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STUDY AND ANALYSIS OF CENTRALIZED TYRE INFLATION SYSTEM USING ANSYS

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Abstract

Wheels are one of the fundamental components of any automobile. Tires of an automobilegreatly affect the stability and performance of the given vehicle. A wide variety of tires are available in the market depending upon the need of the automobile or the preference of the owner. Although tires are manufactured with high durability, there is one aspect that has notyet been profoundly overcome, that is the maintenance of the tire pressure. An air compressor is pneumatic device that converts power(Using an electric motor, diesel or gasoline engine, etc.) into potential stored in pressurized air (i.e., compressed. By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When the tank's pressure reaches its engineered upper limit, the air compressorshuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank. An air Compressor must be differentiated from a pump because it works for any gas/air, while pumps work on a liquid.

Keywords: Tyre inflation, Ansys.

1. Introduction

According to a study, approximately 80% of the vehicles on the road are driven with one and more tire under inflated. Tire loses air during normal driving (especially after hitting pot holes or curbs) and seasonal changes in temperature. The vehicle can also lose one or two psi each month in winter and even more in the summer and you can't feel if they are properly inflated just by looking at them. This is a system which is installed on the vehicle that enables the operator to adjust the inflation pressure of individual tire of the vehicle.

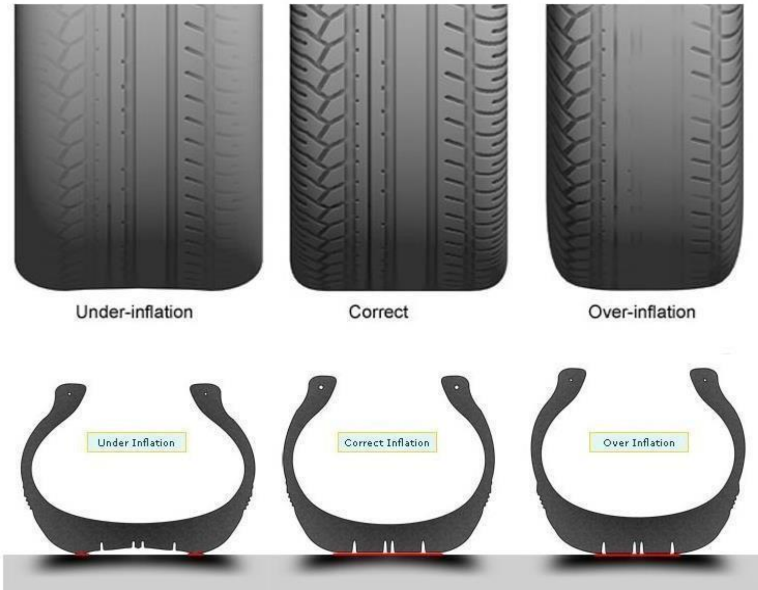


Figure 1.a-*cross of tyre under different pressure*

1.1.1 DEFINITION:

Central Tire Inflation (CTI) is a mechanical component system installed on a vehicle that enables the vehicle operator to adjust the inflation pressure of each individual tire while the vehicle is in motion in accordance with changing vehicle speed, road and load conditions

This system has three general goals:

a) **TO DETECT:** If the air pressure in tire has dropped (Continuously check the air pressure in each tire).

b) **TO NOTIFY**: If there is any dropped in the air pressure in any tire.

c) **TO INFLATE\DEFLATER:** -In case of over pressure or under pressure the tire pressure is maintained inflate the tire to the required level if there is a drop in the tire pressure and there has to be an air supply as well as check wall that opens only when needed. It consists of compressor, which supplies air and air tank is used to stored air at constant pressure. This pressurize air can be filled into tires through flexible ducting with the help of rotary bearing. The pressure conditions are achieved by pressure gauges. The mode of transport is one of the most important criterions these days. The vehicles safety is thus essential Accidents are also increasing at a quick pace. There are several factors which causes these accidents. The improper inflation of tires is one among them. Tires lose air through normal driving (especially after hitting pot holes or curbs), permeation and seasonal changes in temperature. When tires are under inflated, the tread wears more quickly. Under inflated tires get damaged quickly due to overheating as compared to properly inflated tires. The under- inflation also causes a small depreciation in the mileage as well. Above all the vehicles running with under inflated tires can cause accidents. Thus, to rectify all these defects we are using self-inflating systems. The pressure monitoring systems in such systems helps in monitoring the tire pressure constantly. The system which contains sensors feed the information to a display panel which the driver can operate manually. The electronic unit control all the information. The source of air is taken from the vehicles air braking system or from the pneumatic systems. Thus, it helps in re-inflation of the tires to proper pressure conditions. Under-inflated tires increase rolling resistance, which can not only reduce fuel economy, but can also wear out tires and reduce vehicle safety through poor handling. Maintaining correct tire pressures and monitoring for uneven tire wear (which can be caused by poor wheel alignment) can help to ensure optimum vehicle performance. Central tire inflation (CTI) systems offer one solution to managing tire pressure, by automatically maintaining tire pressures within a pre-determined range. Commonly used in off-road vehicle applications, CTI systems are primarily installed for their safety benefit (e.g., reducing tire blow-out) and extending tire life.

