Design system of an automatic tyre pressure inflation and deflation system

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Abstract - As the existing of tire, from that time it required enhancement continuously done for better performance. As we know a small change in pressure is directly noticeable on the effectiveness, performance, life of tire and performance of vehicle. On a long run of vehicle, due to friction of tire and road, temperature of tire increases so for that pressure of tire also increases. Therefore its cause a tire blowout, so for augmentation, we assemble a machine named "automatic tire inflation and deflation system". The major focus of work is to inflate a tire during low pressure and deflate during high pressure. Other focus of that project is to be provided the limited pressure according to the load and tire wear. In this machine we introduced a laser technology that can be able to check the thickness of tire but at a certain point tire temperature will be exceed up to their blowout temperature. So for that consideration, a temperature sensor will be fixed on each tire that can sense the temperature of tire. When the tire temperature reached at that point buzzer would sound and according to condition of tire wear it can be able to maintain limited pressure in tire. Under inflated tires also overheat more rapidly than perfectly inflated tires, which cause major tire damage. In this papers we have design the various dimensions for Automatic Tire Inflation and Deflation system

Keywords —: Design analysis, automatic actuator, tyre pressure sensor, air compressor, Automatic Tire Inflation and tire Deflation, Laser proximity sensor

I. INTRODUCTION

Improperly inflated tires are quite common problems on passenger vehicles. In fact, 80% of passenger vehicles on the road have at least one under-inflated tire and 37% of passenger cars have at least one tire that is 20 percent or more under-inflated. Often pressure loss in tires is a result of natural permeation of the gas through the unpredictable rubber, road conditions (such as potholes), and seasonal changes in. Most vehicle owners are unaware of the fact that their tires are not at the exact pressures because it is difficult to determine the tire pressure visually; a tire that is properly inflated to the accurate pressure looks very similar to one that is either over-inflated or under- inflated. Thus, from the lookout of passenger vehicle owners, they are losing money due to increased tire wear and decreased fuel efficiency [9].

Today automobile sector plays a big role in the economics of all the countries in the world and lots of researches have been carried out to improve the efficiency of the vehicle one the techniques to improve the efficiency of an automobile is inflate the tire regularly. As its well-known, one of the most serious problem that the large motor vehicle have whether they are for the transportation of passenger or cargo and especially those used for middle or longer distance travel, resides the ensuring the correct performance of the tires. This means making sure that tire are inflated and stay inflated for the right amount of pressure for the load being carried.

The Air Maintenance Technology system developed through this project replenishes lost air and maintains optimal tire cavity pressure whenever the tire is rolling in service, thus improving overall fuel economy by reducing the tire's rolling resistance. The deflation is a process of letting air or gas out of the tires. Deflation is the problem of an automobile vehicle because a certain period of time in air reduced to the vehicle for running time. So a long distance travelled vehicle have problem of deflation.

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% [14]. 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

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through elastic rubbers present in tires. 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.

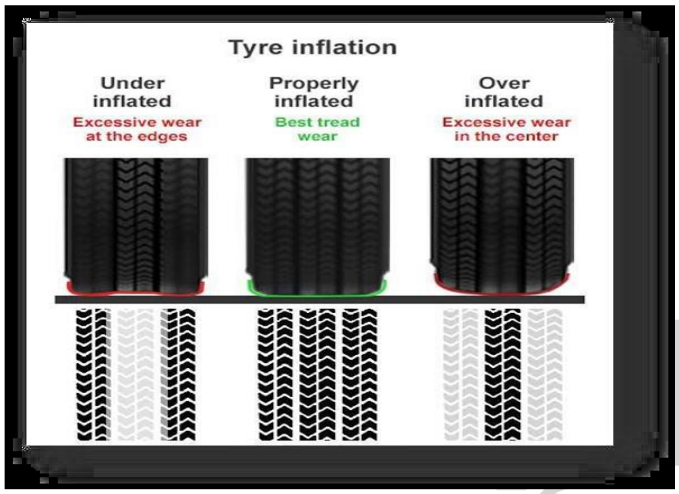

Figure 1: Tyre wear for different condition

The overall goal of our paper is to develop a product that will decrease tire wear while improving fuel economy, performance and safety of a passenger vehicle through dynamically-adjustable tire pressures. However, there are several objectives in our design to meet, and these objectives include both design characteristics and increase life of tyre and safety.

