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# Design and Development of Running Wheel Air Pressure Monitoring System for Vehicles

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***Abstract*** *- Several manufacturers produce tire pressure monitoring systems (TPMS) for heavy trucks which are designed to detect low tire pressure and alert the driver. This paper reports on a series of test procedures conducted on these aftermarket TPMS to determine the suitability of these tests for use in developing performance requirements.*

*TPMS were installed one at a time on two heavy trucks. The minimum activation pressure of the TPMS was determined. After driving for a period of up to fifteen minutes, the vehicle was stopped and air was released from one tire to bring its inflation pressure to a point below the minimum activation pressure for the system. The vehicle was driven and the time needed for the system to detect the loss of pressure and alert the driver was recorded. Multiple tire deflations and failure modes were also tested*

***Keywords*** *- Tire Pressure Monitoring System, Running Wheel Air Pressure Monitoring System, Central Tire Inflation Systems (CTIS), Automatic Tire Inflation Systems (ATIS)*

## I. INTRODUCTION

**Tire Pressure Monitoring System -** A typical tire pressure monitoring (TPM) system specifically intended for automotive use. It serves as a reference to design a real-world system based on various Microchip products. A TPM system primarily monitors the internal temperature and pressure of an automobile's tire. system. For the driver the dynamics of the car seem “normal”, until he is faced with an emergency or an incident occurs. Therefore important to inform the driver of any time, by means of a message displayed on the dashboard. The tire pressure monitoring system fulfils this role. A small electronic module housed in the inflation valve of each wheel permanently monitors the tire. A loss of pressure, an imbalance in pressure between the wheels, or over- or under-inflation immediately triggers an air compressor

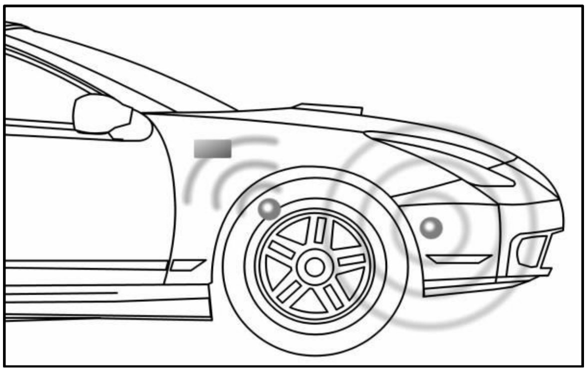

**Fig. 1 Tire pressure monitoring system**

Fig 1 is an electronic system designed to monitor the air pressure inside the pneumatic tires on various types of vehicles. TPMS report real-time tire-pressure information to the driver of the vehicle, either via a gauge, a pictogram display or a simple low-pressure warning light. TPMS can be divided into two different types — direct (TPMS) and indirect (TPMS). TPMS are provided both at an original equipment manufacturer OEM(factory) level as well as an aftermarket solution

**Description of Currently Available Tire Pressure Systems for Commercial Vehicles:**

Based on interviews with tire pressure systems suppliers, other NACFE-conducted fleet surveys, and a review of online information sources including industry standards and recommended practices

The major categories are:

1. **Tire Pressure Monitoring Systems (TPMS)**

These systems provide a direct measurement of pressure, and, in some cases, temperature. The measured pressure is compared to a preset target pressure determined by the fleet user for a given vehicle wheel position. If the tire is underinflated, maintenance staff and the driver are alerted by either a static visual display at the wheel-end, or by the transmission of sensor data to an in-cab display or to a computer system that can be accessed by the fleet. The TPMS category includes mats or plates containing an array of sensors that pick up and transmit the loading conditions of the tire footprint as the tire rolls over the surface of the mat. The mats can be embedded in pavement or placed on the floor of a garage. In addition, fleetwide manual tire pressure check procedures are included in this category. Most of these systems can also signal an overpressure condition. With the exception of the floor sensor mats, all systems included in this report are direct TPMS, that is, systems wherein pressure is measured directly and is not derived from other vehicle or tire parameters.

