STUDYING THE POTENTIAL OF THE ICE TO ELECTRIC POWER PROPULSION CONVERSION FOR LIGHT VEHICLES

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Abstract

This paper studies the potential of internal combustion engine to electric powertrain propulsion conversion for ultralight electric vehicles. When a vehicle is produced a large amount of energy is used therefore the vehicle needs to last a long period of time so the cycle is efficient. However, sometimes there is significant engine, fuel or ignition system failure and it is simply not worth it to repair that car even though the cassis is still in excellent condition. With the development of the electric vehicles during the last decade there is a more efficient approach, namely the ICE to electric propulsion conversion. This paper aims at determining until which point in the life span of the vehicle a conversion is effective solution.

Keywords: ultralight electric vehicles, electric powertrain, ICE to electric propulsion conversion, life span of a vehicle, life cycle efficiency of a vehicle.

ИЗСЛЕДВАНЕ НА ПОТЕНЦИАЛА ЗА ПРЕРАБОТВАНЕ НА ЛЕКИ АВТОМОБИЛИ ОТ ЗАДВИЖВАНЕ С ДВГ КЪМ ЕЛЕКТРИЧЕСКО

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Резюме

Този доклад изследва потенциала за преработване на леки превозни средства от задвижване с ДВГ към електрическо задвижване. При производството на едно транспортно средство се изразходва голямо количество енергия. За да бъде ефективен този процес това превозно средство трябва да бъде в експлоатация дълъг период от време. В някои случай при автомобилите има съществени повреди по двигателя, запалителната или горивната системи и не е рентабилно този автомобил да се ремонтира въпреки, че шасито е в отлично състояние. Развитието на електрическите транспортни средства през последното десетилетие предлага ново решение на този проблем, а именно преработването на тези автомобили в електрически. Този доклад цели да установи до кой момент от живота на транспортните средства този процес ефективен.

Ключови думи: свръх-леки електромобили, електрическо задвижване, преработване на ДВГ към електрическо задвижване, продължителност на живота на автомобилите, ефективност на жизнения цикъл на автомобилите.

INTRODUCTION

On 15th of July 2007 Lewis Pugh did the first swim across the Geographic North Pole [1] an area that has been frozen in about 2.7 million years [2]. Ten years latter instead of taking strict measures the situation gets worse and the ice continues to melt. The scientist have evaluated that if the current trend continues there would be no ice at the North pole in September 2022, according to Fig. 1 [3].

