International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 09 | Sep 2021 www.irjet.net p-ISSN: 2395-0072

Air Powered Vehicle

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Abstract - *Light utility vehicles are quickly becoming a popular mode of short-distance independent transportation. Vehicle manufacturers are developing vehicles fueled by alternative energies as a result of rising costs and pollution from gasoline and diesel. Engineers are focusing their efforts on using air as a source of energy for light utility vehicles. The use of compressed air for energy storage is a strategy that is not only effective and environmentally friendly, but also cost-effective. The lack of torque produced by the "engines" and the cost of compressing the air were the two biggest issues with compressed air cars. Several businesses have recently begun to build compressed air vehicles, which have a number of advantages but also have a number of major hurdles to overcome. This document summarizes the basic principles of technology, as well as recent advances, benefits, and drawbacks of compressed air as a source of energy for automobiles.*

Key Words: **Air, Compressed, Vehicle, Pollution, Utility, etc.**

1. INTRODUCTION

Many governments and vehicle manufacturers have expedited research on new energy vehicles as a result of the climate and energy crises, which is important for reducing the use of fossil fuels and reducing pollution produced by exhaust emissions. Compressed air is seen as an opportunity in the new energy automotive sector as a source of energy and a non-polluting fuel in air-powered equipment. The air powered vehicle (APV) is made up of three parts: an air tank, a compressed air engine, and a control system. The current state of new energy vehicles is summarised in this document.

The compressed air system and compressed air engine are introduced as the primary technologies in air-powered vehicles. The primary assessment criteria, energy density, and compressed air energy conversion efficiency are examined using compressed air energy theory. Practical approaches and related research to improve the efficiency of APVs, such as multistage expansion and energy recovery systems, are also given and discussed. In general, the air-powered vehicle is both technically and practically practicable. The energy conversion efficiency and driving mileage of APVs will be competitive with traditional vehicles and other new energy vehicles if the energy loss of the air compression and decompression process is reduced and the utilisation rate of compressed air energy is improved, and its green nature will make it an important place in the future automotive market.

For decades, scientists and engineers have been interested in compressed air as a source of energy in many applications and as a non-polluting fuel in compressed air vehicles. Using a compressor, compressed air is filled with electricity. When calculating overall efficiency, the electricity required to compress air must be taken into account. The air engine is now the most often utilised technology for converting compressed air potential energy into mechanical energy. Nonetheless, the compressed air vehicle will aid in the reduction of air pollution, with a goal of zero pollution and the promotion of a healthy atmosphere. There is no combustion process going on there.

2. LITERATURE REVIEW

According to S. S. Verma et al., compressed air has captivated scientists and engineers for millennia as a source of energy in various applications and as a nonpolluting fuel in compressed air vehicles. Many developers and manufacturers are working to master compressed air vehicle technology in all aspects for its earliest application by mankind. The current paper provides a quick overview of the most recent breakthroughs in compressed-air vehicles, as well as an overview of the technology's numerous problems and solutions. For the creation of a safe, light, and cost-effective compressed air vehicle in the near future, management of compressed air parameters such as temperature, energy density, requirement of input power, energy release, and emission control must be mastered.

Transportation, according to Ashish Jiotode and others, is the most important aspect of our daily lives. Life would not be as simple if it weren't for it. Cars, trucks, trains, and other modes of transportation all require petrol or diesel to operate. We all know that gasoline is a nonrenewable source of energy, and that its prices are rising every day. So, in this work, we offer some new ideas in the context of this concept. We used AIR as a fuel to power the cars here. Because air is a free and renewable source of energy, it is also the most reliable. We utilized air for the intake and a carbon filter to filter out the dust particles. We don't need gasoline or diesel for this; we can simply run the engine on air. This will be really beneficial to people. It will also be extremely beneficial to businesses. Transportation will be less expensive. It will be more advantageous and useful in the future. TATA MOTORS signs a deal with France's Motor Development International MDI to create a compressed-air vehicle. It will also be more cost-effective and pollution-free. When compared to petrol or diesel, the cost of recharging the air will be quite low.

