Title
Estimating Fuel-Saving Impact of Low Rolling Resistance Tires on Heavy-Duty Vehicle Fleet Operations

Permalink

Authors
Gbologah, Franklin E.
Rodgers, Michael O.
Li, Hanyan "Ann"

Publication Date
2019-05-01

National Center for Sustainable Transportation

RESEARCH BRIEF

Estimating Fuel-Saving Impact of Low Rolling Resistance Tires on Heavy-Duty Vehicle Fleet Operations

Franklin E. Gbologah, Michael O. Rodgers, and Hanyan "Ann" Li
School of Civil and Environmental Engineering
Georgia Institute of Technology, Atlanta

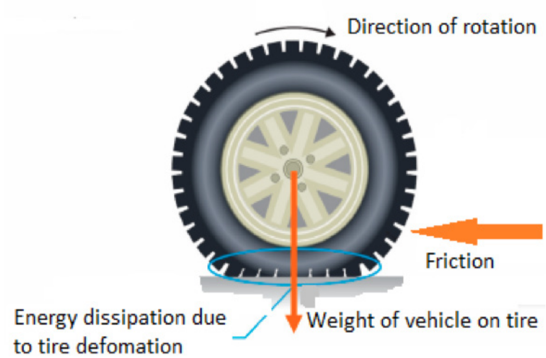
For more information,
contact: Franklin E. Gbologah
franklin.gbologah@ce.gatech.edu

Research Question

The U.S. Environmental Protection Agency (EPA) identified the use of low rolling resistance (LRR) tires as an effective method of reducing vehicle fuel consumption, especially from heavy-duty vehicles (HDV). LRR tires are important to HDV operations because fuel accounts for about 25% of operating costs, and improving fuel economy also reduces emissions of both greenhouse gases and oxides of nitrogen (NOx), a precursor to the formation of ozone, which is harmful to humans, plants, and animals. However, their adoption rate has been slow primarily due to performance uncertainties under real-world operating conditions. Previous mathematical models developed to help fleet operators estimate the impact of LRR tires on their operations have suffered from poor accuracy because they do not account for variable speed profiles in real-world HDV operations. Georgia Tech researchers have developed a new tool for fleet managers that better predicts the benefits of LRR tires under real-world conditions.

Low Rolling Resistance Tires

Rolling resistance is the energy expended by a tire as it rolls on the pavement under the weight of a vehicle. The energy is lost to the constant deformation and recovery in the shape of the tire, and friction on the pavement. Heavy-duty vehicles use approximately 15–30% of their fuel consumption to overcome rolling resistance. When properly inflated to match the load, LRR tires can improve HDV fuel economy by about 10% due to the rubber compounds used in the tire casing and tread pattern.



Methodology

The most accurate way to measure fuel savings would be through direct measurement, while the vehicle is in operation. However, such an approach would be both time- and cost-intensive and would generate data only applicable to the specific type of vehicle being tested. Therefore, the researchers used the Autonomie® simulation tool for modeling automotive performance based on the attributes of its component systems. In this case, the model was calibrated to reflect real-world tractor-trailer performance, then the effect of LRR tires was simulated under a variety of conditions.

Key Research Findings

Fuel savings from LRR tires are not accurately predicted by the previous approaches. In the past, the effect of LRR tires was estimated using the Empirical Law formula, based on vehicle weight and the rolling resistance of tires. But results from this previous formula were found to be inferior when evaluated with this study's more comprehensive results of simulating over 5,000 HDV operations that are based on real-world speed profiles. Specifically, this study finds that results based on the previous formula can vary by about 28% more or less than the average.

Models to predict fuel savings from LRR tires should account for a variety of vehicle, operating, and route characteristics in addition to vehicle weight. The findings of this study show that HDV fuel consumption can be influenced by an additional range of factors including speed, route grade, percentage of time spent accelerating or decelerating, vehicle aerodynamic drag coefficient, and the different road functional classes on the route.

The model presented here shows good accuracy for both constant and varying speed operations. The new model to predict fuel savings from LRR tires was based on two empirical models and was verified with real-world HDV operating data from minor arterials and freeways. The average prediction error on the minor arterials was less than 5% while the average prediction error on the freeways was less than 6.5%.

Fleet operators are likely to adopt LRR tires in certain routes or regions rather than across their entire fleet. The model indicates that the benefits obtained from LRR tires would depend on a fleet's operating characteristics (average speed, acceleration, and deceleration), vehicle-specific characteristics (payload, difference in tire rolling resistance, aerodynamics), and route characteristics (grade, road functional class). This implies different economic returns on their LRR tire investment, which will likely form the basis for LRR tire adoption decisions.

The model identified clear benefits of LRR tires. For the class 8 truck simulated in this study, every 1% reduction in the vehicle's total rolling resistance yielded annual savings of about 7.6 gallons of fuel.

Offering an accessible web-based version of the model would help fleet operators conduct online evaluations. Such a tool would potentially require fleet operators to first upload global positioning satellite (GPS) data for specific routes and download the corresponding road grade information. Fuel-saving benefits could then be performed using the prediction tool developed in this study. The road grade data could be assigned to the GPS information by using a method[i] developed by researchers at Georgia Institute of Technology to extract elevation profiles from the United States Geological Survey Digital Elevation Model database.

Further Reading

This research brief is based on "A Tool to Predict Fleet-wide Heavy-duty Vehicle Fuel-saving Benefits from Low Rolling Resistance Tires," a report from the National Center for Sustainable Transportation, prepared by Franklin Gbologah, Michael Rodgers, and Hanyan "Ann" Li of the Georgia Institute of Technology. To download the report, visit: https://ncst.ucdavis.edu/project/benefits-from-low-rolling-resistance-tires/.

[i] Liu, H., Hanyan. Li, M. Rodgers and Randall Guensler. Development of Road Grade Data Using the United States Geological Survey Digital Elevation Model. Presented at 97th Annual Meeting of the Transportation Research Board. Washington, DC. 2018.

DOI:10.7922/G2QZ285S