Tyre Pressure Monitoring System with Compressor

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***Abstract*— Around 15 million two-wheelers are sold annually in India, where one in three homes has a two-wheeler. The country produces 20 million units of two-wheelers annually. Severe underinflation can result in mechanical and thermal stress brought on by overheating, which can very quickly cause the tyre to blow out. Failures of this nature may result in dangers and mishaps that jeopardise not only the rider but also those around him or her. Under-inflated tyres cause tread separation and tyre failure, resulting in 40,000 accidents, 33,000 injuries, and over 700 fatalities each year, according to average country estimates. However, when taking into account India's population, these figures may soar due to a high number of people owning more 2-wheelers, having less time to physically check, and being unable to routinely get their cars inspected at a repair facility. Without the riders' knowledge, the aforementioned issues will occur more frequently. This project focuses on designing and creating a direct tyre pressure monitoring system (TPMS), which uses a pressure sensor to measure air pressure taken straight from the tyre. The rider does not need to get out of his vehicle and manually pump air into his tyres when the TPMS detects a reduced tyre pressure because the TPMS and the compressor unit are working together to supply the air to the tyre. Energy is provided to the gadget either by a dynamo or a backup battery. To ensure consistency and accuracy in reporting the pressure and providing enough air to the tyre, the key components must be calibrated. Although there are numerous challenges and constraints, this prototype is a promising product for use in the real world.**

***Keywords*— TPMS, compressor, Tire pressure, two-wheelers.**

I. INTRODUCTION

Without a doubt, the most significant aspect of an automobile is safety. Any vehicle can malfunction for a number of reasons. Inadequate tyre air pressure is the main reason for tyre blowouts. While under-inflation causes around 75% of tyre burst-related incidents, overinflation is still not a worry. According to studies, driving with under-inflated tyres dramatically increases fuel consumption as well as CO2 emissions. Unavoidable tyre wear occurs during use and is impacted by the kind of vehicle, tyre characteristics, type of road, ambient conditions, and driving conditions. In general, a tyre burst happens when pressurized air quickly escapes from the tyre. The tyre cannot hold all that air inside when its structural integrity is damaged. This results in the compressed air bursting into flames and seriously damaging the tyre surface as it quickly tears through the tyre. The severity of all these issues can be reduced with regular vehicle maintenance; there are various ways to accomplish this. The Tire Pressure Monitoring System is one of the most significant systems (TPMS). In actuality, lowering the tyre pressure could shorten tyre life, deteriorate the vehicle's adhesion qualities, extend stopping distances, and even cause a sudden tyre failure. Tire wear and tear results in significant waste production, and the increasing usage of plastics—which are resistant to hydrolysis, decomposition, and biological degradation—is contributing to a global ecological crisis. This makes the disposal of most plastics a highly complicated problem. Tire related waste is categorized as a type of rubbish that needs to be processed industrially. The globe is looking for ways to extend the safe operation of tyres and use them more effectively. Following cornering manoeuvres and driving speed, driving behaviours such as braking, accelerating, and not maintaining the right tyre pressure had the greatest effect on tyre wear. Thus, it appears that keeping an eye on tyre pressure and avoiding abrupt acceleration and braking could greatly reduce tyre wear. And this is why Our solution for the rider's and passenger's safety is important. In case of an emergency, it will also include a compressor unit to fill the tyre. The combined efforts of the TMPS and Compressor unit give the user a better experience.

II. LITERATURE REVIEW

[1] This study used a "hybrid" method that determines the tyre pressure for each vehicle tyre using just one pressure sensor. As a result, the measurement performance and system cost for such a solution are well balanced. Unlike standard direct and indirect TPMS, the suggested system is based on the use of a single tyre pressure sensor in conjunction with an estimator that takes advantage of other vehicle data. By doing this, a tire's absolute pressure is assessed in addition to its deflation being recognised, unlike with standard iTPMS. A decrease in tyre pressure may shorten tyre life, affect the vehicle's adhesion qualities, increase stopping distance, or even cause a sudden tyre failure.