II. WORKING PROCEDURES

The Automatic tire inflation system contains a compressor which is used to pass air through the axle of wheel via hoses pipe, Air is channeled through without entangling the hoses. When pressure goes below the desired level it pumps air from compressed storage air tank 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. For the tire wear are set up a Laser proximity sensor for thickness measurement that is based on optical triangulation that serves as a basic concept for displacement measurement of diffuse target surface. Tire temperature sensor is specifically designed to measure the highly transient surface temperature of a tire with spatial fidelity, providing invaluable information for chassis tuning, tire exploitation, compound selection, and driver development. The sensor is also available as a PCB assembly, without an enclosure, amounting to a significant reduction in cost and allowing the user to package the sensor to their specific needs.

III. COMPONENTS:

i. Compressor.
ii. Air receiver tank.
iii. Air inflator and deflator device.
iv. Air flowing system.
v. Laser proximity sensor.
vi. Infrared Tire Temperature Sensors.

i. **Compressor**:-A compressor is a mechanical device that increases the pressure of a gas or air by reducing its volume. A compressor generally gets overloaded so it is provided with a secondary power source except from a 12 Volts DC supply from a battery.

Figure 2: Battery operated compressor

ii. **Air receiver tank**: An air receiver tank is an integral and important part of any compressed air system. Typically a receiver tank is sized at 6-10 times the flow rate of the system. In a compressed air system, a receiver tank provides the following benefits: The receiver tank acts as a reservoir of compressed air for peak demands.

iii. **Air inflator and deflator device:** this component is ingenious device that can able to inflate and deflate the compressed air to the set pressure in the tire. This system consists solenoid valve, pressure sensor and other electronics components.

Figure 3: Automatic air inflator and deflator

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iv. **Air flowing system:** This is general arrangement of the pipe with the automobile tire. Compressed air can be passes and inflated into the tire.

v. **Laser proximity sensor:-**Two sensors are available basically for the thickness measurement. One sensor is used for the references measurement on a roller. The product runs over a roller which is used as a basis for the zero point .the subsequent measurement on the product is set off against the zero point and output as thickness. In the thickness measurement with two sensors the product runs between two sensors, one above and one below the material. The difference between two sensors values gives the thickness. The advantage of this measuring set up is that the product can move vertically to the direction of travel without causing measuring errors. Air cooled optimums sensors are available for measuring warm material. Traversing thickness measuring system is available in addition to the stationary thickness measurement with separate measuring tracks.

vi. **Infrared Tire Temperature Sensors:** -Tire temperature sensor is specifically designed to measure the highly transient surface temperature of a tire with spatial fidelity, providing invaluable information for chassis tuning, tire exploitation, compound selection, and driver development.The sensor is capable of measuring temperature at 16, 8,or 4 laterally-spaced points, at a sampling frequency up to 100Hz, object temperature between -20 to 300˚C; using CAN 2.0A protocol, and enclosed in a compact IP66 rated aluminum enclosure. The sensor is availablewith two field-of-views: ultra-wide (120˚) or wide (60˚).The sensor is also available as a PCB assembly, without an enclosure, amounting to a significant reduction in cost and allowing the user to package the sensor to their specific needs.

IV. MATHEMATICAL ANALYSIS

A. *Calculation for shaft and bearing*

Power of Shaft P = 17 watt

Power transmitted by shaft, [13]

$$P = \frac{2 * \pi * N * T}{60}$$

Where, N→ Rpm of motor shaft = 24

T →Torque transmitted

$$17 = \frac{2\pi \times 24 \times T}{60} \times 10^3$$

$T = 6.76 \times 10^3$ N-mm

Maximum Stress

$T_{max} = (16/\pi D^3)(m^2+Td^2)$

$T_{max} = 0.30 * S_{yt}$

For Shaft SAE 1030 (Mild steel)

S_{yt} = 296 Mpa

Take F.S = 1.63

$T_{max} = 0.30 * S_{yt} = 0.30 * 296 = 88.8$ N/mm^2

We know that,

No. of teeth (Gear) , N1 = 12

No. of teeth (sprocket) , N2 = 36

Ratio = R = 1 : 3

Torque on sprocket = 3 × T

$= 3 \times 6.76 \times 10^3$

$= 20.280 \times 10^3$ N-mm

- **Dia. Of sprocket, (D)**

Periphery = π × dia. Of sprocket

36 × 6.25 = π × D

$$D = \frac{36 \times 6.25}{\Pi}$$

D = 72 mm

- **Torque transmitted,**

T = Force × radius

$20.280 \times 10^3 = F \times 36$

F = 563.33N

$$F = \frac{5630.33}{9.81}$$

F =58 Kg

- **Torque transmitted by shaft,**

$T = \pi/16 \times \tau \times d^3$

Select permissible shear stress (τ) from design data book.