1.2 HISTORY:

During World War II the mobility requirements in the former Soviet Union and Warsaw pact countries were extremely demanding due to poor road and highway quality. Consequently, a considerable effort was made by these countries to develop systems to improve mobility, including primary suspensions and central tire inflation systems (Kaczmarek, 1984). Kaczmarek (1984) stated that “One of the most effective and well proven systems that have been adapted to wheeled tactical vehicles to improve the overall vehicle mobility is CTI.” However, after World War II no serious consideration of the benefits of CTI occurred until the early 1980’s, where after most of the military tactical vehicles produced in the United States were equipped with CTI (Adams, 2002). Today the largest application of CTI is in the forestry industry. Since 1983 the United States Forest Service has been testing the feasibility of Central Tire Inflation technologies (Altunel and de Hoop, 1998). Brown and Sessions (1999) summarized several of the United States Forest Services sponsored research programs to evaluate the impact of CTI in commercial logging operations on Forest Service lands. The rough nature of logging roads forces vehicles to slow down in order to limit the vehicle vibrations which negatively impact the vehicle as well as the health of the operators. The results of their research showed that, with CTI the overall vehicle's speed could be increased as a result of the tires being optimally suited to the road surface conditions. While forestry is considered the dominant user of CTI, it is used extensively in other industries namely; military tactical wheeled vehicles, commercial concrete mixer trucks, articulated dump trucks and assorted agricultural vehicles. However, the benefits derived from CTI are common to all industries, these benefits being potential cost savings in road construction and maintenance, lower vehicle maintenance costs, increased vehicle mobility and traction, extended hauling seasons where applicable and improved health and safety for drivers (Greenfield, 1993).

BASIC OPERATION OF A CENTRAL TIRE INFLATION SYSTEM:

A CTI system permits a vehicle operator to optimize tire and vehicle performance by varying inflation pressures in response to changing operating conditions (load, road and vehicle speed) while the vehicle is moving (Foltz and Elliot, 1996). The idea behind the CTI system is to provide control over the air pressure in each tire as a way to improve the performance of the vehicle as changes in operating conditions occur. Changes in operating conditions such as a truck being fully loaded to being empty, a change in road surface which necessitates a reduction/increase in vehicle speed or a change in the terrain in which one is operating which affects the traction of the vehicle.

Tire deflection is the key to understanding the use of CTI technology. Tire deflection is defined as the change in tire section height from the freestanding height to the loaded height. The percentage deflection is the ratio of that change to the freestanding section height. At the lowered inflation pressures (increased tire deflection), the tire's imprint or contact area is greatly increased and the load is applied over a substantially larger area (Sturos et al., 1995).

- Reduced stress applied to road surfaces,
- Improved traction,
- Reduced tire bouncing (or "hop"), and
- Improved operator comfort.

Decreasing tire deflection (reducing the tire footprint) will result in a smaller contact area which is also beneficial under the correct situation. A smaller contact area reduces the resistance that a tire has when it rolls. The extra rolling resistance that the 4 underinflated tires has causes the vehicle's engine to work harder which results in increased fuel consumption. When tires are underinflated the tread wears more quickly. Underinflated tires also overheat more quickly than properly inflated tires, which cause tire damage. Because tires are flexible, they flatten at the bottom when they roll (see figure 1). This contact patch rebounds to its original shape once it is no longer in contact with the ground. This rebound creates a wave of motion along with some friction. When there is less air in the tire, that wave is larger and the friction is greater and the friction creates heat. If enough heat is generated, the rubber that holds the tire's cords together begins to melt and the tire eventually fails.

CONTROL SYSTEM:

Modern day CTI systems have an electronic control unit (ECU). The ECU processes driver commands and monitors all signals throughout the system. The ECU sends commands to the pneumatic control unit, which directly controls the wheel valves and air system. The pneumatic control unit also contains a sensor that that transmits tire pressure readings to the ECU. The ECU is mounted in the vehicle cab allowing the driver to select tire pressures suitable for the load and speed of the vehicle, the tire pressures are also digitally displayed on the control system. Tire pressures selected for different road sections can be stored within the ECU (Anon, 2006). Figure 5 shows the control panel of the Redline Eltek CTI system, as the operator would see it when mounted on the dash of the car.

PROBLEM IDENTIFICATION:

As we are aware that maintenance of correct tire pressure is extremely important for the enhancement of tire life. Due to drop in the pressure the tire goes underinflated and reduces fuel economy, quickest tire wear, not proper rolling, discomfort ride etc. So, to solve out all these problems we make an automatic tire inflation system which will properly inflate the tire all the times.

DESIGN OBJECTIVE:

The overall goal of our design project is to develop a system that will decrease tire wear while improving fuel economy, performance and safety of a passenger vehicle through dynamically adjustable tire pressures. However, there are several key objectives that the team has targeted our design to meet, and these objectives include both design characteristics and business objectives.

WHAT'S IN A TIRE

Tires contain many rubber compounds and other materials because they are required to safely perform in the face of a wide range of demanding conditions, including varying vehicle loads, flexibility, and speeds, as well as hot and cold, wet and dry, and powerful, abrasive road conditions, all with indefinite inflation pressures. They are expected to perform for thousands of miles retaining their essential performance and safety properties.

