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Recommendations Regarding Dynamic Tire Inflation for Commercial Vehicles

Developed by the Technology & Maintenance Council's (TMC)
Future Tire Durability and Reliability Task Force

ABSTRACT

Current practice for tire inflation pressure maintenance in the commercial vehicle fleet does not account for varying load, speed and environmental operating conditions actually experienced by the tire and vehicle. TMC recommends development of an integrated tire inflation pressure control system that can compensate for these factors and provide an automated means of inflating and deflating each tire to match the conditions encountered. This paper discusses the capabilities needed in such technology to provide value to trucking companies and how the technology could be successfully integrated into fleets.

INTRODUCTION

TMC's Future Truck Committee directed its Future Tire Durability and Reliability Task Force to explore the feasibility of an automated system capable of monitoring and actively managing tire inflation pressures in commercial vehicle operation. Based on the Task Force's research, this position paper defines future features and expectations of such a system, and presents recommendations on operational capabilities, technology integration, and potential regulatory considerations. Such a system should be able to rapidly adjust tire inflation pressure based on changing tire load, temperature, vehicle speed and other conditions such that the tire is operated at the optimum pressure to maximize its performance.

DISCUSSION

Proper tire inflation pressure for the load being carried provides several key attributes necessary for safe, reliable and economical service. Among these are:

- Load capacity.
- Transfer of driving and braking forces from the vehicle to the road.
- Resistance to environmental conditions and aggression from the road surface.

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- Low-rolling resistance.
- Long tread life.
- Casing durability for maximum retreadability.
- Comfort for the vehicle operator and cushioning for the vehicle and load.
- Improved fuel economy.
- Reduced tire and vehicle maintenance.

Establishing proper tire inflation pressure is typically based on the maximum likely load expected at each vehicle wheel position. Today, for the most part, tire inflation pressure is set at a fixed value based on the anticipated maximum tire load at highway speeds, but does not take into account the varying load, speed and environmental operating conditions actually experienced by the tire and vehicle.

Tire pressure systems on the market today — generally known as tire pressure control systems (TPCS) or central tire inflation systems (CTIS) — offer the ability to adjust tire inflation pressures for multiple sets of operating conditions, but are not used outside a fairly narrow range of commercial transportation segments (such as agricultural, logging, and mining operations).

In this paper, TMC's Future Tire Durability and Reliability Task Force conceptualizes what a complete tire inflation pressure management system would be; one that takes a total vehicle systems approach to real-time inflation pressure management based on dynamic operational conditions. Such a system would require integration between the vehicle, environment and tire/wheel assembly to determine the correct inflation pressure for each tire at any given moment. It would require the capability to inflate and deflate the tire as necessary to meet the actual tire operating environment.

BACKGROUND

Proper tire inflation pressure provides many fleet benefits including:

- ***Safety*** — Tires that are underinflated for the load being carried suffer from excessive sidewall flex and higher operating temperatures which can lead to serious material degradation (e.g., circumferential rupture or "zipper condition" — a major cause of "rubber on the road"). Tires that are overinflated for the load being carried have less tread rubber in contact with the ground. Since the tread contact area is the sole physical interface between the road surface and the vehicle, all driving, braking and turning forces are transmitted through this area. Less tread rubber on the ground results in these forces being spread across a smaller amount of tread rubber. This presents a potential negative impact on the vehicle's ability to accelerate, decelerate and respond to a steering force input. Overinflated tires are also more prone to road shock and impact damages.
- ***Performance*** — Tire manufacturers design their products to deliver many attributes, not the least of which are load capacity and tread life. Radial tires are designed to achieve a certain degree of sidewall deflection and tire footprint shape. Excessive tire inflation pressure leads to less sidewall deflection; the resulting smaller tire footprint can have a negative impact on through increased the tire wear and reduction in resistance to irregular wear. Insufficient inflation pressure for the load carried creates excessive buildup of heat in the tire which will reduce its service life.
- ***Economy*** — Tire life can be measured in both tread mileage and cumulative casing mileage. Reductions in tread mileage from rapid or uneven tire wear directly impact total tire life cost. Incorrect tire inflation pressure costs money in the form of tread wear and casing life. In addition, tires contribute to total vehicle fuel consumption and underinflated tires require more energy to rotate due to increased rolling resistance.

Current practices for servicing and operating tires in a commercial fleet are focused on maintaining a fixed tire inflation pressure. Discussion of today's technology and fleet approaches to tire pressure management are helpful to understand how a comprehensive, automated system would help fleets.