[2] This paper describes a newly developed remote tyre pressure monitoring system (TPMS) for a fleet of vehicles. Monitoring data can be used to reduce tyre wear. The investigation on tyre pressure and friction-related tread degradation for a fleet of cars with and without monitoring is compared in the paper. According to the study, making decisions based on monitoring data lowers

waste in the form of prematurely worn tyres. Monitored tyre wear ranged from 7% to 13% while unmonitored tyre wear reached 70%. Suppose that 50% of Polish travel agencies properly employ the recommended monitoring technique.

[3] Data on the quantity of tyre wear that is discharged into the environment and the importance of the numerous elements that influence tyre wear are provided in this study. This information is useful for creating a methodology to calculate the rate of abrasion and for figuring out what has to be done to cut down on microplastic emissions into the environment. The most detrimental effects on tyre wear were caused by occurrences involving braking and accelerating, cornering manoeuvres, and driving speed. In light of this, it would seem that limiting sudden acceleration and braking might significantly reduce tyre wear.

[4] This paper presents a dual-slope ADC and discusses the transfer of 13.56MHz in depth. This paper discusses the following disadvantages of using batteries for TPMS: short battery life, inability to perform real-time surveillance, and lack of stability and reliability guarantees. With an entire CMOS module, these issues can be resolved without the use of batteries. Piezoelectricity method, Electromagnetic coupling method, and Surface acoustic wave battery-less wireless sensor method are the three ways to implement battery-free TPMS. A number of wireless power transfer methods, including close coupling, inductive coupling, and electromagnetic coupling systems, were also discussed. In the battery-free TPMS, the inductive coupling is chosen after consideration of the frequency, transmitting range, and power consumption.

[5] This project includes the construction of a water-gas heat exchanger, a refrigerator a cooling tower, a circulating pump, and a suction pre-treatment system. The cooling tower and refrigerator create low-temperature water that can be utilised to chill the suction air in the water-gas heat exchanger. At the moment, the best air compressor designs emphasise the use of novel structures or materials to absorb heat from the air during compression or to lower its temperature. The air compressor is designed with its maximum load requirement in mind for the vast majority of applications. An air compressor powered by a fixed frequency motor has a low energy efficiency since it frequently operates at partial capacity.

[6] This paper examines LiFi theory and the most recent research in this area. LiFi, a type of wireless optical communication (WOC) technology, has the ability to address the issues confronting 5th and higher generation mobile networks. LiFi is a wireless two-way communication system that enables simultaneous high-speed up- and down-link transmission. LiFi enables high-speed data transfer, however it has significant limitations, including coverage. As a result, a hybrid WiFi/LiFi network can take use of both the speed and range of LiFi. The combination of these technologies can compensate for the limits of each, enhancing network performance.

[7] The negative-pressure system served as a regulator in this experiment. The minute flow check valve was chosen as a check valve based on how the system is configured. The material of the tube has good physical properties and resistances as a result of its thorough compression and restoration. Following the development of a tube performance tester, a computer-aided engineering (CAE) model was developed to compare the results. The tube and regulator have been improved in appearance. The prototype test eventually proved the validity of the investigation. With existing equipment and technology, high-performance and secure tyres may be created.

[8] This research begins with thorough vibro-acoustic analyses of compressor surge evolution, which is then followed by a short-time Fourier transform to reveal time-varying frequency characteristics. The findings show that the rise and fall of the total sound pressure level during deep surge is predominantly caused by pressure pulsation at the centrifugal compressor outlet. The sources of the erroneous noise in the near-surge and deep-surge regions are investigated. The centrifugal compressor surge is next analysed using a mathematical model that contains an additional volume and accounts for changes in sound speed.

[9] The solenoid valve's ability to control the flow channel for a set period of time. A ship's 4 stroke propulsion engine's 3/2 way solenoid valve's flow characteristics are analysed numerically. For the simulation, ANSYS CFX 12.0 commercial software was used. The hand-operated button on the solenoid valve can be pushed, or an electric signal can be sent to move the reel. The valve being studied has a very quick response time to the moving reel. It is a superspeed valve. the rotation of the reel, which is situated in the body's middle of the solenoid.