According to Gaurav Kumar Tandan et al, compressed air has captivated scientists and engineers for millennia as a source of energy in various applications and as a non-polluting fuel in compressed air vehicles. Using a compressor, compressed air is filled with electricity. When calculating overall efficiency, the electricity required to compress air must be taken into account. The air engine is now the most often utilized technology for converting compressed air potential energy into mechanical energy. Nonetheless, the compressed air vehicle will aid in the reduction of air pollution, with a goal of zero pollution and the promotion of a healthy atmosphere.

3. HISTORY

Charles B. Hodges pioneered air-powered engines in 1896 and made a fortune selling hundreds of locomotives through the H. Hodges Company. The K. Porter Company is a company founded by K. Porter. The inventor of the first air automobile, on the other hand, has been a point of contention for decades.

In 1925, the Decatur Review published a story on a man named Louis C. Kiser, who adapted his gasoline car to run on compressed air. In 1926, Lee Barton Williams claimed to be the first to design an air automobile. Williams, a Pittsburg native, claimed the car started on gasoline but switched to compressed air only after 10 mph.

The Hope Star of Hope, Arkansas published an item in 1931 about Los Angeles' Roy J. Meyers inventing the first air automobile. The Troyan air mobile was reported to be the first air automobile in the 1970s. The air-powered flywheel was created in a closed system by inventor Joseph P. Troyan. Willard Truitt exhibited his air car invention in the 1970s as well. However, he sold the design to the US Army and NASA in 1982 because he lacked the financial resources to pursue its development.

Texas' Russel R. Brown claimed to have invented the first air automobile in 1974. Sorgato, an Italian inventor, created an experimental air automobile in 1975 that used nine 2840 pressure air bottles. Ray Starbard designed a pressurized air vehicle in Vacaville, California, in 1976.

Terry Miller invented Air Car One in 1979, and it only cost him $1500 to manufacture. He received a patent for his compressed air automobile. Claud Mead, Des Hill, Ricardo Perez-Pomar, and George Miller claimed to have invented an air automobile in the 1980s.

The MDI City Cat, designed by Guy Ngre and introduced by Tata Motors in 2007, was the first commercial air car. MDI air cars have been showcased in two more models as of 2009.

4. TECHNOLOGY

Uncompressed airpower has been used by mankind for ages in a variety of applications, including windmills, sailing, balloon cars, hot air balloon flying, and hang gliding, among others. The use of compressed air for energy storage is a method that is not only efficient and clean, but also cost-effective, and has been used to power mine trains and naval torpedo propulsion since the 19th century. The Liquid Air Company, based in London, began producing compressed air and liquid air cars in 1903. The lack of torque produced by the "engines" and the cost of compressing the air were the two biggest issues with compressed air cars. Several businesses have recently begun to create compressed air cars, although none have yet been given to the public. Compressed air tanks hold a lot of energy yet have a low power density. They are on par with or better than batteries in terms of charge/recharge efficiency, but they have a far shorter lifespan. Compressed air vehicles have a major problem with higher pressures, whilst chemical batteries have major issues with efficiency, cost, harmful chemicals, and lifespan.

Compressed-air propulsion works by pressurizing a storage tank and connecting it to something that looks like a vehicle's reciprocating steam engine. Compressed air vehicles (CAV) use the expansion of compressed air to drive their pistons instead of combining gasoline with air and burning it in the engine to drive pistons with hot expanding gases. As a result, the method is devoid of the technical and medical challenges associated with employing ammonia, petrol, or carbon disulphide as the working fluid. Manufacturers claim to have created a 90 percent efficient engine. The air is compressed at 150 times the pace at which air is pumped into vehicle tyres or bicycle tyres. The tanks must be built according to pressure vessel safety regulations. Steel, aluminium, carbon fibre, Kevlar, or other materials, or a mix of the above, may be used to construct the storage tank. Fiber materials are lighter than metals, but they are also more expensive. Metal tanks can resist a lot of pressure cycles, but they must be inspected for corrosion on a regular basis. The tanks can be refilled at a service station with heat exchangers, or at home or in parking lots in a few hours by connecting the vehicle to an on-board compressor. Driving such a car is expected to cost roughly Rs. 60 every 100 km, with a complete fill-up at a “tank-station” costing around Rs. 120.

