

A plane that powered by a Thor's hammer

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Abstract. As the number of electric cars in the world surged, it spurred the research on electric vehicle (EV) aircraft in various countries. As a result, a number of small electric airplanes are capable of short-distance flight have been developed. The researches shows that there are many challenges for producing an all-electric jumbo jets. For example, the material of the battery chosen on the aircraft, the composite material for the aircraft covering, how to consist the electric vehicles on the plane in order to save the total mass of the aircraft because the mass of the battery is much heavier than the diesel oil and tank. Moreover, in different countries, the charging modes and standards for the aircraft is different and so on. In this paper, the electric vehicles used in electric-cars would be used as the reference of the challenges for manufacturing the electric jumbo jets. And although there are some small size of electric aircraft (E-Fan aircraft) are created, these aircraft could not afford the commercial purpose, even the international flights by taking hundred of passengers per flight. If these discovered and undiscovered problems are researched and resolved, the electric jumbo jet would be produced in the future and replace the traditional aircraft, which means that people do no need to worry about if the oil would run out any more.

Keywords: electric automobile, Small electric aircraft, Electric jumbo jet.

1. Introduction

As a result of the development of Electric Vehicles Cars, more and more electric cars are being manufactured and marketed to consumers. Since the turn of the last century, research into electric aircraft has grown. Compared to the traditional aircraft, which was constructed using internal combustion engines, the traditional aircraft was constructed using composite materials. Electric vehicles would emit less carbon dioxide, thereby mitigating the effects of global warming.

The Airbus company had produced and flew the E-Fan aircraft in 2014. Due to the fact of the plane was composed of two electric vehicles (60 kW in total) and composite material as its framework, the company's experiment on electric aircraft was a success, indicating that electric aircraft will gradually replace traditional internal-combustion aircraft in the future. However, the E-fan could only accommodate two people per flight, so one would be the pilot and the other would be the passenger. In 2017, the Airbus Company displayed the upgraded E-Fan X model (Figure 1). Airbus introduced the E-Fan X in 2017, and one of the traditional internal combustion engines was replaced by a 2,000,000 Watts electric vehicle. It was a hybrid-electric aircraft that participated in the wind tunnel test in 2020 [1-2].

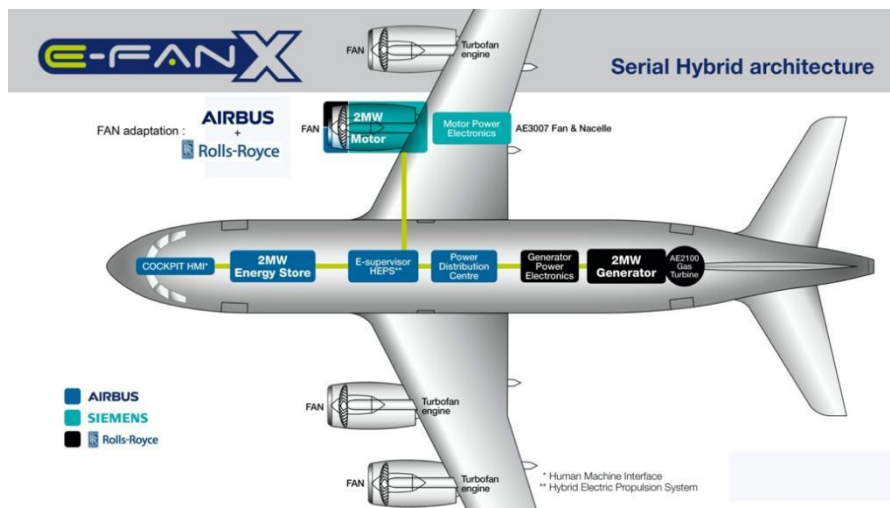


Figure 1. The abridged general view of the E-Fan X [2].

Since the last century, the increasing number of airplanes in the world has given a dramatically upward trend, and in the next two decades, more than 30,000 aircraft will be produced and placed on the market [3]. If traditional commercial aircraft were replaced with electric aircraft, carbon dioxide emissions would be reduced, thereby helping to protect the environment by mitigating the effects of global warming. Moreover, the total amount of oil in the world is limited, which means that if the oil runs out, all of the traditional aircraft that use an internal combustion engine will have to switch to a different source of energy for propulsion, and some developed countries have halted production of traditional internal combustion vehicles, which means electric vehicles will replace them [4].

In this paper, the advantages of Electric Vehicles over traditional aircraft, such as the absence of air pollution emissions and the reduction in flight costs, will be illustrated. In addition, the challenges that a commercial EV aircraft would face, such as battery and aircraft covering material, types of electric vehicles, charging mode, etc., would also be discussed. As the more problems are discovered and resolved, an all-electric jumbo jet would be able to fly by carrying so many passengers in the sky.

