DOE's Vehicle Technologies Office





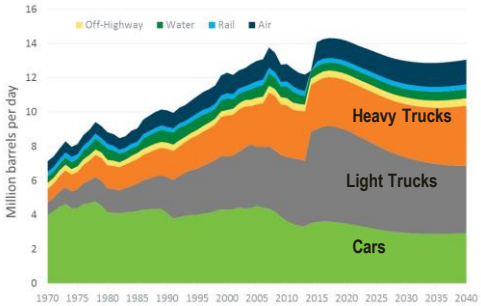


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Sarah Kleinbaum
Vehicle Technologies Office
Office of Energy Efficiency and Renewable Energy

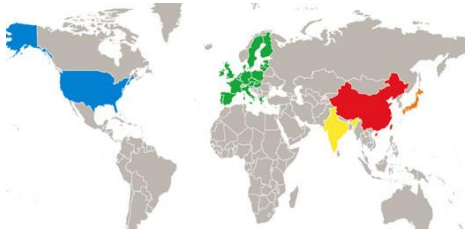
Transportation & Energy Drivers

70% of total U.S. petroleum usage is for transportation



Vehicles account for **85%** of transportation petroleum usage

Transportation is the **2nd** most expensive spending category after housing



75% of cars & trucks are sold outside US - Innovation drives US global competitiveness and domestic supply base

EERE's Vehicle Technologies Office (VTO)

VTO works on research, development, and demonstration of advanced transportation technology that:

- improves energy ***efficiency***
- increases domestic energy ***security***
- reduces operating ***cost*** for consumers & business
- improves global ***competitiveness*** of US Industry

catalyst for innovations that help drive economic development and US leadership in an increasing competitive global transportation industry.

Materials Technology Program - Overview

Automakers are seeking to improve fuel economy while maintaining or improving vehicle performance and safety

Using lightweight components and high-efficiency engines in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030

- For structural components, the market is shifting from traditional steel to lighter weight materials such as advanced high-strength steels, aluminum alloys, magnesium alloys, and carbon fiber composites.
- Lighter structures allow for downsizing engines and increasing power density which requires materials with low density, high strength, and high stiffness at elevated temperatures.

2017 Ford F-150

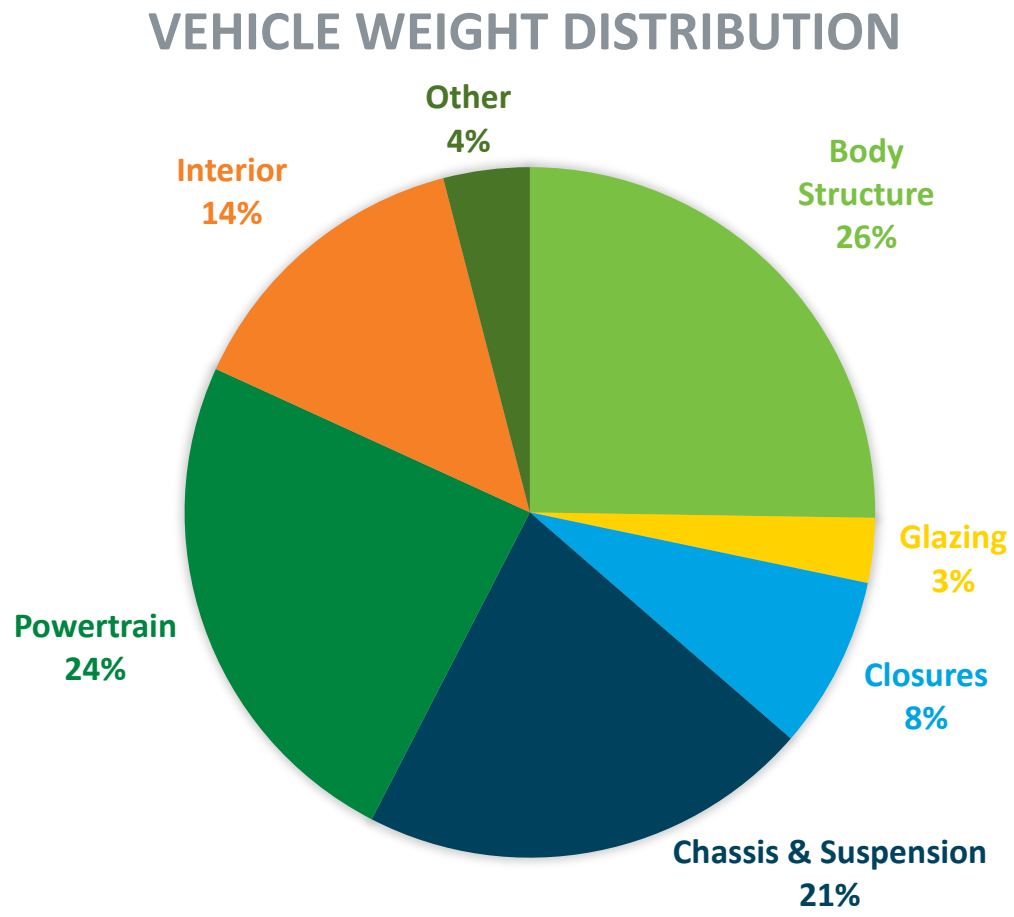
2018 Cadillac Ct-6

2017 Chrysler Pacifica

2017 BMW i3

Materials Technology Program – Focus Areas

The Materials Technology Program focuses on enabling materials solutions in two areas: the glider and the powertrain materials.



