
(the metal tailgate weighs 74 lbs)

The race was May 2-10, 2008. Placed 26th overall out of approximately 80 teams; first in the SUV class.

Honda PILOT – Ongoing Work

GATE students have also fabricated a carbon fiber sandwich composite roof for the *Honda Pilot*. 40% lighter.



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

GATE Workshop: Lost Foam Metals Casting
GATE Faculty: Dr. Robin Griffin & Dr. Alan Drushitz

2 workshops of ~15 students high school and community colleges held to demonstrate metal casting technologies for automotive use - July 2008 and Oct 2008.

GATE Workshop at Rhodes College, Memphis – 10/14/2008. Sandwich composites design

GATE students Leigh Hudson, Michael Magrini, Jason Quinn accompanied by Dr. Selvum Pillay held the workshop.

GATE Workshop: Polymers, Composite Wet-Layup, and Thermoforming
GATE Faculty : Dr. Derrick Dean, Dr. Selvum Pillay & Dr. Uday Vaidya
Summer 2008

DOE Merit Review
May 2009

Accomplishments and Progress: Interaction with Industry Through "Virtual Classrooms"

Real-time video link to the National Composites Center (NCC) demonstrating the P4-molding process. Students were able to interact with the participants at the NCC. Sessions continued like in previous years.

Interactions with DOE Oak Ridge National Laboratory

- Visits to ORNL – Meeting with Dave Warren to discuss carbon fiber lightweighting research
- UAB carbon fiber impregnated tape sent to ORNL – Robert Norris for evaluation and feedback.
- Student exchange under ORISE and 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
- Process modeling of composite materials
- GATE advisory board members from ORNL– Dave Warren, ORNL

Advisory Board Meeting: To be held April 2009

Board Members

- Dr. Tom Jackson, UAB School of Engineering Research Director / Chair, GATE advisory board
- Dave Warren, Oak Ridge National Laboratory
- Tom Heyer, Ticona Inc.
- Dr. Lou Ludteke, National Composite Center, OH
- Dr. Bharat Soni, Chair, UAB Mechanical Engineering
- David Powell, Southern Research Institute

Recommendations from Spring 2008 meeting

The Board participated in a review of the program (the Merit Review presentation was used) and made the following observations/recommendations:

- New course development in automotive areas should continue at a reasonable pace (*Action implemented*)
- Continue workshops and recruiting events, especially recruiting trips to possible “feeder” institutions (*Actions implemented and continued*)
- Increase collaboration with automotive industry in the state of Alabama (*Significant collaboration with HOA ongoing*)
- Use Board member’s automotive contacts to advantage (*Visits to ORNL, NTRC expanded*)

Speakers and Other Activties (Summer-Fall 2008)

- Speakers
  - ❖ Dr. John Petrovic, Hydrogen Storage, Los Alamos Laboratory
  - ❖ Dr. Anil Sachdev, General Motors, Lightweight Power Train Materials
  - ❖ Dr. Walt Chaput, Omnisource, Metallurgy in Metal Castings
  - ❖ Dr. Alan Drushitz, UAB, High Temperature Magnesium Alloys
  - ❖ Dr. Paul Swamidass, Tom Walter Business Center, Auburn University, IP and Tech Transfer

- GATE workshops

  Workshop offerings in Polymers, Castings, Thermoforming, Microscopy, Extrusion of Plastics, Mechanical Test Methods

- Included UAB Honors students to participate in GATE workshop / testing activities
- Visit by GATE participants to Honda of Alabama, Lincoln
- UAB GATE a member and participant in Alabama Automotive Manufacturer's Association (AAMA)
- GATE faculty organizing technical sessions at SPE Automotive Composites Conference, 2009.
- GATE researchers are presenting their work in international/national meetings of DOE relevance – such as SPE Automotive, MS&T, TMS and Lightweighting Materials Conferences
- GATE student recruiting is aligned with departmental graduate student recruiting efforts (February 2009)
- Strong industry relations leveraging

Breaking New Ground:

Structural Composites Applications in Defense, Power Industry, Infrastructure, Transportation and Corrosion-Prevention

March 4-6, 2008

University of Alabama at Birmingham (UAB) • Birmingham, Alabama

ACMA
American Composites Manufacturers Association

UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Summary of Progress towards GATE Goals and Objectives

- ✓ Support 3 graduate students/year - 10 *graduate students have been supported to date by GATE funds (3 years)+4 cost shared*
- ✓ Support 4 undergraduates each year – 13 *undergraduates have been supported to date*
- ✓ Develop and offer two new automotive related courses per year to impact 20 to 30 students per year – *5 GATE courses have been developed with a total enrollment of 60 students; 1 more GATE courses is being offered in the 2009 year period; the 2 other courses will repeat cycle*
- ✓ Influence at least 30 students per year through hands-on workshops – *to date 200+ students have participated in the five UAB GATE Workshops*
- ✓ Interact with industry through Advisory Board meetings, tours of facilities, collaboration through the virtual classroom, and interaction on research projects (including SBIRs and STTRs) – *all aspects are being addressed consistently and increasing industry collaboration with the UAB GATE*

IP Disclosures / Patents

IP disclosures filed……..