[10] This study provides a non-intrusive solenoid valve failure diagnostic technique. This approach applies a solenoid valve failure pattern detection algorithm in conjunction with an eigenvalue extraction methodology to merge time-frequency analysis and time domain analysis of the current signal. In order to analyse four common solenoid valve states, the study team built a working solenoid valve model that included a magnetic circuit, circuit, and spool motion (normal, spring broken, spool stuck, and slightly stuck). For each of these states, the team collected current signals during the solenoid valve energising and shutting procedures.

III. METHODOLOGY

Temperature affects the tire pressure, to control maximum heat, the following steps are brought into consideration: 1.The limit ranges before filling the air are set separately for both the front and rear tires. 2.Display units for keeping track of entire process.

3.Buzzer Alarms mainly for emergency situations to avoid any further consequences. 4. Pressure sensors for data collection, connectivity, data processing etc. 5. Compressors to fill the air inside tires. 6.Microcontroller for better communication between sensors.

A. Proposed System

Below is the block diagram of the transmitter and the receiver unit. 1. The transmitter has the TPMS is connected to the valves at the front and rear tires for continuous monitoring pressure in the tire. 2. The receiver consists of a display unit. 3. The transmitter and receiver and transmitter are connected through a wired connection.

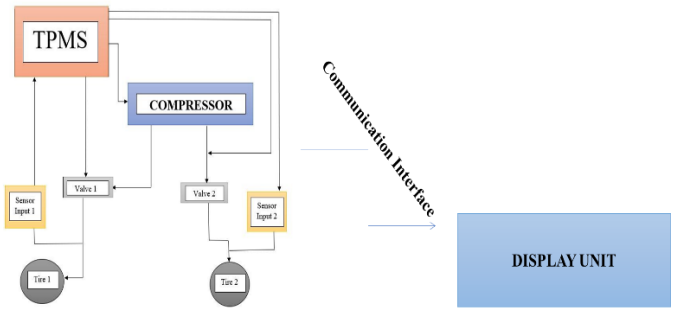


Fig. 1 Block diagram of Proposed system

B. Device Mechanism

Below is the flow cart the describing the device mechanism of the Electronics Control Unit. The ECU is in charge of controlling the solenoid valve's opening and closing, and the electric supply to the valves is regulated according to the device mechanism algorithm. The display of the sensor outputs and the alerts are given both in digital and analog means.

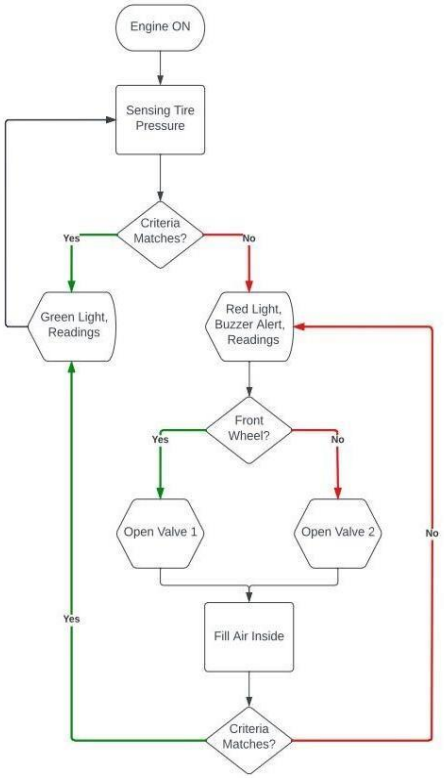
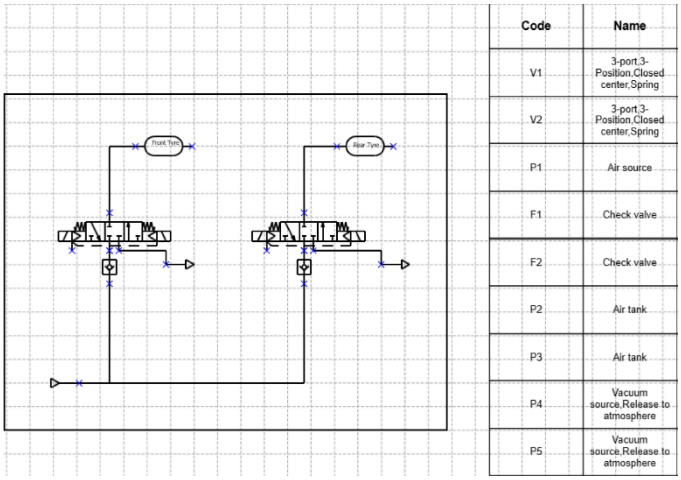


