Status and prospect of feasibility study on all electric commercial aircraft

Yuxin Liu*

Department of Mechanical & Aerospace Engineering, Rutgers University-New Brunswick, Piscataway, 08854, the United States

*Corresponding author: yl1422@scarletmail.rutgers.edu

Abstract. Earth's temperature has risen violently since 1981 which was more than twice before 1980. People believe that human activities increased the concentration of carbon dioxide and other gas in atmosphere resulting in a sharp rise in temperature over the decades which is called Greenhouse Effect. The Greenhouse Effect has become a risk of our survival. Glaciers are melting year by year which leads to flooding of coastal areas and countries like Maldives are under the risk of being submerged. The drought is also one of the consequences, high temperature triggered by Greenhouse throughout whole year especially in summer dries out the sources of water like rivers, lakes. This will lead us some other problems in shipping, irritations, power systems and other industries that are critical to human's survival. With the development and growth of aviation, the problems tend to be more crucial. Governors have been trying to make plans to use renewable and sustainable fuel on aircrafts. The hard part is still about the electric engines that can be used on the giant airplanes.

Keywords: Feasibility study; Aircraft; Greenhouse effect.

1. Introduction

Earth's temperature has risen violently since 1981 which was more than twice before 1980. People believe that human activities increased the concentration of carbon dioxide and other gas in atmosphere resulting in a sharp rise in temperature over the decades which is called Greenhouse Effect [1]. The Greenhouse Effect has become a risk of our survival. Glaciers are melting year by year which leads to flooding of coastal areas and countries like Maldives are under the risk of being submerged [2]. The drought is also one of the consequences, high temperature triggered by Greenhouse throughout whole year especially in summer dries out the sources of water like rivers, lakes. This will lead us some other problems in shipping, irritations, power systems and other industries that are critical to human's survival [3]. Aviation is one of the biggest resources of greenhouse gas emissions among all the industries. "A passenger taking flight from New York to London and back emits more emissions than an average person in Paraguay over the course of an entire year." "In 2010, the aviation industry carried 2.4 billion passengers; in the next 15 years, that number is forecast to rise to 8.2 billion [4]. Without action, emissions from increased air travel could triple from pre-COVID levels by 2050" [1].

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2. The study of current electric engines

2.1 Power output

When talking about motors, batteries always come first. The larger the battery capacity is, the more power can be generated which means heavier airplanes can be used and longer flights can be achieved [5]. A Cessna Grand Caravan 208B is the world's biggest ever all-electric commercially focused aircraft made by the industry-leading company "magniX". It is powered by a magniX 750HP magni500 EPU which provides 750 horsepower as the name suggests. There are more aircrafts like

this have been designed, but they all use propellers. Almost all of today's big commercial jets use the turbine engines which generate far more power than electric motors by burning aviation fuels. In a narrow-body commercial airplane such as Airbus 320, a single engine can produce around 16000hp, and A320 has 2 of them [6]. The bigger jets used for longer intercontinental flights easily need more than 30000hp to be powered by. There is still a huge difference of generating power between the electric motors and turbine engines [7].

Table 1. The specifications of engines on A-320 family

Parameter	IAE V2527-A5	CFM56-5B4	PW1127G
Aircraft	Airbus A320-232	Airbus A320-214	Airbus A320NEO
Thrust	26,600 lbs (118.3kN)	27,000 lbs (120.1kN)	27,000lbs (120.1kN)
Bypass Ratio	4.8 : 1	5.7 : 1	12 : 1
Architecture (Stage Count)	1-4-10-2-5	1-4-9-1-4	1-G-3-8-2-3
Fan Diameter	63.5 inches (1613 mm)	68.3 inches (1735 mm)	81 inches (2057 mm)
Overall Length	3201 mm	2600 mm	3800mm (estimated)*
High Pressure Spool RPM (N2)	14,950	15,183	18,000 – 20,000 (estimated)*
Low Pressure Spool RPM (N1)	5,650	5200	10,500 (estimated)*
Fan RPM	5,650	5200	3,500 (estimated)*
Overall Pressure Ratio	27.2	32.6	Unknown**
Engine Weight	2400 kg	2500 kg	Unknown**

Fig. 1 The specifications of magni500 electric motor [2].

