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A Study on Hybrid Aircraft Battery Pack Charging Techniques Using the Airport Charging Station Concept

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Abstract

In the aviation sector, manufacturers are now researching hybrid electric aircraft with the goal of lowering the cost index and environmental effect. Wide-body aircraft, on the other hand, are prepared for takeoff once their check-list requirements are met. An aircraft is ready for landing when it has reached its maximum operational altitudes after a period of flight. Keeping the battery at its maximum level is therefore a significant task between these two stages. During takeoff and landing, the aircraft's thrust and reverse thrust require high battery levels. Exporting oil is a little difficult for some countries, but not all of them, especially those who run tiny airlines.

Keywords — Impact on the Economy, Cost Index, Battery Charging Techniques, Airport charging station, electric motor

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I. INTRODUCTION

Aircraft operations depend heavily on thrust and reverse thrust, both before takeoff and after landing. An airplane's internal combustion engine (ICE) and electric motor (EM) systems work in tandem to generate the thrust that the aircraft requires. Fully powered by the battery backup system, the electric motor operates. In order to reach their next destination, some planes will remain at the airport for thirty minutes. According to this study, we can recharge the airplane battery utilizing a variety of charging techniques. However, the creation of airport batteries stations had an adverse economic influence on the nation's growth and development, and experts have been trying to lessen the environmental impact of aviation for decades.

Literature Review

Design of an airport electric charging station Half of the functions of hybrid aircraft—takeoff, landing, and regular airborne operations—are powered by electricity [8]. The design and installation of an electric charging station at the airport is one method of charging an aircraft's batteries; another option is to charge the battery pack while the aircraft is in flight by addressing the various electrical machines that power it. motors as well as generators. The implementation of motors and generators for battery recharge in aircraft is more complicated than we may believe due of their weight. Battery packs in airplanes will therefore be powered by the installation of charging stations. Implementation of the afore mentioned system. General specifications for charging stations in modes 3 and 4 are included in Part 1.

Part 2-22: Describe the Electro Magnetic Compatibility (EMC) standards for off-board EV charging systems. These requirements determine whether the charging station is classified as Class A or Class B. **Part 23**: DC charging station requirements (plug attached and permanently hooked).

Part 24: The car and DC charging station must communicate digitally in order to control DC charging. Vehicles that run on electricity can use these 24 parts. Thus, these will provide the fundamental details for the airport charging station design.

Economic Impact

Implementing the aircraft charging stations at airports is a good sign for the growth of the country in economic and financial aspect. Consider any emergency situations between the countries; at that time, these situations will affect the country's imports, exports, and aircraft operations (restrictions on aircraft flying across the country). If those restrictions will happen on oil imports, then aircraft operations are done by only charging stations. It supports to minimizing the oil import cost to government bodies and controlling the cost index for both private and government airlines. The airport charging system will create more career opportunities; it will increase the financial situation of regional people. So, that they will pay taxes to their government bodies. By this, GDP per capita [1] is going to increase. Aircraft hybridization needs more electrical instruments compared to current manufacturing (motors, batteries, converters, etc.). Government authorities will show the green flag to electric equipment manufacturers for investments. It supports the country's GDP, globalization, imports, exports, and technological developments.

Environmental Impact

Part 1: When compared to other forms of transportation, aircraft emissions are increasing at a higher rate. Emissions from aviation contribute to climate change. Fossil fuel is used to power aircraft engines, which emit CO2 and non-CO2 gasses (such as nitrous oxides and sulfur dioxide) into the environment. Non-CO2 gases affect the environment twice as much as CO2 gases do. Between 1990 and 2019, emissions doubled; at the European Union, aviation emissions increased from 1.5% to 4.5%. Once more, by 2050, aircraft emissions will have doubled from 2019 levels, and the temperature will have risen by about 10%, or 1.5 °C. Therefore, in this case, concentrating on implementing aircraft hybridization will help reduce global warming by mitigating aviation emissions [10]. Authorities and airlines have a significant challenge in the area of aviation sustainability. In this decade, the technology of aircraft hybridization must be modified. Airport charging stations serve as a source of power for electric vehicles, such as buses, cranes, and push-back vehicles, in addition to recharging airplanes.

Methodology

If we talk about the airport charging station, recharging the aircraft battery pack will happen at the airport, but the turn-around time for an aircraft varies from 30 to 45 minutes based on its model. Turnaround times means it is time between the aircraft arrival and next departure for its next stop. Airport electric staff should have to utilize this time very efficiently to charge the battery. After analysis of different charging methodologies, here are some best suitable methods for aircraft, and those are high-power DC Fast Charging (DCFC), Battery Swapping at airport. If airport works on better efficiency, then apply the both charging methodologies (DCFC, Battery Swapping) are given good results.

