Aluminum Association
Fuel Efficiency Impact of Vehicle Weight Reduction in Class 8 Trucks

May 2010

Summary

Substituting high strength, low weight aluminum for more traditional materials can eliminate 3,300 lbs from the vehicle weight. As such, transporters are able to load their vehicles with an additional 6.5 percent of payload at gross vehicle weight (GVW). For equivalent average ton-mile freight efficiency, this equates to fewer trips and an "effective" fuel and emissions savings of 6.5 percent.

Based on these findings the return on investment for materials substitution with aluminum, could yield annual savings of fuel and emissions for a weight constrained vehicle is estimated to be as high as 1,612 gallons and 17.9 tons of CO_2. When considering these results for the total United States fleet of approximately two million vehicles, the overall economic and ecologic impact of weight savings in Class 8 trucks and trailers may be on the order of one billion gallons of diesel and 10 million tons of CO_2 per year.

Methodology

The Aluminum Association commissioned Ricardo Inc. to study the fuel efficiency impact of lightweighting Class 8 Trucks and Trailers in the United States. The study was conducted based on the simulation of three different configurations of vehicles and three payload conditions (i.e. unloaded, gross vehicle weight [GVW] and half-GVW load). The three vehicle configurations studied include (1) a baseline conventional truck and trailer (2) conventional vehicle with today's typical lightweighting options and (3) an aluminum intensive vehicle that shaves 3,300 lbs. off the conventional vehicle and provides the same amount of payload increase; 6.5 percent more than the conventional vehicle's payload at GVW.

This study was conducted for the major drive cycles representing commercial transportation in the United States. Ricardo used a physics-based model developed for a Class 8 truck with 2010 emission regulation equipment based on Ricardo proprietary data as well as published information. The model simulates what happens to the vehicle when the driver applies the accelerator and/or brake pedal in order to achieve a certain vehicle speed at a certain time. The simulation runs on a millisecond-by-millisecond basis and predicts the fuel usage and actual speed with time as the model driver follows a certain vehicle speed trace (drive cycle). The drive cycles used in the study include the following:

Highway Fuel Economy Test (HWFET)

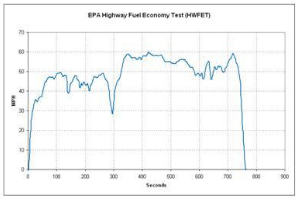
- One of EPA's official highway cycles designed to measure light duty vehicle fuel economy and emissions on a dynamometer
- Duty cycle strictly designed for medium to high speed operation with no mid-cycle stops

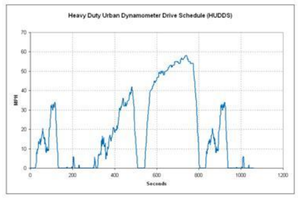
Heavy Duty Urban Dynamometer Drive Schedule (HUDDS)

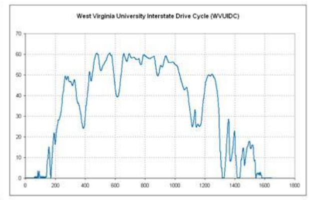
- One of EPA's official drive cycles for heavy duty vehicles
- Features several idle and stop-start portions to simulate heavier traffic
- Contains many acceleration and deceleration events to potentially showcase advantages of weight reduction

West Virginia University Interstate Drive Cycle (WVUIDC)

- Created by West Virginia University to simulate interstate operation
- Speeds vary from medium to high, including many moderate acceleration opportunities







In addition to the cycles shown above, the simulation was conducted for steady-state driving at various speeds. Details of the model configurations are available upon request. The vehicle specifications relevant to the study results on lightweighting are as follows:

- Frontal area: 10.68 m2
- Coefficient of drag (Cd): 0.6 baseline
- Gross vehicle mass: 80,000 lbs. (36,287 kg)

The vehicle and payload configurations simulated in this study are shown below. The parts of the vehicle that were considered in the weight reduction are also shown below.