2. **Dual Tire Pressure Equalizer**

In these systems, a single sensor unit is mounted to the vehicle wheel end, monitoring the pressure in both tires of a dual-tire assembly, with a hose connection to each tire valve stem. If pressure levels between the tires do not match, either due to temperature warming of one tire position versus the other, unequal loading, or slow air seepage, the system will attempt to bring the inflation pressure of the two tires to the same level. No air is added or removed from the dual assembly by the equalizer unit. If air loss continues, the leaking tire is isolated and a static visual display indicates the progressive loss of pressure.

3. **Central Tire Inflation Systems (CTIS)**

The operation of this type of system is similar to ATIS, with the difference that the driver can select the target pressure from an in-cab display, in order to raise or lower the tire inflation level depending on the operating conditions of the vehicle. Most systems of this type are intended for off-road or military truck applications.

4. **Passive Pressure Containment Approaches**

Another category of technologies capable of preventing tire pressure loss attempt to retain air in the tire once it has been inflated. These most commonly function by reducing natural air loss through the tire casing. However, certain products in this category can mitigate the effects of small punctures. Use of an inflation medium such as nitrogen that has a lower permeation rate than oxygen, and alternative means to providing barriers to air loss through the use of sealants, are represented in this category.

## II. OBJECTIVE

The overall goal of our design project is to develop a product that will decrease tire wear while improving fuel economy. Increases performance and safety of a passenger vehicle through dynamically-adjustable tire pressures. A synthesis of commercially available tire pressure monitoring and maintenance systems and their features. An exploration of the potential benefits and challenges for fleets related to system implementation. Recommendations/guidelines for selecting and incorporating tire pressure systems into fleet operations

## III. MATERIALS AND METHODS

The following are the parts of running wheel air pressure monitoring system

**Compressor**

An air compressor is a device that converts power (usually from an electric motor, a diesel engine or a gasoline engine) into kinetic energy by compressing and pressurizing air, which, on command, can be released in quick bursts. There are numerous methods of air compression

**Fig 2 Single-stage**

**Pressure Switch**

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall


**Fig 3 Differential & ranging pressure switch**

**Rotary Joint**

A Rotary Union transfer's media (water, steam, air, oil, Hydraulic fluid, etc.)from a stationary source (or) to rotating source. Fig:-3.7 show rotary joint. A rotary union is that allows for rotation of the united parts. It is thus a device that provides a seal between a stationary supply passage (such as pipe or tubing) and a rotating part (such as a drum, cylinder, or spindle) to permit the flow of a fluid into or out of the rotating part. Fluids typically used with rotary joints and rotating unions include various heat transfer media and fluid power media such as steam, water, thermal oil, hydraulic fluid, and coolants.

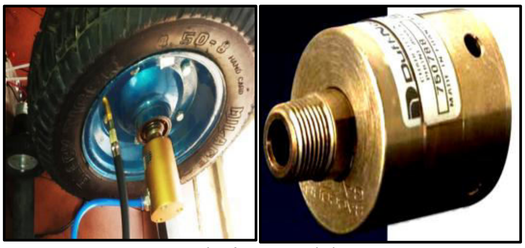

**Fig 4 Rotary joints**

A rotary union is sometimes referred to as a rotating union, rotary valve, rotary coupling, rotary joint, hydraulic coupling, pneumatic rotary union, through bore rotary union, air rotary union, electrical rotary union, vacuum rotary union

**Axial Hollow Shaft**

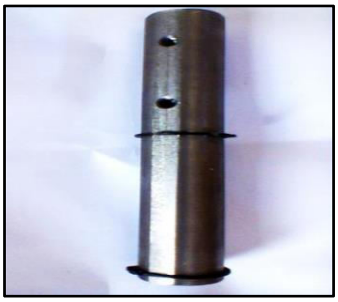

**Fig 5 Axial hollow shaft**

Axial are the shafts on which road wheels are mounted. . Fig:-3.9 shows the axial hallow shaft. The road wheels are provided with the required drive through these axial.