$\tau = 70$ N/mm^2

Therefore, $20.28 \times 10^3 = \pi/16 \times d^3 \times 70$

D= 12 mm.

TakingFactorof Safety = 1.6

Actual dia. of shaft = 12 x 1.6 = 19.2 mm

We select dia. Of shaft = 20 mm.

For 20 mm shaft dia. we select standard **PEDESTAL BEARING P204.**

- **Calculation for compressor selection:**

For tire pressure of 35 psi

Where, 1 psi = 0.06895 bar

Therefore,

35 psi = 35*0.06895 bar

= 2.41325 bar

= 2.5 bar (approx.)

Therefore, we are selecting 12V D.C., 5.5 bar Compressor for tire pressure of 35psi.

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V. DRAWING

The drawing of this system has been made in CATIA V5. In the figure we have assemble compressor, compressed air tank, motor and rear wheel on the frame of the vehicle. Figure 4 is representing the top view, front view and side of the assembly while figure 5 shown the isometric view of the assembly.

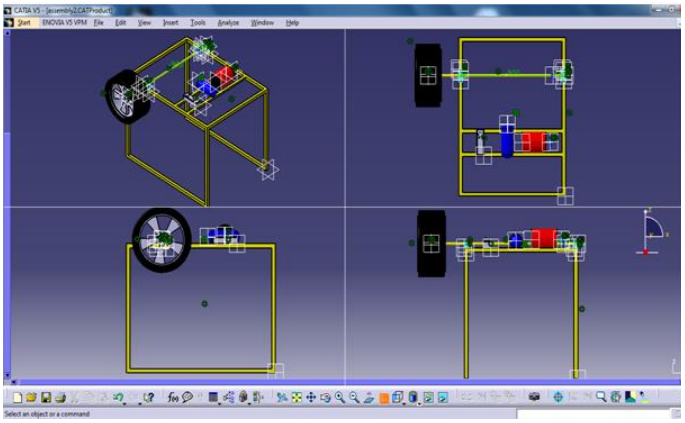

Figure 4: drawing of assembly model view

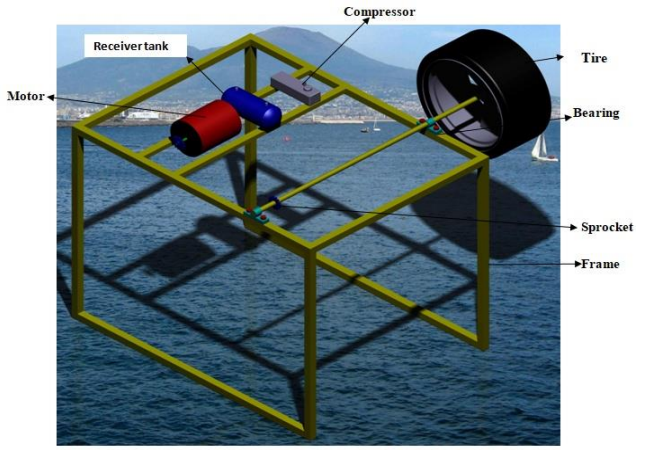

Figure 5: Isometric view of assembly

VI. CONCLUSION

Proper tire pressure thus always helps to improve the tire life, attains greater braking Efficiency, improved ride quality and cargo safety due to reduction in the vehicle Vibrations, improved vehicle mobility due to the increase in traction when tire pressure are lowered. When the required pressure in the tire is reached, the buzzer will indicate it to the driver and the solenoid valve will shut off the air supply to the tire. Thus on Implementing the Tire pressure inflation system to the four wheeler vehicle, the system will helps the driver to regulate and maintain proper pressure inside the tires. Because such a product does not currently exist for the majority of passenger vehicles, the market conditions would be favorable 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 and enhance safety and life of tyre and vehicles.

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