Electric Flying Vehicles

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1 Introduction

Electric powered transportation has been prevalent in the automotive industry and the rail way industry for many years, but has yet to have a large impact within the aerospace industry. The aviation industry is responsible for around 2 % of all human induced CO2 emissions and 12% of global transportation CO2 emissions [1].

One solution to reduce the environmental impact of the aviation industry is the implementation of electric and hybrid electric aircraft as a means of commercial and private transportation. Battery technology has yet to reach the point where 100% electric flight is sustainable in a commercial application. Some smaller scale aircraft and concepts, like the NASA X-57 Maxwell, have been created that are capable of electric powered flight. Currently the pioneering technology used to increase fuel efficiency and reduce emissions include hybrid electric and turbo electric propulsion systems.

2 Full Electrical Flight

NASA is working on developing the first all-electric x-plane, called the X-57 Maxwell. The plane will be built by modifying an already existing aircraft to use electric propulsion, with the main purpose of validating and demonstrating the benefits that electric propulsion may yield for the future of aviation. [2].

The X-57 Maxwell will use 14 electric motors powered by batteries that drive propellers mounted on the wing. Only the two primary motors mounted on each wingtip however will be used whilst cruising. The other 12 are high-lift motors with the sole purpose to accelerate airflow over the wing during take-off and landing through a technology knows as distributed electric propulsion. By using this setup, the performance is increased in many different areas such as fuel efficiency and handling performance. According to NASA, they can see as much as a fivefold decrease in energy consumption [3].

Using DEP technology works especially well for electric aircrafts due to the importance of efficiency as a result of current limitations on batteries and energy storage, and NASA hopes that their implementation of the distributed electric propulsion system will provide critical data to other companies who are also working towards a future of electric aircrafts.

A major drawback of fully electric flight is the energy density of batteries. With current battery technology fully electric flight is not feasible for commercial flight. Another drawback of fully electric flight is that fuel weight is not consumed during flight, which does not reduce the required lift throughout the flight.

3 Turbo Electric Flight

One workaround of the cons of fully electric flight is turbo-electric propulsion technology. The propulsive and power-producing devices are decoupled and individually designed and optimized [4]. Turbo-electric propulsion is divided into fully turbo-electrical and partial turbo electric. With a fully turbo-electric system the thrust is completely produced by electric fans(e-fans). While in a partial turbo-electric system the energy for the e-fans is produced by another Turbo fan engine (compare fig. 1).

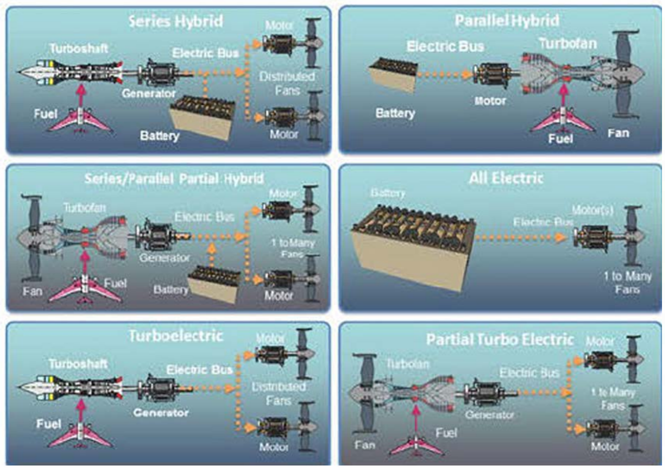

Fig. 1 . Types of electric propulsion [5]

The power is supplied by one or several gas generators(turboshaft engine) and is transmitted directly to electric driven propulsion, that can utilize a propeller or ducted fan. Decoupling the propulsion sys-

tem from the power generation system provide opportunities to optimize both configuration as the thermodynamic constraints no longer apply to the thrust generation system and vice versa.
As the energy storage is one of the main challenges for electrical flight, this technology provides a feasibility that manufacturers can currently implement. E-fans can be adapted into arays of small fans like on the NASA N3-X concept. This example is a blended wing body configuration that uses its body as lift generating surface. It is projected to have a high specific power weight (>10 kW/kg at 98% efficiency [5]). The trailing velocity sink behind an aircraft fuselages produces drag due to shear layers and high velocity gradients. A wide blown engine array can reduce the total drag by distributing the velocity evenly thus removing the sink. Furthermore, boundary layer ingestion can cause additional drag reduction by positioning a fan in the aft of an aircraft.
The bypass ratio for turbo-electric propulsion is the mass flow rate through the fans divided by the mass flow rate through the (core-) power plant. Therefore, very high bypass ratios and high efficiencies can be achieved [4].
Electric transmissions provide lower transmition losses when compared to traditional geared transmitions (0.23-0.4% vs 4-5% [4]). One disadvantage of electrical propulsion is the limit of achievable airspeeds. The combination of turbofan and e-fan engines mitigates this drawback. Higher velocities than any full electric configuration can be reached. Scalability is another challenge of full electrical flight, and can be easily achieved by combining turbo machines with electrical machines.
Turbo-electric technology is may be applicable for the next generation of aircraft. Before emissions can be reduce completely, new power sources and configurations have to be developed.

4 Hybrid Electric Flight

Another category of electric powered aircraft is called hybrid electric. Hybrid means supplying one engine with multiple types of power. The aim of the hybrid power distribute the benefits each propulsion type and distribute the benifits within the applicable flight modes. This brings the possibility of energy recovery. However, there are some nuisances that have to be dealt with. One of these restrictive factors is the weight and larger süace requirements of hybrid engines when compared to turbine engines. [6]. Once these disadvantages are mitigated, the final product is a machine with significantly lower fuel consumption and emissions which is therefore environmentally friendly.
Unlike turboelectric, the fan is powered by both, turboshaft and battery. It can be further divided into series hybrid and parallel hybrid, which uses battery and fuel powered turboshaft engine at the same time.
For the series hybrid engine, the turbo engine and the electric motor are arranged in series. The conventional engine serves here only as a source of energy for the electric motor or battery. An issue might be an unavailability to fully optimize the working area of the internal combustion engine[6].
An example of a hybrid powered aircraft is the aviation start-up called Zunum. The American company is currently developing a series hybrid small regional aircraft that uses fans with integrated electric motors and controllers. Thanks to the exceptionally efficient low-pressure fans, the company claims that the aircraft requires 40% less runway length and causes 75% less noise. The batteries are located inside the wings. Since there is no need to carry as much fuel, it can be designed into more aerodynamical friendly shape, helping the aircraft to achieve the required performance. Zunum is expected to have a seating capacity of 10 to 50 passengers with a range of almost 500 km [7].
All in all, hybrid powered aircraft have a great potential for the future. Since the technology uses both conventional engines and electric motors concurrently, it is a necessary step to start using the fully electric airliners. So, if mankind wants switch to electric power in the future, the starting point must be hybrids.

5 Conclusion

Electric flight is necessary in order to completely reduce the emmisions from the aviation industry. Hybrid electric flight is the necessary stepping stone to help reduce emmisions and envirnomental impact of the industry. The current state of battery technology limits that feasibility of fully electric commercial transportation. The X-57 Maxwell is an example that the concept will be feasible in the future. With the current state of technology hybrid-electric and turbo-electric propulsion systems will be utilized in order to decrease emmisions and the environemntal impact of the aerospace industry.

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