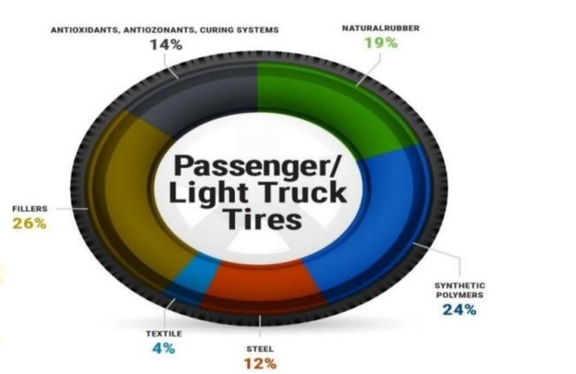


Figure 1.b-*Composition of light truck tyres*

NATURAL RUBBER:

Natural rubber provides specific performance characteristics to tires. It is especially good for tear and fatigue crack resistance.

SYNTHETIC POLYMERS:

The two main synthetic rubber polymers used in tire manufacturing are butadiene rubber and styrene butadiene rubber. These rubber polymers are used in combination with natural rubber. Physical and chemical properties of these rubber polymers determine the performance of each component in the tire as well as the overall tire performance (rolling resistance, ear and traction).

STEEL:

Another important synthetic rubber is halogenated polyisobutylene rubber (XIIR) commonly known as halo butyl rubber. This material causes the inner liner to be impermeable, which helps to keep the tires inflated. steel wire is used in the tire belts and beads, and the piles for truck tires. The belts under the thread serve to stiffen the tire casting and improve wear performance and tire handling. The bead wire anchors the tire and locks it onto the wheel.

TEXTILE:

Textiles in tires are various types of fabric cords that reinforce the tire. Tire fabric cords provide dimensional stability and help support the vehicle weight. These textiles are polyester cord fabrics, rayon cord fabric, nylon cord fabric, and aramid cord fabric. They are used to make the tire piles in passenger tires. While they serve as the primary reinforcing material in the tire casing and they also help the tire keep its shape in different road conditions which provide added endurance and performance characteristics to the tire

FILLERS (Carbon Black, Amorphous Precipitated Silica):

Both carbon black and silica are fillers that reinforce the rubber, that is, improve properties such as tear, tensile strength and abrasion. This results in improved wear performance and traction. Silica use improves rolling resistance.

ANTIOXIDANTS:

Antioxidants help to keep rubber from the breaking down due to the effect of temperature and oxygen exposure.

ANTIOZONANTS:

Antiozonants are used to impede the effects of exposure to ozone on the surface of the tire.

CURING SYSTEMS (Sulphur, Zinc Oxide):

Sulphur and zinc oxide, are crucial ingredients to transform sticky black rubber into a solid article during vulcanization or tire curing. Curing systems shorten the vulcanization time and impact the length and number of crosslinks in the rubber matrix that from during tire curing or vulcanization.

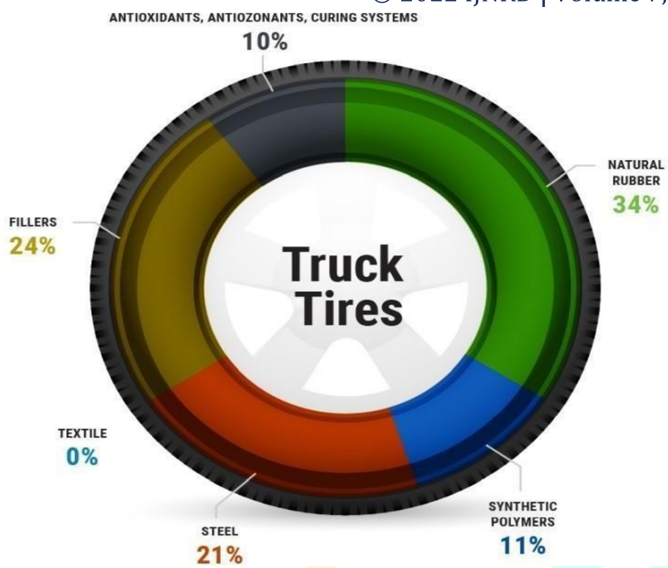


Figure 1.c-*Composition of heavy truck tyres*

2. Materials and Methods

This project started with discussion with project guide about design. This discussion covering project overview and throw out opinion that related about title and instruct to proposed a certain design and concept before go up to next step. Then start to make and decide the best idea about the title. Before that literature review and research about title is the important point to get the best idea. Then study and make a lot of investigation about conventional air filling system this includes a study about concept of conventional air filing system process to fabricate, and material, these tasks have been done through study on the internet, books, and other information. After gather and collect all related information and obtain new idea and knowledge about the title, the project would continue with the design process. In this stage, the knowledge and idea should throw out in sketching process. After several design sketched. The best design would be chosen among previous design so that we could carry on designing process. Then the selected design would be transfer to engineering drawing using CAD software in order to for analysis process. After that material preparation which is has been confirm initially. Purpose of this process is to determine the suitable and follow the product and design requirement. This process covering purchased material, measuring material and cutting off based on requirement. Here, this process is important because the material would determine whether our product in way to failure or otherwise.

