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Design and Development of Automatic Tire Inflation System for Two-Wheeler

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Abstract - *An automatic tire inflation system, often referred to as ATIS, is a cutting-edge technology designed to enhance vehicle safety, performance, and efficiency. This innovative system constantly monitors and adjusts the air pressure in a vehicle's tires, ensuring they remain at the optimal level for various driving conditions. By maintaining proper tire pressure automatically, ATIS not only improves fuel economy but also reduces the risk of accidents caused by underinflated or overinflated tires. In this discussion, we will delve deeper into the benefits, components, and working principles of automatic tire inflation systems, highlighting their significance in modern transportation. This paper explores the benefits, components, and operational principles of ATIS, emphasizing its role in modern transportation. Real-time monitoring and automatic inflation features of ATIS ensure enhanced vehicle safety, improved fuel efficiency, and extended tire lifespan. The paper also discusses the severe consequences of driving with low tire pressure, such as reduced fuel efficiency, compromised handling, increased risk of blowouts, and overall vehicle instability. Understanding and implementing ATIS can lead to safer, more efficient, and environmentally friendly driving experiences.*

Key Words: Automatic tire inflation system (ATIS, Vehicle Performance, Pressure monitoring, underinflated tires, Safety.

1. INTRODUCTION

An automatic tire inflation system, often referred to as ATIS, is a cutting-edge technology designed to enhance vehicle safety, performance, and efficiency. This innovative system constantly monitors and adjusts the air pressure in a vehicle's tires, ensuring they remain at the optimal level for various driving conditions. By maintaining proper tire pressure automatically, ATIS not only improves fuel economy but also reduces the risk of accidents caused by underinflated or overinflated tires. In this discussion, we will delve deeper into the benefits, components, and working principles of automatic tire inflation systems, highlighting their significance in modern transportation. This paper explores the benefits, components, and operational principles of ATIS, emphasizing its role in modern transportation. Real-time monitoring and automatic inflation features of ATIS ensure enhanced vehicle safety, improved fuel efficiency, and extended tire lifespan. The paper also discusses the severe consequences of driving with low tire pressure, such as reduced fuel efficiency, compromised handling, increased risk of blowouts, and overall vehicle instability. Understanding and implementing ATIS can lead to safer, more efficient, and environmentally friendly driving experiences.

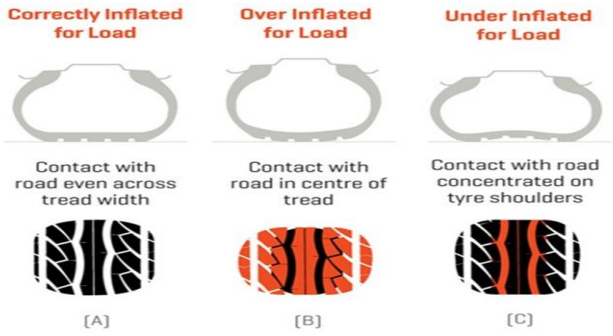

Fig.1:- Tire Thread contact as per the pressure

2. RELEVANCE

The Automatic Tire inflation system project is highly relevant in today's context due to various reasons such as

Handling: Tire pressure influences handling by altering the tire's stiffness and its response to the input received. When the tire pressure is low, tire becomes softer and exhibits poor performance in changing direction and maintaining the right direction as required by the steering.

Fuel Efficiency: Some of the ways of how to conserve fuel include ensuring that your vehicle has the right tire pressure. An ATIS can reduce fuel consumption of vehicles and entails cost savings as well as reductions toward vehicles' negative impact on the environment.

Tire Longevity: Maintaining correct tire pressure is economical as it makes the tires to last longer and therefore the periods between replacements are longs and thus the costs.

Convenience: Automatic tire inflation can therefore be described as an advantage because it saves time that would otherwise be used in checking and adjusting the pressure.