2.2 Space and weigh

In terms of weights and sizes of electric motor system on an EV-plane and regular jet engines, it is clearer to analogize them with engines and electric motor system on cars. In today's cars, electric motors system normally takes more space and is much heavier than an engine when they have approximately the same power output [8]. If people pump the hood of a tesla, they will always find that it is surprisingly simple in there compared to cars fueled by gas. Therefore, people always think that electric cars have a lighter and smaller power system than regular cars. In fact, electric cars always have their batteries at the bottom, and these batteries are the heaviest part in their power systems [9]. The newest Porsche Taycan Turbo S using a two-deck performance battery plus can generate a maximum of 616 horsepower, but the battery set weighs 1389Lb (630 Kg). In contrast, still Porsche, the twin turbo flat 6 engine that is used on the newest Porsche 911 turbo s has a maximum weight of 507Lb which can generate a maximum of 850 horsepower. This comparison indicates that electric motors working on the airplanes do makes the plane weight more and takes more space. Especially for a larger plane, when much more power is needed, the weight and space will be an extremely complicated factor [10].

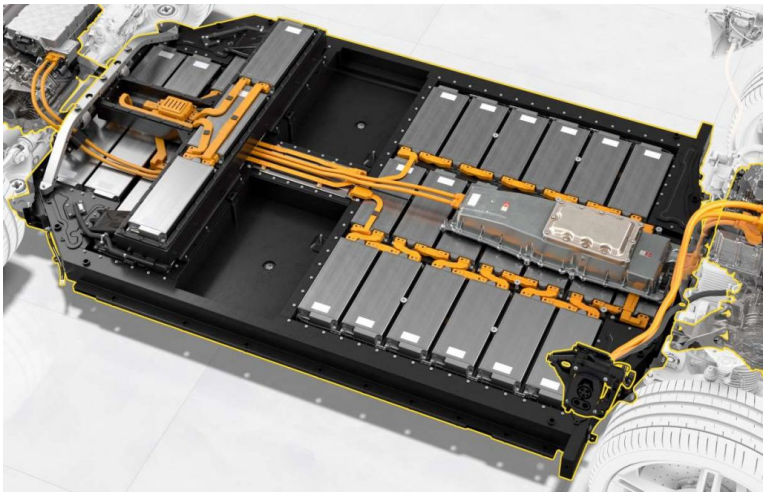

Fig. 2 the internal battery arrangement on an electric car.

2.3 Durability

Electric motors are far more reliable and durable than any type of combustion engines. The number of moving parts in the engine systems are the key factor to determine the durability of an engine. The more moving parts will lead less reliable which means more maintenance and parts changes are needed. An average electric motor consists of 20 moving parts, the Tesla model s for example, there is only one moving piece which is the rotor. However, a normal combustion engine has about 200 moving components which will lead more wears and tears. If this article attempts to understand the engine system on the aircraft, especially the larger commercial airplanes that carry hundreds of people. With the application of electric motors on airplanes, there will be far less work for the mechanics to do after each flight. The operation efficiency in the airports and the cost for maintenance may reduce accordingly.

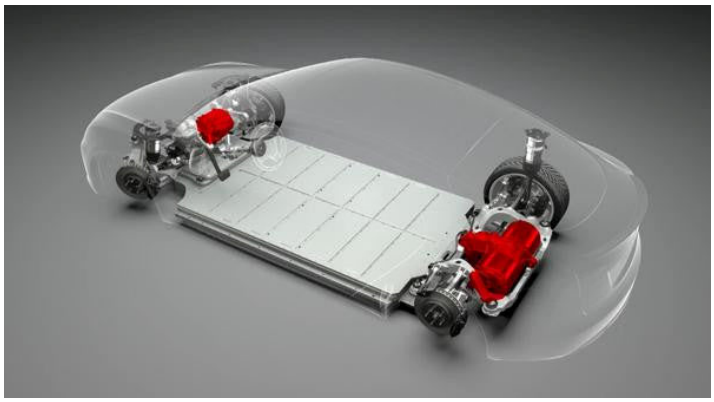

Fig. 3 The positions of electric motors on electric cars.