2. The drawbacks of the traditional aircraft

2.1. The production of the carbon dioxide

Utilizing an internal combustion engine, traditional jet aircraft generated their energy from diesel fuel. It was evident that a significant amount of carbon dioxide would be emitted from these aircraft, as they consumed approximately 5,000,000 barrels of oil per day. However, Electric Vehicles would use electricity from a battery and produce significantly less carbon dioxide than internal combustion engines [5-6].

2.2. The Price cost for airline per time

Compare the cost per unit of travel between traditional airlines and EV aircraft. The primary difference is the cost of the energy source. In 2022, the global average price of diesel oil is \$1.38/L, while the price of electricity is \$ 0.131/kWh [7]. For instance, on a 2000 km journey, the oil cost for a Boeing 747-8 aircraft (oil consumption 13 L/km) would be approximately \$ 36,000. However, the total cost of electricity would be significantly less than diesel oil [7-8]. As the cost per flight is reduced, the price of the ticket would be decreased that more and more passengers could afford to take a flight by saving the time on the journey.

3. The challenges of producing an all-electric commercial aircraft

3.1. The battery on the aircraft

On the market today, there are numerous types of rechargeable batteries. For example, Ni-MH, Lead-acid, and Lithium-ion batteries, among others. Among these batteries, however, the lithium-ion battery is the most popular in electric vehicles. The power sources (battery) for electric aircraft must be rechargeable. For the aircraft E-Fan, a 250-volt Lithium Polymer Battery was used to power the Electric Vehicles; the battery could provide the aeroplane with sufficient power for flight in an hour and could be recharged in the same amount of time [1, 4, 9].

For the fuel battery as the source of the aircraft, the DLR-H2 aircraft was created in Germany in 2009. The fuel battery used the reaction of hydrogen with oxygen from the air to provide the power for the aircraft to fly. Due to the fact that the hydrogen and oxygen would not react to produce carbon dioxide, which was the original intention for the production of electric aircraft vehicles. However, the DLR-H2 could only support the weight of one person, so there are still challenges for the commercial aeroplane, such as storing enough liquid hydrogen in the tank for the airline [10-11].

The consumption of lithium-ion batteries has exhibited an upward trend for various battery components. In comparison to Lithium-ion batteries, lead-acid batteries have a low ratio of energy density to specific energy. The production of Nickel-Cadmium is costly because the Cadmium element is scarce in the universe. Similar to the Sodium Chloride and Nickel battery, the Sodium Sulfur battery has a higher working temperature during operation. The characteristics of various battery components are shown in Table 1 and figure 2 [12].

Table 1. The difference among the characteristics of different battery [12].

	Pd- PdO ₂	Ni-Cd	Ni-MH	Na-NiCl	Na-S	Li-ion
Working temperature (Centigrade)	-20-45	0-50	0-50	300-350	300-350	-20-60
Specific Energy (Wh/kg)	30-60	60-80	60-120	160	130	100-275
Energy Density (Wh/L)	60-100	60-150	100-300	110-120	120-130	200-735
Cycle Durability	500-800	2000	500	1500-2000	2500-4500	400-3000