After all the drawing and material preparation done the next process is fabrication process. This process based on dimension has been determined from drawing. During this process, all the manufacturing process which is suitable could be used such as drilling process, thread using lathe machine welding process and cutting material using disc cuter. Analysis stage has been implemented before fabrication stage. The evaluation is by considering the strength portable, durability, safety and others. After al process above done on schedule without any problem such as product defect all material for report writing is gathered.

Rotary valves are pneumatic valves that handle and meter the flow of granular bulk or powders. Material is fed into the valve via a hopper (see Figure 1) or other inlets, handled through the valve rotor, and then deposited onto a conveyor system in discrete packets, all with minimal pressure loss. They are most often used in air conveyor systems to minimize the loss of pressure across the valve, but rotary valves are also used to meter materials at a controlled feed rate. They work almost exclusively in air systems and function as airlocks, explosion/flame barriers, and process isolators, among other tasks. They can move dry to slightly sticky products, and find many applications in chemical and food, pharmaceutical, plastic, and other manufacturing markets. Rotary valves are composed of 4 main components: an outer housing, a rotor, a rotor bearing and seal, and a drive. The housing is the rightmost component in Figure 2 and provides the inlet/outlet ports as well as the protective pathway for material through the valve.

3. Results and Discussion

DATA COLLECTION:

This trial involved an in-field assessment of two cement tankers operating regional line haul routes in NSW. The vehicles operated over an average of 12 week between February 2013 and May 2013.

Both trial vehicles underwent a monitoring period of 6 weeks with the CTI system turned on. This was followed by a 6-week period with the CTI system turned off. In order to ensure that the operation of each vehicle was directly comparable before and after the intervention, data loggers were fitted to each vehicle to capture key descriptors of vehicle operation

Specifically, information was collected in relation to:

- AVERAGE SPEED: average speed (km/h).
- IDLE TIME: time spent at idle.
- PTO: time spent using power-take-off.
- STOPPING INTENSITY: number of stops per kilometre travelled.
- FUEL CONSUMPTION: total fuel consumed (L).

DATA ANALYSIS:

The first stage of the analysis involved validating that the fuel consumption results could be compared before and after the trial. This was done by comparing four duty cycle descriptors (average engine load, average speed, idle time and PTO time) for each truck during both phases of the trial. As shown in Figure 1, a comparison of the speed profiles for both vehicles (with and without the CTI units turned on) revealed a strong level of correlation. A comparison of the engine load profiles for both vehicles also shows a strong correlation between the baseline and trial periods for each trial vehicle. Comparisons for idle time and PTO time for both vehicles are displayed in Figures 3 and 4. Both vehicles showed higher average idle and PTO times for the trial period when the CTI units were turned on, and lower average times for the period when the CTI units were turned off. In summary, comparison of the duty cycles indicated that operation of the vehicles when fitted with and without CTI systems was very similar, with the exception of slight differences in idle time. Following data validation, the fuel consumption of the two trial vehicles was compared. The results are summarized in Section 4.

RESULTS:

A summary of the results for each of the trial vehicles when using automatic tire inflation is provided in Table 1.

Comparison of the fuel consumption data revealed that when using a CTI system changes in fuel efficiency ranged from a 1.22% fuel use reduction in Truck 2, to a 0.84% fuel use increase in Truck Of the two trial vehicles, Truck 2 provided a stronger argument in support of CTI producing fuel savings, despite more idling and more PTO use during the CTI period. Combined, the average fuel efficiency benefit was 0.19% (Figure 5). Analysis of the GHG performance (Figure 6) mirrors the fuel trend: GHG emissions generated by the trial vehicles were, on average, 0.19% lower than before the monitoring intervention.

