【欧州】【航空】

Common - Emerging technologies: In search of alternative propulsion systems for aircraft - hybrid propulsion as stepping stone towards full electrical propulsion

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【概要：Summary】

When considering ways to reduce the CO2 emissions in the transport sector, the aviation is the most difficult sector to achieve a reduction due to the problems to replacing combustion engines with environmentally friendlier propulsion systems. The technological development of a low to zero emission propulsion system for aircraft is the most challenging of all sectors. The need to reduce air pollution and CO2 emissions of aircraft has led to considerations to develop electric propulsion systems for aircraft.

In the same way as electric cars and road vehicles, also electric aircraft could get their propulsion energy from on-board batteries, which are charged with electricity. Electrically driven aircraft are considered being especially beneficial for the environment as there would be no emissions at the aircraft itself and electricity could be generated by completely renewable sources.

There are start-up companies as well as established aircraft manufacturers like Boeing and Airbus that intend to launch an all-electric commercial passenger jets capable of flying passengers on short-haul routes within a decade.

In recent years, a number of projects have been launched in order to explore the viability of electrification for aviation, ranging from short-range/urban applications to electric or hybrid designs for small regional aircraft. The main task when developing electric aircraft will be to overcome the several difficulties surrounding the development of batteries and electric propulsion systems.

This article gives a non-exhaustive overview of concepts and companies with projects for developing electric aircraft. Given the current level of technology, electric propulsion is only realistic for very small aircraft, while for larger aircraft, only hybrid-electric concepts could become feasible in medium term. Those hybrid-electric aircraft could become the first generation of at least partially electrically propelled aircraft.

Finally, the uptake of electric propulsion in aircraft technology is only meaningful if this new technology will be based on an environmental friendly source of power generation. Only if electric propulsion systems are based on renewable energies, this transition towards electric propulsion in the aviation sector could be meaningful and sustainable.

【記事：Article】

1. Background

International aviation is not included in the United Nations Climate Change Conference (UNFCCC))'s global treaty on the reduction of global warming and climate change, the Paris Agreement. Instead, the CO2 emissions from aviation will be regulated under the International Civil Aviation Organisation (ICAO)'s

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA has become the main focus of the aviation industry's four-pillar climate strategy, which includes improved technology, including the deployment of sustainable low-carbon fuels, more efficient aircraft operations, infrastructure improvements, including modernized ATM systems and a single global market-based measure. However, ultimately, due to further increasing GHG emissions caused by more air traffic, the aviation industry needs to accelerate the development of new aircraft technologies and new sources of propulsion for the utilisation of new sustainable alternative aircraft fuels.

Some EU airlines themselves are also taking action to reduce GHG emissions. Recently, the Scandinavian airline SAS announced it aims to run domestic flights on biofuels and cut emissions by 25% within the next decade. KLM is even encouraging people not to fly, and suggests customers to take the train for short distances instead.

2. Electric propulsion for aircraft

Besides the utilisation of alternative fuels, like biofuels, electric propulsion systems are considered for reducing air pollution and GHG emissions in aircraft. Regarding electric propulsion, batteries are at the heart of the on going electric mobility uptake. Aviation start-ups as well as major aircraft manufacturers are working to remove kerosene fuelled, polluting jet engines and replace it with electric batteries. Electric planes would also eliminate the non-CO2 air pollutants, but with the technology currently available, the electric propulsion systems cannot replace the kerosene-fuelled turbines in jumbo jets.

According to Roland Berger Consulting there are currently around 170 electricity-propelled aircraft in development worldwide. From technological development and investment by new entrants, to activity by major aircraft manufacturers, all kinds of aircraft manufacturing companies are developing electrically propelled aircraft. Therefore, it seems only a question of time when the electric propulsion aircraft will enter the market. Electrical propulsion technology could also keep aviation's share of emissions at roughly current levels. There are currently several barriers to electrical propulsion, which include battery density, efficient electrical systems, effective system integration, and effective regulation/airworthiness solutions to enable new propulsion systems and architectures. Out of the approximately 170 aircraft in development, most are all electric with only batteries as their power source. The major part of these projects is focusing on general aviation and urban air taxis. Around 12% of the projects are focusing on the development of regional and large commercial aircraft concepts. However, companies aiming at developing larger aircraft type and targeting the regional and large commercial aircraft markets are mainly experimenting with turbo-electric hybrid propulsion. This includes the utilisation of traditional hydrocarbon based fuels for greater range and/or power output.

Besides Europe and the US, China could play a leading role in the development of electrically propelled aircraft in the future.