DC Fast Charging

DCFC is also known as level 3 charging due to its charging speed, 80% battery of the charge within 20 minutes. In cable charging methods, till now it is the only available fast charging technique for battery charging vehicles. DCFC is operating on a three-phase power supply, and it requires 480 volts and above. So, perfectly, it provides fast charging to the aircraft. Extra-large converter systems are not needed for battery charge.

Stage-1: AC Power Source

The input of the system connects to three phase AC mains, typically 380V AC or 480V AC for high-power applications up to 350kW.

More electric load requires more advanced electrical infrastructure (electric equipment) [5], like high-level transformers [3], switchboards, electrical metering, and electrical protection devices (e.g., electrical relays) [6].

Stage-2: PFC —Power Factor Correction (AC/DC)

Stage 1, both input and output are AC power supplies. Stage 1 output connected to stage 2 as an input. The PFC section will take the AC supply from stage 1 and convert it to pulsating DC, by using AC to DC converter with an active power factor correction. i.e. it maintains the stable power factor as required by the load and reduce the unwanted harmonics along with unwanted reactive power drawn from the grid [7].

Stage-3: DC/DC Conversion

Stage 2 output (variable DC) is fed to stage 3 input. The DC/DC conversion changes the variable or pulsating DC to fixed DC or pure DC along with the complete elimination of harmonics.

Stage-4: DC connection to vehicles

DCFC connection requires fast and high-capacity connectors, and those are;

- CHAdeMO Connector

CHAdeMO stands for CHArge de MOve; it means charge for moving. It is in a large, round shape, along with two smaller pins at its bottom. Mainly used in Japan and Korea.

- CCS

Combined Charging System (CCS) is a direct current fast charging connector in a circular shape, that contains four pins for charging, and is captured by European and American states.

- **Tesla Supercharger Connector**

The connector, which is developed by Tesla in a circular shape, consists of six pins.

Stage-5: Control and Feedback System

Controller circuit is not only considering the final stage; it supports to all the stages by feeding the feedback signals from each stage of the system. i.e. it takes all the feedback signal from voltage and current sensors, which are connected at each stage of output. It analyses and again send the same signals to the input of each stage individually, to work on measurements of final system it may, efficiency, temperature and safety issues.

Battery Swapping

The main thing of battery swapping is to replace the fault batteries and discharge batteries with fully charged batteries, which helps to minimize the aircraft turn-around time. The battery swapping is done by the electric vehicle-trained technical; they are well known persons to maintain and handle the electric batteries. Some companies allocate the aircraft ground handling agents, so they do battery swapping and ground handling services. Also, airline maintenance staff are trained for root maintenance tasks and battery swapping. Before swapping we need to check the battery status and system of aircraft; if identified any low level one disconnects the supply and removes the connection, and take away the battery from aircraft and replace the fully charged battery. Now give the connection to the new battery.

Battery Swapping process

After completion of checking all connections again, they have to check the aircraft system and the battery's functional condition. The process for changing batteries also includes upkeep, monitoring, and safety considerations for working conditions, thermal monitoring, and overcharge prevention. Battery swapping can help to shorten the charge period and eliminate the need of external charging. Airbus and Boeing have been implementing a battery swapping system from the last five years with collaborative industry partnerships of two distinct individual partner firms. The benefits of battery swapping include longer battery life, decreased overheating issues during charging, and reduced operating time (the battery just needs to be changed).

II. CONCLUSION AND FUTURE DIRECTIONS

The adoption and use of hybrid electric aircraft technology encourages new technological advancements and supports the enhancement of better economic and environmental conditions. However, this system will be compatible with high-quality electrical systems like machines, power electronics, control systems, and high-speed operating equipment (relays and circuit breakers). The hybridization process for electric aircraft requires further advancements in advanced battery production at bulk size. For these systems to be maintained, highly qualified individuals are needed. More batteries will be produced as a result of airplane hybridization, however at least 10% of the raw materials used in lithium-ion batteries cannot be recovered. It is beneficial for the economy and the environment if future studies are conducted on the reuse of finished batteries (lifetime-overcharged batteries). If not, carry out more solid-state battery (SSB) research. The new battery can be manufactured since enhanced SSBs include 50% material.

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