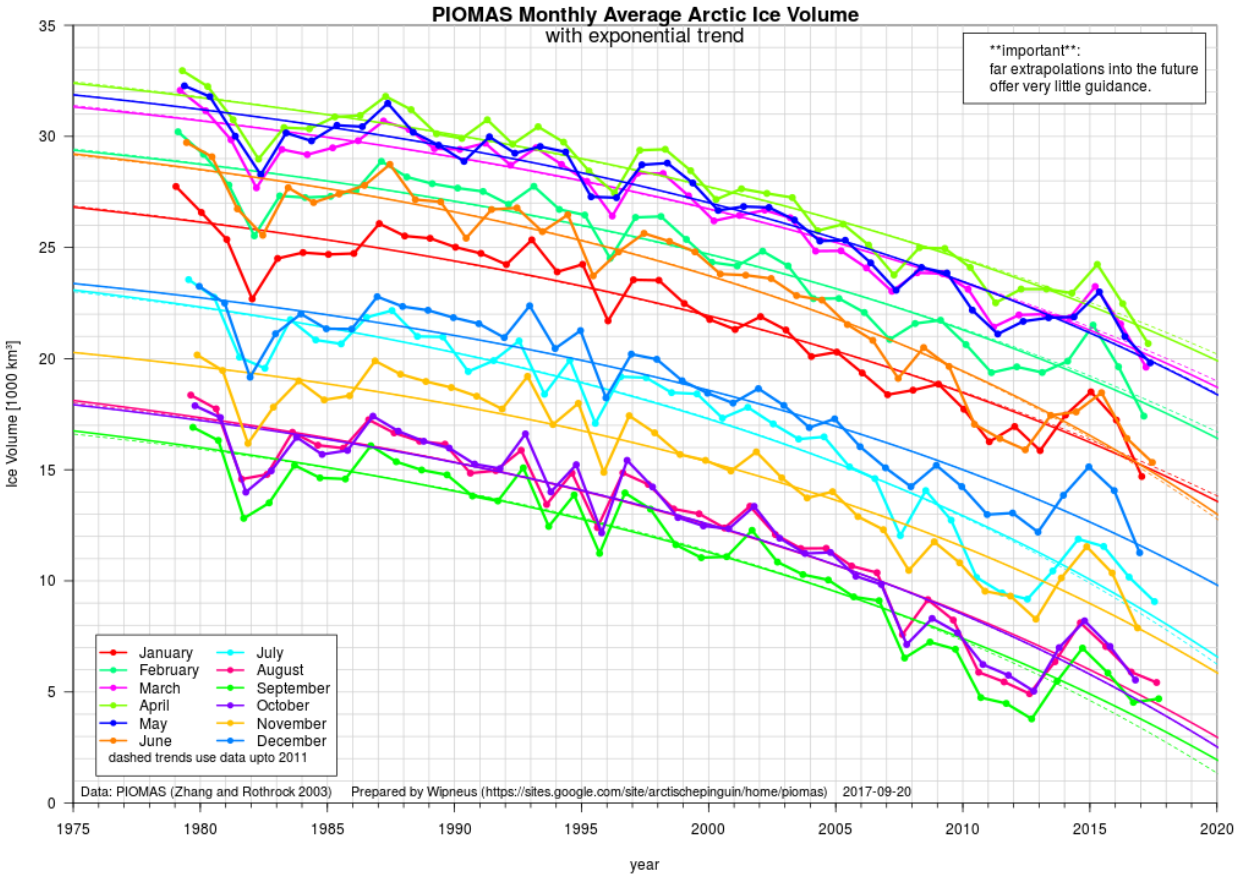

Fig. 1. *Average Arctic ice volume through the years*

However, we do not have 5 years to see if they are correct but somehow we would manage, we have already wasted 10 years what are five more. And what then? Well it is not exactly rocket science, if there is no ice 60 % of the sunlight is not reflected and heats the water. As a result the ice continues to melt and there is no ice at the pole during half the year (as late as 2032), so the water continues to heat up. Moreover, parallel to this process Greenland continues to melt more rapidly. As a result Antarctica can not compensate the ice loss and if that trend continues it would start melting at the same rate. If only Greenland melts a 7 m rice in the ocean level is expected, if Antarctica melts as well it would take half the time. As a summary if we continue to "improve" the global warming (increase of CO_2 and CH_4 emissions) at the end of the century millions of people (if not our children, our grandchildren for sure) would lose their homes to the sea [4].

Why is this happening?

The global warming is caused and constantly "improved" by the mankind via expansion of the "greenhouse effect" [5]. A major contribution of about 20 ÷ 30 % has the transportation sector. The vehicles emit particulate matter (fine particles), Hydrocarbons (HC), Nitrogen oxides (NOx), Carbon monoxide (CO), Sulfur dioxide (SO_4), hazardous air pollutants (genetically toxic (cause birth defects)) and greenhouse gases (mainly Carbon dioxide (CO_2)) [6]. As a summary the global warming is a result of burning excessive amounts of fossil fuels.

What can be done?

In transportation the ICE can be replaced with alternative powertrain like pressurized air or more commonly electrical propulsion. However, using any electric vehicle is not enough [7], although racing and developments of the so called "electric hypercars" is advantageous for the whole segment we can not afford to make the same mistakes as with the ICE cars resulting in a family estate car

with more than 450 kW of power. Therefore, ultra-light EVs with factor 4 reduction in greenhouse gas compared to "normal" EVs should be used.