**Frame**

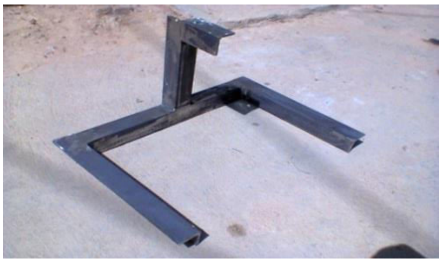

**Fig 6 Frame**

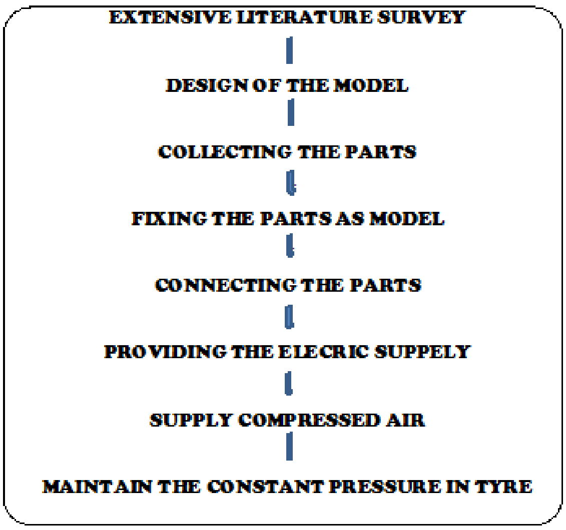


**Fig 2 Flow chart of the methodology**

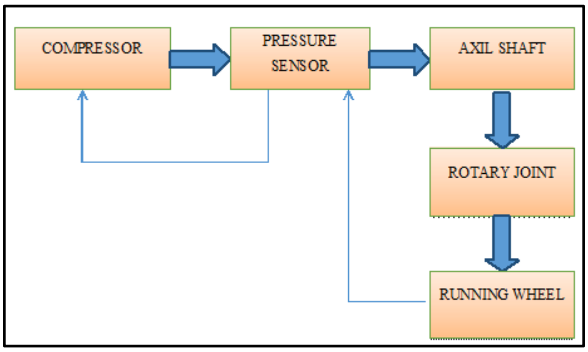


**Fig 3 Block diagram of RPMS**

## IV. RESULTS AND DISCUSSION

**Working principle of pressure switch.**

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall.

Another type of pressure switch detects mechanical force; for example, a pressure-sensitive mat is used to automatically open doors on commercial buildings.

A pressure switch for sensing fluid pressure contains a capsule, bellows, Bourdon tube, diaphragm or piston element that deforms or displaces proportionally to the applied pressure. The resulting motion is applied, either directly or through amplifying levers, to a set of switch contacts. Since pressure may be changing slowly and contacts should operate quickly, some kind of over-centre mechanism such as a miniature snap-action switch is used to ensure quick operation of the contacts. One sensitive type of pressure switch uses mercury switches mounted on a Bourdon tube; the shifting weight of the mercury provides a useful over-center characteristic.

The pressure switch may be adjustable, by moving the contacts or adjusting tension in a counterbalance spring. Industrial pressure switches may have a calibrated scale and pointer to show the set point of the switch. A pressure switch will have a differential range around its setpoint in which small changes of pressure do not change the state of the contacts. Some types allow adjustment of the differential.

The pressure-sensing element of a pressure switch may be arranged to respond to the difference of two pressures. Such switches are useful when the difference is significant, for example, to detect a clogged filter in a water supply system. The switches must be designed to respond only to the difference and not to false-operate for changes in the common mode pressure.

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The contacts of the pressure switch may be rated a few tenths of an ampere to around 15 amperes, with smaller ratings found on more sensitive switches. Often a pressure switch will operate a relay or other control device, but some types can directly control small electric motors or other loads.

Since the internal parts of the switch are exposed to the process fluid, they must be chosen to balance strength and life expectancy against compatibility with process fluids. For example, rubber diaphragms are commonly used in contact with water, but would quickly degrade if used in a system containing mineral oil.

Switches designed for use in hazardous areas with flammable gas have enclosure to prevent an arc at the contacts from igniting the surrounding gas. Switch enclosures may also be required to be weather proof, corrosion resistant, or submersible.