Fig. 2 Device mechanism

C. Pneumatic Circuit

Below is the pneumatic circuit of the compressor unit. Pneumatic circuit consists of the compressor and two valves with a pneumatic back line compressor, connected to valves which is connected to the pneumatic pipeline which is then connected to the wheels so the pressure sensor is connected in between valve and the tire. Whenever the pressure is sensed in the pressure sensor the response is given to the TPMS and if the pressure is less than the range then the valve is turned ON and the compressor

is also turned ON along with-it Air is added into the wheel which increases the pressure of the Tire and once the adequate pressure is reached the valves turn OFF and the compressor turned OFF.



Code	Name
V1	3-port,3-Position,Closed center,Spring
V2	3-port,3-Position,Closed center,Spring
P1	Air source
F1	Check valve
F2	Check valve
P2	Air tank
P3	Air tank
P4	Vacuum source,Release to atmosphere
P5	Vacuum source,Release to atmosphere

Fig. 3 Design of the pneumatic circuit

D. Wheel setup

Below is the 2D illustration of the wheel and the axle. The valve end of the hose travels the circumference of the tire.Axle end of the hose perform the circular motion at the point. We will transverse at this point circular motion to the TPMS using a L-shaped bearing coupler or straight bearing coupler.

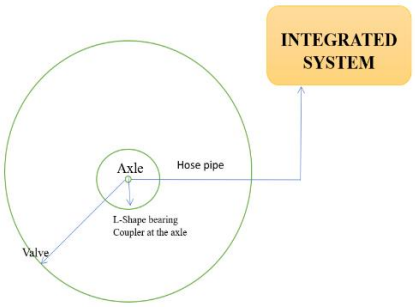


Fig. 4 Illustration of wheel setup

E. Circuit diagram

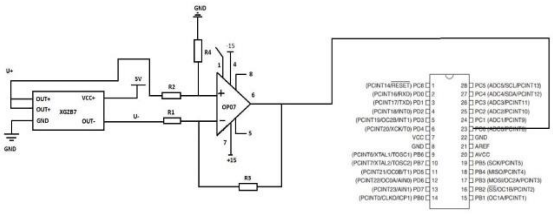


Fig. 5 Circuit diagram of sensor unit

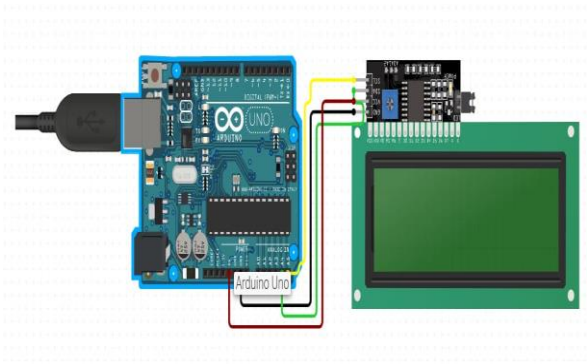


Fig. 6 Circuit diagram of display unit

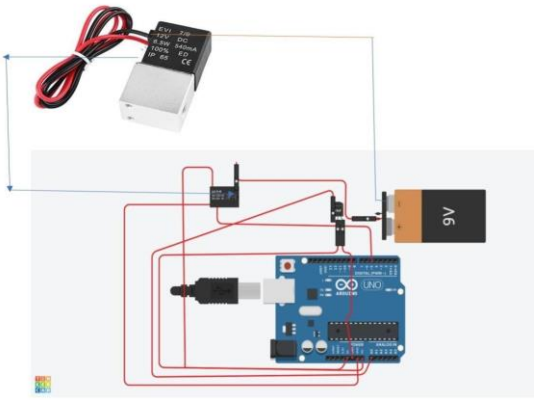


Fig. 7 Circuit diagram of solenoid valve

F. Flowchart

Below is the flowchart of the algorithm of the ECU: The sensor input is read and displayed simultaneously; it is then compared with the PSI range set for each tire. If the sensor input meets the constraints the display shows green light else the electricity is supplied to the tires through the solenoid valve. The loop continues to check the tire pressure until the pressure reaches to the required range.