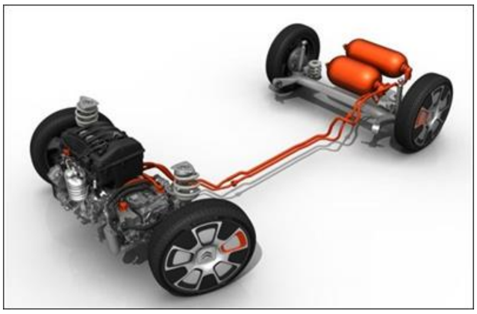

Fig -1: Layout of Vehicle

5. COMPONENTS OF VEHICLE

5.1 Engine

Compressed air automobiles are propelled by compressed air motors that are held at high pressures, such as 31 MPa, in a tank (4500 psi or 310 bars). Rather than using an ignited fuel-air mixture to drive engine pistons, compressed air cars use compressed air to expand, similar to how steam expands in a steam engine. Since the 1920s, there have been prototype cars that use pressurized air for torpedo propulsion.

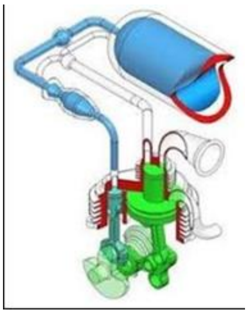

Fig -2: Engine

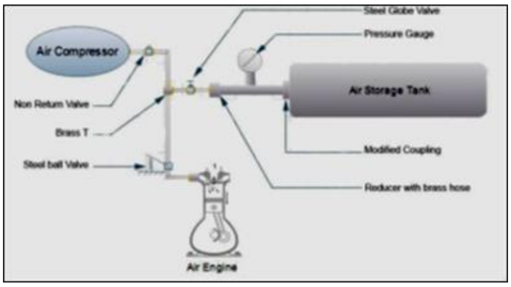

Fig -3: Experimental Setup of Engine

5.2 Storage Tanks

The tanks must be built according to pressure vessel safety requirements, such as ISO 11439. In contrast to hydrogen's difficulties with damage and hazard in high-impact accidents, air is non-flammable on its own. It was claimed on Seven Network's Beyond Tomorrow that carbon-fiber is fragile and can split under enough force, but does not emit shrapnel when it does so. Carbon-fiber tanks are comparable to steel tanks in that they can safely contain air at a pressure of roughly 4500 psi. The vehicles are built to be refueled at a high-pressure pump. Tanks in compressed air vehicles are typically isothermal, with a heat exchanger of some sort used to keep the temperature (and pressure) of the tank constant when the air is removed. It boasts a lightweight and durable design, consistent dependability and performance, consistent pressure output, good flow, and a high level of efficiency.

Fig -4: Storage Tank

5.3 Body

1. It is made of injected foam and fibre glass.

2. It is not too heavy.

3. It is a little pricey.

Fig -5: Body

5.4 Emission

At the exhaust, compressed air cars might be emission-free. Because compressed air cars rely on electricity for power, their total environmental impact is determined by how clean the electricity source is. Most air cars, on the other hand, feature petrol engines for various jobs. The amount of carbon dioxide emitted is comparable to half of what a Toyota Prius produces (being around 0.34 pounds per mile). Because different regions have extremely varying power sources, ranging from high-emission power sources like coal to zero-emission power sources, some engines can be powered otherwise. A region's electrical power sources might also alter over time, enhancing or worsening total emissions.
However, even with the most optimistic assumptions, a 2009 study found that energy storage in the form of air is less effective than chemical (battery) storage.

5.5 Pressure Gauges

The study of an applied force by a fluid (liquid or gas) on a surface is known as pressure measurement. The most common unit of measurement for pressure is force per unit of surface area. The measurement of pressure and vacuum has spawned a slew of new approaches. Pressure gauges and vacuum gauges are instruments that measure and show pressure in an integral unit.