3. Research on new aircraft types with hybrid or electric propulsion

3.1. NASA, Boeing and start-ups

NASA has developed experimental aircraft with electrical propulsion concepts to significantly reduce fuel consumption and emissions. NASA has been researching electric aircraft architectures for nearly two decades. In 2010, a group of NASA researchers started to develop an aircraft with 12 electric motors. An electrically powered flight demonstrator called the GL-10 employed for vertical take-off a tilt wing and horizontal stabilizer. Aircraft engine manufacturer GE plans to cooperate with NASA's Advanced Air Vehicles Program to develop a central component, next-generation inverter, for the electric propulsion of a commercial aircraft. The size, power, efficiency and altitude requirements for flight operations are specified by NASA. Electrified

Aircraft Propulsion (EAP) is the use of propulsors (propellers or fans) driven by electric motors to propel aircraft ranging from air taxis to subsonic transports. NASA is developing technology, aircraft concepts, test aircraft, and ground test facilities for this EAP project.

Also Boeing and Safran have announced a joint investment in Electric Power Systems, which is developing aviation-grade energy storage systems.

Furthermore, there are several start-up companies focusing on the development of electrical propelled aircraft. The Seattle-based electric propulsion start-up MagniX is developing electric propulsion systems for air transportation in the 160 to 1,600-kilometer range, which accounts for 50 to 70% of all commercial flights. MagniX expects all-electric planes to initially go into operation by 2022. However, for that to happen "battery technology and regulatory certification and approvals will need to improve and be in place.

Wright Electric intends to build an electrical propelled commercial 100-seater passenger plane that runs on batteries and that can handle flights of under 500 km distance. Wright Electric announced it is developing a 150-seat plane for these short-haul trips. Wright Electric will have to develop a completely new motor technology with the electric drive. Furthermore, the company will also have to wait for the battery development. Currently, the construction of an electric airplane for commercial service is not feasible because the batteries available are too heavy. However, Wright and its partner airline EasyJet are anticipating that improvements in battery technology will make the batteries they need possible within ten years. The plan is to launch an aircraft prototype for nine passengers in the near future. If the tests are successful, the next test aircraft will have 50 seats before the final passenger aircraft follows.

If the development of electric motors will not proceed due to the lack of adequate batteries, Wright Electric can still switch to a hybrid planes with a propulsion mix of electricity and fossil fuel.

Since 2013, the US aviation technology start-up Zunum Aero has been working with Boeing and JetBlue to develop an electric aircraft with a capacity of up to 50 passengers. The company started the development of a 12-seat plane in October 2017, aiming to fly in 2020. Zunum Aero also cooperates with the French company Safran as engine supplier. Zunum's investors included Boeing's innovation investment unit HorizonX and JetBlue's investment arm JetBlue Technology Ventures. However, recently, Zunum has reported significant delays to its hybrid-electric aircraft development project amid insufficient funding. Boeing and JetBlue were early investors in Zunum, but are currently taking a more-passive approach. Zunum Aero has experienced delays in investor fundraising since October 2018 and is looking for more funding. However, Zunum remains committed to developing electric-powered flight and is continuing its project to develop a hybrid-electric aircraft.

The start-up Ampaire is working on six- and 19-passenger electric planes for regional travel. By the end of 2019, Ampaire wants to retrofit a six-passenger plane into an electric and hybrid craft, called TailWind, but it has designs for a 19-passenger plane concept aircraft.

3.2. European developers of electric aircraft

The first electric planes flew across the English Channel in July 2015, including an Airbus E-Fan. Meanwhile, Airbus and SAS Scandinavian Airlines are also cooperating and have signed a memorandum of understanding for joint research into a hybrid and electric aircraft eco-system in order to explore the technology's potential. In addition, Airbus has teamed up with its main competitor Boeing to study alternative fuels, alternative propulsion systems and designing more fuel-efficient planes. Airbus decided to refocus its efforts on developing a hybrid model, signing a partnership with British engine maker Rolls-Royce and German industrial group Siemens. The first flight is planned for 2020.

In Germany, a partnership between Siemens,

Rolls-Royce and Airbus is developing the E-Fan X as a hybrid-electric airline demonstrator, with four engines out of which one engine will be an electric engine. This hybrid-electric aircraft demonstrator is expected to achieve significant fuel savings and it is expected to launch in 2021.

Furthermore, German Aerospace Center (DLR) is conducting research into planes powered by batteries and expects e-planes to enter the market in around 20 years. Electric flying is most useful for regional traveling in distances from 250 kilometres (155 miles) to a maximum of 2,000 kilometres (1,200 miles). An interesting segment would be to create small hubs for "air buses" with 10 to 12 seats, or up to 40 seats. Also the German company Siemens is considering to develop the propulsion for Eviation's Alice electric planes with 12 to 15 seats. Eviation aims to bring electric flights to short-haul routes in its nine-passenger plane.

