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Electric aircraft: alternative power sources

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TMAL02, Linköping University, 2018

1 Introduction

We live in an era, marked by a very rapid development in technology, which is constantly searching for alternative power sources and promoting the electrification of everyday things. We have come a long way in all these years, modern technology allows us to have electric bikes, motorcycles, cars and we've reached a point where we even want to electrify planes. The main topic in this article will be the presentation of the alternative power sources for the airplanes that we find interesting.

2 Electric propulsion

As we know, electric cars are becoming popular, and we are also trying to follow that trend in the aircraft industry. Companies are investing a lot of money in the research of the electric airplanes, but they are still in the early stages.
The main concern about the electric powered airplane is that we have to power the electro motor with batteries. As it is known, our batteries do not have the required capacity to replace the standard aviation fuel. For example the specific energy of the avgas is around 43 MJ/kg, and our best battery has around 0.9 MJ/kg. This means that for every kilogram of fuel we replace with batteries, we add around 50 kg to the total weight of the airplane. Also the charging of the batteries causes skepticism, as it is known that charging is a time consuming process and for example the companies operating the aircrafts are not really fond of their planes being inoperable for longer durations. However this problem can be easily solved by replacing the battery packs.

The future is not that dark for the electric airliners, there are new types of batteries, called solid state batteries, which are being developed and could bring higher specific energy. Also the electric aircrafts are not limited by the oxygen from the atmosphere, since they carry everything with them. However the propeller has to provide enough thrust to propel the aircraft forward, which might be a problem in higher altitudes when the density drops.



Fig. 1 . Fully electric powered aircraft by Pipistrel [1]

Fully electric airplanes actually exist. The example is Pipistrel Alpha Electric, which could revolutionize pilot training and drastically decrease the training costs. [1] The Pipistrel alpha Electric an be seen in 1

Another thing to mention is the hybrid electric power train. Hybrid propulsion is one of the first steps to the electrification of our airplanes. It is a combination of a gas turbine and electric motor, which reduces the need to carry batteries with us, because the gas turbine is charging the batteries using a generator. This type of propulsion will be implemented faster than the fully electric propulsion. [2]

3 Solar powered aircrafts

The sun is one of the biggest power sources that we can access on planet earth and one of the greenest as well. The best way so far to utilize this energy are solar cells. Since energy consumption and environment is a big problem in transportation, especially aviation, solar cells might be the solution. Today there are a few working aircraft that fly using only the power of the sun. To harness as much energy as possible and create a lot of lift these solar aircrafts have large wings to accommodate for the many solar panels required to generate the necessary amount of energy. One of the working prototypes today is the Solar Impulse 2. The plane has a wingspan of 72 meters to accommodate the 17248 monocrystalline silicone cells. The

solar cells harness energy from the sun and the energy is used to charge the lithium polymer batteries. The batteries power four 17.4 HP engines. [3] Unfortunately you need batteries since the solar cells are not enough to maintain constant flight. Flight during night is also a problem, since the batteries wont charge which means the plane is time and location dependent. But when the conditions are perfect the plane has managed flights as long as 8,924km and it was airborne for 4 days 21 hours and 52 minutes [4]. This plane is just a concept and not meant for commercial use, but it shows where the future is headed and what we can expect.



Fig. 2 . Solar powered aircraft concept [3]

As we can see from the Figure 2, the aircraft has solar cells all over the wings and even the horizontal stabilizer is covered in solar cells. It can also be seen that it has four electro motors, which rotate the propellers.

4 Hydrogen powered aircrafts

When it comes to powering smaller aircraft, Hydrogen might be the future. Fuel cells are always increasing in efficiency, and with the introduction of the new hydrogen fueled cars, aircraft might be the next step. A hydrogen fuel cell works like a battery, but instead of charging the battery, the power is harnessed by converting hydrogen gas to water in a similar manner. In doing so the only emissions produced are water and heat. The heat is used to heat the cabin and water which is a highly natural part of the atmosphere at the altitudes that small aircraft operates. But how efficient is the hydrogen in providing power?

As a comparison we can look at the Cirrus SR-20, a avgas powered four seater aircraft. [5] It's powered by a 200 hp continental engine weighing in at 140 kg.[6] The fuel tanks contain around 125kg of 100 ll gasoline, so the power train weighs around 265 kg. Then we look at a commercially existing hydrogen powered car solution, the Toyota Mirai. The Mirai has a fuel cell stack of 370 cells weighing in at around 57 kg [7]. It has hydrogen tanks which store 5 kg of hydrogen at 700 bar and has a total weight of around 90 kg [8]. A typical electric motor of similar capacity as the Mirai has a weight of 30 kg and a power output of 154 hp. With battery and other parts needed we are looking at a similar weight, 3/4 of the power output, clean energy and a similar endurance. All in all it sounds like a reasonable solution for the future. Then why isn't it already implemented? The big problem is the storage of the hydrogen, with diffusion and volatility. You would need very rigid fuel tanks, which can hold the high pressure needed to store the hydrogen. Hydrogen is also very flammable, which could be disastrous in a plane. On the other hand, it can be released in the atmosphere, since hydrogen dissolves by itself.



Fig. 3 . HK36 Super Dimona [9]

Just how possible is it then? Boeing made a fuel cell powered plane back in 2008, based on a Diamond HK36 Super Dimona (Fig. 3), which achieved straight and level flight powered only by hydrogen fuel cells. Back then the plane could not reach the power needed for takeoff though, and so they used a lithium ion battery as a booster for the electric power. [10] But who knows what kind of power we will see in the years to come?

5 Conclusion

To conclude, there are a lot of alternative power sources which could propel our airplanes in the future. However our technology is not yet on the level which would allow us to realize all of the ideas and concepts. In the near future we can expect the first hybrid powered airliner. We are also curious to see what the future holds for the hydrogen powered airplanes. But the right combination of the different types of propulsion explained above, could make aviation more sustainable.

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