International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 2; Issue 6; November 2017; Page No. 23-26

Impact of inflating gases on the performance of tire: A review

[1] Ramandeep Singh Johal, [*2] Krishna Pundhir, [3] Ankit Garhiya, [4] Arshdeep Singh, [5] Gaurav Jaryal
[1] Assistant prof. Department of Mechanical Engineering, DAV Institute of Engg. & Tech. Jalandhar, Punjab, India
[2-5] Students, Department of Mechanical Engineering, DAV Institute of Engg. & Tech. Jalandhar, Punjab, India

Abstract
From old days shop dry air is used to inflate the tires for various automobiles. Now days Nitrogen is an alternative of shop dry air. This study shows us a number of advantages of Nitrogen over shop dry air. Literature review suggests that there was considerable improvement in fuel economy, tire tread wear, and tire life. The reason for this is that the shop dry air has small molecules in comparison to Nitrogen molecules, shop dry air leaks in more quantity than the Nitrogen in the same time period. Nitrogen decreases deterioration of rubber which affects tire life.

Keywords: safety, tire inflation pressure loss rate, tire life

1. Introduction
Earth is surrounded by layers of gases to make an atmosphere of earth. These gases are retained to earth surroundings by earth's gravitational pull. The air is a homogeneous mixture of Nitrogen 78.09%, Oxygen 20.95%, Argon 0.92%, Carbon Dioxide 0.04% and <0.01% other gases and water vapours. Mostly shop dry air is used to inflate tires everywhere. According to NHTSA study, more than 25% accident occurs due to underinflated tires of the vehicle. The study also found that 5% of all vehicles experienced tire problems immediately before a crash, with 66 % of those representing passenger cars, 17 % being SUVs, and the rest being pickups and vans. Only 31% of single vehicle accident was not due to under inflation [1]. A tire loses pressure while it is running on the road and also at static condition. Due to temperature variation in the environment, the pressure of tire looses constantly. The vehicle is driven under extreme conditions like a rough road, irregular surfaces (pits and curbs), load variations which will affect the performance, handling, tire life etc. Nitrogen is used to inflate tires of army trucks, airplane, racing cars, racing bikes etc. to maintain the right level of air pressure in tires and to attain maximum efficiency. While a vehicle is running at very high speed, temperature rise more in air inflated tires and temperature rise is less in Nitrogen inflated tires at the same speed. The molecular size of the air is small so that's why tire inflation pressure loss rate is more, on the other hand, molecular size of Nitrogen is greater than air molecular size so tire inflation pressure loss rate is less.

In order to achieve the primary goal of the project, two individual correlated objectives are identified. The first one is to investigate the relationship between rolling resistance and various tires Parameters including pressure, load, velocity as well as tire filling strategy. The second objective is to provide the technical support for the statement that Nitrogen filling tires do have a positive effect on the tire performance and vehicle fuel efficiency.

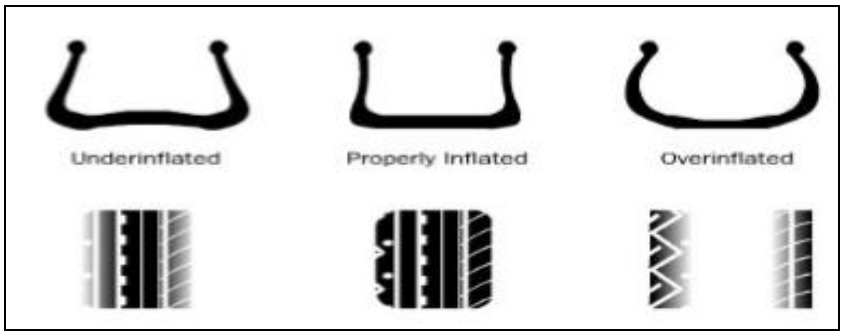

Fig 1: Tire profile of (a) under-inflated, (b) properly inflated and (c) overinflated [9]

2. Literature Review
The most important part that affects the motion of the vehicle is the rolling resistance and it contributes the major part of the vehicle load and the fuel consumption. Therefore plenty of research work was done to determine how various tire parameters such as [e.g. load (L), inflation pressure (p), and speed (V)] affect the rolling resistance so that the fuel economy can be increased. Recent studies show that using

Nitrogen in the tires can increase the tire life and can maintain proper inflation [2]. Therefore Dr. Nader Jalili did a project to explore the advantages of using Nitrogen in tire inflation and to improve the vehicle safety. Various Qleak and Sleek tests were performed to obtain the main objective.