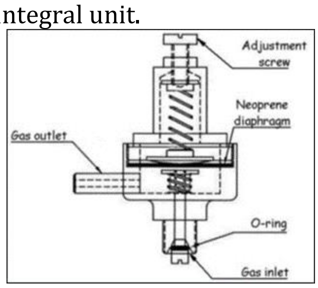

Fig -6: Pressure Gauge

5.6 Poly Pipes for Air Systems

Poly pipe is a company that makes plastic piping systems for the residential, commercial, civil, and infrastructure markets. Drainage, plumbing, water supply, water management, cable management, heating, and ventilation are just few of the applications for pipe systems.

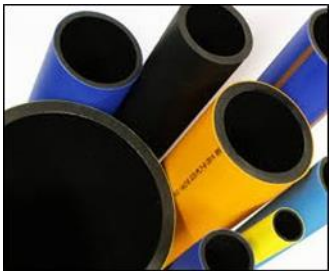

Fig -7: Hose

6. CRASH-SAFETY

The safety of light-weight vehicle air tanks in severe collisions has yet to be proven. The feasibility of an ultra-light vehicle assembled with adhesives to provide acceptable crash safety results has yet to be tested in North America, and sceptics question the ability of an ultra-light vehicle assembled with adhesives to produce acceptable crash safety results. The vehicle, according to Shiva Vencat, vice president of MDI and CEO of Zero Pollution Motors, would pass crash tests and exceed US safety standards. He is adamant that the millions of dollars spent on the Air Car would not be wasted. There has never been a lightweight, 100-mpg-plus automobile that has passed crash testing in North America. Although technological advancements may eventually make this possible, the Air Car has yet to prove its worth, and doubts about crash safety persist. Reduce the power required to operate the automobile as much as possible to achieve an acceptable range with an air car. This forces the design to be as light as possible.

According to a survey by the National Highway Traffic Safety Administration of the United States, “very little cars” have the highest mortality rate per mile travelled among ten distinct classes of passenger vehicles. For example, a 55-year-old driver who drives 12,000 miles per year has a 1% probability of being killed in a car collision. This is more than twice the incidence of fatalities in the safest vehicle class, a "big automobile." The number of fatal crashes per mile, according to the statistics in this report, is only marginally connected with vehicle weight, with a correlation coefficient of just 0.01. (-0.45). The size of the vehicle within its class has a stronger correlation; for example, “large” cars, pickup trucks, and SUVs had lower fatality rates than “small” cars, pickup trucks, and SUVs. With the exception of mid-size vehicles, where minivans and mid-size cars are among the safest classes, while mid-size SUVs are the second most fatal after very small cars, this is true in seven of the ten classes. Even though heavier vehicles are sometimes statistically safer, the greater weight is not always the reason for this.

”Historically, heavier cars have done a better job cushioning their occupants in crashes,” according to the NHTSA research. Their larger hoods and additional space in the occupant compartment allow for a more progressive deceleration of the vehicle, as well as the occupant within it... While light vehicles might theoretically be designed with comparable long hoods and moderate deceleration pulses, this would very certainly necessitate significant changes in materials and construction, as well as the removal of weight from their engines, accessories, and other components.

7. DEVELOPERS AND MANUFACTURER

Compressed air automobiles are being researched, developed, and deployed by a number of firms. Reports of anticipated production that were too optimistic stretch back to at least May 1999. The MDI Air Car, for example, debuted in South Africa in 2002 and was expected to go into production “within six months” in January 2004. The air automobile was never produced in South Africa as of January 2009. In order to extend the range and performance of their cars, most of the cars in development use similar technology to low-energy vehicles.

7.1 MDI

AIRPod, One Flow Air, City Flow Air, Mini Flow Air, and Multi Flow Air are among the vehicles proposed by MDI. One of the company's most notable breakthroughs is the adoption of its "active chamber," which is a compartment that heats the air (using a fuel) to double the energy production. In 1904, this 'invention' was first used in torpedoes.

7.2 TATA Motors

Tata Motors of India had intended to produce a car with an MDI compressed air engine in 2011 as of January 2009. The short range and low engine temperatures were causing problems, according to Tata's vice president of engineering systems in December 2009. In May 2012, Tata Motors reported that the design had passed phase one of the ”proof of technical concept” process, paving the way for full manufacturing for the Indian market. Tata has moved on to phase two, which entails “further detailed development of the compressed air engine for specific automotive and stationary applications.”