Environmental Impact: Optimizing the tire pressure means that there is less wear and tear on the tires, including

the subsequent shedding of micro plastics from wear, which makes cars environmentally friendly.

Safety: ATIS can reduce the number of stops required during a long trip as it can be unsafe for rider to stop in middle of road especially during night time.

3. LITERATURE SURVEY

In the paper [1], it describes an Automatic Tire Inflation System that tends to sustain tire pressure for the vehicles. It utilises a compressor, a rotary joint, tubes, and pressure indicators that help in inflating tires as soon as they get deflated below the recommended rate. The system optimizes fuel consumption and the vehicle stability as well as democratizes the tire safety and durability, saves time on regular tire pressure checks, and also increases overall vehicle control. A special emphasis is made to understand how each of the components helps address the above benefits.

In the paper [2] discusses the integration of an automobile Tire Pressure Monitoring Systems and Automatic Air Filling System including its parts and its working. It employs a squad of sensors as well as a compressor to regulate and to check tire pressure as a way of promoting safety of vehicles, efficiency in their usage of fuel and durability of tires. The study of this system helps in understanding of the incorporation of real-time detection and simultaneous control in vehicular systems.

The paper [4] presents a new portable compressor driven by permanent magnet brushless DC motor. This study encompasses the designs of three dimensional model, analysis of forces and simulations/experiments. In this research, high efficiency and low vibration are highlighted for the compressor indicating notable enhancements compared to the conventional compressor designs.

From paper [5], it studies and investigates the influence of risk perception and anticipated regret on drivers' intention to use TPMS implementations which is a measure to lower the number of tire blowout accidents. Results indicate a significant positive relationship between risk perception and intention to adopt TPMS but not for anticipated regret. There was no moderation of these relationships by the optimism bias.

The Paper [6] , proposes a hybrid TPMS (h-TPMS) which integrates both direct and indirect approach sensors to monitor the state-of-inflation of all four tires using a single pressure sensor, some mathematics and data processing tricks. The main advantage of this h-TPMS is the low cost and high performance which is experimentally verified under different road conditions and loads. The system also satisfies the European normative requirements for TPMS.

The Paper [7], conducts an analysis of tire failure-related crashes and injury severity on a mountainous freeway. Crash-level factors that may contribute to the occurrence of tire failures, including low tire pressure, smooth tires, and rough roadway surface, are investigated in this paper. Tire failures have a substantial impact on injury severity, particularly when combined with rollover, fire, or guardrail collision. The findings of this study suggest the need for state-wide mandatory tire inspection laws and propose some countermeasures to alleviate the problems of tire-related crashes and improve traffic safety.

4. METHODOLOGY

Requirement Analysis: The methodology commenced with a comprehensive analysis of vehicles parts and dimension of wheel. This involved identifying dimensions of wheel's axle and spacing in bike where the Automatic tire inflation system can be equipped.

Component selection: The system requires various components, including an air compressor, pneumatic pipes, tire pressure monitoring sensors, a microcontroller, and a rotary joint. The rotary components will be designed and modelled using CAD software to ensure precise integration and functionality.

System Design: The ATIS's parts are designed on a CAD software such as Creo where the rotary joint which is equipped on the axle of wheel is designed as per the dimension of axle and spacing between the wheel and the suspension rod.

Analysis: The rotary joint is then analyzed on the CFD software to check the proper flow of compressed air from the air compressor to the rotary joint while rotating along the wheel. The simulation is done to provide proper information of pressure at different points in rotary joints.

Prototyping: The designed part after the analysis and simulation is then prototyped with the help of 3-D printing where a PLA (Polylactic acid) which is a biodegradable and recyclable material and has low melting point, high strength, low thermal expansion, and good layer adhesion which makes it easy to test it in real life conditions.

Testing: The prototyped part is attached to the bike's wheel and tested in real-life conditions. This allows for the collection of data and feedback which helps in the improvement of the system. These tests results offer us insights into the part's toughness, practicality, general efficacy of the system.