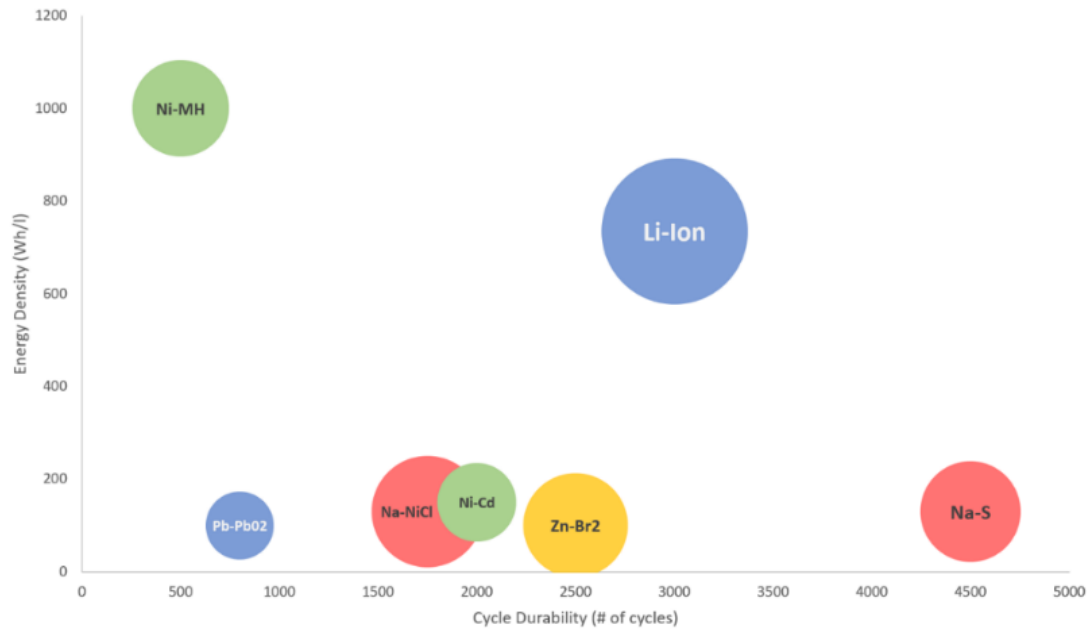


Figure 2. A comparison of the Energy density versus the Cycle durability of various battery types. The warmer colour indicates that the battery's optimal operating temperature is higher, and the larger size of the circle indicates that the battery's specific energy is greater [12].

For aircraft propulsion, the battery storage on board the aircraft is more complex than that of electric vehicles. The aircraft's battery pack is composed of numerous cells arranged in parallel or serial configurations. The different cell configurations would affect the battery system's parameters. Moreover, the Lithium-ion battery on the aircraft must be safe during operation, which necessitates that parameter data such as the circuit is resistance, the battery's capacity, etc. be carefully considered [4].

As the Lithium-ion battery offers a variety of benefits, it also contains a variety of different components. The energy density of the Lithium Iron Phosphate (LiFePO₄) battery is approximately 220 Wh/L, and this type of battery is durable because it can be used in 2000 to 10,000 cycles and can withstand high temperatures during operation. Even though the Lithium-Metal battery has twice the capacity of traditional lithium batteries, the toxic metals in its components would pollute the environment, making it difficult to dispose of spent batteries. Furthermore, the Lithium-Air battery requires a large amount of oxygen for the reaction with the lithium to release energy, which is not suitable for aircraft flying at high altitude [12].

Furthermore, the disposal of the retired battery would be problematic due to the fact that its capacity would still be 80%, meaning that a reasonable reutilization of the battery would be less expensive than the production of a new battery and would reduce pollution from the waste battery if it were used in another appliance [4].

3.2. The structure of an electric aircraft

Compared to traditional aircraft, the new electric aircraft may be constructed from composite materials; otherwise, the mass of the entire aircraft would be excessively high due to the weight of the battery, which may be greater than the amount of diesel fuel and fuel tank on traditional commercial aircraft.

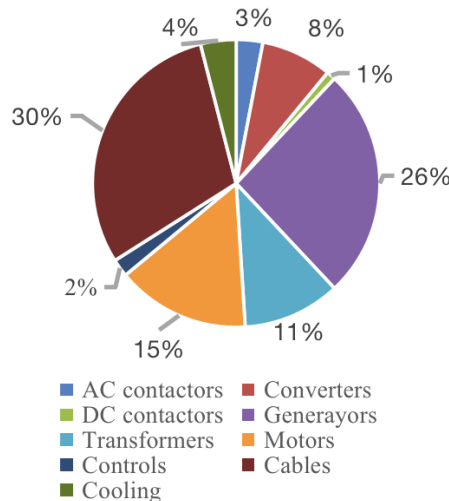


Figure 3. The percentage of different parts' mass in producing a 300-people commercial airplane's electrical system [13].

According to figure 3, the mass of cables, generators, and motors comprised a significant portion of the total mass of the electrical system. For the production of an all-electric aircraft, the weight of the cables would be taken into account. Consequently, installing Electric vehicles on the rear of the aircraft was illogical because the cost of cables would exceed the cost of installing the vehicles on the wing (as shown in figure 1) [13].

Using composite materials for manufacturing would also assist in resolving the problem of the Electric Vehicles' aircraft batteries being too heavy. As an illustration, for the Boeing Company's 787 aircraft manufactured in 2009, composite material accounted for 80% of the total material used, as it was predicted that composite material would replace traditional material in aircraft construction. And the advancement of the aircraft market has facilitated the growth of the material industry in terms of new material and technology research [10, 14]. Figure 4 depicts how the aircraft "OWL" utilised a composite engine cover and an aluminium alloy for the rest of the plane's structure, demonstrating that the selected composite material for the aircraft must be strong and stable. Because the structure and production of the composite material were not uniform, data simulation and experimentation are required for testing the safety and other properties of the manufactured engine cover. For the continuation of research on the aircraft's structure cover, it is necessary to conduct numerous in-flight evaluations of the composite material's characteristic feature [14].