An electronic pressure switch incorporates some variety of pressure transducer (strain gauge, capacitive element, or other) and an internal circuit to compare the measured pressure to a set pont. Such devices may provide improved repeatability, accuracy and precision over a mechanical switch.

**Working of tyre inflation system.**

The pressures switch with is couples to tyre through the 6 od tubes circuit, in the circuit the ball valve is introduced which imitates the tyre puncher or air leakage, ones the empty tyre is coupled with the air compressor, pressure switch, rotary joint & air filling knob, the whole system is ready to test. the desired pressure will be set to desired level depends on the tyre type. ones the power is enabled the air is starts filling to the tyre & it will be triggered off when the desired pressure is reached in tyre.

The running wheel will be filled with air through the rotary joint, which will have rotor & stator of having knob size 1/4$^{th}$ which is fitting with desired fittings, the rotor will be fixed to the tyre with air filling knob and stator is fixed to axial shaft.

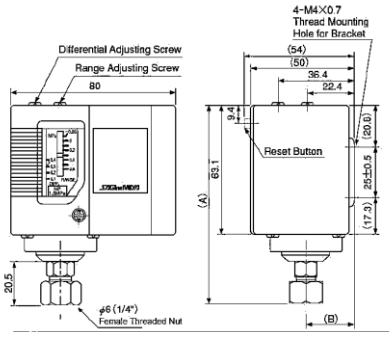
The ball valve is imitates the air leak in the system & that cause the pressure drop in the pressure switch which will be again triggers the on board air compressor the process respites.

**Steps by step procedure**

Connect the all tubes to the desired devises & please absorb the leakage of air(leakage will cause the pressure drop in system & more power consumption through the compressor, rectify with proper push in & air tight fitting with Teflon ).

1) Differential adjusting screw – this is the screw which defines & controls the how much difference in the system has to react. Example if u set pressure range adjustment to 2 bar, differential screw is set for 0 bar exactly at 2 bar system will on & stops, it will lades to frequent on and off of compressor. If we set for 0.5 bar it will on at 2bar +/- 0.5 bar.

2) Range adjusting screw – this screw is used to directly set the pressure of the system & depends on the type of vehicle & tyre.




3) Connections to terminals- from the 12 v DC battery either (+) or (-) will be always connected to compressor terminal & one will be connected to pressure switch

**Test pressure chart**

| Test pressure chart | | | | |
|---|---|---|---|---|
| Sl no | Differential adjusting screw pressure in bar | Range adjusting screw pressure in bar | Results Yes/no | Remarks |
| 1 | 0 | 1.25 | | |
| 2 | 0 | 1.5 | | |
| 3 | 0.25 | 1.25 | | |
| 4 | 0.25 | 1.5 | | |

The tyre inflation system has to react for the above test pressure chart & result will be filled in the test chart.

**Working Principle Running Wheel Air Pressure Monitoring System**

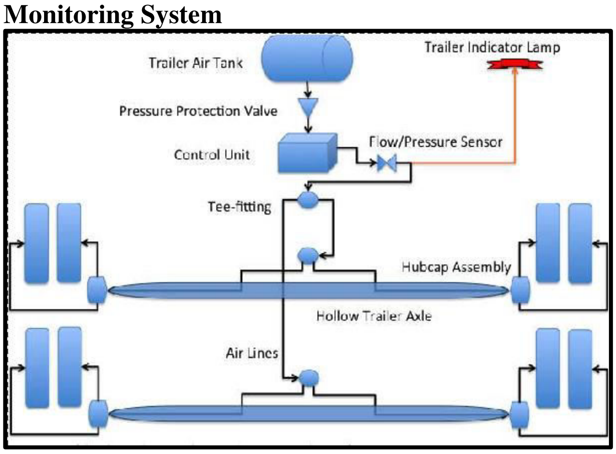



**Fig 4 Working principle of running wheel air pressure monitoring system**

Fig:-4 indicates working principle of running wheel air pressure monitoring system Individual tire pressures were transferred to the sensors using a network of rotary unions, valves, Couplings, hoses, and transducers. To allow for wheel rotation, rotary unions were installed in the air lines at each wheel to couple the air compressor & pressure monitoring sensor switch, which triggers the compressor. A tire pressure monitoring system (TPMS) is an electronic system designed to monitor the air pressure inside the pneumatic tires on various types of vehicles. TPMS report real-time tire-pressure information to the Driver of the vehicle, either via a gauge, a pictogram display, or a simple low-pressure warning light. TPMS can be divided into two different types — direct (DTPMS) and indirect (ITPMS). TPMS are provided both at an (factory) level as well as an aftermarket solution