Deployment, Monitoring and Feedback: After the experimentation and fine-tuning of the prototype in imitation-life condition, a new system is created for commercial use which is installed in actual automobiles for using in different types of bicycle such as scooters,

commuters, sports bikes and adventure bikes etc. These various vehicles are used in various occasions offering exhaustive information on the operation and reliability of the part. In use, constant monitoring is done with the help monitoring sensor such as tire pressure monitoring sensor which are made to ensure that the system is fully functional

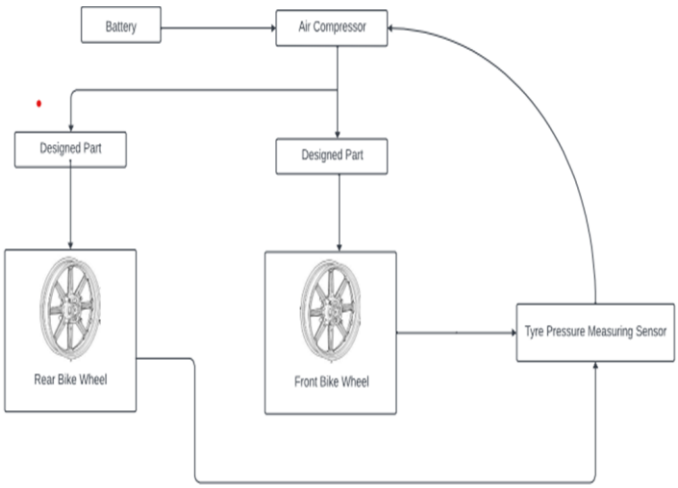

Fig.2:- Block diagram of Automatic Tyre Inflation System

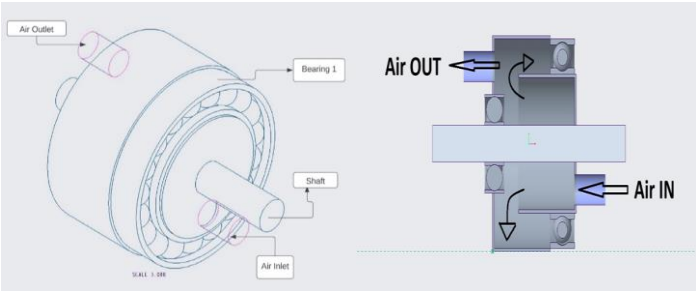

Fig.3:- Design and Working of Rotary Joint designed on CREO Software

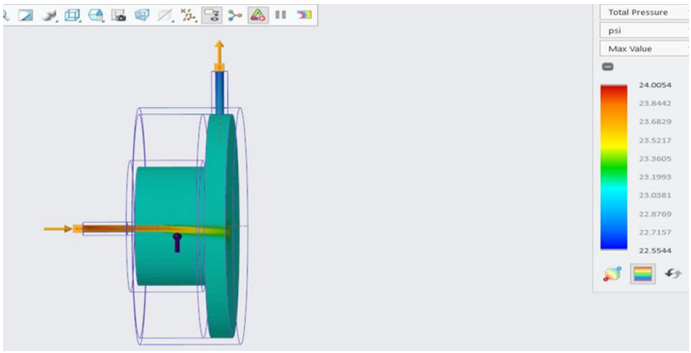

Fig.4:- CFD analysis and simulation of the part

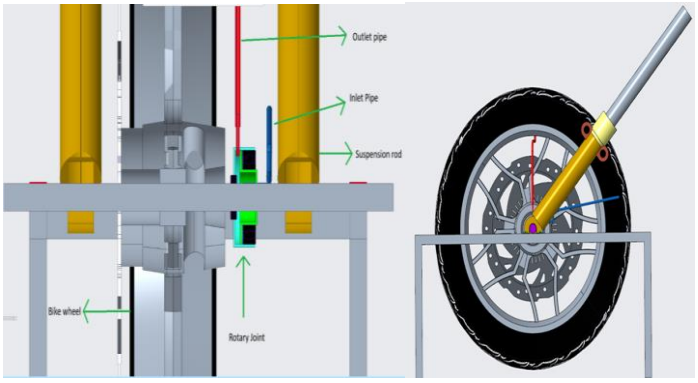

Fig.5:- Experimental setup of ATIS

5. RESULT

The outcomes of the project encompass several key aspects that contribute to enhancing vehicles performance and user safety. Firstly, ATIS has all the key assets to enhance the tires performance by providing options such as remote monitoring or maintaining proper tire pressure. With the help of this system, the users will be able to always keep their tires in the right condition hence making their vehicles more efficient. Furthermore, ATIS enhances safety by offering features for constant and proactive monitoring and controlling of the tires thus increasing the ability to prevent accidents resulting from bad tire conditions. Combined with other penalties that could arise from poor or blown tires, and addressing the opportunities for tire problems before they turn into failures, ATIS plays a role in avoiding accidents occasioned by tire blowouts or poor conditions. ATIS has the potential of helping users to reduce expenses associated with vehicle maintenance as when using vehicle with low tire pressure there is increase in vibrations in the vehicle causing damage to major parts and loosening of the joints in the vehicle which can lead to expensive repairing of vehicle parts. ATIS provides robust benefits since it increases tire's performance, optimizes vehicle efficiency, minimizes probable accidents, and leads to great cost savings for the user.