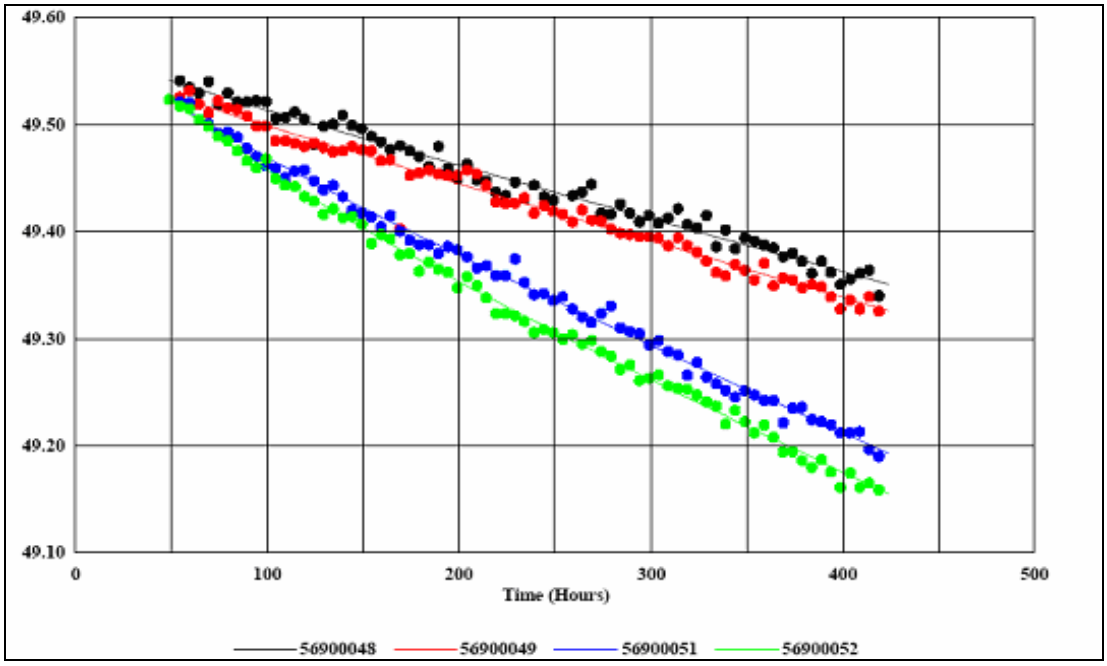

Fig 2: Inflation Pressure vs. Time in Qleak Test [2]

The figure2 shows various types of the leakage of gas at different tire pressures. The Qleak experiment shows that when we fill Nitrogen in tires the pressure is maintained about 35% to 55% better than the shop dry air depend upon different tire types. The sleek experiment shows that when we fill Nitrogen in tires the pressure is maintained about 29%-35% better than the shop dry air at oven temperature.

The second phase of the project was to check contribution of the tire inflation pressure on the rolling resistance and tire tread wear. Three different locations were taken into consideration and at what locations, the tire inflation pressure were recorded. Rolling resistance of each tire were first calculated and then it was used to find out the rolling force on each truck and then the extended to all the trucks in each location and compared for both the air and Nitrogen inflated tires and the results simply shows that the tires which were filled with Nitrogen possess less rolling force as compared to the tires filled with air. Figure 3 shows the amount of rolling resistance on Nitrogen and air inflated tires at three different locations (DC1, DC2, DC, 3).