Most trucking fleets establish an inflation pressure for each axle type — steer, drive and trailer — and, in many cases, use the same value for multiple axle positions. This approach simplifies the maintenance program, giving technicians and drivers fewer inflation pressure values to manage.

Inflation pressures are typically checked as part of a routine maintenance program which takes many forms, such as daily pre-trip inspection by the driver, inbound or outbound safety lane pressure checks, incorporating pressure checks as part of a routine time or mileage based inspections, and routine "lot checks" of every vehicle present at the facility. The use of remote tire inflation pressure monitoring has increased in commercial service, employing reliable systems currently on the market which display actual tire pressures to the driver and/or transmit these values to a central maintenance location.

Automatic tire inflation systems (ATIS), commonly equipped on trailers, are widely used within the industry. These systems are designed to maintain the tire at a constant minimum inflation pressure to ensure the performance and safety attributes of the tires.

CTIS has been successfully used for many years and gives the operator the capability to adjust tire inflation pressures remotely and automatically based on set load and vehicle speed parameters.

Fleet tire inflation pressure standards are typically set for "cold" tires, or tires in which the internal temperature matches the ambient temperature outside the tire. Tire pressure will increase during operation as the flexing of the tire generates heat. Typically, tire inflation pressure will increase 10-15 percent from ambient "cold" to "hot" when the tire is operation.

RECOMMENDATIONS

TMC recommends development of an integrated tire inflation pressure control system that can compensate for various operating conditions and provide an automated means of inflating and deflating each tire to match the conditions encountered. Such a system should be able to:

- ***Determine the load on each axle end then adjust inflation pressure for each tire to match this load***. For tires in a dual configuration, the tire inflation pressure system should maintain a connection between the tires in a dual set to ensure they always have equal inflation pressure with the ability to be isolated in the event of a problem such as a rapid loss of inflation pressure.
- ***Compensate inflation pressure in all tires based on current ambient temperature and ambient barometric conditions resulting from altitude changes.***
- ***Adjust tire inflation pressure when a vehicle is operating at lower speeds for a continuous period such as city driving or stop and go conditions.*** This should also incorporate vehicle speed monitoring with automatic inflation capability if the speed is exceeded above a preset level.
- ***Provide an immediate alert to the driver regarding adverse inflation pressure conditions***, including an alert if either an unusual, unexplained loss of inflation pressure occurs, or if an unusually high increase in pressure occurs — e.g., more than 20 percent — caused by an outside heat source (such as a wheel bearing failure or dragging brake). These alerts should be visible to the driver as

well as available for transmission through vehicle telematics to a central maintenance facility.

- ***Monitor tire inflation pressures when the vehicle (either the tractor or trailer) is not operating, in order to facilitate proactive tire maintenance.*** For combination vehicles – tractor and trailer(s) – integrate monitoring and inflation of all tires in the combined vehicle automatically after the coupling has been completed.
- ***For trailer operations, incorporate smart technology that is cognizant of loading and unloading during loading operations*** (i.e., weight transfer from forklift movement should be considered when designing a system).
- ***Provide capability for rapidly inflating and deflating a tire should positive or negative pressure adjustment be necessary.*** An interlocking system would require the minimum operating inflation pressure prior to operation. During operation, vehicle speed should be monitored and governed to respect the current operational tire load, with an immediate alert sent to the driver and the central maintenance facility when the inflation pressure is below the required inflation pressure for the current load.
- ***Be robustly designed such that critical hardware for such a system, such as air lines, air valves, mounting brackets and electronic sensors are protected from corrosion and operational damage.*** Operational damage may occur from objects in the road could be thrown into the tire or wheel by other tires, or by the forces present during a tire rapid loss of inflation pressure event or blowout.
- ***Be designed such that the performance of critical hardware in such a system would ensure that the quality of compressed air provided to the tire is free of contaminants and water.***

Along with the capabilities listed above, such a technology should be easy to integrate into the fleet's equipment and maintenance system. This integration should encompass:

- Compatibility between tractors and trailers if both units are not equipped with the system.
- Simple set up and adjustment of key parameters such as tire size and other parameters necessary for system operation.
- Ease of maintenance with electronic diagnostics capabilities.

CONCLUSION

A system that inflates and deflates tires based on the dynamic factors detailed above would be a significant change to the "normal" practice of inflating tires today. Some consideration should be given to how such a system would fit into the current, and future regulatory environment governing commercial vehicles and tires. Tire pressures checked during a roadside inspection could vary greatly from the tire's sidewall maximum pressure marking depending on tire load and other conditions. Government regulators would need to be made aware of these new technologies and industry stakeholders should work to have the capabilities of such new systems recognized in government regulations and enforcement practices. ❑