Dr. Tim Leverton, president and head of Tata Advanced and Product Engineering, said in February 2017 that the company was “starting industrialization” and that the first vehicles will be available by 2020. According to other sources, Tata is also considering bringing back plans for a compressed air version of the Tata Nano, which was previously considered as part of their collaboration with MDI.

7.3 Peugeot

Peugeot and Citron revealed their intention to develop a vehicle that runs on compressed air. However, the automobile they're working on features a hybrid system that includes a gasoline engine (which is utilized to get the car up to 70 km/h or when the compressed air tank runs out). "Disappointing news from France: PSA Peugeot Citroen has put an indefinite hold on the development of its promising-sounding Hybrid Air powertrain, apparently because the company has been unable to find a development partner willing to split the huge costs of engineering the system," according to a press release from January 2015. The system's development expenses are estimated to be 500 million euros, and it would appear that it would need to be installed in roughly 500,000 automobiles each year to make financial sense. In 2014, the project's leader left Peugeot.

8. CASE STUDY

8.1 AirPod – The Mini Car

AirPod is a hybrid vehicle created by Motor Development International in partnership with Tata Motors in India and Air France in Paris. It is powered by compressed air. The AirPod's engine is made up of two cylinders that are linked together. At a constant pressure of 20 bars, compressed air enters the smaller cylinder first. The intake is closed when the smaller piston bottoms out, and the air in the small cylinder expands, pouring into the bigger cylinder. The cycle then repeats itself as both pistons move to exhaust the increased air. When completely expanded at constant temperature, the 80 kg of compressed air in the AirPods tank can generate 11.2 kilowatt-hours of mechanical energy. The manufacturing plant in Sardinia, Italy, has been built up, and the product will be ready in the market by the summer of 2014.

Fig -8: AirPod- The Mini Car

The AirPod, which is presently at the prototype stage, is expected to hit the market in a few years. The AirPod is powered by a battery-powered electric motor and compressed air. What's actually revolutionary is that the ease with which air can be converted into energy using simple compressors means charging stations can be installed everywhere, with no provisioning, no trucks transporting gas, ethanol, or hydrogen, and no emissions, just air discharge. It creates and stores some energy while braking, just as traditional electric vehicles.

The AirPod can travel 125 miles (200 kilometers) at a top speed of 28 to 43 mph (45 to 70kph). The vehicle is designed for one person and features a tiny cargo compartment in the back. While the technology is a breakthrough in terms of clean and ecologically friendly engines, the car's single-user design may make it unsuitable for many users, particularly in India and other highly congested areas of the world.

None of the other businesses working on air cars, including Tata, have firm manufacturing plans. There are certainly issues that need to be addressed, but will there ever be an air car that is practical enough to attract consumers away from future electric vehicles?

Fig -9: Interior of AirPod

For the time being, the concept has only been tested in two Tata vehicles, and both Tata and MDI are striving to further enhance the technology. It would be at least a couple of years before we learn anything major about the product's launch in India. MDI reports that the device costs roughly $10,000 USD, which translates to around Rs. 5-6 lakhs in India.

8.2 Results and Analysis

8.2.1 Driving Shaft Speed vs Pressure

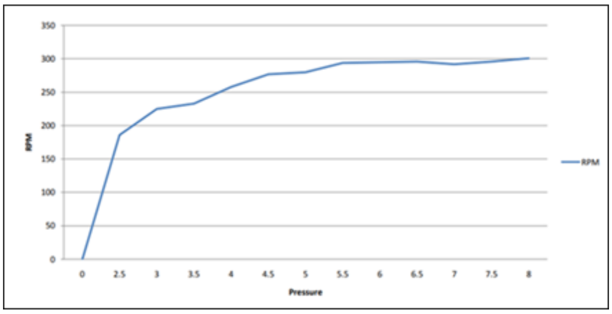

Chart -1: Graph Speed vs Pressure

When seen in the diagram below, as the pressure grows gradually, the speed achieved increases linearly, however after a certain pressure range, as the pressure increases, a rated or top speed is obtained. With an increase in air pressure at inlate, there will be a very tiny change after this speed.

