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Zero CO_2 and Zero Heat Pollution Compressed Air Engine for The Urban Transport Sector; Theme Formulation

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Abstract – The Ozone layer's depletion, which results from our emission of greenhouse gases, is a bone of contention for the engineering field nowadays. Engineers who are custodians of modern living are responsible for orienting the world through more sustainable energy exploration technics. The accomplishments of IC engines do exceed their initial purpose these days but it also reveals many weaknesses, which never considered during their first conception. For this reason, it is time we move on to something more sustainable. Electric engines seem to be the new big thing; yet again, we fail to consider how unsustainable the technology may be. This article helps us avoid having more than 100 million BEV vehicles plying our streets before we discover this mistake. A revisit of some ancient ideas might just be the proper move here for much development around some fields have taken place to think we cannot do better. Compressed air engines are remarkable solutions for no matter the energy root source, the engines can operate at very high efficiencies giving generally high well to wheel efficiencies when compared to others.

Keywords – Zero CO2, Zero Heat Pollution, Compressed Air Engine, Urban Transport Sector, Theme Formulation.

I. INTRODUCTION

Ozone is a natural form of oxygen, consisting of three oxygen atoms (O_3). Its build up throughout evolution, some say from about 3000 million years ago, between 10km to 50km in the earth's atmosphere (stratosphere) created what we now call the ozone layer (Sivasakthivel & K.K. Siva, 2011). The development of the ozone layer is the origin of formation of more advanced life forms including human beings, here on Earth, as this layer absorbs harmful electromagnetic radiations emitted by the sun. These radiations are classified as ultraviolet rays in the electromagnetic spectrum which are principally destructive to organic cells (Morrisette, 1995) thus its main contribution to our evolution.

As any gas, one should not forget that this layer is not a solid one; it consists of very loosely packed molecules of all the gases that make up the atmosphere of which ozone is just one and a half in a million of such molecules. This layer of the atmosphere is named the ozone layer because there we find over 91% of the ozone molecules in the earth's atmosphere (Albritton, 1998). This implies this layer could be subdued to changes due to variations in temperature and pressure, and so too can it be easily diluted with increased concentrations of other gases. As an oxygen rich gas, ozone can become reactive with other atoms/gases emitted in the atmosphere, for example the Chlorofluorocarbons (CFC), more so when physical conditions are favorable for such reactions to occur.

When the natural balance of ozone destruction and production is altered more towards destruction, the term "ozone depletion" is christened (Angell & Korshover, 2005). The gases that cause a rapid depletion of the ozone layer equally fall under the greenhouse gases category. Greenhouse gases are the main contributors of global warming. These gases consisting of mainly carbon oxides, methane and CFCs, accumulated in the troposphere (8 to 16 km in the atmosphere). These gases absorb long wavelength radiations emitted by the earth after being stroked by shorter wavelength sun rays. Their absorption of these radiations, keeps the troposphere relatively warmer and so the stratosphere is left colder. This cold stratosphere favors the generation of polar stratospheric clouds (PSCs) favorable for the reaction of CFCs with ozone when stroke by short wavelength sun rays. Convection too is an eventuality under such circumstances as the warmer air turns to rise while the colder one sinks, further depleting the ozone layer and so too the evolution of global warming (Fergusson, 2001).

The effects of the depleting nature of the ozone layer and the global warming phenomena are not myths in these modern times. This purge of what is known as the most beautiful planet of the Milky Way Galaxy is not to be under looked by the entire scientific world, especially when engineers considered to be the custodians of added value; are said to have the major blame to bare. This article introduces us to a new area of research, which is all about looking for sustainable solutions to ozone layer depletion and global warming.

II. Method

The method used for this article is a complete review of what was identified as a plausible sustainable solution to global warming and the depleting ozone layer. A study of recent day popular solutions to this problem (improving the efficiency of internal combustion engines, and battery electric vehicles) will be discussed critically in the paragraphs that follow. These discussions will be concluded with an acknowledgement of how answerable the proposed solution is to the main article problem which is how to sustainably improve our attempts to save the planet Earth. The much needed hypothesis for this review article is based on the fact that a change in the urban transport section will significantly affect our ecological footprint.

Why not IC engines?

In an average developed county like Great Britain, 68% of urban displacement is done by saloon cars (Kronberg & Shawn, 2019). These cars have a passenger capacity of four or six persons which are hardly filled. These cars have a GVM (Gross Vehicle Mass) of 3.5 tones. They run averagely bellow 60km/h when in cities and have an average annual mileage of 2000 miles (3220 km) (Kavalec, 1999).

