

## AUTOMATIC TIRE INFLATION SYSTEM

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**Abstract** - Since the discovery of tires, amelioration is being done in tires of a vehicle on a regular basis for its improved life and its role in increasing vehicular safety. As we all know that vehicle is the most important part of our life, because it helps us in traveling miles in a few minutes. The air pressure of the tires needs to be maintained at ideal level for better running of vehicle and for its safety purposes. So this system was introduced keeping in mind the fuel consumption, vehicular safety and comfort. It maintains the required tire pressure of vehicle, increases fuel efficiency and reduces tire wear thus increasing their life and reducing the tire replacement time and cost. Significant aim of introducing this system is to maintain ideal pressure in tires and when the pressure of tire goes below ideal value pressure gauge monitors it and the tire is inflated again. This paper provides a better understanding for researchers and new learners on the working, advantages and limitations of the "Automatic tire inflation system" used in tires of a vehicle.

**Key Words:** Automatic tire inflation, tire pressure, tire life, fuel consumption, vehicle safety.

### 1. INTRODUCTION

It was first introduced in the American DUKW amphibious trucks in 1942. Nowadays it is a standard in Czech's heavy military Tatra trucks and also common in Soviet and Russian military trucks. Apart from military trucks it was also introduced in civilian Hummer H1, [7]. It is most important in them because the military vehicle have to go to remote places like mountains, deserts and snowy areas where no fuel pump or tire pressure refilling system is available. Tires are the 2<sup>nd</sup> highest costly part for trucking industries. According to the AAA (American Automobile Association), 80% of the vehicles have at least 1 underinflated tire also their stats shows that **when the pressure of tire is below 2 psi than the ideal pressure the fuel efficiency is reduced by 10% [8]**. Also the researches done by the NACFE (North American Council for Freight Efficiency) in 2013 shows that an improperly inflated tire leads to vehicle consuming more than necessary fuel. The pressure also decreases due to natural passage of air through elastic rubbers present in tires. When there is a decrease in 10 degree Fahrenheit of

surrounding temperature, 1 psi pressure of tire decreases. When tire comes in contact with ground due to friction heat is generated which melts the rubber of tire and underinflated tires gets overheated easily. In an underinflated tire engine has to work harder thus taking more fuel to run the vehicle. As the environmental conditions are also not similar everywhere so it becomes essential to maintain ideal tire pressure in order to improve the fuel economy as petrol or diesel are non-renewable sources of energy and many countries imports fuel/oil from Dubai and Oman due to abundance. Generally there is a decrease of 0.5 to 1 psi tire pressure per month under normal atmospheric conditions. The vehicle and its passenger's safety, fuel economy, improving tire life, reducing tire blowouts chances are the most essential aspects in a vehicle, fortunately Automatic tire inflation system substantially helps in taking care of these aspects. As it regularly compensates the lost air in the tire thus reducing human effort by not regularly checking the tire pressure manually. Another aim of introducing this system is to improve handling and control over vehicle thus reducing the chances of accidents. System consists of a compressor which supplies air to rotor assembly and inflating tire via flexible ducting and rotary bearing. By maintain ideal pressure in tires braking and handling works at its best. Once the system is installed there no need for driver or any passenger to check the pressure manually thus reducing time and drudgery.

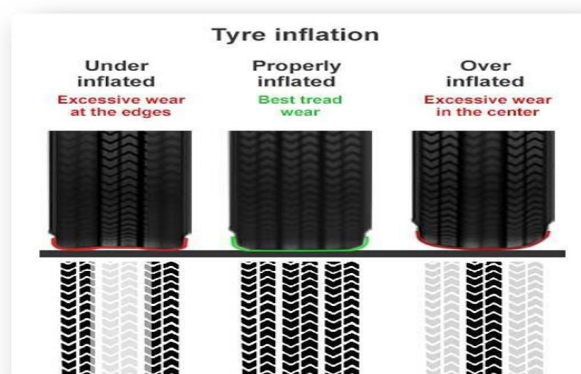


Figure 1- Types of inflated tires

## 1.1 WORKING PRINCIPLE

The Automatic tire inflation system contains a compressor which is used to pass [1] air through the rotary joint (which is fixed between wheel spindle and wheel hub at each wheel) via hoses, providing the rotary motion of wheel assembly. Air is channeled through rotary joint without entangling the hoses. When pressure goes below the desired level it pumps air and tire inflates. The compressor gets power from the battery. This operation takes place when the vehicle is moving and there is a requirement of inflation of tire due to reduced tire pressure level.

