Electric aircraft: Alternative power sources

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1 Introduction

The development of electric aircrafts is going on to a great extent today. Many large well-known companies in the aerospace industry are working hard to achieve functional and useful aircrafts that can handle the demands required for longer and more efficient air travel.

This project examines how electric aircraft work today and the limitations that exist. How they can be developed and function in the future. The aim of this project is to understand how electric aircrafts work and why they are not used today, as well as what is required for them to function as commercial aircrafts in the future.

Fig. 1 The company Eviation prototype electric aircraft "Alice"

2 Theory

The idea of developing an electric aircraft is to reduce the emmsions coming from the aviation industry. According to a study published in the article Forget cars. We need electric airplanes [1] there is a possibilty to reduce the aviation fuel usage by as much as 15 percent if all short flights only used electric aircrafts. Short flights are in this case is flights less than 600 nautical miles, in which range the about half of all flights fits. The main problem with this vision today is the battery capacity and weight. However, the battery energy density has increased by 3-4 percent per year in the last years, and if this trend holds up, we could have batteries packing up to 800 Wh per kg. Electric aircrsafts might be viable for short domestic flights up to around 600 nautical miles as mentioned briefly in the article.

On MIT's website there is an "Electric aircraft range calculator" where it's possible to play around with four different variables which then gives you the theoretical range of such an electrical aircraft. The variables are: Specific energy [Wh/kg], Lift to drag ratio, efficiency, and battery mass fraction.

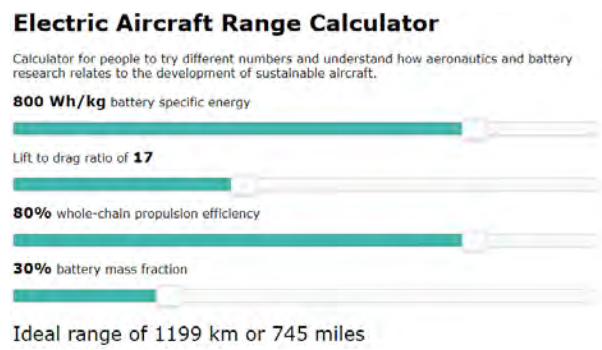

Fig. 2 Electric aircraft range calculator

3 Existing electric aircraft

A company that has developed an all-electric aircraft is Eviation with their Alice. This plane is designed to carry 9 passengers up to 650 miles at a cruise speed of 445 km/h. it has a length of 12,2 meters and a wingspan of 16,2 meters. The maximum take-off weight is 6350 kg and it is powered by 3 propellers with 260 Kw each. It is estimated that the cost per flight hour will be around 200 dollars which is about 20 percent of the cost for a regular propeller aircraft. The company aims for the aircraft to be certified and used commercially as early as 2021 according to Nyteknik.

4 Discussion and/or Conclusion

The problem with todays electrical aircrafts is that the batteries are not powerful enough. The most commonly used batteries for aircrafts today is Lithium-ion batteries. The reason why is because lithium-ion batteries has the highest energy density. Lithium-ion batteries however do have one disadvantage, they can short-circuit and end up combusting. In the beginning of a NASA-project one cell in a lithium-ion battery was short-circuited and that resulted in the entire battery caught on fire

Currently the best lithium-ion batteries have an energy density of approximately 250Wh/kg. That is more than good enough to power an electric car but advances in battery technology is needed before these batteries will be good enough to power a large passenger airplane. For example,A-1 jet fuel have a minimum energy density of circa 11700 Wh/kg.

The energy density of the battery is not the only variable that limits the range of electric aircrafts. The range of an electric airplanes also depends on its battery to mass fraction, that is the weight of the battery divided by the total mass.

Using the equations (1)-(4), with a battery mass fraction of 0.8, a lift to drag ratio of 25, a propulsion efficiency of 80 percent and an energy density of 300Wh/kg we get a range of 1763 km.

Even with very optimistic future estimates of energy densities of 750 Wh/kg in batteries the range is still only around 4400 km, about the distance of LA to New York.

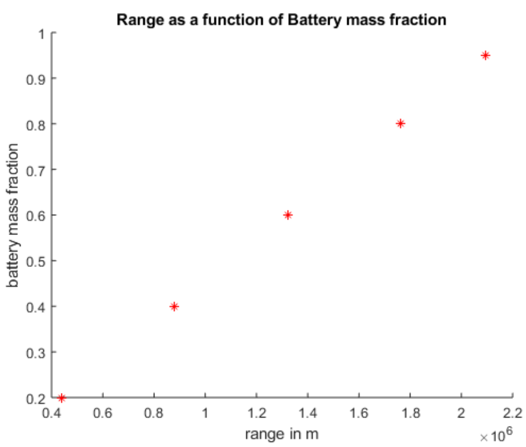

Fig. 3 Range as a function of battery mass fraction

5 Formatting

5.1 Equations

$$E = TR \quad (1)$$

$$E = E^{*} m_{batt} \eta_{total} \quad (2)$$

$$R = v \frac{L}{D} I_{sp} ln\left(\frac{m_{fuel}}{m}\right) \quad (3)$$

$$R = E^{*} \frac{m_{batt}}{m} \frac{1}{g} \frac{L}{D} \eta_{total} \quad (4)$$

Nomenclature

Designation	Denotation	Unit
E	Energy	J
T	Thrust	N
R	Range	km
E*	Battery specific energy	Wh/kg
m_{batt}	Battery weight	kg
η	Efficiency	-
L/D	Lift-drag ratio	-
v	Velocity	m/s
I_{sp}	Propulsion efficiency	-
m_{fuel}/m	Fuel-mass fraction	-
g	Gravitational constant	m/s^2

Fig. 4 Table of the different variables used in the equations

6 References

[1] Forget cars. We need electric airplanes https://www.vox.com/2019/3/1/18241489/electric-batteries-aircraft-climate-change
[2] Range calculator http://web.mit.edu/lochie/www/erange/main.html
[3] Eviation Alice https://www.eviation.co/alice/
[4] NyTeknik https://www.nyteknik.se/fordon/elflygplanet-alice-visas-upp-lanseras-2021-6962303
[5] Nasa-project-one https://spinoff.nasa.gov/Spinoff2019/t_1.html
[6] A-1 jet fuel http://large.stanford.edu/courses/2012/ph240/greenbaum1/

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