Norway's airport operator Avinor announced on 20 June 2018, that the country's short-haul flights should become entirely electric by 2040. All flights lasting up to 1.5 hours could be flown by aircraft that are entirely electric, including all domestic flights and to neighbouring Scandinavian capitals. In June 2018, a two-seater electric plane was tested, with Norwegian Transport Minister Ketil Solvik-Olsen and Avinor's CEO Dag Falk-Petersen, taking a few minutes' flight around Oslo airport in an Alpha Electro G2 plane, built by Pipistrel in Slovenia. The Slovenian Pipistrel's aircraft Alpha Electro G2 is the first electric two-seater aircraft to be approved for commercial series production. The range is approximately 130 km and the aircraft can remain airborne for about 1 hour per charging.

4. Hybrid powered solutions as first step toward full electric aircraft

A hybrid-powered solution for aircraft is considered more likely to be available sooner than a full electric aircraft. This step towards hybrid-electric aircraft could allow for the development of electric propulsion motors and power electronics and prepare the change to full electric operation systems. As a start, a "More Electric-Hybrid" system could extend the use of batteries to power all remaining systems on the aircraft. A thereafter following "Full Hybrid" solution would combine the power available from the generator and batteries to power all aircraft systems, with each means of energy supply augmenting the other in different ratios during different flight phases. Both architectures can be described as hybrid solutions and enable the development of a Full Hybrid solution with electrical energy being combined from both sources to power all systems. In hybrid systems, the emission reduction come from an optimised efficiency of the gas turbine engines as a variety of different thrust requirements are needed for different phases of flights like take-off, climb and cruise, as well as different air flows coming onto the aircraft, among others. The current generation of gas turbine engines are designed to operate in all flight conditions, but they are not functioning with optimal efficiency in all cases. In a hybrid solution, the gas turbine could be kept relatively isolated from those shifting conditions. In turn, it would power an electrical generator that drives the conversion systems needed to give electrical energy. A risk to this approach would be the reliance on unproven power distribution systems and high power electric motors. These aspects are addressed through prototype development, like the Airbus E-Fan X. If suitable battery technology does not emerge, the system also presents the option of switching the kerosene to hydrogen, which in itself will have challenges.

While considering all the benefits the electrification of aircraft could have regarding the reduction of GHG emissions and air pollution, the currently available electric propulsion systems for aircraft are still too small and far from the needed power of the estimated two to fifty megawatts to fly a commercial aircraft. However, the hybrid-electric propulsion systems for aircraft could become an intermediate step on the way to full electric propulsion systems for aircraft.

5. Outlook

The electric propulsion for aircraft promises to increase fuel efficiency and to reduce GHG emissions, among others. Electrical propulsion for aircraft could cause a paradigm shift in the aviation sector. It has the potential to make flights environmentally friendlier and quieter. It could also open up new markets of aviation, including urban air taxis and a new sub-regional aviation. Furthermore, electric aircraft that could cover short-haul flights represent new opportunities for air travel. Several international manufacturers are currently working on their development. However, so far, large electric planes are not feasible due to the battery weight, design problems, limited capacity and limited range. Considering the availability of batteries that could be used as source of energy for the electric propulsion of aircraft, it is currently expected that 6% to 10% of commercial airline flights could be electric by 2050. The accelerated development in the battery technology is the key factor to enable such a development. Electric propulsion systems in commercial aircraft could be able to reduce CO2 emissions and other air pollutions caused during flights. However, in case of CO2 emissions, this highly depends on the source of energy by which the electricity has been produced. However, although significant progress is being made to overcome the technological problems of electric propulsion, there are many other issues to be considered, including the need to introduce the adequate regulatory policy, certification and airport infrastructure requirements. A hybrid-electric aircraft capable of carrying 50 passengers could be flying on short-haul routes by the early to mid 2030s. Instead, predictions on when an all-electric passenger aircraft would come into commercial operation are more varied. However, the early 2040s are considered as a possible date. Moreover, the new aircraft systems need to meet the specific power, weight, and reliability required for a successful commercial fleet. Another aspect is the life span of aircraft, which are utilised on average 26 years. Even if electric propulsion was available for aircraft flying short-haul distances, it would take several decades to replace all kerosene fuelled aircraft with the electric aircraft.

Since electric propulsion for aircraft is not developed yet, the aviation sector will have to relay on alternative fuels to reduce its GHG emissions. Realistically, only the introduction of hybrid systems, which use gas turbine engines for propulsion and for charging batteries, with the batteries providing energy for propulsion during one or more phases of flight, could be the most viable target in medium term, but more research and development will be necessary.

In the short to medium term, biofuels will have the greatest chance of reducing CO2 emissions and the aviation industry's reliance on conventional fossil fuels. Electric propulsion systems could be expected to be introduced for short-haul aircraft operations in the 2035-2040 timeframe.

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