- Goal: Enable a 25 percent weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2012 baseline at no more than a $5/lb-saved increase in cost;

- Goal: Validate a 25 percent improvement in high temperature (300 ^{o}C) component strength relative to components made with 2010 baseline cast aluminum (AL) alloys (A319 or A356) for improved efficiency of light-duty engines.

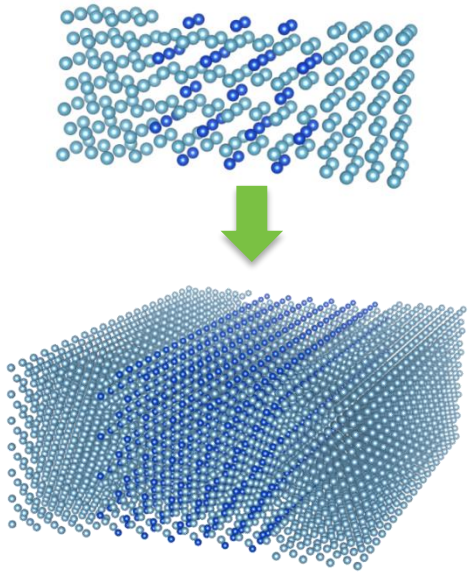
Propulsion Materials Technology

High Performance Cast Aluminum Alloys for Next Generation Passenger Vehicle Engines

Oak Ridge National Laboratory, Oak Ridge, TN

Other Participants: CRADA Partners: Fiat Chrysler Automobiles (FCA) and Nemak; Collaborators: Granta MI, ESI North America, Flow Science, MAGMA Foundry Technologies, and Minco.

Objective: To develop high-performance cast aluminum alloys with castability, high temperature strength, and fatigue performance that is a 25% improvement at 300°C compared to baseline properties at 250°C.



Scaled up lattice simulation for HPC

November 2012 – November 2017

Total Project Budget $5.50M

DOE Cost Share $3.50M

Innovations

- HPC addressing practical physical metallurgy questions: What are the best combination(s) of solute atoms that stabilize the α-Al/θ' interface? Are there positive synergies among solute elements?
- DFT calculations for 168 atom super cells on 32 cores required half a year to run, scaling up to 1,544 atom super cells can be completed in a couple weeks using ORNL's TITAN supercomputer

Impacts

- Tensile properties exceed 300oC targets by greater than a factor of 2. High temperature goals exceeded and alloys with stable microstructures up to 350°C have been developed.
- Research team has cast a number of alloy compositions with the above characteristics and filed a U.S. patent application for 350°C stable alloys.

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Lightweight Materials Technology

High Performance Computing Tools to Advance Materials Joining Technologies

General Motors, Warren, MI

Other Participants: Electric Power Research Institute (EPRI) and Oak Ridge National Lab

Objective: Develop new HPC-based integrated computational weld engineering (ICWE) modeling tools to reduce the computational time of laser and arc welding simulation to days or hours in order to optimize the welding technology and proactively mitigate the detrimental welding-induced residual stresses/distortion.

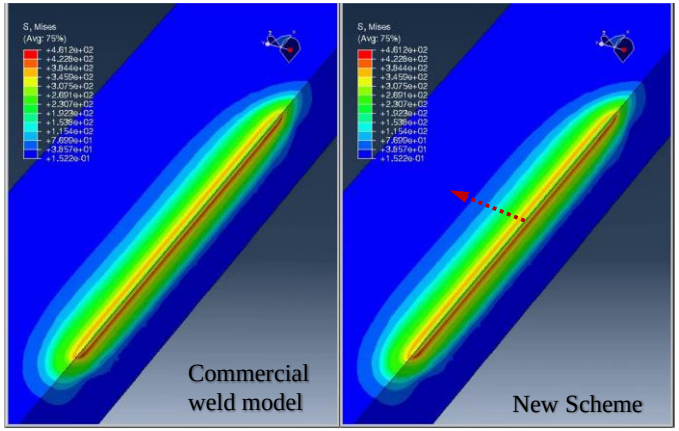

Fig. 2 Comparison of Mises residual stress in short stitch laser welding of thin-gage steel (auto-body welding scenario)

Innovations

- Apply explicit FEM based solver with a novel acceleration scheme to drastically speed up welding simulation (formulated based on insight of unique physical features of welding processes).
- Effective use of massive parallel computers (with sufficient performance scalability on cluster type HPC having 500 to 2000 processing cores)

Impacts

- High fidelity simulation requiring 10-12 weeks in the past can be completed in less than 24 hours.
- Offers the ability to realistically evaluate welding innovations numerically rather than rely on expensive and time consuming iterative physical trial and error methods.

February 2017 – February 2018
Total Project Budget $360k
DOE Cost Share $300k

Future Challenges

New projects using HPC are focusing on:

- Designing multi-material joint interfaces through a top-down approach
- Lowering the cost of carbon fiber precursors using ICME tools

High Performance Computing could also be applied to solving challenges in:

- In-situ process control of manufacturing processes such as HP-RTM or adhesive application
- Identifying the ideal composition for novel corrosion protection of Mg
- And many others!

Contact

H. Felix Wu – Materials Program Manager
felix.wu@ee.doe.gov

Will James – VTO HPC4Materials Lead
charles.james@ee.doe.gov

Sarah Kleinbaum
sarah.ollila@ee.doe.gov

Jerry Gibbs
jerry.gibbs@ee.doe.gov

Carol Schutte
carol.schutte@ee.doe.gov

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