Drag Reduction of Tractor Trailers

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The United States Department of Transportation reported that a total of 2,245,0852 combination trucks, which includes tractor trailers, traveled over 138 billion miles in 2003, consuming almost 27 billion gallons of fuel. Just a 5 percent reduction in fuel consumption would result in billions of dollars of savings for the transportation business, reduce the need for domestic and foreign oil and have a positive environmental impact. Almost 65% of the total engine power is used to overcome the drag of a tractor-trailer at speeds approaching 70 mph and as such, the need for improved aerodynamic strategies can not be over emphasized in light of increasing fuel costs.

Clarkson University has initiated a series of studies over the past several years to determine the feasibility of devices attached to the rear of trailers on Class 8 vehicles for improving fuel mileage. Federal regulations dictate that devices to improve aerodynamics that are less than 5 feet and carry no cargo are allowable. Experimental and numerical studies at Clarkson have focused on the effectiveness and feasibility of drag reduction using unventilated, planar-sided cavity devices. Full scale testing is presently underway on the most favorable geometries.

An example of the numerical flow-field results is shown in Figure 1. These studies were used to confirm the viability of the open cavity concept on the aft end of the trailer. Wind tunnel testing was then conducted on over 100 different design geometries using a 1:15 scale Peterbilt 379 tractor and 48 foot trailer illustrated in Figure 2. Cavity length, boat tail angle, and inset from the trailer edge were varied at yaw angles up to 9 degrees. Model drag increments, obtained at zero yaw and a Re of 2.3e105, based on trailer width, indicated drag coefficient reductions up to \( C_D = 0.12 \) or about 9% of the baseline model trailer drag for the optimum geometry of a four foot device with a boat tail angle of 10° and no inset. Removal of the top plate reduced the drag savings for each device by up to 45 percent and device performance decreased with yaw angle.

A full-scale prototype utilizing rigid composite sides with a flexible top and bottom, shown in Figure 3, was road tested in 2000, exhibiting cross-country road fuel savings of about 0.5 mpg, or 8%, over a 10000 mile trip. Estimated fuel savings for a typical 120,000 miles per year traveled were 1500 gallons per truck.

Recently, Composite Factory of Plattsburgh, NY has teamed up with Clarkson University to work towards a viable commercial product of the open cavity design. Since the previous full scale testing involved only a single vehicle and no control, a new series of tests has been initiated to optimize the full-scale geometry. Two different full scale tractor-trailer prototypes were evaluated each in various configurations as illustrated in Figure 4. Preliminary results from the configurations, three different sections of road, including interstate and secondary roadways, and 2500 miles of data collecting indicate the optimal geometry of side and top angles set at 15deg, and a bottom plate angle of 7 deg. Figure 5 illustrates a sample of the over the road averaged differences between the baseline and the optimum geometry for a series of 4 continuous runs between Potsdam and Canton. This configuration was found to provide the most benefit under normal operating conditions.
A finalized prototype based on the recent full scale tests is now being designed and a year-long fleet test of 50 vehicles is being planned to confirm the results under real world operating conditions. Device construction will be accomplished at Composite Factory, Inc. Funding for the project has been generously provided by the New York State Energy Research and Development Authority (NYSERDA), under the direction of Joseph R. Wagner, Sr. Project Manager.

**Figure 1** – Numerical simulation of tractor trailer

**Figure 2** – Wind tunnel testing at Clarkson University of 1:15 scale model
Figure 3 – Full scale cross country test rig (June 2000)

Figure 4 – Full scale geometry optimization test rigs (August 2005)
Figure 5 – Full scale optimum geometry fuel savings (August 2005)