

Design & Development of Automatic Air Tyre Inflator System

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Abstract

Roads are the most important modes of transport now a days & cars are integral part of it. Tyres lose air through normal driving-especially when run through pot holes & permeation. Moreover temperature changes (seasonal) are also one of the reason due to which tyres lose air. Thus vehicles run with an under-inflated tyre which may cause accidents. Studies show that a drop in tire pressure by just a few PSI can result in the reduction of gas mileage, tire life, safety, and vehicle performance. This project aims to develop an automatic, self-inflating tire system. Such a system ensures that tires are properly inflated at all times. Our project design is successfully tested and implemented with the help of centralized compressor. The compressor will supply air to all four tires via hoses and a rotary joint fixed between the wheel spindle and wheel hub at each wheel. The Rotary joint is an integral component of the system-which has half of its part rotating with the wheel & rest half part is stationary. The rotary joints effectively allow air to be channelled to the tires. Thus the rotary joint facilitates untangling of hoses. Considering today's ever increasing environmental threats; oil price hikes & energy consumption our system is most compatible and potential improvement in gas mileage & tyre wear reduction which leads to an increase in performance of Tyre in Diverse Conditions.

Keywords — Automatic self-inflating tire system, tire pressure monitoring, under-inflated tires, centralized compressor, rotary joint mechanism, pneumatic system, vehicle safety, gas mileage improvement, tire wear reduction, temperature variation, energy efficiency.

INTRODUCTION

Tire pressure plays a critical role in determining the safety, performance, and efficiency of a vehicle. Properly inflated tires ensure maximum contact with the road surface, which improves stability, braking, traction, and fuel economy. However, maintaining the correct tire pressure is a continuous challenge because it changes due to environmental and operational factors such as

temperature variations, road conditions, vehicle load, and natural air leakage.

Under-inflated tires increase rolling resistance, which leads to higher fuel consumption, excessive heat generation, faster tread wear, and an increased risk of tire blowouts. Over-inflated tires, on the other hand, reduce the contact area between the tire and the road, resulting in poor traction, reduced control, and increased susceptibility to damage from road impacts. Despite its importance, tire pressure is still commonly maintained through manual methods such as air pumps and pressure gauges, which depend on user awareness and are often inconsistent.

To address these limitations, modern vehicles are equipped with Tire Pressure Monitoring Systems (TPMS), which provide real-time pressure information. However, TPMS only alerts the driver when the pressure is low and does not actively correct it. This limitation has led to the development of Automatic Air Inflation Systems (AAIS), which are capable of continuously monitoring and automatically adjusting tire pressure without human intervention. These systems use sensors, microcontrollers, compressors, and valves to maintain optimal pressure under all conditions.

Central Tire Inflation Systems (CTIS) were among the first technologies developed for automatic pressure control and are mainly used in military and heavy-duty vehicles. They allow drivers to adjust tire pressure while driving, which is useful for different terrains. However, CTIS systems are bulky, complex, and expensive, making them unsuitable for regular passenger vehicles. To overcome these issues, Active Tire Pressure Control (ATPC) systems were introduced. These systems are more compact, efficient, and suitable for modern vehicles, as they use advanced electronic control and smaller components.

Recent advancements in this field include self-inflating tire technologies, where inflation mechanisms are integrated within the tire itself, and energy harvesting systems that generate power from tire motion to operate sensors. Artificial intelligence and machine learning are also being used to predict pressure loss, detect faults, and optimize tire performance in real-time. These innovations

improve system reliability and reduce maintenance requirements.

In addition to improving safety and performance, automatic tire inflation systems contribute to environmental sustainability by reducing fuel consumption and minimizing tire wear. They also help reduce operational costs in commercial and heavy-duty vehicles. With the rise of electric vehicles, maintaining proper tire pressure has become even more important, as it directly affects battery efficiency and driving range.

In conclusion, automatic tire inflation systems represent a significant advancement in automotive technology. They provide a reliable solution to maintain optimal tire pressure, improve vehicle safety and performance, reduce environmental impact, and enhance overall driving efficiency. As technology continues to evolve, these systems are expected to become a standard feature in future vehicles.

METHODOLOGY

The methodology adopted for the design and development of the Automatic Air Tyre Inflator System focuses on maintaining the optimum tire pressure automatically without human intervention. The system is designed to continuously monitor tire pressure and perform automatic inflation or pressure release whenever necessary. Maintaining proper tire pressure is essential for vehicle safety, fuel efficiency, ride comfort, and tire life. The developed system utilizes a **PX100 pressure sensor**, **Arduino Uno microcontroller**, **air compressor**, **drain valve**, **relay module**, **LCD display**, and a regulated power supply to achieve automatic pressure control.

The first stage of the methodology involves identifying the pressure range required for the tire. Based on vehicle specifications, minimum and maximum pressure limits are predetermined and programmed into the Arduino Uno microcontroller. These limits serve as reference values for controlling the inflation and deflation process. The hardware components are then selected and integrated to form a closed-loop pressure control system.