Class 8 Truck - Tractor and Trailer Weight Assumptions

	Tractor (lbs)	% Weight Reduction	Trailer (lbs)	% Weight Reduction	Tractor + Trailer (lbs)	% Weight Reduction
Conventional	16,000		13,500		29,500	
Lightweight	15,500	3.1%	12,500	7.4%	28,000	5.1%
Aluminum Intensive	14,500	9.4%	11,700	13.3%	26,200	11.2%
Total Weight Savings: Conventional --> Al. Intensive	1,500		1,800		3,300	

Weight Savings for Aluminum Intensive Vehicle

Tractor	(lbs)	Trailer	(lbs)
Frame Rails	440	Side	985
Wheels	350	Rear	150
Cab	330	Slider	145
X-member	70	Door	185
Doors	50	Landing	50
Roof	55	Wheels	285
Misc	60		
Casting / Suspension	145		
l Weight Savings	1500	l Weight Savings	1800

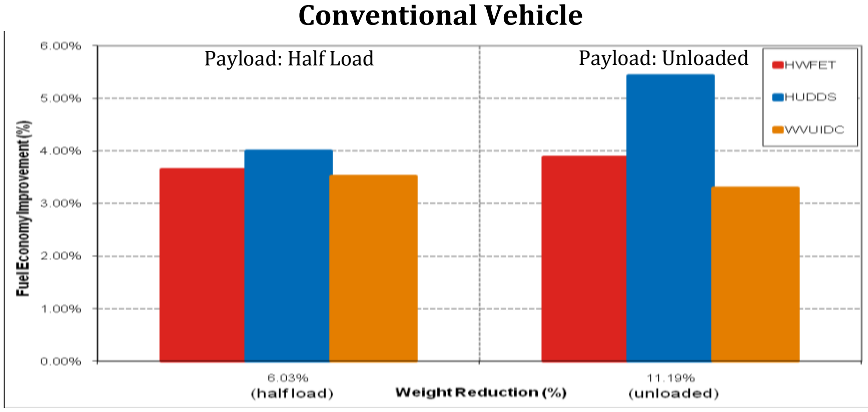
Vehicle Configuration	Tractor Mass (lbs)	Trailer Mass (lbs)	Payload (lbs)	Total (lbs)	
Conventional	16,000	13,500	50,500	80,000	GVW
			25,250	54,750	Half Load
			0	29,500	Unloaded
Lightweight	15,500	12,500	52,000	80,000	GVW
			25,250	53,250	Half Load
			0	28,000	Unloaded
Aluminum Intensive	14,500	11,700	53,800	80,000	GVW
			25,250	51,450	Half Load
			0	26,200	Unloaded

For clarity, the discussion of results in this summary are focused on the aluminum intensive vehicle relative to the conventional. Additional results can be provided upon request.

The aluminum intensive vehicle is 11.2 percent lighter than the conventional vehicle. However, when the vehicles are loaded to half of GVW payload, the total weight reduction is reduced from 11.2 percent to 6 percent. The unloaded and half-loaded conditions are representative of a significant portion of a fleets' actual situation due to the realities of freight logistics. In other words, sometimes when a payload is dropped off there is not a new load, or at least not a full load, available for the return trip.

Simulations were then run on both configurations to predict the fuel efficiency improvements from the aluminum intensive vehicle while being operated unloaded and half loaded within three different drive cycles. These results are shown in the chart below. For the HUDDS cycle with an empty load, the fuel economy of the aluminum intensive vehicle is 5.4 percent better than that of the conventional vehicle. The other drive cycles resulted in improvements between 3-4 percent for both payloads.

Fuel Economy Improvement of Aluminum Intensive Vehicle Relative to Conventional Vehicle



Not shown in the chart above is the "effective" fuel savings derived from the aluminum intensive vehicle at GVW. In other words, by removing 3,300 lbs from the vehicle weight, transporters are able to load their vehicles with an additional 6.5 percent of payload at GVW. For equivalent average ton-mile freight efficiency, this equates to fewer trips and an "effective" fuel and emissions savings of 6.5 percent. Therefore, 1,612 gallons and 17.9 tons of CO_2 per vehicle would be saved when assuming 100,000 miles traveled in the HUDDS cycle. This would be 777 gallons and 8.6 tons of CO_2 for the WVUIDC cycle.

In addition to assessing the impact of weight savings alone, this study analyzed the combination of weight savings and aerodynamic drag reduction. The study found that when combining the aluminum intensive weight reduction with an 8 percent improvement in aerodynamic drag, the overall fuel economy improvement relative to the conventional vehicle was as high as 8.2 percent for the HWFET cycle.

Conclusion

The overall conclusion from this study is that significant freight and fuel efficiency as well as emissions reduction are available today with the appropriate use of lightweighting solutions like aluminum. These solutions are further enhanced when lightweighting is combined with other improvements like aerodynamics, engine optimization, low rolling resistance, etc.

Based on this study, the annual savings of fuel and emissions for a high aluminum content, weight constrained vehicle is estimated to be as high as 1,612 gallons and 17.9 tons of CO_2. When considering these results for the total United States fleet of approximately two million vehicles, the overall economic and ecologic impact of weight savings in Class 8 trucks and trailers may be on the order of one billion gallons of diesel and 10 million tons of CO_2 per year.