Environmental Benefits of More Electric Aircraft; Optimizing Power Distribution and Taxiing Systems

More Electric Aircraft (MEA) are the next big thing in the aerospace industry. Over the past decade an increasing amount of investment has been put into the development of MEAs. This is for good reason: increasing the number of systems that use electric power instead of conventional power systems can have a significant number of benefits.

Often the most touted advantage is cost. More Electric Aircraft reduce the weight and fuel consumption of aircraft significantly while simultaneously simplifying maintenance. However, a perhaps equally important benefit is that these aircraft are also friendlier to the environment than those using mainly pneumatic, mechanical, and hydraulic power.

The environmental benefits of MEAs are significant. Due to the weight reduction and more efficient components, these aircraft can operate with a measurable decrease in fuel consumption. Additionally certain electric systems run cleaner than their traditional counterparts, resulting in lower emissions.

However, the centralization of systems means a number of new design considerations in terms of efficiency and optimization. In particular the power distribution systems on MEAs will require continued development in order to ensure that they reach their full potential for cost and emission containment. Another area of design focus is how the aircraft taxis, a historically costly and cumbersome activity. Fortunately new systems being designed for MEAs are showing promise to make significant forward progress with both of these systems.

New Aircraft Power Distribution Systems for MEAs

The gradual elimination of pneumatic, hydraulic, and mechanical systems in favor of more modern electric variants is an exciting opportunity for the industry. However, the inherently more centralized electric systems also require significantly more sophisticated power distribution systems in order to ensure continuous power delivery to all systems. This introduced some new design considerations for aircraft manufacturers, particularly with respect to operation of auxiliary systems while the main engines are not in use. Additionally, ensuring power redundancy is essential to guaranteeing the safety of the craft and avoiding critical failure.

In their paper for the Institute for Defense Analyses, K.M. Spencer and C.A. Martin examine the potential use of fuel cells in aircraft power systems. In particular, their report covers proton exchange membrane (PEM) and solid oxide fuel cell (SOFC) technology, their potential benefits, and technical challenges[i].

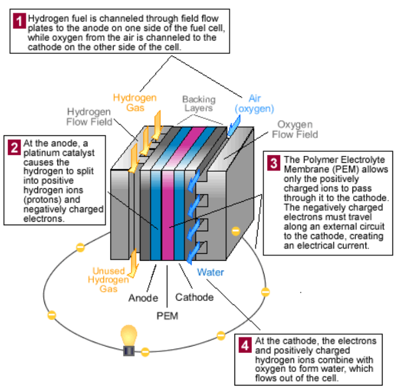

Figure 1: Diagram of a PEM fuel cell

Fuel cells, unlike internal combustion engines, are able to directly translate chemical energy into electrical energy. This could mean significantly improved fuel efficiency auxiliary systems in MEAs. Additionally, fuel cell produce significantly less harmful emissions than combustion engines. As such they represent a much greener form of electrical power for MEAs compared to more conventional auxiliary power units.

Thanks to investment by both the aircraft and automotive industries, fuel cells using PEM and SOFC technologies are both in fairly advanced stages of development. PEM fuel cells use hydrogen as a fuel source, whereas SOFC use oxygen. PEM fuel cells operate at a much lower temperature, 60-80 degrees Celsius, than SOFC, 600-1000 degrees Celsius.[i]

In their study, Spencer and Martin examined the results of using each of the two fuel cell types in a Global Hawk UAV. Ultimately they concluded that while PEM and SOFC technologies represent a roughly equal set of advantages and disadvantages, the use of fuel cells in general was a significant improvement over conventional power sources.[i] For example the engine size could be reduced, the energy conversion became more efficient, and the emissions were notably lowered. While several technical challenges still exist, including development of electrical actuators, high power electronics, and efficient power control systems, Spencer and Martin are confident that fuel cells could represent a large step toward the realization of the MEA vision.[i]

Another study, conducted by Hamid Radmanesh, Seyed Saeid Heidari Yazdi, G. B. Gharehpetian, and S. H. Fathi, simulating fuel cell dynamics for use in aircraft also showed the potential value of this technology. This simulation focused specifically on PEM fuel cell technology as part of a hybrid power system for the C-130 Hercules military aircraft.[ii]

The group's analysis revealed that PEM fuel cells could be used as an especially reliable option for powering a plane's auxiliary systems. Their use of the fuel cell as a backup to conventional power generation mechanisms led to a substantial improvement in performance consistency. Additionally they concluded that a hybrid model would not represent a significant additional cost compared to just conventional power generation due to the efficiency of the PEMFC. [ii] Both of these studies show great promise for the usage of fuel cell technology to support MEAs' power distribution systems.