2.4 Safety

Fireproof is always a lethal part on an airplane. “According to an international study, there were 95 fire-related civil passenger aircraft accidents worldwide over a 26-yr period, claiming approximately 2400 lives”. Maybe not all these fire accidents are caused by engines, some of them are the circuits failures. However, most of the fire-related accidents on the airplanes start from the engine systems where all the aviation fuel are stored. What about the electric motors? Normally, an electric engine system is less possible to catch on fire compared to a combustion engine system. However, it is exceedingly difficult to put out the fire happen in an electric engine system because of lithium-ion battery that has been used widely in today’s battery industry. The high temperature and the reignition make electric engines become far more dangerous, especially in the air, where there is no effective measure to deal with the fire. For electric motor systems being safe on the planes,

engineers need to develop a much safer way for fireproof on the airplanes and may need to consider to change the materials that are used to make these batteries.

2.5 Charging time

An electric power system takes a much longer time to charge than a combustion engine to refuel. An electric plane called eCaravan, built by Magnix needs 30-40 mins to charge [7]. A Boeing 747-8, one of the largest commercial airplanes ever made, takes about 44 mins to refuel [8]. It seems they have a close time of refueling, but they are largely different in weight and the power output. The eCaravan has a 750 horsepower, weighs about 4 tons. In contrast, the Boeing 747-8, weighs about 500 tons, generates about 60000 horsepower. A larger electric airplane will definitely take much longer to charge than the current turbine airplane. Accordingly, the operating efficiency in the airport will decrease.

2.6 Environmentally friendly

In order to evaluate the impact of all-electric planes on environment, it is very important to understand how people generate electricity. “Most of electricity is generated with steam turbines using fossil fuels, nuclear, biomass, geothermal, and solar thermal energy. Other major electricity generation technologies include gas turbines, hydro turbines, wind turbines, and solar photovoltaics” [9]. A lot of these technologies emit a large amount of CO_2, for example, Fossil fuels are the largest source of electricity generation nowadays around the world. It generates a big amount of CO_2. “In 2020, total U.S. electricity generation by the electric power industry of 4.01 trillion kilowatt-hours (kWh) from all energy sources resulted in the emission of 1.55 billion metric tons—1.71 billion short tons—of carbon dioxide (CO_2). This equaled about 0.85 pounds of CO_2 emission per Kwh”. The all-electric airplanes do have a significantly lower emission than the regular combustion engine planes, but emissions from the producing electricity offset a big part of the difference, especially in some countries that are highly rely on fossil fuels to produce the electricity. To make the all-electric aircrafts really environmentally friendly, more changes in the electricity industry are needed.

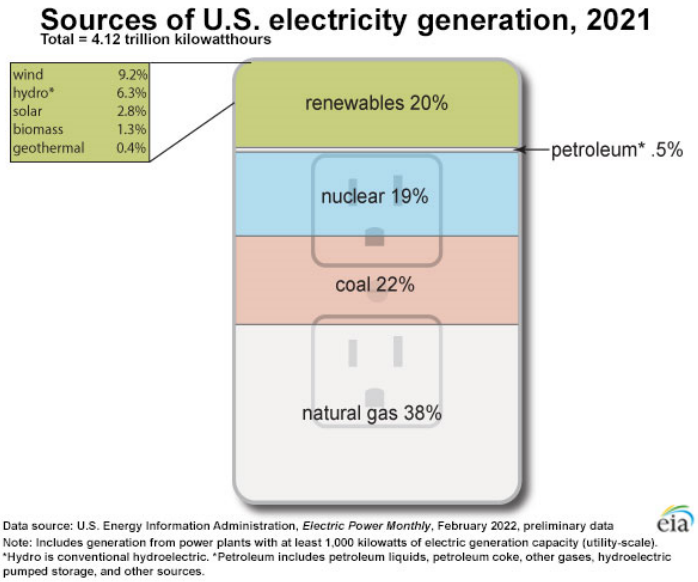

Fig. 4 The positions of electric motors on electric cars.

3. Conclusion

The all-electric airplanes certainly have a lot of benefits and advantages in comparison to today’s airplanes. However, there is still a long way to go to realize the electrification of the entire industry. In order to make it happen, not only in the aviation, also some related fields like electric energy,

battery, materials, there are still technological barriers that need to be resolved. It is predictable that the new energy planes like electric aircrafts will be the mainstream of research in this industry.

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