EXPOSITION

A major problem in the EV industry is the so called "range anxiety", a symptom of people which does not fully understand that the differences between petrol and electricity powered vehicles in terms of energy conservation. What we mean by that efficient source (good power density and specific power) of energy and inefficient propulsion more or less equals inefficient source of energy and efficient propulsion. An example comparison between conventional vehicle (IEC propulsion) and BEV would result in:

gasoline has 13 kWh/kg specific power and a lead-acid battery has 42 Wh/kg so a 310:1 ratio, but nowadays more efficient batteries are used. An advanced lithium based battery has 200 Wh/kg, resulting in 66:1 ratio and those are the best batteries currently used in series production EVs. However, at the propulsion side the numbers are reversed, we have 13 % efficiency of a gasoline engine and 91 % [8] for the conventional BLDC motor gives 1:7 ratio and 9:1 overall (gasoline burned in ICE compared to BLDC motor powered from batty pack). If we focus at city driving conditions the numbers change to 4,5:1 (ICE are even more inefficient in cities). Furthermore, we can put more batteries than a tank of fuel. For example 40 L weigh 30 kg, so with 60 kg of batteries we have 2.25:1 ratio and at 120 kg battery pack the scale is more or less even at 1.125:1. Therefore, those people need to be educated and realize that when the battery is empty you do exactly the same as when the petrol tank is empty, just refill it.

ICE to electric propulsion conversion

This paper studies the potential of internal combustion engine to electric powertrain propulsion conversion for ultralight electric vehicles. When a vehicle is produced a large amount of energy is used (73 GJ) therefore the vehicle needs to last a long period of time so the cycle is efficient. This is known as a life span of the vehicle. However, sometimes there is significant engine, fuel or ignition system failure and it is simply not cost efficient to repair that car even though the chassis is still in excellent condition. In this case there is a significant energy loss because the vehicle has not reached its life span and significant amount of energy is needed to recycle it (about 30 % of the production energy). Therefore a conversion until 75 % of the life span is cost effective.

Conversion techniques

Conversion of ICE to electric propulsion in the case of motorcycles is much more straight forward. It starts by removing all the parts connected with the ICE (fuel system, air filtering system, electrical system and exhaust system). Those parts are then replaced by electric motor, motor controller and battery pack with BMS [13]. Normally a larger sprocket at the back with 50 ÷ 100 % more teethes because of the rpm and torque differences between the ICE with transmission and electric motor. Therefore, a new chain is also needed. Typically the electrical drive does not use transmission. A custom made stand for the motor and the batteries are also required and a heatsink for the motor controller according to Fig. 2. The conversion can be completed with digital instrument panel and LED lights. In general the conversion is quite clean and typically does not add more weight if any [10].

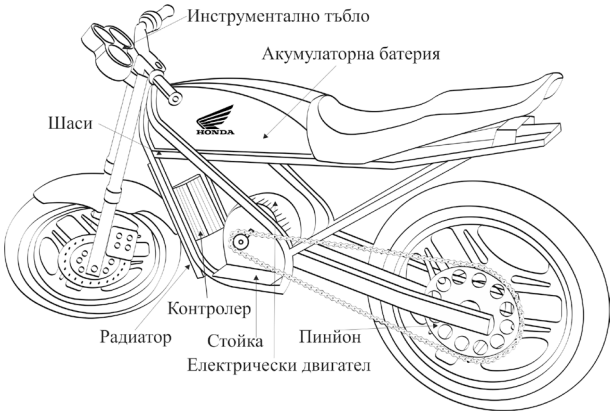

Fig. 2. *Block scheme of the conversion of ICE powered motorcycle to electric*

Conversion of a vehicle is no that straightforward. First there is a number of drivetrains that can be employed. The most simple one is to keep the clutch, the transmission and the deferential (the ICE is replaced with electric motor). This approach requires

customized plate to match the clutch. Another solution is to connect the electric motor directly to the deferential. This approach requires reduction gear and some customized parts to couple the motor to the differential. The last and most efficient approach is to use two electric motors and realize electrical differential [11, 12].

