Design and Modelling of Automatic Air Filling System in Tire of Car

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Abstract-*Driven by studies that 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, we have developed an automatic, self-inflating tire system that ensures that tires are properly inflated at all times. Our design proposes and successfully implements the use of a centralized compressor that 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 joints effectively allow air to be channelled to the tires without the tangling of hoses. With the recent oil price hikes and growing concern of environmental issues, this system addresses a potential improvement in gas mileage; tire wear reduction; and an increase in handling and tire performance in diverse conditions. In this paper we have taken into consideration design aspects of the automatic tire inflation system in tire of car.*

Keywords-Tire pressure monitoring system, Automatic air filling, etc.

I. INTRODUCTION

Automobiles have become an important and reliable companion of humans. The usage of the automobiles is increasing in a rapid manner. The various Automobile industries are now competing each other to win the hearts of humans. In order to do so, the companies are improving the safety systems in automobiles. So more reliable, the more successful the car becomes.

The results of a survey released by the US Department of Transportation's NHTSA in 2001 showed that a decrease of 0.55 bar, from the recommended inflation pressure, resulted in the reduction of fuel efficiency by 3.3%, in miles per gallon. This survey also found that one in four cars on the road had at least one tyre that was under-inflated. The on board air inflation system is used to maintain the pressure of tires in running condition. The environmental conditions varies according to regions, seasons because of this, it requires maintaining the tyres pressure for better performance according to conditions.

The pressurize air from compressor can be filled into tyres through flexible ducting with the help of rotary bearing. The pressure conditions are achieved by pressure gauges. Maintaining correct inflation pressure in tyre helps to keep vehicle handling and braking at its best, as well as improving fuel efficiency and Tyre life. Additionally it can prevent such events read separations and Tyre blow outs which may cause loss of control of a vehicle and severe crashes such as Roll overs. Centralized automatic tire inflation systems monitor and continually adjust the level of pressurized air in tires, maintaining proper tire inflation automatically even while the vehicle is in motion.

The easiest way to reduce CO2 emissions in a vehicle is to reduce its fuel consumption since the CO2 emission is directly proportional to the amount of fuel consumed. With over 12 million cars added (in 2012) to the roads each year, it is possible to imagine the impact having proper tyre pressure can have on the economy and ecology of a nation.

II. LITERATURE SURVEY

Balakrishnanet.al[1] researched onTire pressure monitoring and automatic filling system. This system is developed for use by commercial vehicles. It is an electronic system designed to monitor air pressure and temperature inside the tires and inform to driver via display.

Kumar et.al [2] researched on Tire Pressure Monitoring System and Fuel Leak Detection. To inflate a tire, the driver has to go to a gas station or he has to attach a pump manually. Both these involve human labor. This project is aimed at removing such unwanted strain and save time. The system has a dedicated unit for filling air whenever required.

Junankar et.al [3] explained that tires are the second-highest cost for the trucking industry. The most important application of this system is in military vehicle. For the military vehicle, the environmental condition, land conditions are continuously varying and they have to face very worst condition like heavy rainfall, snowfall, deserts. . Thus there arises a need for automatic tire inflation system. This can be done by employing appropriate technique.

From the all research papers we understood that due to improper air pressure in tire there are more chances of

accidents, more fuel consumption, less efficiency, more wear and tear of tire and automatic air filling system is used in military vehicles but not implemented in cars, so by using automatic air filling system in car we can overcome all problems discussed above.

III. PROBLEM DEFINATION

Improper tire pressure & temperature is a safety issue that is often overlooked or ignored. A drop in tire pressure by just a few pounds per square inch (psi) can result in the reduction of fuel mileage, tire life, safety, and vehicle performance and when tyres are under-inflated, the tread wears more quickly. Underinflated tyres gets overheat more quickly than properly inflated tyres, which cause more tyre damage.

To reduce this problem we are designing this system. In this system we will continuously check air pressure of tyre and when low pressure is detected, air from compressor will be released and will be supplied to tyre.

IV. OBJECTIVES

The ideal functional objective of our design is its capability to adjust the pressures in all four tires of a passenger vehicle to obtain the proper pressure for varying road or driving conditions. There occur many traffic accidents due to the malfunction of tires that can reduced by continuous pressure monitoring. Fuel efficiency decreases due to rolling resistance. We can avoid these problems by using automatic air filling system in tire of car.

V. SELF-INFLATING SYSTEM

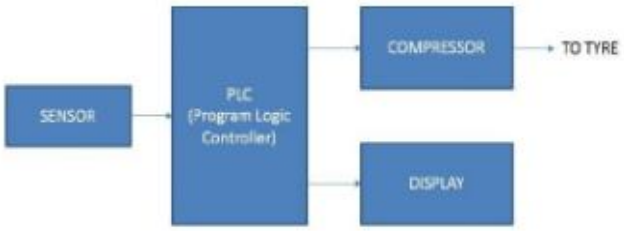

Fig no:- 5.1

5.1 Tire-inflation systems have three general goals:

1. Detect when the air pressure in a particular tyre has dropped. This means they have to constantly monitor the air pressure in each tyre.
2. Notify the driver of the problem.
3. Inflate that tyre back to the proper level - This means there has to be an air supply as well as a check valve that opens only when needed.

5.2 Parts of self-inflating system

1. Pressure Sensor:

Fig no:- 5.2.1

A pressure sensor is used to sense the pressure inside tire. We are going to place a pressure sensor on the rim of the tire. And its connection will be given to controller which will display the actual and required pressure to driver.