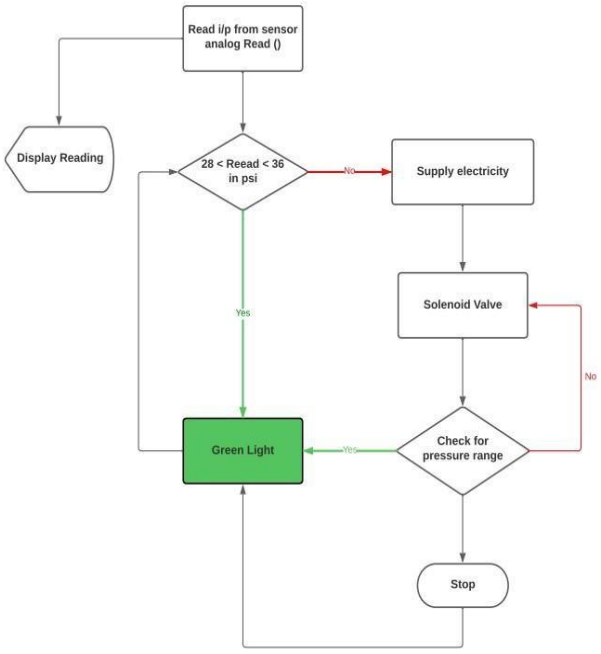


Fig. 8 Flow chart of the algorithm

G. Experiment setup

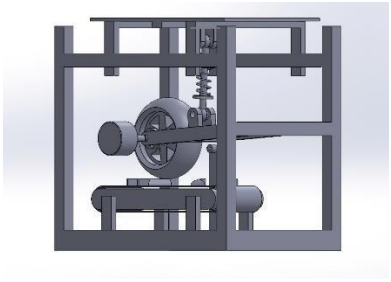


Fig. 9 Diagram of Experimental setup

The experimental setup consists of a frame to which a support arm us connected which is then connected to the wheel setup.

The support arm is connected to suspensions which is then connected to the weight plate. The wheel and motor are connected to support arm.

And under the wheel is a treadmill like setup. The treadmill setup and weights constitute to replicate real time performance for analysis.

IV. RESULTS AND DISCUSSION

A. Expected outcome

The system will be feasible with most of the 2-wheeler vehicles, To provide users with a smooth experience of inflating the tyre without having to go through a long procedure. The system will have alerting features with few tire health monitoring features as well.

B. Market analysis

An electronic device called the Tire Pressure Measuring System is utilised to keep track of the tire's temperature and air pressure while also showing those values in real time on the screen. This notifies the driver of the vehicle's driver of the change in tyre pressure. Vehicle performance, safety, mileage, and shortened tyre life are some of the main factors that are connected to the reduction of vehicle pressure. The device like TPMS has helped in reducing the number of accidents along with helping in increasing the fuel milage, durability of tires and better handling of vehicle by the driver. The batteries used in TPMS can last from 6 to 10 years. Because of pandemic, the market saw a decrease in the manufacturing of the device. However, now the market is coming back to normal and hence it is expected that the demand will be higher again in the future. The TPMS market was halted for a while but now numerous governments have given leverage for the import-export trades. The market for tyre pressure monitoring systems (TPMS) was estimated to be worth $5.67 billion in 2021. By 2027, it's anticipated that the value of TPMS in Asia Pacific would increase to 13.60 billion USD.