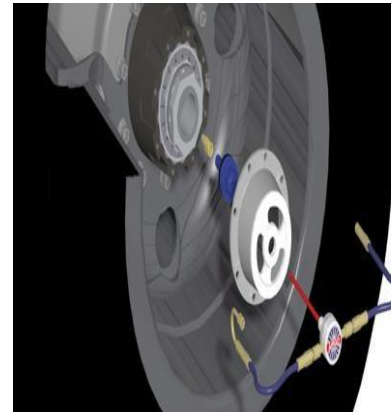


Figure 3- Closer view of the Housing

## 2. COMPONENTS AND THEIR WORKING

The overall system is primarily composed of the Wheel-end assembly and a control module. The wheel-end assembly comprises of a flexible hose with check valves. The check valves only permits air to flow into the tires inspecting no leakage of air. The basic working of this system is that it has a rotary joint which sends air to nozzle which are fitted in the rim and the rotary joint allows rotary motion to wheel assembly. [10]

**Rotary Union:** The rotary union consists of an air chamber through which the passage of air takes place along the shaft rotation [3]. A detailed view of the rotary union is shown in Figure-2.

**Compressor-** A gas compressor is a mechanical device that increases pressure of same air and reduces its volume [2]. There is a slight difference between a compressor and pump is that a pump is used to increase the pressure of water especially in fluids. The desired pressure is achieved due to the reciprocating nature of compressor. Simultaneous air supply is given by the rotary joint's rotation. A compressor generally gets overloaded so it is provided with a secondary power source except from a 12 Volts DC supply from a battery [1]. Since it has to maintain the required pressurized air to all the wheels, its position is very critical. Generally a 300 psi compressor is used in automotive vehicles.

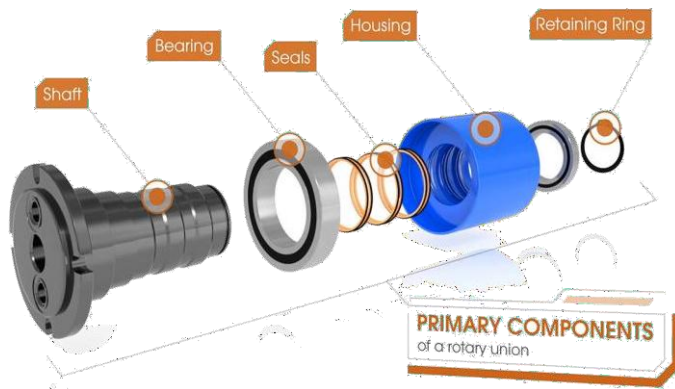


Figure 2- Rotary union and its components

Further it has parts as discussed below:

- a) **Housing-** All the other components of the rotary union are held together by the housing. It consists of an inlet port which is threaded and housing supplying medium is attached to it. The housing remains stationary. It is made up of a shaft, bearing and mechanical seal from inside



Figure 4- A Compressor

**b) Air delivery system-** It consists of pipes which carries the pressurized air as sent by the compressor after being sensed by the pressure gauge sensors. The parts of the air delivery system is generally short made and softer (strong enough to withstand the air pressure) so that it can fit into the wheels, avoiding any damage to it. These pipes are joined to small tubes which will join to tires and delivering air from compressor. This system contains self-actuating valves which ensures safe and required pressure delivery of air. To prevent the backflow, kill switches are installed for constant pressure supply to the tire. A diagram (Figure 5) is shown for the better understanding of air delivery system and its components.[9]

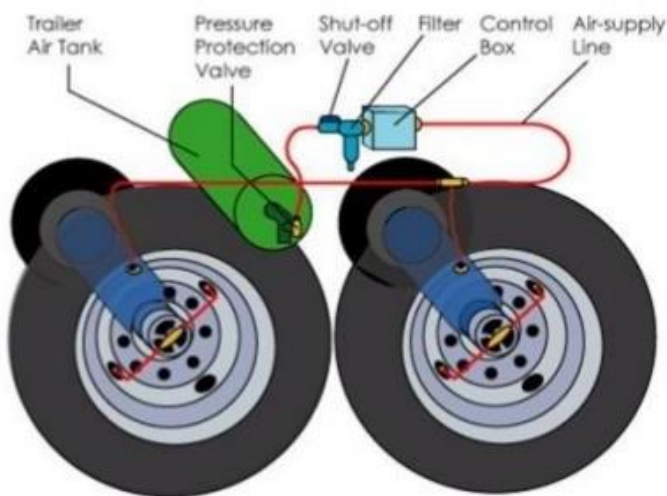


Figure 5 - Components of an Air delivery system

**c) Pressure Gauge and sensors-** The most important task in this system is to detect the actual tire pressure and measure how much is exactly needed to be supplied so that the tires are re-inflated, so the pressure gauge and sensors are the most important devices. The sensors detects the minimum and maximum pressure level. It will be in ON position whenever the pressure level goes below the boundary level of  $P_{\text{optimum-min}}$ . (minimum optimum pressure) and consequently will be turned OFF when the pressure level goes above  $P_{\text{optimum-max}}$ . (maximum optimum pressure). The pressure gauge housing is filled with a viscous oil. The oil filling has various advantages like it dampens the pointer vibrations and it also doesn't leaves any space for ambient air to enter the system therefore

is fully digital hence it is very accurate and easy to read for the user. The pressure gauges are classified according to the precession (least accurate is grade D – 5% error and most accurate is grade 4A - 0.1% error). A diagram (Figure 6) illustrates the opening of seals due to pressure and it remains open until pressure is relieved.