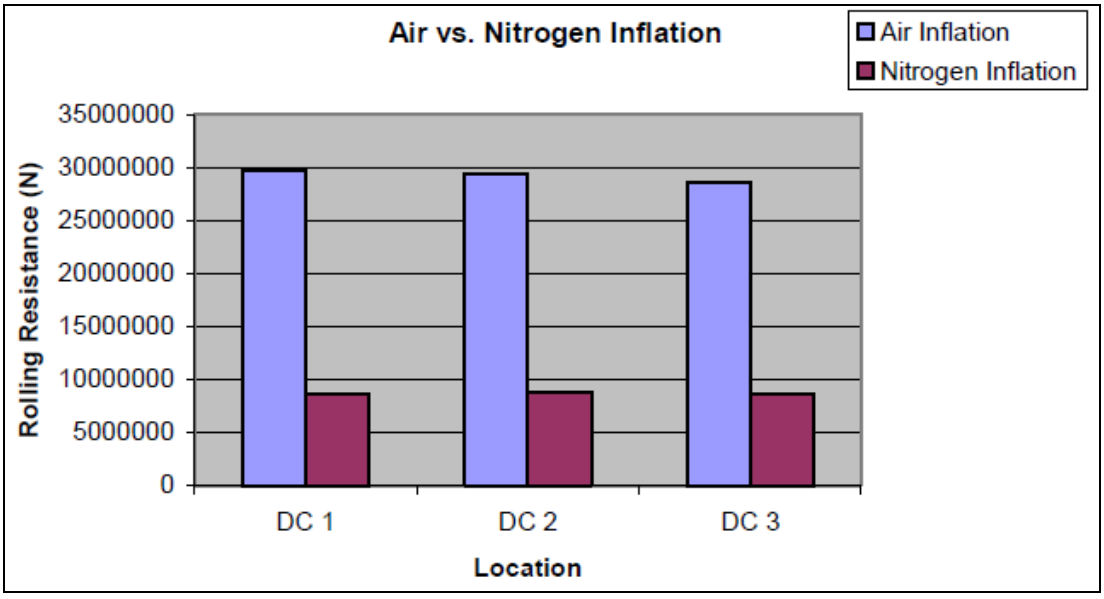

Fig 3: Comparison of rolling resistance at each location [2]

From figure 3 we can simply conclude that the air leakage from the tire which is inflated with Nitrogen is less than the tire which is inflated with the air. If we drove the truck to 2500 miles/week then the leakage in the air inflated tire is about 0.11 kpa per week whereas the leakage rate of the Nitrogen inflated tire is about 0.029 kpa per week for the same distance. Again the results are in the favour of Nitrogen that is the Nitrogen inflated tires can maintain tire pressure of about 74% better than the shop dry air at normal working conditions and temperature. The result indicates that Nitrogen inflated tires simply produce 70% less rolling resistance than inflated air tires. The data for the tables and plots were obtained from truck tires in static and rolling resistance with the variation of pressure. All the results are consistent with the objectives.

3. Tire Tread Wear

It was found that the tires wear with time as there are many factors which affect it. One of the important factors which effect is the tire inflation pressure, so it is important to study the tire wear with different tire inflation diffusion. Again the result shows that the tire inflated with Nitrogen have low wear rate. The table1 shows tire inflated with Nitrogen have 48% less wear per mile over the shop dry air filled tire.

Table 1: Tire tread wear of inflated with Nitrogen and air [2]

	Front Tires				Rear Tires			
	Nitrogen Inflation	Air Inflation			Nitrogen Inflationed	Air Inflation		
Location	Wear/mile (mm)	Wear/mile (mm)	Increment (mm)	Percentage (%)	Wear/mile (mm)	Wear/mile (mm)	Increment (mm)	Percentage (%)
DC 1	0.00005082	0.0001	0.000049	49	0.000071	0.00015	0.000079	53
DC 2	0.000068	0.00013	0.000062	48	0.000081	0.00016	0.000079	49
DC 3	0.000052	0.0001	0.000048	48	0.00006	0.00012	0.00006	50

4. Fuel Economy and Environmental Effects

It is important to increase the fuel economy as it simply cut down the money which we spent on the fuel. By "Vrakash Venkataraman" use of Nitrogen increase fuel economy by 23% and improves life of tire by 50% [11] by increasing fuel economy the amount of CO2 released into the atmosphere is reduced by 4905 tonnes every year by using Nitrogen inflated tires. Rolling resistance can be reduced by 70%, every 3% decrease in the rolling resistance the fuel economy can be increased by 1%. Table2 shows the increment in mileage by using Nitrogen instead of shop dry air by 23% per miles [2].