The **PX100 pressure sensor** acts as the primary sensing element of the system. It is connected to the tyre air line and continuously measures the internal tyre pressure. The sensor converts the pressure into an electrical signal proportional to the applied pressure and transmits this signal to the Arduino microcontroller. Since the PX100 sensor provides continuous pressure feedback, it enables real-time monitoring of tyre conditions and allows the system to react immediately to pressure variations.

The **Arduino Uno microcontroller** functions as the

central control unit of the system. It receives pressure data from the PX100 sensor and compares the measured pressure with the preset reference values stored in its memory. The control algorithm programmed into the Arduino determines whether inflation or pressure release is required. The controller continuously executes this monitoring process, ensuring that tyre pressure remains within the specified range throughout vehicle operation.

When the measured tyre pressure falls below the minimum pressure limit, the Arduino identifies an under-inflation condition. The controller then sends a signal to the relay module, which acts as an electrically operated switch. The relay activates the air compressor, allowing compressed air to flow into the tyre through pneumatic tubing. As the compressor operates, the tyre pressure gradually increases. During this process, the PX100 sensor continuously measures the pressure and provides updated readings to the Arduino. The controller monitors these readings in real time and compares them with the target pressure value. Once the desired pressure is reached, the Arduino deactivates the relay, causing the compressor to stop automatically. This automatic shutoff mechanism prevents excessive air supply and protects the tyre from over-inflation.

In situations where the tyre pressure exceeds the maximum allowable limit, the system performs automatic pressure reduction. Instead of using a solenoid valve, a **drain valve** is incorporated into the system to release excess air from the tyre. When the PX100 sensor detects pressure above the preset upper limit, the Arduino activates the drain valve. The valve opens and allows a controlled quantity of air to escape from the tyre. The sensor continuously monitors the pressure reduction process and sends feedback to the controller. As soon as the tyre pressure decreases to the desired value, the Arduino closes the drain valve automatically. This process ensures that the tyre pressure remains within safe operating limits and avoids the adverse effects of over-inflation.

To provide real-time information to the user, an **LCD display module** is connected to the Arduino. The display shows important operating parameters such as current tyre pressure, desired pressure value, compressor status, drain valve status, and system condition. This feature enables the user to monitor the performance of the system easily and verify proper operation. Additional indicators such as LEDs or buzzers may also be incorporated to alert the user during abnormal conditions such as sensor failure, compressor malfunction, or excessive pressure variation.

The power required for operating the system is supplied from the vehicle battery. Since the Arduino and PX100 sensor require stable low-voltage DC power, a voltage

regulation circuit is used to convert and regulate the battery voltage. Proper electrical protection components such as fuses and voltage regulators are included to ensure safe and reliable system operation under varying environmental conditions.

After the hardware assembly and software programming are completed, experimental testing is conducted to evaluate system performance. Different pressure conditions are intentionally created to verify the operation of the PX100 sensor, compressor, drain valve, and control algorithm. Initially, the tyre pressure is reduced below the preset minimum value to observe the automatic inflation process. The time taken by the compressor to restore the pressure to the desired level is measured and recorded. Similarly, the tyre pressure is increased above the preset maximum value to evaluate the effectiveness of the drain valve in releasing excess air. The pressure readings obtained from the PX100 sensor are compared with those of a standard pressure gauge to determine measurement accuracy.

Multiple trials are performed under different operating conditions to assess system reliability, repeatability, and response time. Performance parameters such as inflation time, deflation time, pressure control accuracy, power consumption, sensor sensitivity, and overall system efficiency are analyzed. The collected data are used to validate the effectiveness of the developed Automatic Air Tyre Inflator System and to identify any areas requiring improvement.

The final system operates as a fully automated closed-loop pressure control mechanism capable of maintaining tyre pressure within a specified range without manual intervention. The integration of the PX100 pressure sensor, Arduino Uno microcontroller, air compressor, and drain valve provides an efficient solution for real-time tyre pressure management. The developed system improves vehicle safety, enhances fuel economy, reduces tyre wear, increases tyre lifespan, and minimizes maintenance efforts, making it suitable for modern automotive applications.