The presence of the actuator also ensures that the system would be automatic. Also, because this system only involves small actuator-controlled valve power requirements for this process would be minimal. Nevertheless, several items have ultimately led this concept to be considered deficient. Because of the limited volume of the reservoir, several refills may be necessary over the life of the system. In addition, the presence of the reservoir would introduce extra mass in the system and a potential rotating unbalance. This rotating balance could lead to a potential hazardous condition due to vehicle instability. Maintenance effort for this system would also be high as the reservoir would have to be removed before servicing any other components in the system. Moreover, the appearance of a reservoir on such a conspicuous surface such as the wheel rim would result in unsatisfactory visual aesthetics.

The final concept documented in this section involves a high-pressure reservoir system. In this setup, a high pressure reservoir would be placed directly on each wheel rim with air passageways linking the reservoirs with the tires. Actuator-controlled valves would then maintain the tire pressures as specified by the consumer. It should be noted that the actuator-controlled valve would be nominally set to the cold tire pressure and that a pressure relief valve would be placed on each tire to reduce pressure as necessary

**Fig 5 Model of running wheel air pressure monitoring system**

**Fig 6 layout and arrangement of running wheel air pressure monitoring system**

**Factors Influencing Tire Pressure Monitoring System**

(i) The precondition for fleets to match their needs with the specific capabilities of the various tire pressure systems when making purchase decisions.
(ii) The importance of user readiness, in terms of personnel training and preparation of internal operating procedures around new tire pressure systems, to ensure successful deployment in the fleet.
(iii) The need for the functionality of tire pressure systems (alerts, warnings, data reporting) to integrate relatively seamlessly into normal, day-to-day fleet operations without requiring significant system oversight or maintenance by the fleet.
(iv) A tire pressure monitoring system or TPMS will be distinguished from an ATIS (automatic tire inflation system) and a CTIS (central tire inflation system) by the following features
(v) A TPMS monitors pressure and in some cases, temperature, for each individual tire. TPMS can identify underinflated tires by using a device that senses pressure and temperature and in most cases, transmits the data and displays it to the operator.
A TPMS monitors each tire based on a pre-set target pressure, and issues alerts based on the difference between the target pressure and the actual measured pressure in the tire

**Advantages of Running Wheel Air PMS**

When selecting a tire pressure monitoring system ("TPMS"), and assuming that a tire pressure monitoring system has all the necessary capabilities (temperature, over and under inflation alarming and slow leak detection), then the following advantages can be realized

1. Overall tire life can be substantially extended by monitoring tire pressure in real time. (A 20% under-inflated tire reduces tread life by approximately 25 %.)
2. Properly inflated tires predictably increase overall fuel economy.
3. Tires that are under-inflated by 20% lose approximately 30% of the life of the casing. A TPMS system significantly extends the life of the casing so that a tire can be safely rethreaded up to five (5) times to a useful life of over 1 million miles.
4. Increases overall safety of the vehicle by detecting overheated, under-inflated, over-inflated and slow-leaking tires.
5. Helps to prevent late deliveries from unforeseen tire mishaps.
6. Reduces overall liability exposure for property damage and workers compensation and insurance cost increases from tire blow-outs and tire separation.
7. Provides the means to help compare various manufacturers' overall tire performance (tread wear, rethreads, etc.) as it relates to tire expense by brand.
8. Aids in tire benchmarking by collecting, comparing and statistically analysing tire data. Such things as tire temperature versus tire pressure levels over time, by vehicle type, vehicle weight and tire position can be documented, leading to improved performance against predetermined benchmarks.
9. Increased traction
10. Longer tire life.
11. Reduced fuel consumption.
12. Protection against soil compaction.
13. Increased driving stability.
14. Enhanced productivity for field work.
15. Improved pulling performance.