Figure 1
Comparison of average vehicle speed across the trial period

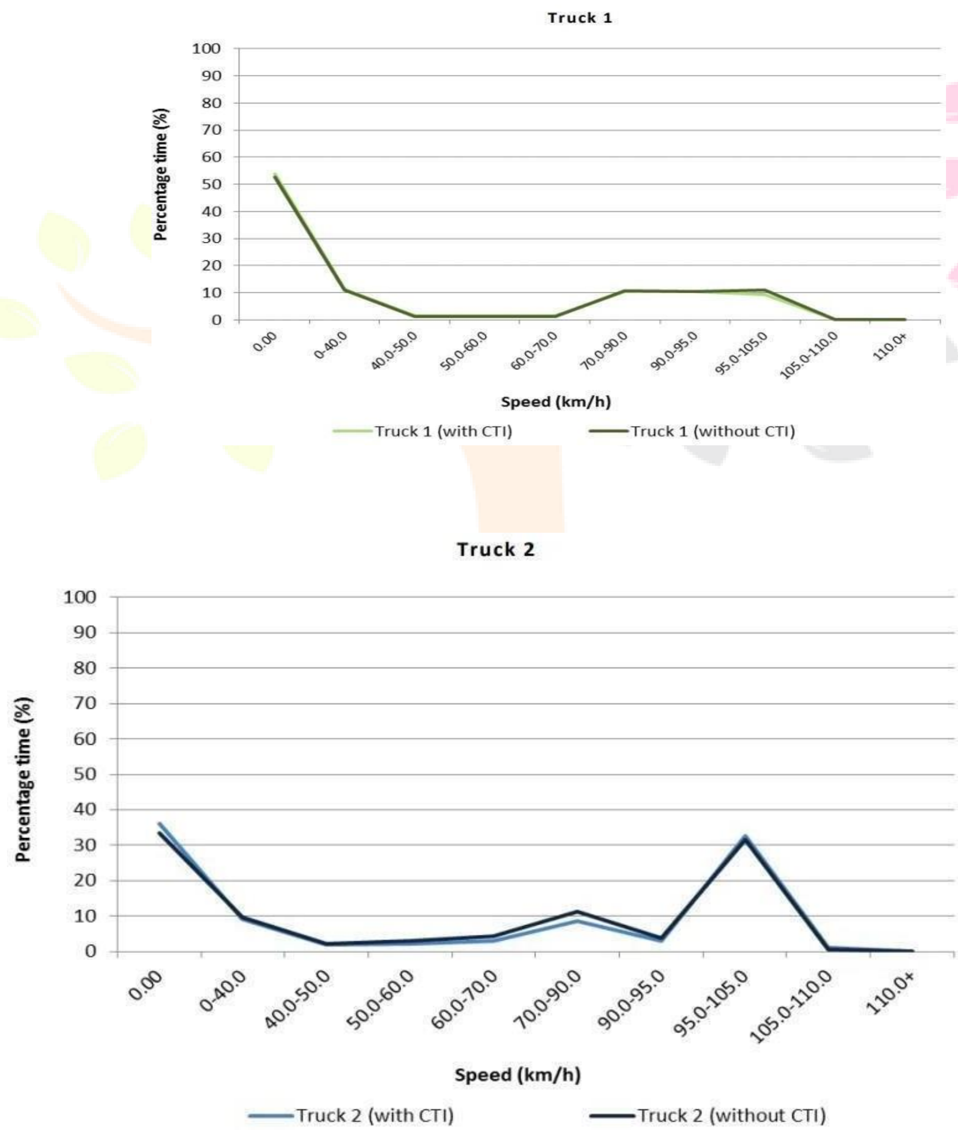
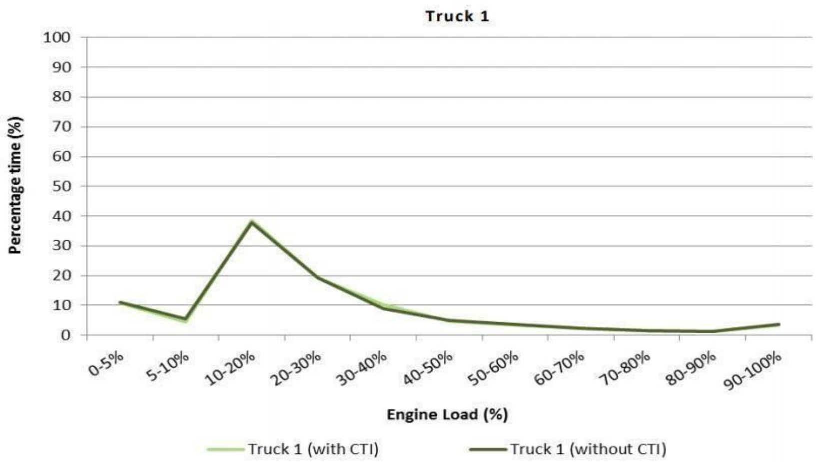