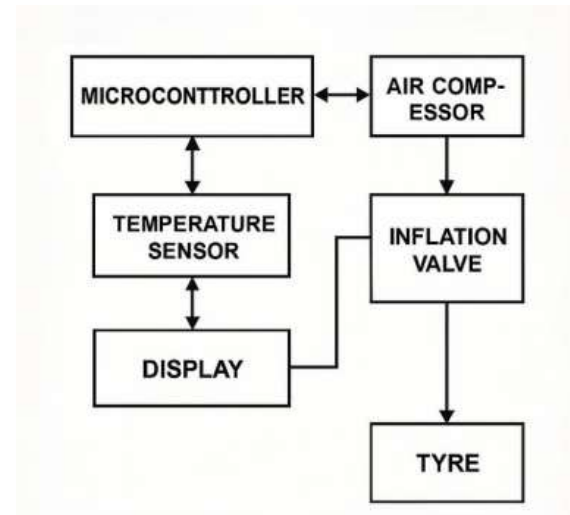


Fig: System block diagram

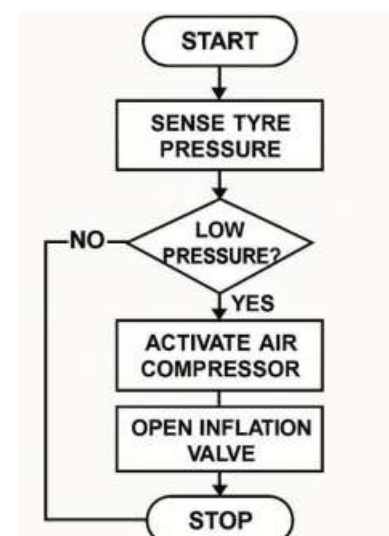


Fig: Proposed block diagram

GEOMETRIC MODELLING

The geometric modelling of the **Automatic Air Tyre Inflator System** was carried out using **SolidWorks** software. Individual 3D models of the major components, including the tyre, air compressor, PX100 pressure sensor, drain valve, pneumatic tubing, Arduino Uno, and supporting structure, were created based on their actual dimensions. These components were then assembled using SolidWorks Assembly tools to obtain a complete system model.

Appropriate assembly mates were applied to ensure correct positioning and alignment of all components. The pneumatic connections between the compressor, pressure sensor, drain valve, and tyre were also modelled to represent the airflow path accurately. Interference checking was performed to avoid component clashes and ensure proper assembly.

The final SolidWorks model provided a clear visualization of the system layout and helped in verifying component placement, compactness, and feasibility before fabrication. The geometric model served as the basis for the successful design and development of the Automatic Air Tyre Inflator System.

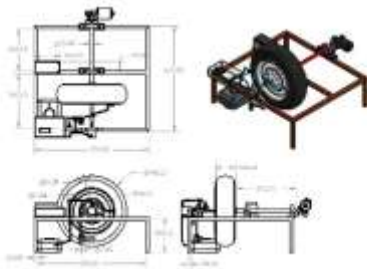


Fig: CAD Model

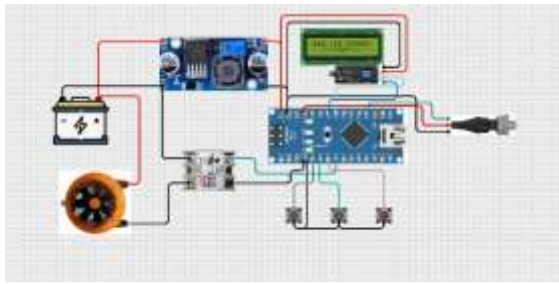


Fig: Circuit Diagram

RESULT

The developed **Automatic Air Tyre Inflator System** was successfully designed, modelled in **SolidWorks**, fabricated, and tested. The **PX100 pressure sensor** accurately measured the tyre pressure and continuously transmitted real-time data to the **Arduino Uno** microcontroller. The system effectively monitored the tyre pressure and maintained it within the preset pressure limits.

During testing, when the tyre pressure dropped below the specified value, the **Arduino** activated the air compressor through the relay module, and the tyre was automatically inflated to the desired pressure level. Similarly, when the pressure exceeded the maximum limit, the drain valve released excess air until the pressure returned to the acceptable range. The system responded quickly to pressure variations and operated without manual intervention.

The experimental results demonstrated that the system was capable of maintaining optimum tyre pressure with good accuracy and reliability. The automatic inflation and deflation functions reduced the need for frequent manual pressure checks and ensured consistent tyre performance.

The developed system improved vehicle safety, reduced tyre wear, enhanced fuel efficiency, and provided a cost-effective solution for automatic tyre pressure management. Overall, the proposed Automatic Air Tyre Inflator System achieved its intended objectives successfully and proved suitable for practical automotive applications.

CONCLUSION

The Automatic Air Tyre Inflator System was successfully designed, modelled using SolidWorks, fabricated, and tested. The system utilized a **PX100 pressure sensor**, **Arduino Uno microcontroller**, **air compressor**, and **drain valve** to continuously monitor and regulate tyre pressure automatically. The developed system was able to detect pressure variations accurately and perform automatic inflation or pressure release whenever required.

The experimental results demonstrated that the system effectively maintained the tyre pressure within the desired range without manual intervention. This helped improve vehicle safety, reduce tyre wear, enhance fuel efficiency, and increase tyre life. The integration of automatic monitoring and control reduced the need for frequent manual pressure checks and ensured reliable tyre performance under varying operating conditions.

Overall, the developed Automatic Air Tyre Inflator System proved to be a cost-effective, reliable, and efficient solution for tyre pressure management and has significant potential for application in modern automotive systems.

FUTURE SCOPE

- Integration of **IoT technology** for remote tyre pressure monitoring and control.
- Development of a **mobile application** to display real-time tyre pressure and system status.
- Implementation of **wireless pressure sensors** to reduce wiring complexity.
- Use of **artificial intelligence (AI)** for automatic pressure adjustment based on road and driving conditions.
- Integration with **vehicle diagnostic systems** for predictive maintenance and fault detection.
- Addition of **GPS-based features** for location-based monitoring and alerts.

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