More Electric Aircraft Trends

By Kaushik Rajashekara

THE MORE ELECTRIC AIRcraft (MEA) system is being widely recognized as the future for the aerospace industry to meet the power demands of increasing electric loads, reducing aircraft emissions, improving fuel economy, and lowering the cost of the total system. The airframers, parts suppliers, and even the military have been putting significant effort into converting most of the pneumatic and hydraulic systems in the aircraft to electric. The Advisory Council for Aeronautics Research in Europe has also set several goals to be achieved by 2020 for air transportation. These include a 50% reduction of carbon dioxide emissions through a drastic reduction of fuel consumption; an 80% reduction of nitrogen oxide emissions; a 50% reduction of external noise; and a green design, manufacturing, maintenance, and disposal product life cycle.

To meet these challenges, MEA technologies are continually evolving, and there is much opportunity for improvement as systems continue to be refined and enhanced. New MEA-based requirements for electric engine starting, high-power inverters, and bleedless environmental control systems are also being introduced. This has been further reinforced by the successful application of many of these technologies in passenger aircraft such as the Boeing 787 and Airbus A380.

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Kaushik Rajashekara.

Although MEA architecture offers significant overall system benefits in reliability, improved fuel efficiency, and reduced emissions, the MEA concept imposes increasing demands on the electrical power generation, conversion, and distribution. In addition, it has to be safe, reliable, efficient, and fault tolerant. In a traditional airplane, the jet engine is designed to produce thrust as well as pneumatic, hydraulic, and electric power. Even in an airplane like the 777, there is only 240 kVA of electric power generation using two 120-kVA, 115-Vac, 400-Hz engine-driven generators and one 120-kVA, 115-Vac, 400-Hz auxiliary power unit (APU)-driven generator. However, in the 787, there are four 250-kVA engine-driven generators of variable frequency (about 360–800 Hz) and two 225-kVA APU-driven generators. In addition to powering 230-V ac loads, the generators' electrical power is converted into 115-V ac and 28-V dc power to feed many of the legacy subsystems that require more conventional power. In addition, ±270 V dc is derived from 230 V ac using an autotransformer rectifier for powering the environmental control systems and for starting the engine.

In an MEA system, the jet engine is optimized to produce both the thrust and the electric power. Also, the same electric machine that is coupled to the engine can be used for starting the engine and for generating electric power. An active front-end power electronic converter and dc–dc converters can be used to generate the required dc voltages, thus eliminating the need for autotransformer rectifier units. Most of the loads are electric, including de-icing and the environmental control system. Even the fuel, hydraulic, and oil pumps, which are mounted on the accessory gear box of the engine, could be driven by the electric motors.

High-power-density electric machines, power electronics, and power distribution are the enabling technologies for the successful advancement of MEA. Conventionally, for power generation, mainly synchronous generators coupled to the propulsion engines through the accessory gear box are used. Recently, several other types of generators, such as permanent-magnet synchronous machines, switched reluctance, and induction machines, have been examined for power generation. Similarly,

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the use of different power types of power conversion circuits including active rectifiers are being investigated for use in MEA systems. This issue of *IEEE Electrification Magazine* focuses on MEA technologies. The three feature articles in this issue have been selected to introduce the readers to the technology and challenges of MEA, electric machines, as well as the power generation, power electronic systems, and the simulation of a hybrid aircraft power train.

Aerospace companies need to continue to invest in MEA-related technologies and work closely with national labs and research organizations to develop the new-generation architectures and technologies that will lead to increased electric systems to optimize their value function. The long-term goal is an "all-electric" aircraft, with MEA being the evolutionary step. Meanwhile, MEA will bridge two eras in aircraft technology as airplanes move toward the deployment of increased electric and electronic systems. NASA's future hybrid wing-body electric airplane with a turbo-electric distributed-propulsion system is a step in the right direction to achieve these goals. Terrafugia's TF-X, a fixed-wing street-legal aircraft with electric ground drive and electric power assist on takeoff and landing, which can recharge its batteries either from its engine or by plugging into electric car charging stations, is also an important step for the future of personal air transportation.

Biography

Kaushik Rajashekara (k.raja@utdallas.edu) earned his Ph.D. degree from the Indian Institute of Science, Bangalore. Since 1 August 2012, he has been a distinguished professor of engineering and endowed chair in the Erik Jonsson School of Engineering and Computer Science at The University of Texas at Dallas. He is a member of the National Academy of Engineering and is the recepient of the IEEE Richard Harold Kaufmann award for outstanding contributions to the advancement of electrical systems in transportation.