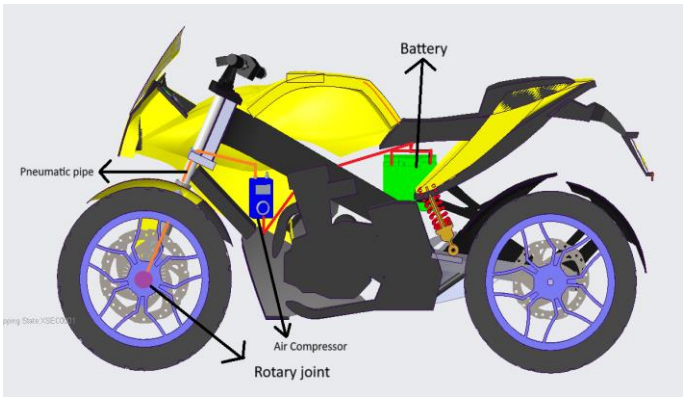

Fig.6:- Deployment of Automatic Tire inflation system in a sports bike

6. FUTURE SCOPE

The future scope of the Automatic tire inflation system is that it is expected that most passenger cars and commercial vehicles will be equipped with this technology. It will ensure safety from tire-related accidents and will also keep the environment clean by preventing punctures. The fuel economy of the vehicles will increase as the tires will be kept inflated to the desired pressure, which will in turn decrease fuel consumption and hence emissions into the environment. The governments and regulatory bodies will be compelled to enforce laws for using such a technology, which will boost its usage among the general public. In commercial vehicles, the Automatic tire inflation system will be the backbone of the operation, as there will be huge involvement of capital and labour. The downtime due to flat tires will be eliminated, which will increase the operational life and efficiency of such vehicles. They will become a necessity in the trucking industry.

7. CONCLUSIONS

The development of Automatic tire inflation systems and the successful deployment of such products are hence major milestones in improving vehicle safety and efficiency. Through advanced technologies that comprise real-time monitoring of pressure, Automatic mechanisms for adjustment, and compatibility with vehicle types, these systems represent a robust and complete approach to maintaining optimum pressure in the tire. These systems are put through extensive tests and iteration for their reliability and effectiveness in providing users with improved safety, decreased environmental impact, and increased confidence in vehicle performance. Besides, they reduce the number of accidents caused by underinflated tires and minimize environmental wastes by extending the life of the tires to prevent their disposal.

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