Figure 2
Comparison of average vehicle engine load across the trial period



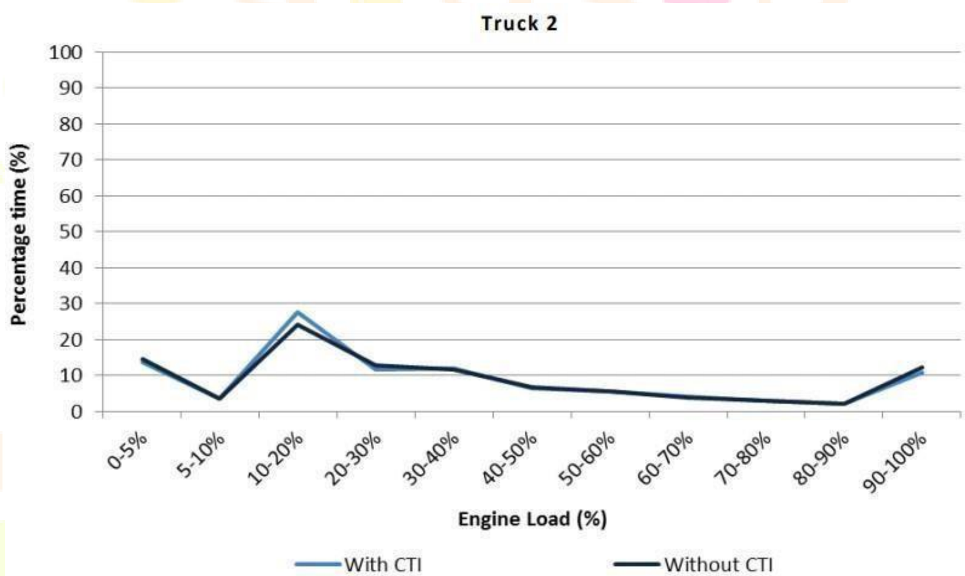


Figure 3
Comparison of average vehicle idle time across the trial period

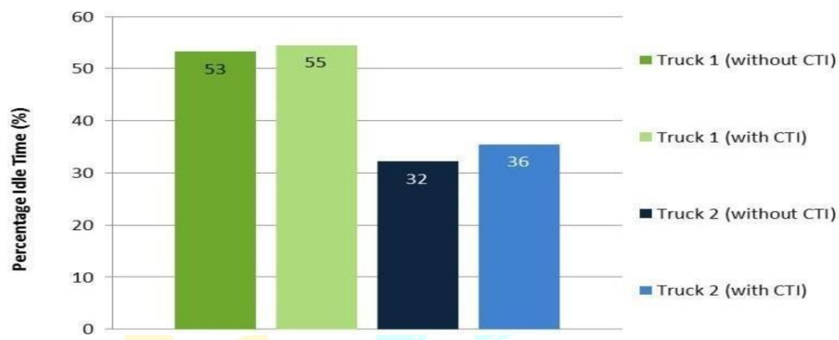


Figure 4
Comparison of average vehicle PTO time across the trial period

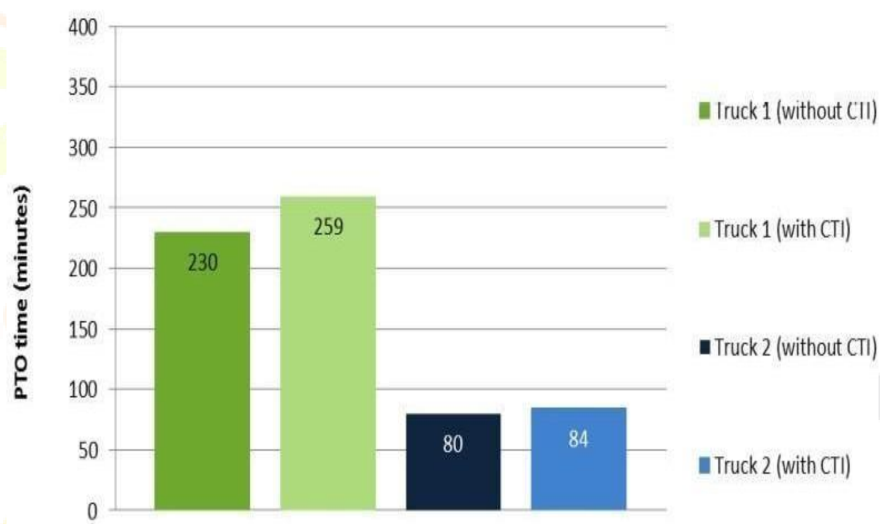


Figure 5
Comparison of average vehicle fuel consumption across trial period

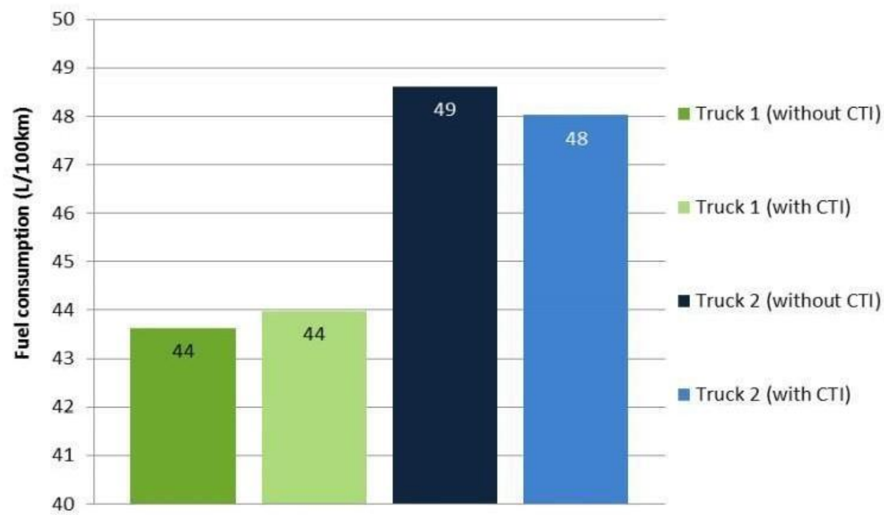


Figure 6