CONCLUSION

The global warming and its effects are known at least from 1896 [9], the disturbing fact is that the mass of the people are still unaware of it, thing it is infinitely far in time or simply rely on other people to take action.

However, if no restrictive and preventive actions are taken the climate change would affect the crops (if the warm current Gulf stream shifts for example Europe should grow its plants elsewhere), the weather (some cities would get to warm for people to live and natural disasters would occur much more frequently) and millions of people would lose their homes to the sea (60 km inland in Belgium has 7 m altitude above the sea level and more than 95 % of Netherlands is below 40 m).

These consequences of the global warming are not that far away in time as most people thing, moreover we may live to say how next generations pay for our mistakes (most of the effects presented above are expected to occur before the end of the century).

We are at the tipping point of global warming at the moment and the climate scientists say that it can not be stopped. However, if we continue to emit CO_2 and CH_4 at the same rates the consequences would be grater.

Furthermore, when those gases are in the atmosphere they would remain there for hundreds or thousands of years and there won't be a special hole for the green countries (the greenhouse gases distribute more or less evenly across the globe).

About 30 % of the greenhouse gasses are generated from the transportation sector and 80 % of the CO_2 emissions are product of burning fossil fuels.

Using EVs is not enough, we should push the technology as far as possible and develop ultralight electric vehicles.

The energy used to produce conventional goods should not be overlooked. The energy used to produce a conventional means of transportation and recycling then prematurely can be used more efficiently by conversion to electric powertrain so the chassis can reach its full life span and only then be recycled.

Changing the form of transportation alone is not going to solve the global warming problem, neither it can be solved only by a group of people. To leave any future for the generations to come we should change our way of thinking and live.

REFERENCE

[1] http://www.independent.co.uk/environment/lewis-pugh-to-undertake-worlds-most-dangerous-swim-in-antarctic-for-campaign-to-make-ross-sea-a-10021130.html

[2] https://www.eurekalert.org/pub_releases/2005-02/uadb-sdw022305.php

[3] http://greatwhitecon.info/resources/arctic-sea-ice-graphs/

[4] Alex Van den Bossche 23th February 2017 update 26th March 2017 EELAB UGENT BELGIUM, "For those who still doubt about global warming and sea level rise?" Update March 17, 2017, Conference: Workshop on Mobility, 16th March Zwijndrecht, Belgium.
https://www.researchgate.net/publication/314117508_For_those_who_still_doubt_about_global_warming_and_sea_level_rise

[5] IPCC Fifth Assessment Report, 2014

[6] http://www.ucsusa.org/clean-vehicles/vehicles-air-pollution-and-human-health/cars-trucks-air-pollution#.WdtHFGinPcs.

[7] Towards Low Energy Mobility Using Light and Ultralight Electric Vehicles Alex Van den Bossche, Peter Sergeant, Isabelle Hofman, ICEE 2012, November 21-22, Skikda, Algeria.

[8] Masataka Miyamasu, Kan Akatsu, "Efficiency comparison between Brushless dc motor and Brushless AC motor considering driving method and machine design", IECON 2011 - 37th Annual Conference of the IEEE Industrial Electronics Society, 7-10 Nov. 2011, pp. 1830 – 1835.

[9] Jian Cao, Ali Emadi, A New Battery/UltraCapacitor Hybrid Energy Storage System for Electric, Hybrid, and Plug-In Hybrid Electric Vehicles, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 27, NO. 1, JANUARY 2012.

[10] Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground", Philosophical Magazine and Journal of Science Series 5, Volume 41, April

1896, pages 237-276.
[11] N.D.Madzharov,A.T.Tonchev, "Inductive high power transfer technologies for electric vehicles", Journal of electrical engineering, Vol. 65, No. 2, pp. 125–128, 2014.
[12] Madzharov N.D., Tonchev A.T., Contactless Charging System For Electric Vehicles., International Scientific Conference PCIM2012, Nuremberg, Germany, pp.1400-1408.
[13] B. Pattipati, K. Pattipati, J. Christopherson, Automotive Battery Management System, IEEE Autotestcon, Salt Lake City, USA, 2008.