Recent research shows that the disproportionate burning of fossil fuel is a major contributor to the amount of greenhouse gases in the atmosphere. Passenger and freight transports contribute to 19% of the energy used and 23% of energy related CO_2 emissions globally (International Energy Agency, 2009). Road transport accounted for 12% of Australia's carbon dioxide emissions in 2006; this implies it is a major contributor to its greenhouse gases as previous statistics revealed greenhouse gases emitted in this sector has grown by approximately 1.7% annually since 1990 (Department of Climate Change Australia, 2008). In 2019, the transport sector accounted for 46.9% of a country like Brazil's energy-related carbon dioxide emissions which are figures that could be generalised for all developing countries worldwide as they will be more and more significant as levels of industrialisation drop. Not too long ago, the partial lock down due to the COVID-19 pandemic caused a drop of up to 30% in the global greenhouse gases emissions (Lambert, 2020). This was primarily thanks to the drastically reduced circulation in cities. Thus the ecological footprint of the urban transport sector is a major call for concern.

Internal combustion engines, which muscle the greater share of transport vehicles in our cities, are known for their gross inefficiency as barely 20% of the potential energy stored in the fuel is put to effective use on an average car (Rucks, 2015). For urban cycles, the tank to wheel efficiency further drops to 10-13% (Odd André, Arnesen, Torstein, & Sondell, 2020). Such inefficiencies are not acceptable in an era where sustainability is the order of the day for inventions. If one were to consider instead the well to wheel efficiencies of these vehicles, these figures will fall even much lower. Repetitive attempts to improve on the efficiency of IC engines has led engineers to make very large vehicles with larger engine compartment proportions, thus making almost worthless, investments made for such researches. All these bring us to the conclusion that internal combustion engines for the urban transport sector should be considered grossly outdated.

Why not battery electric vehicles?

The development of battery electric vehicle (BEV) technology in the 21st Century hastily generated the assumption that electric engines are the most prominent solutions to cutting completely greenhouse gases emissions in the transport sector. However BEVs' struggle in the last decade with short drive ranges, important recharge durations, lack of appropriate infrastructure especially in developing countries and expensive materials used in their manufacturing, has made humanity start questioning the sustainability of this technology (K.T. Chau, 2014).

BEVs are propelled by electric motors that use electric energy stored in batteries. Electric engines differ significantly from normal internal combustion engines. These engines are much more efficient as compared to IC engines, and their efficiency is not necessarily linked to the load as is the case with IC engines. They have the ability to deliver high instant torque from the very first round of engine rotation. This ability implies an electric motor needs only one gear in either directions and so no need for complex gearboxes.

BEVs' engines equally have the advantage of regenerative breaking. That is, the motors can be used as breaks as the energy generated due to the inertia of the vehicle can be used to recharge the batteries for a later use, which is contrary to it being dissipated as heat by the shoe pads of the breaking system (Gustafsson & Johansson, 2015). When considering these advantages alongside some already obvious others, one might be forced to think this technology is the absolute best solution to eliminating greenhouse gases from our cities. Further development of these engines has brought up numerous weaknesses faced by the technology.

BEVs have recorded some increase in their range in the last couple of years, some BEVs like the Tesla Model S records up to a 400km range. This is quite impressive but when we consider that it cost roughly USD 150 to get a 1kWh lithium battery capacity (Lewis M., Seleem, Boshell, Salgado, & Saygin, 2017), then this development becomes questionable. More so some of these batteries are still cobalt dependent, a precious mineral that is minded mostly in the Democratic Republic of Congo. Its scarcity due to political uncertainties, made it reach values of USD 45/lb in 2018 (Engelskirchen, 2019). The lithium market can be better managed but it will cost an average of USD 7216 (4.5 million XAF) to produce a 41kWh battery for an average BEV in 2018 (Engelskirchen, 2019). Other precious minerals used in BEVs include; nickel, copper, aluminum and manganese, which each cost over USD 1/lb (XAF 1346/kg) (Chengjian, Qiang, Gaines, Hu, Tukker, & Steubing, 2020).

Like all electrical systems increase in current flow insinuates increase in heat that needs to be dissipated for safe operations. High performances BEVs attend temperatures of up to 150 ºC in the absence of cooling systems. These temperatures are destructive for these vehicles as they can result to battery thermal runaway (Dinakar & Rajeeve, 2016). To prevent such an event, BEVs have a cooling system to dissipate the excessive heat energy generated by their engines and even their transmission system, usually keeping them between 20 to 40 ºC. The heat energy dissipated is a loss in the useful efficiency of the vehicle and the additional weight of this cooling system implies more mass to carry why ply the urban streets. In the Tropics, where the ambient temperatures are relatively high, this dissipated heat is equally a nuisance to the comfort of the vehicle. Not only do BEVs need to dissipate heat, they also need to maintain the temperature of their batteries above 20ºC to maximize their output. Research findings indicate that lithium batteries at 20ºC recording a range of 150 km could see their range drop to 85 km at 0ºC and even 60 km at -15ºC (Iora & Tribioli, 2019).

Most BEVs' manufacturers claim it takes 30minutes to charge their batteries up to 80% using fast chargers. This is completely true, but what they always leave out is the fact that charging the remaining 20% takes at least twice that time (COLWELL, 2020). Super chargers charge up to rates of 50kW, which is enormous especially when we take into consideration the 1hour 15minutes it takes to fully charge a 60kWh battery of a GM Chevy Bolt (Ryan Collin, Yu Miao, Yokochi, Enjeti, & Jouanne, 2019). A larger picture to this analogy is taking into consideration the fact that during this 1hour 15minutes delay, at the peak of application of this technology, the possibility of coincidentally having 1000 vehicles in an urban city strapped to such chargers is almost eminent. This implies an eminent 50 000kW rate on the city's electricity grid just for electric vehicles. No Urban grid in developing countries can offer that much electricity instantaneously, thus there is also a serious problem of infrastructure to take into consideration when considering the widespread use of BEVs for the urban transport sector.