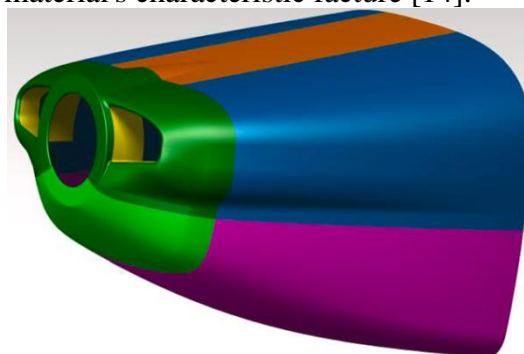


Figure 4. the 3-D model of the engine cover [14].

3.3. The charging standard of the electrical vehicles among different areas

Because the battery capacity for the Electric Aircraft is so large, the battery must be charged in a more efficient and expedient manner. Therefore, it is necessary that the circuit is cable utilizes a safe method for allowing high-voltage electric current to pass through it. Otherwise, it could waste a great deal of time on charging and cause a traffic jam at the airport if there are plenty of aircraft need to be charged at the same time, as charging a commercial electric aircraft using the most recent technology

would require more time than adding oil to traditional aircraft. Therefore, the development of the charging procedure would aid the study of electric flight. However, different regions have different standards for charging batteries for electric vehicles, such as SAE-J1772 in North America, GB/T 20234 in China, IEC-62196 in Europe, etc. The voltage standards and power type (Alternating current and direct current) among these regions vary, and there are numerous international flights around the world every day, so a unified standard for charging would make the aeroplane safer regardless of where it is being charged. Intelligent algorithms could be added to the circuit system to adjust the charging voltage from the pile to the aircraft, and the intelligent plugs with the transformer for the aircraft would encourage Electric Vehicles to gain a larger market share than traditional internal combustion vehicles. Moreover, the connector between the charging cable and charging mouth for aircraft from different countries varies, resulting in approximately eight types of connectors with varying standards for electric-powered vehicles worldwide. Adding all types of connectors to an international airline's aircraft would not be reasonable, whereas it might be appropriate for a domestic airline. Therefore, an identity standard for the production of connectors is significant and could assist in the faster charging of aircraft and reduce the cost of charging system installation [12].

3.4. The types of Electric Vehicles chosen for aircraft

The energy density of the battery, which is only 2.2 kWh/kg for the Lithium-ion battery, is lower than diesel oil when comparing electric vehicles to conventional internal combustion engines. Therefore, for the propulsion of aircraft by Electrical Vehicles, the energy transfer efficiency of the battery to the electric vehicles must be greater than that of internal combustion vehicles [12].

There are numerous types of electric vehicles in the automobile industry, such as battery electric vehicles, which are now widely used in the car industry, such as the TESLA Model-X, BMW-i3, etc., but this kind of battery system now might not be suitable for commercial electric aircraft due to the excessive weight of the batteries. Therefore, hybrid electric vehicles would be more practical for commercial aircraft until the latest technology, which means that if something happens to a flying aircraft and it must land on the ground, but the total mass of the aircraft is heavier than the landing requirements, releasing diesel oil or liquid fuel from the fuel tank would help solve this type of issue. So producing an all-electric aircraft would have a problem of the efficiency of the electric vehicles and the energy transfer from the battery to the electric vehicles [15-17].

Currently, electric planes are divided into two categories: fully electric aircraft and hybrid aircraft. Because the energy density of the battery may not be sufficient for commercial aircraft, fully electric aircraft are typically designed as diminutive aircraft such as the E-Fan. For this reason, it would be difficult to use electricity exclusively on commercial aircraft. However, the Airbus Company has developed the E-Fan X model with a jet engine replaced by a 2MW electric vehicle. The model has been tested in a wind tunnel, and it is anticipated that the all-Electric Vehicles aircraft will be manufactured in the future [2, 10].

4. Conclusion

The development of electric vehicles would have numerous advantages, including the elimination of air pollutants such as nitrogen dioxide, sulfur dioxide, etc. And the cost of the flight would reduce by using the electric aircraft that more and more people could afford the flight ticket. Moreover, the size of an electric vehicle is smaller than that of a vehicle powered by an internal combustion engine, meaning that replacing a traditional vehicle with an electric vehicle on an aeroplane would not only be less expensive, but the cooling system and engine noise need not be considered. Despite the fact that all-electric vehicles for small aircraft have been developed, there are still so many known and unknown challenges and issues that must be addressed in the future for commercial aircraft, such as the material of the battery, aircraft covering material, electrical vehicle power and so on. As new materials and technologies are going to be developed in the future, these kinds of problems could be considered and resolved that an all-electric jumbo jet will be produced by taking plenty of people

each flight whatever the domestic or international airline. Because one electric vehicle will replace the internal combustion engine on the Airbus Company's E-Fan X, all the traditional engines will be removed from aircraft in the future. In this paper, some challenges of producing an electric jumbo jet are discussed and these could help the further research of the electric aircraft enterprise.

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