8.2.2 Torque vs Pressure

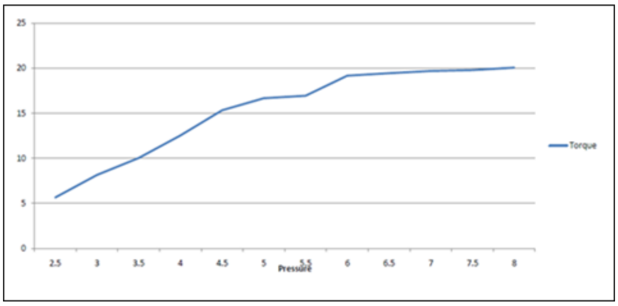

Chart -2: Graph Torque vs Pressure

The nature of the graph is depicted in the diagram. We can see from the graph that the initial torque produced is quite modest, but as the pressure grows, so does the torque.

9. ADVANTAGES AND DISADVANTAGES

9.1 Advantages

The main benefits of an air-powered engine are:

- It uses no gasoline or other bio-carbon based fuel.
- Refueling can be done at home, but filling the tanks to full pressure would necessitate compressors capable of 250-300 bars, which are not often available for home use due to the dangers associated with these pressures. If such cars become popular enough to warrant it, service stations would have to construct the required air facilities, just as they would with gasoline.
- Because no cooling system, spark plugs, starter motor, or mufflers are required, compressed air engines minimize vehicle production costs.
- In comparison to batteries that progressively decrease their charge over time, the rate of self-discharge is quite low. As a result, unlike electric cars, the vehicle can be left unattended for longer periods of time.
- When compressed air expands, its temperature drops, which can be used as air conditioning.
- Hazardous substances such as gasoline and battery acids/metals are reduced or eliminated.
- By compressing and storing air, some mechanical arrangements may provide energy recovery during braking.
- According to Lund University in Sweden, utilizing an air-hybrid system, buses might improve their fuel efficiency by up to 60%. However, this only applies to hybrid air vehicles (owing to energy recuperation during braking), not compressed air-only cars.

9.2 Disadvantages

The main drawbacks are the energy conversion and transmission phases, which both have inherent losses. When chemical energy in fossil fuels is transformed by the engine to mechanical energy, energy is lost in combustion engine cars. Electric automobiles use electricity from a power plant (from any source) to charge their batteries, which then send the electricity to the car's motor, which transforms it to mechanical energy. Compressed-air cars use electricity from a power plant to operate a compressor, which compresses the air into the car's tank mechanically. The compressed air is subsequently converted to mechanical energy by the car's engine.

- When air expands in the engine, it cools rapidly and requires a heat exchanger to bring it up to ambient temperature. To achieve a considerable portion of the theoretical energy output, heating is required. While the heat exchanger serves the same purpose as an intercooler in an internal combustion engine, the temperature differential between the incoming air and the working gas is lower. The device becomes extremely chilly when heating the stored air and may frost up in cool, humid regions.
- This necessitates thoroughly dehydrating the compressed air as well. The engine will halt owing to interior ice if there is any dampness in the compressed air. Complete removal of humidity necessitates more energy that cannot be reused and must be wasted.
- When air is squeezed to fill the tank, however, the temperature rises. If the stored air is not cooled when the tank is being filled, the pressure of the air will drop and the amount of energy available will decrease.

10. CONCLUSIONS

Compressed air is already being investigated for vehicle propulsion, and air-powered vehicles are now being developed as a more fuel-efficient mode of transportation. Some automakers are looking on compressed air hybrids and compressed fluids to store energy in vehicles, which might pave the way for the development of a low-cost air-powered vehicle design. Unfortunately, serious issues must be resolved before air-powered vehicles can become a reality for widespread use. However, with advances in science and technology, as well as a growing awareness of the need to replace expensive transportation methods, air-powered vehicles will undoubtedly see the light of day.

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[3] French Car PEUGEOT Source Google

[4] Layout of Vehicle Source Google

[5] Engine Source Google

[6] Experimental setup of Engine Source Google

[7] Storage Tank Source Google

[8] Body of pneumatic Vehicle Source Google

[9] Pressure Gauge Source Google

[10] Hose Source Google

[11] Interior of Airpod Source Google