- Design and Manufacturing of Long Fiber Thermoplastic Composite Access Doors for Mass Transit, Light Rail and Other Transportation Applications (July 2007)

- Design and Manufacturing of Thermoplastic Composite Doors for Mass Transit, Light Rail and Other Transportation Applications (Sep 2007)

Representative Publications and Presentations (there are over 50)

1. T. Balaji, H.Ning, S.Pillay and U.K.Vaidya, Process simulation, design and manufacturing of a long fiber thermoplastic composite for mass transit application., **Composites Part A: Applied Science and Manufacturing**, Volume 39, Issue 9, September 2008, Pages 1512-1521.
2. Lina Herrera Estrada and U.K.Vaidya, Banana Fiber Composites for Automotive and Transportation Applications, **SPE Automotive Composites Conference**, Troy, MI, Oct 2008.
3. Vaidya U.K. H. Ning and S.Pillay., Design and develoment of thermoplastic composite roof door for mass transit bus., **Materials & Design**, Vol. 30, April 2009, Pages 983-991.
4. T. Balaji, U.K.Vaidya, Processing and Characterization of Co-Molded Continuous Fiber Reinforcement with Long Fiber Thermoplastics, **SAMPE Long Beach**, May 2008.
5. N. Chawla and K.K. Chawla, "Metal Matrix Composites in Ground Transportation," **J of Minerals, Metals and Materials Society, JOM**, 58 (2006) 67-70
6. Naiyu Sun, Burton Patterson, Jaakko Suni, Eider Simielli, Hasso Weiland, Puja Kadolkar, Craig Blue, and Gregory Thompson, “Heating Rate Effect on Microstructure Evolution during Annealing of Twin Roll Cast AA3105,” in Aluminum Wrought Products for Automotive, Packaging, and other Applications, Eds. S. Das, G. Jha, Z. Li, T. Zhai, and J. Liu, TMS, pp. 119-124, 2006
6. U. K.Vaidya., Fire Response of Thermoplastic Composites., Managing Corrosion with Polymers, CD-ROM Proceedings, **NACE International Corrosion 2008**
7. N. Chawla and K.K. Chawla, "Modeling of Particle Reinforced Metal Matrix Composites Using Actual Microstructures," Global Advances in Material and Process Engineering, **SAMPE,** (2006)
8. Derrick Dean, Apollo M. Obore, Sylvester Richmond and Elijah Nyairo, “Multiscale Fiber-Reinforced Nanocomposites: Synthesis, Processing and Properties,” **Composites Science and Technology 66** (2006) 2135–2142
9. Haibin Ning, Gregg M. Janowski, Uday K. Vaidya, and George Husman., Thermoplastic sandwich structure design and manufacturing for the body panel of mass transit vehicle, **Composite Structures**
10. P. Scarber, Jr., C.E. Bates, and J. Griffin, "Effects of Mold and Binder Formulations on Gas Evolution When Pouring Aluminum Castings", 2006 **AFS Transactions**
11. K.Balaji, U.K.Vaidya., Rheological Characterization of Long Fiber Thermoplastics **–** Effect of Temperature**,** Fiber Length and Weight Fraction., **Composites Part A: Applied Science and Manufacturing**, In-press.

Technology Transfer/Collaborations

Companies Funding Research Relevant to the GATE Program

#	Collaboration	Interaction
1	Triton PMC, AL	Automotive Parts Manufacturer
2	Britt Engineering, AL	Fire Suppression - Automotive Floors
3	North American Bus Industries (NABI), AL	Mass Transit - Components
4	National Composite Center, OH	Prototyping, Virtual Manufacturing
5	Shepherd Color Co., OH	Functional Inorganic Paints
6	Glasforms, AL	Thermoplastic Pultrusion for Transportation
7	Ticona Inc.	Long Fiber & Thermoplastic Materials
8	Propex (CURV)	PP fibers/PP matrix for Body Panels

Partners for Workshops and Guidance

#	Collaboration	Interaction
1	Lawson State Community College, AL	2-year college/Student Pipeline / Workshops
2	Miles College, AL	HBCU/MI college; Student Pipeline / Workshops
3	Rhodes College, Memphis	Work Force Development / Workshops
4	Milwaukee School of Engineering, WI	Strong Pool of BS Graduates / Workshops
5	Calhoun Community College, Decatur, AL	Student Pipeline/ Workshops
6	Oak Ridge National Laboratory, TN	Guidance & Program Relevance

Activities for Next Fiscal Year

TECHNICAL AREAS

- Expand the carbon fiber thermoplastic impregnation work consistent with ORNL interest.
- Advance carbon fiber thermoplastic materials in extrusion-compression, vacuum forming and pultrusion processes with focus on product development and lightweighting.
- Advance lightweight castings and expand on magnesium casting work.
- Further ongoing work in natural fiber composites and nanostructured biocomposites into automotive applications (work on banana fiber composites has already produced a MS thesis from a GATE fellow).
- Interactions of biomechanics aspects/crashworthiness with lightweight materials.

GATE FELLOWS AND THEIR INTERACTIONS

- Continue to recruit and train graduate and undergraduate students into the GATE program (use workshops, personal contacts and financial support to attract students)
- Develop the 6thGATE course and continue the offering cycle of the developed courses
- Expand industry visits to other plants and facilities in the State
- Leverage GATE activities with other transportation and automotive industries (for e.g. the HOA interaction was expanded in 2008-09) including student internships & expanded faculty/staff interactions. Relationships have been developed with medium and heavy trucks and trailer manufacturers.
- 'Automotive Certificate' for students who have completed 4 GATE course offerings
- Continue workshop offerings throughout 2009. Some of these workshops will be "off site"
- Continue industry interaction and technology transfer
- Expand the relationship with ORNL