Automatic Air Inflation System in Tire with Pressure Control and Monitor System

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Abstract

An automatic tire inflation system for a vehicle includes a plurality of wheel assemblies. Each wheel assembly includes a rotatable portion connected to its associated tire and a non-rotatable portion connected to the vehicle chassis. A sealed air passageway is provided between an inlet in the non-rotatable portion and an outlet in the rotatable portion of the wheel assembly which is connected to the tire. The sealed air passageway is provided in part by way of a longitudinally extending bore in the spindle which communicates with a chamber defined by a sleeve and a pair of air seals between the sleeve and spindle. A manually actable selector device in the vehicle is provided to permit the user to select one of a plurality of preset air pressure settings for the tires. An air regulating system quickly responds to the selected setting to automatically regulate the air pressure within the tires at the preset pressure associated with the selected setting of the selector device. A master-slave valving arrangement controlled by pilot air is preferably used to perform the inflation or deflation process.

Keywords—rotary joint, compressor, pneumatic pipes, tire

1. Introduction

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 tyres 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 tyres is one among them. Tyres lose air through normal driving (especially after hitting pot holes or curbs), permeation and seasonal changes in temperature. When tyres are under inflated, the tread wears more quickly. Under inflated tyres get damaged quickly due to overheating as compared to properly inflated tyres. The under- inflation also causes a small depreciation in the mileage as well. Above all the vehicles running with under inflated tyres 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 tyre pressure constantly. The system which contains sensors feed the information to a display panel which the driver can operate manually. The electronic unit controls 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 tyres to proper pressure conditions.

2. Problem Identification

When tyres are under inflated, the thread wears more quickly. This equates to 15 percent fewer miles you can drive on them for every 20 percent that they're under inflated. Under inflated tyres also overheat more quickly than properly inflated tyres, which cause more tyre damage. The faded areas below indicate area because tyres are flexible; they flatten at the bottom when they roll. 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 tyre, that wave is larger and the friction created is greater -- and friction creates heat. If enough heat is generated, the rubber that holds the tyre’s cords together begin to melt and the tyre fails. Because of the extra resistance on under inflated tyre has, when it rolls, your car’s engine has to work harder. Statistics show that tyres that are under inflated by as little as 2 psi reduce fuel efficiency by 10 percent.
3. Methodology

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 filling system, process to fabricate, and material. These tasks have been done through study on the internet, books, and others 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 choose 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 a 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 cutter. Analysis stage has been implemented before fabrication stage. The evaluation is by considering the strength, portable, durability, safety and others. After all process above done on schedule without any problem such as product defect all material for report writing is gathered.

A. Selection of Parts:
- Air Compressor
- Car wheel
- Rim
- Rotary Joint
- Tyre
- Pressure gauges

Fig. 1 Tyre inflating conditions

Fig. 2 General Block diagram of Automatic tyre inflation System
3.1 Air Compressor

An air compressor is a device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its upper limit the air compressor shuts 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.

3.2 Pressure Gauges

Under inflation can cause tyres to wear more on the outside than the inside. It also causes reduced fuel efficiency and increased heat buildup in the tyres. It is important to check the tyre pressure with a gauge at least once a month. So it is essential to have a tyre pressure monitoring system in our vehicles.

3.3 Axle

An axle is a central shaft for a rotating wheel or gear. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to the vehicle, with the wheels rotating around the axle. In the former case, bearings or bushings are provided at the mounting points where the axle is supported. In the latter case, a bearing or bushing sits inside a central hole in the wheel to allow the wheel or gear to rotate around the axle. Sometimes, especially on bicycles, the latter type axle is referred to as a spindle.

3.4 Wheel

Tires are mounted onto wheels that most often have integral rims on their outer edges to hold the tire. Automotive wheels are typically made from pressed and welded steel, or a composite of lightweight metal alloys, such as aluminum or magnesium. These alloy wheels may be either cast or forged. The mounted tire and wheel assembly is then bolted to the vehicle's hub. A decorative hubcap and trim ring may be placed over the wheel.