Table 2: Increased fuel economy by Nitrogen [2]

	Front tire			Rear tire		
	Air inflation	Nitrogen inflation	Increment	Air inflation	Nitrogen inflation	Increment
Location	Mileage (miles)	Mileage (miles)	Mileage (miles)	Mileage (miles)	Mileage (miles)	Mileage (miles)
DC 1	130,000	193,700	63,700	250,000	382,500	132,500
DC 2	130,000	192,400	62,400	250,000	372,500	122,500
DC 3	130,000	192,400	62,400	250,000	375,000	125,000

5. Conclusion

1. All the experiments simply conclude that filling the tires with Nitrogen not only increase the fuel economy but also increase the passenger safety by simply maintaining the inflation pressure. The tires which are inflated with Nitrogen can maintain the pressure 74% better than the shop dry air and decreases the rolling resistance by 70%.
2. By using Nitrogen in the tires the fuel economy can be increased by 23% and the tire life can be increased by 50%. The overall cost which is spent on the fuel and tire changing reduces drastically and the emission of co2 in the atmosphere is reduced by 19%. These results provide the technical support to the statement that using Nitrogen is beneficial to the tire life, fuel economy, safety of the passenger and also good impact on the atmosphere as compared to using shop dry air.

3. The deflection of a tire which is inflated with nitrogen is less as compared to shop dry air inflated tire. The inflation pressure directly influences to the stiffness of tire.
4. When nitrogen is used as inflating gas, the concentration of bump transferred to chassis and passenger is minimum, so nitrogen is safe and provides comfort to the passenger.
5. In earlier studies inflation of tire with Helium is not done. The inflation of tire with Helium can give the positive results i.e. enhancement of tire life, tread wear, rolling resistance of the tire and fuel economy of vehicle.

6. Future Scope of Study

1. Due to numerous positive effects, dry shop air can be swapped by nitrogen.
2. As helium is the 2nd most cool gas and light in weight, so it can be used to inflate tires and can give positive results.