A November, 2013 paper released by Pierluigi Nuzzo, John Finn, Mohammad Mozumdar and Alberto Sangiovanni-Vincentelli of the University of California at Berkley and California State University Long Beach, presented a design methodology to assist the development of aircraft electric power systems (EPS).[iii] This approach could represent greater capacity to address some of the technical challenges identified by Spencer and Martin.

Nuzzo et al set out to support more ambitious design of aircraft EPS, a process that is normally restricted to incremental change by uncertainty and cost. Their methodology, which follow the platform-based design (PBD) paradigm is aimed at more accurately modeling concept designs in early stages. PBD emphasizes a distinction between a system's function and architecture.[iv] The group described an approach using Systems Modeling Language to represent function and the Simulink SimPowerSystem to represent architecture.[iii] In doing so they were able to effectively model an aircraft EPS; and, as such, can enable greater forward progress in addressing the technical power distribution system challenges presented by fuel cell usage and MEAs.

Usage of eTaxi Systems to Increase Efficiency and Reduce Environmental Impact

Another significant new technology in the development of More Electric Aircraft is eTaxi systems. Electric taxiing systems use aircrafts' auxiliary power units enable locomotion using the forward landing gear on the aircraft. This is an alternative to conventional movement methods like tugging and using the main engines for motion. Electric taxiing systems greatly reduce the amount of fuel needed to move the aircraft on the ground. Additionally, they offer greater maneuverability than more traditional methods and provide more control to pilots.

One of the most prominent projects in the eTaxi space is EGTS, or Electric Green Taxiing System, a joint venture between the Safran Group and Honeywell Aerospace. Using the aircraft's APU, EGTS powers electric motors that can be fitted to the craft's main landing gear. This project is principally designed for the A320 aircraft; and in December of 2013, the joint venture was awarded the backing of Airbus in a memorandum of understanding.[v]

Figure 2: Safran & Honeywell's EGTS

According to the Safran Group, usage of EGTS could represent a reduction of total fuel consumption of 4%.[vi] This would be equivalent to around $200,000 per aircraft annually. Additionally they expect carbon emissions to be reduced by up to 75% and nitrous oxide emissions by up to 50%.[v] The lower fuel consumption and emissions offered by EGTS makes it an attractive option in terms of the environmental impact of aircraft. Because taxiing will no longer require use of the main engines, their life will be extended and the level of maintenance required will be reduced.

EGTS and eTaxi systems in general also represent greater autonomy for More Electric Aircraft than their conventional ancestors. This can result in improved timeliness of commercial flights due to the independence from tugs. Safran and Honeywell estimate that the EGTS could reduce pushback time by two minutes per flight. [iv]

Through their strategic alignment, Airbus, Honeywell, and Safran hope to ensure more efficient and compatible development of the EGTS for A320. This single-aisle aircraft is already one of the most fuel efficient commercial transportation planes in use. The addition of EGTS will solidify this position further, hopefully encouraging competition in fuel cost and emissions reduction.

Another competitor in the eTaxi space is WheelTug, a subsidiary of Borealis Exploration Limited. Wheeltug is developing an electric taxiing system for the A320 as well as the Boeing 737NG[vii]. Similarly to EGTS, WheelTug is a solution that can be added to existing aircraft with relative ease. It also uses the aircraft APU to power an electric motor mounted to the forward landing gear.

WheelTug anticipates even more substantial cost savings than Safran's EGTS, with cost savings of up to $1 million per aircraft annually. [vi] The firm has already secured orders for around 1,000 aircraft, about 10% of the total number of active A320 and 737NG aircraft. Once rolled out, this technology could mean an enormous improvement in the environmental impact of aircraft, a big step toward the realization of the MEA vision.

MEAs a No-Lose Proposition

More Electric Aircraft offer a significant number of benefits to a variety of stakeholders. In many ways they represent a no-lose situation. Airline operators will be able to significantly reduce fuel and maintenance costs; manufacturers will realize the next evolution of aircraft design; customers will have a better, timelier experience when flying; and the environment will be less impacted by air travel. In order to fully realize these benefits, a substantial amount of additional research will be necessary. New innovation in power systems and taxiing represent an opportunity to reduce the negative impact that aircraft will have on the environment in the future.

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Maryruth can't help but seek out the keys to environmental sustainability - it's the fire that gets her leaping out of bed every day. With green writing interests that range from sustainable business practices to net-zero building designs, environmental health to cleantech, and green lifestyle choices to social entrepreneurism, Maryruth has been exploring and writing about earth-matters and ethics for over a decade. You can learn more about Maryruth's work on JadeCreative.com.

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