B. Barriers To Enter The Market

1) *Natural or structural barriers:* The existing companies already have made their move towards the two wheelers sector in India which will be a great problem to enter the market. Companies that are in market have built a greater network towards the High end companies and towards lower end companies. So it might give us a limited exploitation towards the market or thMe network. To get control over the raw material network will be quite difficult.

2) *Artificial or Strategic Barrier:* When existing firms set a low price and a high output. So that to gain profits in initial stages will be problematic. We need to establish our brand identity to stand out in a saturated market. And for ourhalf of the target audience to accept the product that is the motorcycle companies. Contracts, Patents, And license Must met the Government rules and regulations and to get the license is quite difficult. When the existing firms have license other contracts and patents.

3) *Technology:* How rapidly is technology advancing and can it render our product obsolete within the next five years? The technological advancement in the tyres changing to a non- puncturable one could become one of our greatest threats in the coming years. A more compact and easier model similar to our device before the branding could also be a possible threat to our product advancement.

4) *Branding:* We need to establish our brand identity to stand out in a saturated market. And for our ½ of the target audience to accept the product i.e the motorcycle companies.

5) *Competition:* Many air inflator products with manual and feasible products as mentioned above would be a great competition to face in the pre-saturated market.

C. Players in market:

Continental AG ZF TRW, Valor TPMS, Delphi Automotive, DENSO Company.The safety solution for India is strengthened by Continental AG in February 2022. India is the largest two-wheeler market in the world, and Continental is primarily focused on offering advanced safety technology, such as ADAS and TPMS. Continental has developed a new combine-tire monitoring system for its Combine Master and Combine Master VF tyres, which will be available in May 2022. They keep tabs on temperature and tyre pressure.

India's first AI-driven smart truck tire-pressure monitoring system, Fleeca Kawach, was introduced in February 2022 by Jaipur-based startup Fleeca India Private Limited. This TPMS is an electronic device positioned on the rim that keeps track of signals emanating from the exterior of the tyres as well as the rotational speed of the wheel.

D. Target audience

As our product is the combination of both tyre pressure monitoring system and inflator, therefore the scale of audience would vary in large scale i.e from common to that of the Supplier.

Possible companies who would buy us that are TVS, Bajaj, Suzuki, Honda, Royal Enfield, Hero motocorp, Jawa Motorcycles, Boom motors etc and it we can even link it with common motorcycle sale shops to reach a larger number of audience as well as selling it individually through online and offline platforms for it to reach the common man.

V. CONCLUSIONS

To summarize, tyre pressure is an important part of vehicle performance and efficiency, and incorrect tyre pressure can cause heat and mechanical overload and tyre failure, posing a possible hazard to the rider and their surroundings. While installing a monitoring system in larger vehicles is simple, compressing and installing one in 2-wheelers without sacrificing performance or accuracy is a problem. The suggested device would integrate alerting and tyre health monitoring features to provide users with a smooth experience of inflating the tyre without a lengthy operation. The device is planned to be compatible with most two-wheeler vehicles, resulting in more secure and effective trips for riders.

Furthermore, having the device placed in 2-wheelers can aid to extend tyre life, reduce fuel consumption, and improve overall vehicle stability. Furthermore, the gadget can save riders both money and time by detecting and correcting any tyre faults early on, avoiding the need for expensive repairs or replacements. Moreover, the gadget is simple to integrate into the existing 2-wheeler system, making it a comfortable and cost-effective alternative for riders. Tire health monitoring tools can also assist motorcyclists in keeping track of their tyre's condition and avoiding any unexpected accidents.

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