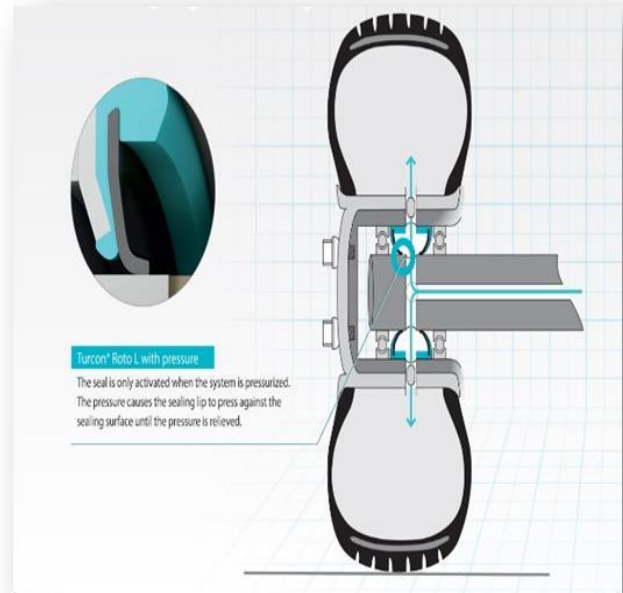


Figure 6- Opening and closing of seals due to air pressure

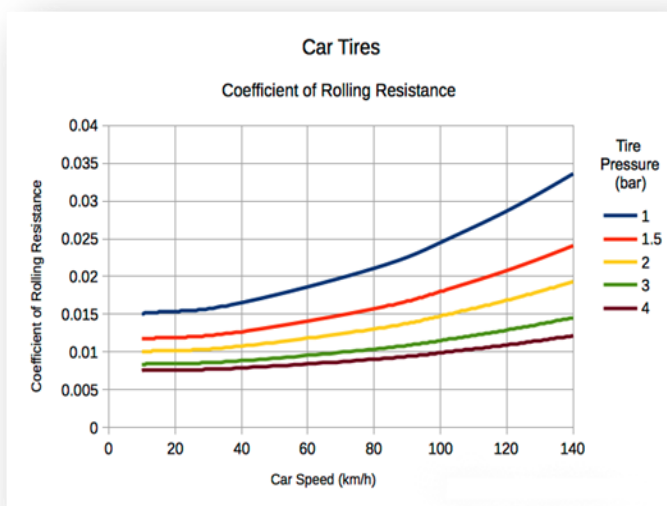
water doesn't condens. Reading shown by gauge

### 3. ADVANTAGES OF AUTOMATIC TIRE INFLATION SYSTEM-

Inclusive of the fact that it is very economical it also serves a very cardinal function i.e. safety of the passengers and vehicle itself and this type of system is not very common in passenger vehicles it can add great value to the automobile industry and can grab handsome amount of market in the industry. Except these valuable points it has some more advantages-

- Tire wear will reduce significantly because correctly inflated tire doesn't wear much [10].
- Vehicle will consume less fuel [8].
- Ideal amount of air will be supplied without consequential leakage.
- Driver's or passenger's work will reduce and there will be no wastage of time in regular checking of tire pressure.
- Although it is costly at the time of installation, it can serve for longer span of time without changing the system and reduce air re-filling cost.

- No special requirement of sound person as it is user-friendly.
- **Stopping distance** of the vehicle would be ideal. When the tire will be properly inflated then the coefficient of rolling resistance will be smaller resulting in proper motion and reduced heat generation in tires resulting in stopping the vehicle at the proposed distance. A graph is shown in *chart 1* giving an idea about how tire pressure & coefficient of rolling resistance is dependent upon vehicle speed.[6]



**Chart 1- Dependence of coefficient of rolling resistance and Tire pressure on Car Speed**

#### 4. LIMITATIONS

Automatic tire inflation system rarely have any disadvantage but there are quite a few:

- As the rotary joint continuously moves its life is limited it needs to be replaced after sometime time but with proper maintenance it can work for longer duration of time.
- Seals must be replaced regularly for optimum results.
- Pipes and tubes must be inspected from time to time.

#### 5. CONCLUSION

In order to serve efficiently and increase the vehicle performance, tire life and overall safety of the vehicle or society as a whole, it becomes essential to implement this technique. This system doesn't exist in majority of

passenger vehicles till date so it will be a boom to the automobile industry. As discussed earlier it will lead to thrifty fuel consumption, better vehicle mobility due to better traction and the vehicle vibrations lessens thus ameliorating cargo safety as it is capable of retaining ideal tire pressure by providing sufficient air flow with minimum leakage, taking care of the loads transferred on rotary joints simultaneously.

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