3.5 Tire
A tire (American English) or tyre (British English) is a ring-shaped vehicle component that covers the wheel's rim to protect it and enable better vehicle performance. Most tires, such as those for automobiles and bicycles, provide traction between the vehicle and the road while providing a flexible cushion that absorbs shock. The materials of modern pneumatic tires are synthetic rubber, natural rubber, fabric and wire, along with carbon black and other chemical compounds. They consist of a tread and a body. The tread provides traction while the body provides containment for a quantity of compressed air. Before rubber was developed, the first versions of tires were simply bands of metal that fitted around wooden wheels to prevent wear and tear. Early rubber tires were solid (not pneumatic). Today, the majority of tires is pneumatic inflatable structures, comprising a doughnut-shaped body of cords and wires encased in rubber and generally filled with compressed air to form an inflatable cushion. Pneumatic tires are used on many types of vehicles, including cars, bicycles, motorcycles, trucks, heavy equipment, and aircraft. Metal tires are still used on locomotives and railcars, and solid rubber (or other polymer) tires are still used in various non-automotive applications, such as some casters, carts, lawnmowers, and wheelbarrows.

4. Valve Stem

The valve stem is a tube made of metal or rubber, through which the tire is inflated, with a check valve, typically a Schrader valve on automobiles and most bicycle tires, or a Presta valve on high-performance bicycles. Valve stems usually protrude through the wheel for easy access. They mount directly to the rim, in the case of tubeless tires, or are an integral part of the inner tube. The rubber in valve stems eventually degrades, and, in the case of tubeless tires, replacement of the valve stem at regular intervals or with tire replacement reduces the chance of failure.

5. Rotary Joint
A rotary union or swivel joint is a mechanism used to transfer fluid (under pressure or vacuum) from a stationary inlet to a rotating outlet, preserving and isolating the fluid connection. Also referred to as rotary joints, rotary couplings, fluid swivels or swivel joints; rotary unions are engineered to endure a large range of temperature and pressure for a variety of conditions and environments. In addition, rotary unions may integrate multiple independent flow connections (passages) and handle different types of media simultaneously. Rotary unions typically function by connecting to an input and securing onto another mechanism while allowing a moving connection to be preserved. Rotary unions are utilized in a variety of applications; from compact rotary unions for the semiconductor industry to large, rugged-duty fluid swivels for industrial applications. Additionally, a variety of materials, sealing technology, and bearing types can be incorporated. Bearings are fixed to the rigid supports via nuts and bolts. The axle is rotate on which wheel or rim is mounted on one end. One end of coupler is connected to axle and other end is connected to rotary joint. There are electronic sensors are used to detect the tyre pressure with the help of pressure gauge. In the process of automatic tyre Inflation system, the compressor is used to compress the air. The air is taken from the atmosphere and compressed it at required pressure. There is ducting which is used connect to the compressor outlet port and one end of the rotary joint. The compressed air is supplied to the rotary joint through the ducting. Two Pedestal bearings are used to nature that’s why it’s easy to obtained the desired pressure level. Rotary joint is used to rotates well as to supply compressed air simultaneously when requires.

6. Working

7. Tire Pressure Monitoring System
TPMS systems measure the actual Tyre pressure using sensors which incorporate radio transmitters. The radio signals are picked up by a receiver unit which provides an alarm signal to the driver. Various types of information can be provided for the driver (alarm lamp, actual pressure, audible alarm, voice), and the sensors are either internally wheel mounted or may be externally fitted on the Tyre valve in place of the valve cap. More advanced TPMS show the actual Tyre pressure on a display/receiver unit inside the vehicle. Actual Tyre pressure is measured by miniature sensors in each wheel which each transmit an encoded radio signal. The receiver/display is a digital back-lit display unit which recognizes your vehicle's pre-coded radio signals and sounds an alarm at high or low pressure conditions. Some also indicate and monitor Tyre temperature. Most work with no external aerial fitted to the receiver, others require an aerial lay along the car underbody. Models are available for various types of vehicle (2 wheeled, 4 / 5/ 6 wheeled, or even 24 wheeled installations. For the motorcyclist simple operation and weather proofing is more important. For the car user, style may be more important. Some TPMS wheel sensors transmit adverse pressure conditions immediately, others that power off when parked only wake-up after the vehicle has achieved a minimum speed (usually 15 mph). For the racing specialist, RS232 links are available to enable conditions to be sent via computer telemetry to the pit. The receiver/display typically require either a 12v or 24v DC supply, usually switched with the ignition. Options include combined Display and Receiver, or separate Display Module and Receiver Module with interconnecting cord.