Comparison of average vehicle GHG emissions across the trial period

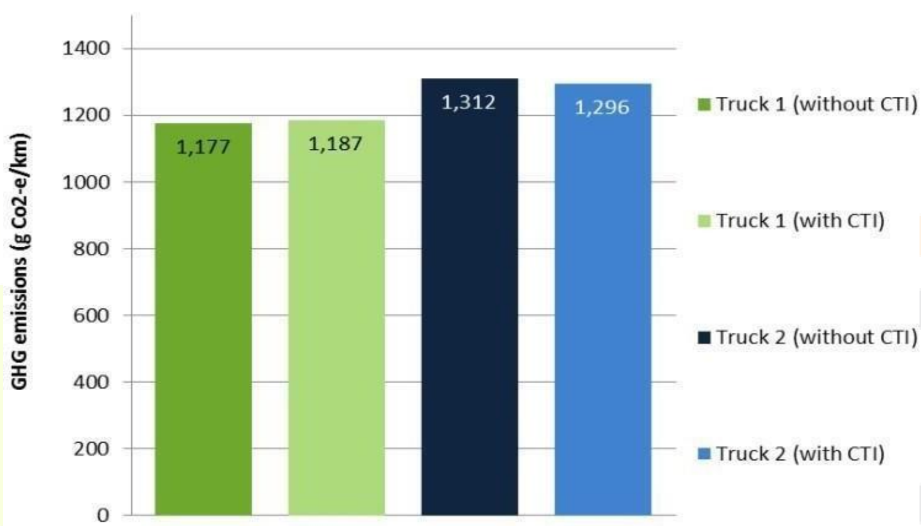


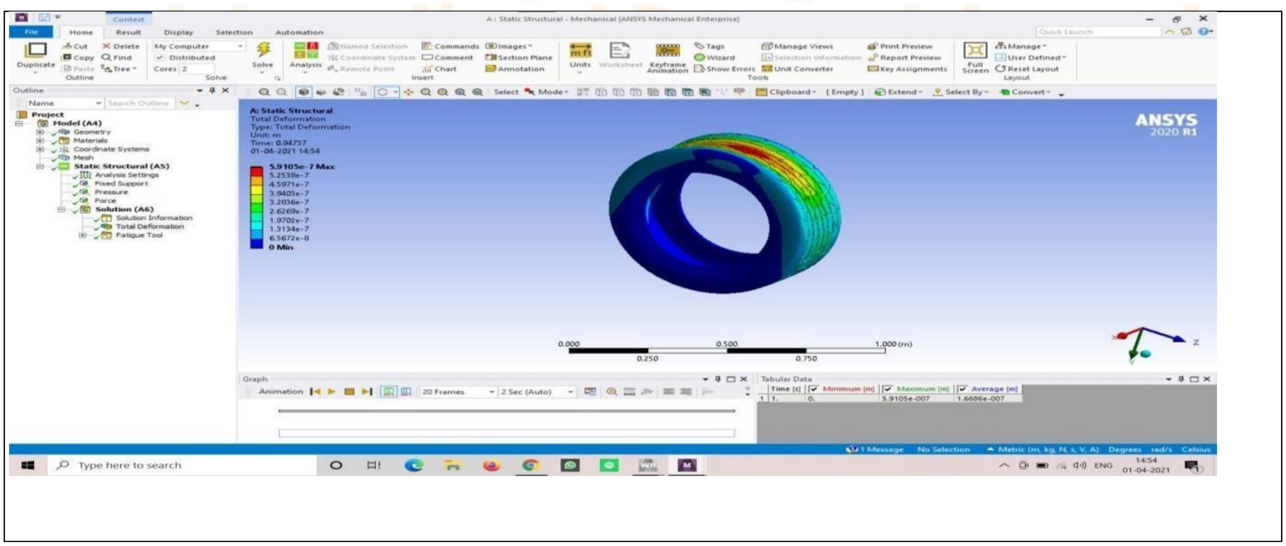
Table 1 Vehicle performance with automatic central tyre inflation (CTI) system

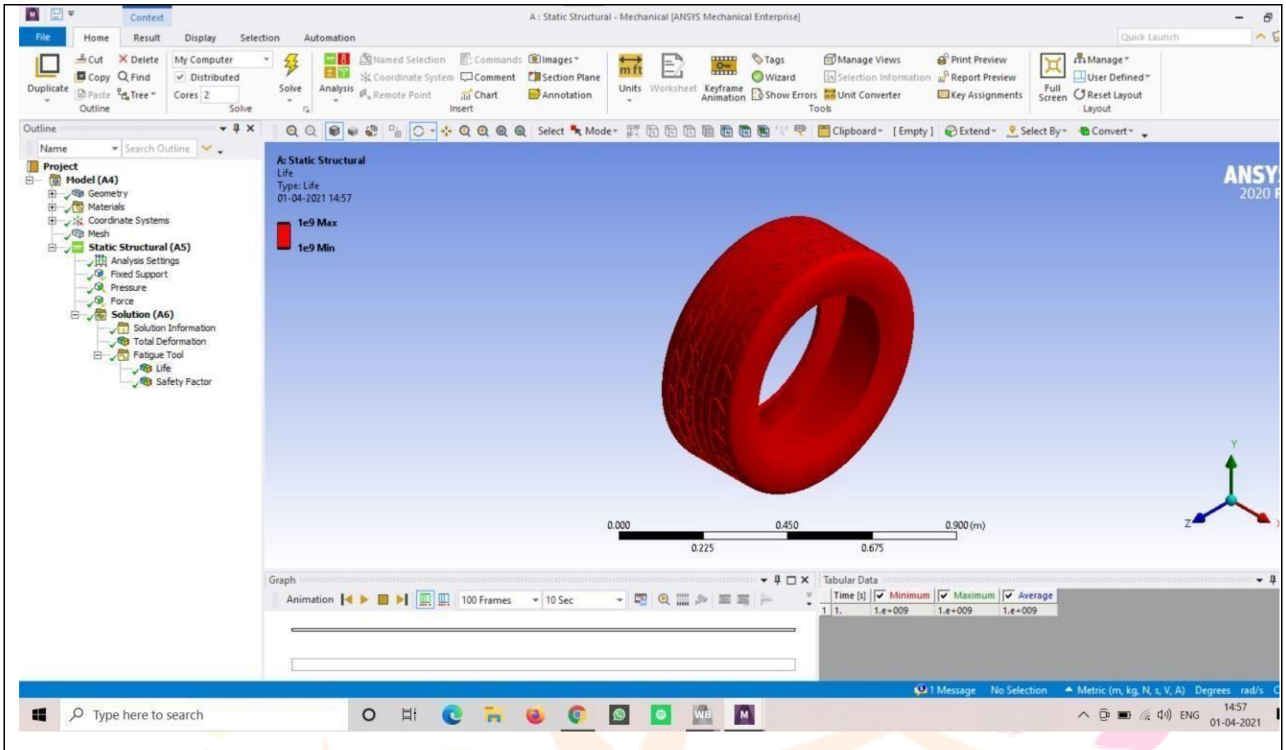
Driver	Vehicle type	Fuel saving (L/100 km)	Relative fuel saving (%)	GHG benefit (g CO_2-e/km)	Economic benefit ($/100 km)
Truck 1	Concrete tanker	–0.36	–0.84	–9.79	–0.51
Truck 2	Concrete tanker	0.59	1.22	15.79	0.82