## V. CONCLUSIONS

The dynamically-self-inflating tire system would be capable of succeeding as a new product in the automotive supplier industry. It specifically addresses the needs of the consumers by maintaining appropriate tire pressure conditions for:

(i) Reduced tire wear
(ii) Increased fuel economy
(iii) Increased overall vehicle safety

Because such a product does not currently exist for the majority of passenger vehicles, the market conditions would be favourable for the introduction of a self-inflating tire system. Through extensive engineering analysis, it has also been determined that the self-inflating tire system would actually function as desired. In particular, the product would be capable of:

• Providing sufficient airflow to the tire with minimal leakage
• Withstanding the static and dynamic loading exerted on the rotary joints Note that likewise, this system would not produce any negative dynamic effects (such as CV joint failure due to resonance) on surrounding systems. Most significantly, the self-inflating tire system would be a successful product because of its economic benefits to investors. Specifically, the final product would:
• Sell at about $900/unit, with total first year profit and sales of nearly $2.1 million and 58,000 units, respectively
• Experience 12% annual market growth each year for the first five years of the product, bringing total sales up to 370,000 units
• Break-even on the capital investment in just under three years for further development of this product, we recommend increasing the capability of the system

## SCOPE FOR FUTURE WORK

From this survey administered a 27 question to potential users for this dynamically self-inflating tire system to gain an understanding of their knowledge regarding the topic as well as to observe their preferences for certain aspects that we can incorporate with our system. Below is a list of the main points discovered.

From our results:

1. Only 4.3% of those surveyed check their tire pressures on a weekly basis.
2. Only 5.3% of survey participants check their tire pressures for fuel economy.
3. Most participants check their tire pressures for safety reasons instead of tire wear.
4. Those that do not check their tire pressures either do not care or do not know the correct pressures.
5. Roughly half of those surveyed have had their tires replaced in the 3-4 year timeframe.
6. Almost half of those surveyed never check their tire tread depth.
7. Those that do check their tread depths mostly check it for safety concerns.
8. Those that never check their tread depths either do not know the correct depth or do not care.
9. 70% of those surveyed drive on the highway a moderate amount (50% of all driving done on highways)
10. 48% of survey participants drive over the legal speed limit.
11. 52% of those surveyed drive compact cars and the rest sports cars, trucks/suns, and mid-size cars.
12. 66% care about vehicle appearance.
13. 86% of survey participants listen to music/radio at a moderate to loud volume level.

14. Almost half of those surveyed get their vehicle service every 6 months and are mostly willing to wait either 1 hour or 1 day depending on the type of service required.
15. 70% of survey participants would look to purchase a middle grade vehicle
16. With regards to system override, people are most interested in being able to control the pressures in each tire.
17. Of all options presented to them, people mostly want a light to show them that the system is turned on as well as a numeric display of the pressures in each tire.
18. 52% of those surveyed expect to see a return on investment for this device in 1 year.

Thus, these survey results were used to narrow down the scope of our project and help to define key targets. The following is a list of conclusion and changes to our design scope based on our survey

## ACKNOWLEDGMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of the people who made it possible, whose consistent guidance and encouragement crowned our efforts with success. I consider myself proud to be part of **Nitte Nagarjuna College of Engineering & Technology,** the institution which stood by throughout my endeavour career. I would like to express our gratitude to our beloved principal **Dr. S. G Gopala Krishna,** NCET for providing us congenial environment and surrounding to work in. It has been my great fortune to have **Dr. N. KAPILAN**, Professor & H.O.D Dept of ME (PG), NMIT Bangalore. In fact he has been the source of inspiration for me in and outside the classroom for the successful completion of my project. I would like to express my deepest gratitude to my guides **Mr. Chethan Kumar N,** Asst Professor, Dept of ME, NCET, Bangalore, for his valuable guidance and encouragement. I would like to thank my **Parents, brother** & **sister** for their co-operation and guidance through all aspects of my life.

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