8. Benefits of TPMS

The dynamic behavior of a pneumatic tire is closely connected to its inflation pressure. Key factors like braking distance and lateral stability require the inflation pressures to be adjusted and kept as specified by the vehicle manufacturer. Extreme under-inflation can even lead to thermal and mechanical overload caused by overheating and subsequent, sudden destruction of the tire itself. Additionally, fuel efficiency and tire wear are severely affected by under-inflation. Tires do not only leak air if punctured, they also leak air naturally, and over a year, even a typical new, properly mounted tire can lose from 20 to 60 kPa (3 to 9 psi), roughly 10% or even more of its initial pressure. The significant advantages of TPMS are summarized as follows:

**Fuel savings:** According to the Giti, for every 10% of under-inflation on each tire on a vehicle, a 1% reduction in fuel economy will occur. In the United States alone, the Department of Transportation estimates that under inflated tires waste 2 billion US gallons (7,600,000 m³) of fuel each year.

**Extended tire life:** Under inflated tires are the #1 cause of tire failure and contribute to tire disintegration, heat buildup, ply separation and sidewall/casing breakdowns. Further, a difference of 10 pounds per square inch (69 kPa; 0.69 bar) in pressure on a set of duals literally drags the lower pressured tire 2.5 metres per kilometre (13 feet per mile). Moreover, running a tire even briefly on inadequate pressure breaks down the casing and prevents the ability to retread. It is important to note that not all sudden tire failures are caused by under-inflation. Structural damages caused, for example, by hitting sharp curbs or potholes, can also lead to sudden tire failures, even a certain time after the damaging incident. These cannot be proactively detected by any TPMS.

Decreased downtime and maintenance: Under-inflated tires lead to costly hours of downtime and maintenance.

**Improved safety:** Under-inflated tires lead to tread separation and tire failure, resulting in 40,000 accidents, 33,000 injuries and over 650 deaths per year. Further, tires properly inflated add greater stability, handling and braking efficiencies and provide greater safety for the driver, the vehicle, the loads and others on the road.

**Environmental efficiency:** Under-inflated tires, as estimated by the Department of Transportation, release over 26 billion kilograms (57.5 billion pounds) of unnecessary carbon-monoxide pollutants into the atmosphere each year in the United States alone.

Further statistics include:

The French Sécurité Routière, a road safety organization, estimates that 9% of all road accidents involving fatalities are attributable to tire under-inflation, and the German DEKRA, a product safety organization, estimated that 41% of accidents with physical injuries are linked to tire problems. The European Union reports that an average under-inflation of 40 kPa produces an increase of fuel consumption of 2% and a decrease of tire life of 25%. The European Union concludes that tire under-inflation today is responsible for
over 20 million liters of unnecessarily-burned fuel, dumping over 2 million tonnes of \( \text{CO}_2 \) into the atmosphere, and for 200 million tires being prematurely wasted worldwide.