What next then?

Conclusion that could be drawn from the above reviews is that we have the tendency to focus on unique attainments with much negligence on how sustainable they might be. It was our thirst for more power that made us go digging underground for rich energy stores. Now in our attempt to solve the problem created by this thirst, greenhouse gas emissions, we cannot likewise use the same approach which is think one form of energy exploration is the absolute solution. It is time we contextualize solutions to this problem. To Consider using BEVs in the Tropics as the principal means of urban transport is a little farfetched for all the difficulties earlier earmarked are eminent in these regions. A more adaptable solution will be needed to cut greenhouse gas emissions in the urban transport sector of the Tropics and this research is the means through which a sustainable solution to this problem is introduced.

Why Zero CO_2 and Zero heat pollution Compressed air engine?

Considering an ever growing demand for new technology, the atmospheric carbon dioxide crossing 400 PPM threshold in 2015 (Kahn, 2016). The increasing record holding global temperatures for particular months (Thompson, 2016) and, the ever increasing scarcity and cost of fossil fuels (Heinberg, 2011) including difficulties faced with the use of BEVs in the Tropics; the use of a zero CO_2 and zero heat pollution compressed air engine for our everyday urban displacement is an absolute solution to this effect. Such an engine will not only completely cut down the air and heat pollution of the major cities in the Tropics – rendering life in them more conducive – but will also increase the economy of what is left of fossil fuels and precious minerals as a result.

III. BACKGROUND

A compressed air engine consists of a motor that is powered and lubricated solely on compressed air. Compressed Air Engine technology has proven its feasibility over centuries as its designs have moved from pneumatic engines, pneumatic heated engines to compressed air engines.

Dennis Papin first spoke of such an engine in 1687, but it was not until 1872, that the Mekarski invented an air engine that functioned as Papin had earlier mentioned (Verma, 2008). This engine consisted of a single stage motor just as Papin mentioned. The engine was further developed into a pneumatic engine as research advances were made in thermodynamics. A tank of boiling water was used to heat the air, which as a result, increased the range of the engine between fill-ups. This led to the manufacturing of a good number of locomotives, the first one in Nantes in 1879. In 1892, another heating method was introduced by Robert Hardie to improve on the range of the engine. (K., P.Rathod, & Arvind S., 2012). In 1898, Hoadley and Knight, made the first urban locomotive based on the principle that the longer the air is kept in the engine the more heat it absorbs and the greater its range. As a result, they introduced a two-stage engine (Thipse, Compressed Air Car, 2008). Charles B. Hodges is remembered as the true father of the compressed air concept applied to cars, as he was the first person, not only to invent a car driven by a compressed air engine but also to have considerable commercial success with the technology. The H.K. Porter Company of Pittsburgh sold hundreds of his vehicles to the mining industry in the eastern United States, due to the safety of their method of propulsion for the mining sector. Later on, in 1912, the American's method was improved by Europeans, adding a further expansion stage to the engine giving their own engine design three stages (Thipse, Compressed air car, 2008). Engineair Pty Ltd of Australia and Moteur Development International of France are some of the few companies nowadays that hold international patents for compressed air engine designs.

IV. AIM

Recent designs like the Di Petro Compressed Air Motor of Engineair Pty Ltd have proven they can achieve remarkable efficiencies and absolute pollution-free standards (Pietro D. , 2010) but these designs are not properly characterized. The main objective of this work is to design while characterizing properly a zero CO_2 and zero heat pollution compressed air engine for the urban transport sector, with more adaptability to the cities of the Tropical regions.

The technical objectives of the research include;

- Census of already existing reusable component parts of the engine design.
- Thorough simulation of the engine's durability and functioning.
- Realisation of a widely acceptable engine model.
- Development of a specification booklet of the engine.
- Registration of the engine patent.

This research is executed with the believe that fixed plants meant to produce compressed air at relatively high efficiencies without pollution are much cheaper and easier to assemble than internal combustion engines or electric vehicle to ply the roads of Tropical cities.

V. Conclusion

The realization of a widely acceptable zero CO_2 and zero heat pollution compressed air engine principally adapted for the cities in the Tropics will be a significant step towards generating contextualized solutions to this climate change calamity. This research work is not just all about terminating the use of other energy forms in the transport sector but it is about assuring their more sustainable use. This research will as a result champion all efficiency findings of preexisting compressed air engines; it will put to use many borrowed ideas from the practicality of the preexisting urban transport sectors of the Tropics while giving chance for further research developments for the amelioration of the system in the future. This technology has the capacity to revolutionize the urban transport sector globally thus its remarkable sustainability.

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