7. References

1. NHTSA. report on accidents due to underinflated tires https://www.consumerreports.org/cro/news/2012/05/nhtsa-study-finds-underinflated-and-worn-tires-increase-the-likelihood-of-a-crash/index.htm
2. Nader Jalili, Ph.D. Prakash Venkataraman, Graduate Student "tire Nitrogen filling system"
3. NHTSA. The Effects of Varying the Levels of Nitrogen in the Inflation Gas of Tires on Laboratory Test Performance' DOT HS 811 094 March 2009
4. Wong JY. Theory of ground vehicles, Second Edition, New York, John Wiley. 2001, 8.
5. Guan D, Yam LH, Zhang A, Shang J. Modeling of Tire Rolling Properties by Using Experimental Modal Parameters, SAE 2000 World Congress, PN: 2000-01-0361, Detroit, MI.
6. Grappe F, Candau R, Barbier B, Hoffman MD, Belli A. Rouillon JD. Influence of tire pressure and vertical load on coefficient of rolling resistance and simulated cycling performance. Ergonomics. 1999; 10:1361-1371.
7. Rolling resistance and why the laboratory may be different than the real world", Tire Tech/General Tire Info, last access time, 01-01-2006, accessed, 2006.
8. Indrajeet Burase, Suyash Kamble, Amol Patil, Avinash Kharat. "A Survey on Automatic Air Inflating System for Automobile. 2016; 5(10).
9. Harshal Junankar1 Vishnusagar Bihare2 Nishant Giradkar3 Chetal Gupta4 1, 2, 3U.G. Student 4Assistant Professor 1,2,3,4Department of Mechanical Engineering 1,2,3,4Priyadarshini College of Engineering, Nagpur, India Automatic Tyre Inflanation System IJSRD - International Journal for Scientific Research & Development. 2015; 3(1). ISSN: 2321-0613
10. Miss PY. Mhaske1, Prof. P.A. Narwade2, Prof. M.P.Nagarkar3 1 PDVVPCOE Ahmednagar, Maharashtra, India 2 PDVVPCOE Ahmednagar, Maharashtra, India 3 SCSMCOE Ahmednagar, Maharashtra, India 'Stiffness analysis of passenger car tire using Nitrogen' International Journal of Scientific and Research Publications. 2016; 140:6(1). ISSN 2250-3153
11. Parkash Venkataraman. Effect of Nitrogen Filling on tire Rolling resistance and vehicle fuel economy, 12-2007 Clemson University all theses papee, 236.
12. Brian Brasch, Branick Industries Chris Lien, Get Nitrogen Institute the Past, 'Present and Future of Nitrogen Tire Inflation, 2011.
13. N-TYRE® nitrogen in tyres An→Outstanding→Investmen
14. Gyadari Ramesh, Malloji Mallesham, Dr. VVRLS. 'Gangadhar3Fe Analysis of Effect of Tyre Overload and Inflation Pressure on Rolling Loss in Cars' Gyadari Ramesh *et al*. Int. Journal of Engineering Research and Applications, 2015; 5(8):01-08. www.ijera.com ISSN: 2248-9622.
15. Alexander Varghese. 'Influence of Tyre Inflation Pressure on Fuel Consumption, Vehicle Handling and Ride Quality Modelling and Simulation' Department of Applied Mechanics Division of Vehicle Engineering and Autonomous Systems Vehicle Dynamics Group Chalmers University of Technology Göteborg, Sweden Master's thesis. 2013, 75.
16. Miss. PY, Mhaske, Prof. Narwade PA, Prof. Nagarkar MP. Pdvvpcoe Ahmednagar, Maharashtra, India 'Stiffness analysis of passenger car tire using Nitrogen' International Journal of Scientific and Research Publications. 2016; 6(1):140. ISSN 2250-3153.
17. By Uday Karmarkar Akron Rubber Development Laboratory, Inc. 2887 Gilchrist Rd. Akron, Ohio 44305 udayk@ardl.com 'Effect of Nitrogen Purity on the Oxidation of Belt Coat Compound' Presented at a meeting of the International Tire Exhibition and Conference 2006 Akron, Ohio.
18. Sivaraos MJ, Raguvaran AS, Dahlan Kadirgama K. Amran MA. Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Pahang, Malaysia 'Air Permeability Investigation Towards Automotive Tyre Pressure Sustainability And Life Saving' E-Mail: sivarao@utem.edu.my. 2015, 10(10). ISSN 1819-6608 ARPN Journal of Engineering and Applied Sciences ©2006-2015 Asian Research Publishing Network (ARPN). All rights reserved.
19. Inderjeet Singh1, Bhupendra Pratap Singh2, Hari Shankar Sahu3, Raunak Chauhan4, Novel Kumar Sahu5 B.E. Student, Department of Mechanical Engineering, R.S.R. Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, India1,2,3,4 Assistant Professor, Department of Mechanical Engineering, R.S.R. Rungta College of Engineering & Technology, Bhilai, Chhattisgarh, India5 'To Study on Implementation of Tyre Inflation System for Automotive Vehicles' International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization). 2016, 5(4).
20. Ajas MA, Aiswarya TG, Adersh Vinayak, Surya Balakrishnan, Janahanlal P.S 1, 2, 3, 4, 5Department of Electronics and Communication Engineering, Matha College of Technology, M.G University, Ernakulam, Kerala, India 'Tire Pressure Monitoring and Automatic Air Filling System' IJREAT International Journal of Research in Engineering & Advanced Technology. 2014, 2(2). ISSN: 2320-8791.