9. Pressure Control in a Tyre of Moving Vehicle

If any prickle occurs in the tire of our vehicle, we get a gradual decrease in the tire pressure which obstructs our drive which may lead to an accident. Also at times, if we are stuck in some situation where we cannot get an immediate aid for the problem, this system is very useful and helpful for the purpose. In this system with decrease in pressure, sensor senses the pressure change and actuates the non-return valve which allows the compressed air from the compressor to pass to the tire from the LPC to make the pressure equal to the required pressure. Once the pressure gets equalized, the sensor cuts off the supply of compressed air by closing the non-return valve. If this process takes place more than 3 to 4 times in a specific period, the display warns the driver that the tire is punctured and needs replacement or repair. The losses which are to be considered are mainly from piston ring and cylinder which are due to the continuous rotational motion of piston. The analysis for the work done and heat.

10. Advantages

1) Reduced tyre blowouts since tyres remain at the proper inflation level at all times.
2) Reduce maintenance cost and time efficiency.
3) Reduce human efforts.
4) Increase the vehicle efficiency.
5) Increase the life span of tyre.
6) Avoids accidents and fatality.

10. Applications

1) It can be used in military vehicles.
2) It can be used in emergency vehicles like ambulance, police vehicles and fire vehicles.
3) It can be used in trucks and trailers.
4) It can be used in very costly vehicles where maintenance of standard is important.
5) It can be used in sports cars as there is need of regular checking of air pressure in tyres.

11. Tire Safety And Maintenance

11.1 Tire Problems to Look for During a Visual Inspection

Over inflation: Too much air pressure causes mostly the tire’s middle section to contact the road. This creates wear primarily in the center of the tread, with less wear at the tire’s edges.

Under inflation: Too little air pressure causes mostly the tire’s outer edges to contact the road. This creates wear primarily on both edges of the tire tread, with less wear in the center.

Tread wear on one edge of the tire: This typically occurs when the wheels are out of alignment.

Erratic tread wear: This is often called cupping, and may mean the wheel is out of balance, or that the shock absorbers or other suspension components need to be replaced.

Raised portion of the tread or sidewall: May indicate that one of the belts in the tire carcass has separated from those next to it.
11. The Future of Self-Inflating Tyres

Michelin is working with several other companies to develop an active pressure-management system called TIPM (Tyre Intelligent Pressure Management), due to be available sometime in 2005. This system has a compressor that automatically adjusts the pressure in each tyre while the vehicle is in operation to compensate for leaks and slow-leak punctures. The driver will be able to adjust the pressure depending on the desired driving mode: comfort, sporty, all-terrain or over-obstacle. There are at least two other systems in the early development stages that are oriented toward the consumer market the En-tyre system and the Cycloid Air Pump system. The entire self inflating system uses a valve that pulls in air from the atmosphere. It then pumps the air into the under-inflated tyre using a peristaltic-pump action. The goal is to constantly maintain a specific pressure.

12. Self-Inflating Tyres for Bicycles and Motorcycles

Now cyclists can also motor with the peace of mind that a flat tyre isn't going to ruin their ride. Bridgestone Cycle of Japan has developed the Air Hub, which uses a rotating air pump that replenishes air in the tyre as you pedal. Like the En-tyre method, it keeps the air in the tyres at a constant pressure level. The air pump is in the hub and is run by the rotation of the wheel. A small tube runs compressed air to the tyre's air valve to maintain the pressure. When the air pressure in the tyre is where it should be, excess air is exhausted through a device in the middle of the hose. Pirelli has also come up with a self-inflating tyre system for motorcycles and scooters. The Pirelli Safety Wheel System uses a monitoring system along with a special rim and an internal tube containing compressed air. It also has a valve to regulate the pressure between the tube and the tyre. When the tyre deflates naturally, the valve opens and pumps air into the tyre until it reaches the correct pressure. If there is a puncture, the system warns the rider as it allows air to move into the tyre.
13. Conclusions
We applied all these techniques to reduce the process time and human efforts of the conventional manual air filling system. The system helps to reduce cost and friction between surface of tyre and road so that will reduce the wastage of tyre material. As a result, It will increase the life of tyre. After fabrication of automatic tyre inflation system, the result obtained that if the system utilization will be executed in proper by taking and concerning all the relevant according to the project demand the process time, cost and human efforts can be reduce in a great manner.

References