2. 12 volt DC Compressor

Fig no:- 5.2.2

A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of gas and gives compressed air to tire via air hoses.

3.Rotary joint / rotary union:

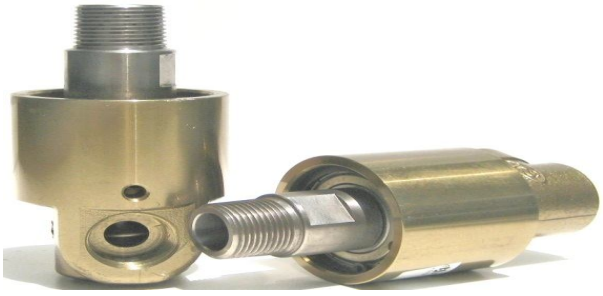

Fig no:- 5.2.3

A rotary union is a union that allows for rotation of the united parts. It is thus a device that provides a seal between a stationary supply passage (such as pipe or tubing) and a rotating part (such as a drum, cylinder, or spindle) to permit the flow of a fluid into and/or out of the rotating part.

VI. WORKING

It consists of compressor, which supplies air and air tank is used to store 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. Maintaining correct inflation pressure in tyre helps to keep vehicle handling and braking at its best, as well as improving fuel efficiency and Tyre life. In Addition it can prevent such events read separations and Tyre blow outs which may cause loss of control of a vehicle and severe crashes such as Roll overs. Centralized automatic tire inflation systems monitor and continually adjust the level of pressurized air in tires, maintaining proper tire inflation automatically even while the vehicle is in motion.

Once an automatic tire inflation system is installed, it should not require any special attention from the drivers. This eliminates the need to check tire pressure manually, which saves time and labour while ensuring consistent and proper tire inflation.

VII. MODELLING OF TIRE INFLATION SYSTEM

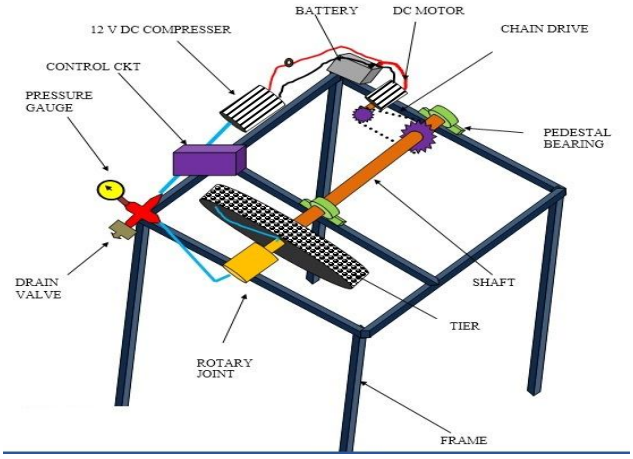

Fig- 7.1

VIII. DESIGN OF TIRE INFLATION SYSTEM

8.1 Design of correct air pressure to be maintained in tire:

We have taken Maruti Suzuki Swift Dzire Petrol car as reference for our calculation.

Tire selected: Apollo AMAZER XL (TT) Tube Type/Apollo AMAZER 3G Tubeless.

Table no:- 8.1

Tire width	165
Aspect ratio	80
Construction type	R
Rim diameter	14
Load rating	85
Speed rating	T

From the Maruti Suzuki Swift Dziretable, we can see that a load index of 85 means the maximum load for the tyre is 515 Kg.

The recommendation from the tyre industry though is you should never exceed 90% of the tyre's load index, so in this case the maximum axle weight would be 927 Kg.

We know from the tyre specification: the Maximum Tyre Inflation Pressure = 33 PSI
Weight of car: 940 Kg
33 / 515 =0.064 (Max Pressure for tire divided by load rating)
0.064 x (940 / 2) = 30.08 PSI (inflation factor times half the weight of the caravan)
So the correct tire pressure is 30.08 PSI

8.2 Design of piston and cylinder :

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 losses are as follows:
Cylinder bore dia. - 0.052 m
Piston ring width – 0.00115 m
RPM of wheel (assume average speed 80 kmph)
Dia. of wheel = rim dia. + (2*tire section length)
= 38 + (15 * 2)
= 68cm
Circumference = π D
= 215cm

Car will travel 80 km in hour so in one minute it will travel 1.34 km, if we convert 1.34 km in to inches it will come 133332cm.
Therefore, RPM = distance travelled / circumference of wheel
= 133332 / 215
= 619.03

Now revolution of the piston ring will be exactly equal to that of wheel.
So, rev per second of a piston ring will be 619.03 / 60
= 10. 317
The pressure between the ring and cylinder is normally 0.9Mpa.
Force between each piston ring and cylinder
= 0.00115 * π * 0.052 * 900000
= 169.08 N
Coefficient of friction between piston ring and cylinder is approximately 0.2
Friction force = 169.08 * μ
= 169.08 * 0.2
= 33.82 N
Work done = displacement in 1 sec * frictional force
= 10.317 * π * 0.052 * 33.82
= 57.00 N-m
Total work done = work done by each ring * no. of rings
= 57 * 2
= 114 Nm.

IX. RESULT AND CONCLUSION

From the design and modelling of automatic air filling in tire of car we found an exact tire pressure i.e 30.08psi to be maintained in tire. We designed a model of automatic tire inflation to maintain exact pressure in tire of car.

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