TRIAL SUMMARY

This trial sought to quantify the fuel efficiency benefits of an automatic central tyre inflation system. The trial was conducted with two cement tankers running regional linehaul applications in NSW.	**Fuel benefit (L/100 km)**	**GHG benefit (g CO_2-e/km)**	**Economic benefit ($/100 km)**
	0.19%↑ (saving 0.23 L/100 km)	0.19%↑ (saving 3 g CO_2-e/km)	0.19%↑ (saving $0.15/100 km)

↑ performance better than conventional vehicle
↓ performance worse than conventional vehicle

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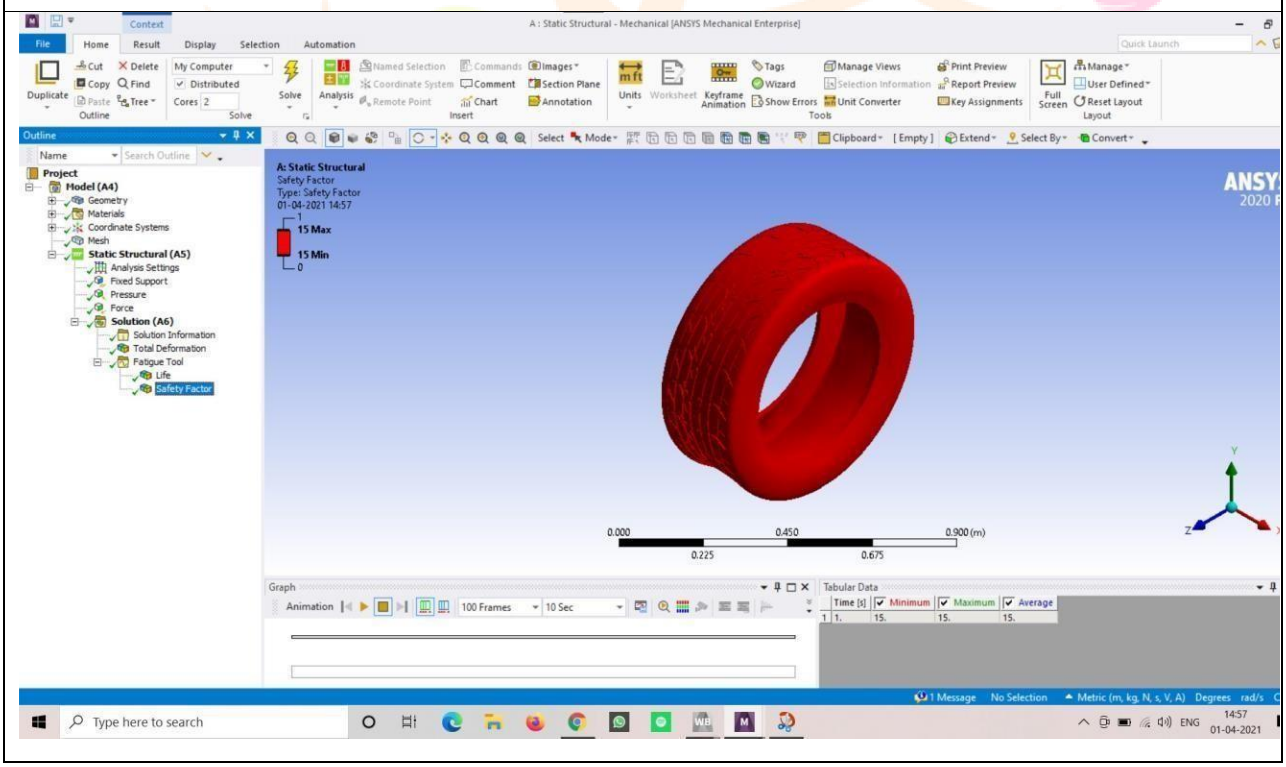
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4. Conclusion

Contrary to anecdotal evidence and the results of overseas studies, this trial showed a negligible impact on fuel consumption for both trial vehicles. Overall, the average result was inconclusive (showing a small average benefit of 0.19% with the CTI fitted in a line haul application). Taking into account the duty cycle penalty (idling, PTO) the benefit for truck 2 was considered promising. However, the result was not conclusive given the background variability in fuel use data.

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