Hybrid & Electric Powered Aircraft

Overview

**LEVEL**
Knowledge

**PURPOSE**
This course provides newcomers and staff working in the field of aeronautics with a deeper knowledge on the new ways (based on electrification) which the world of aviation is moving towards concerning propulsion or auxiliary power generation.

It also covers the electrification of aircraft combustion engines to replace traditional pneumatic or hydraulic actuators.

**LEARNING OBJECTIVES**
Upon completion of the course, participants will be able to:
- assess the needs and constraints of aircraft engines based on their utilization,
- know the general context of current hybridization and the different forms of hybridization,
- master the basic principles and specifications of hybrid and electrical propulsion systems developed for the aerospace industry,
- know the main stages of life of electrical or hybrid propulsion engines,
- know the main stages of life of hybrid auxiliary power supplies,
- know the operating principles and limits of electrical and hybrid engines, batteries and power electronics,
- understand the specific aeronautical elements constituting the hybrid and electric systems,
- know the certification requirements of these new technologies.

**WAYS AND MEANS**
Mainly interactive, supported by real examples, it addresses the main technical areas of electrical and hybrid aircraft engines.

**PREREQUISITES**
The “Introduction to aeronautics and astronautics” training course is recommended for people new to the world of aeronautics or beginners in this area to improve their understanding of the aircraft propulsion and auxiliary systems operations and their utilization profiles.

**Agenda**

**INTRODUCTION TO AERONAUTICS**
Aeronautical technology reminders. Positioning technique: type of use, conditions of use, power range, aircraft associated; products, strategies and markets. Issues and context.
Technology: two classes of hybrid architectures (serial, parallel); power branching systems, electrical lead.
Earnings function of consumption, energy recovery, energy optimization, comparing benefits, pollution.
New bodies: the engine, electric motor, inverter, converter, booster, battery.
Panorama, techno-economic assessment and conclusions.
Mission profiles: mission profiles of electric and hybrid engines by kind of aircraft and aircraft operations; stages of life; operating points.
Definition of power requirement. Stabilized and transient operation related to flight mechanics. Influence of the environment: altitude, pressure, temperature, speed, ice, resistance to damage (lightning, obstacles etc.). Specifications for auxiliary power generation unit (APU).

Electrification engines: using electric actuators instead of hydraulic and pneumatic traditional aeronautical combustion engines.

Design and production: regulation and certification.

ON BOARD ENERGY STORAGE SYSTEMS
Electrochemical battery: principle of operation, characteristics and performance of different technologies (nickel-cadmium, nickel hydrogen, lithium ion, lithium polymer, …). Supercapacitors: principle and performance. Integration into an aircraft.

Fuel cells.

POWER ELECTRONICS
Power components: MOSFET, IGBT, SiC, NGa…
Electronic structures of power: DC-DC converters, DC-AC…
Power characteristics, layout constraints, thermal and vibration aspects.
Electromagnetic compatibility.
Circuits involved in the making of aircraft: electrical, hydraulic, air conditioning, oxygen, icing and fuel, as well as the main organs that compose them.

ELECTRIC MOTORS
Different technologies of electric motors: principle of operation, characteristics, performance, evolution. Layout constraints: compact cooling; examples of applications on aircraft.

ELECTRIC & HYBRID ENGINE MANAGEMENT
How to order electric motors, various converters? Which physical principles? For what? Main functions related functions.

HYBRID CONTROL OF ROCKET & ENERGY MANAGEMENT
Energy flow and energy supervision.
Objectives and constraints: consumption, energy balance, energy recovery, boost function, validation.
Techniques: empirical tests, aircraft application case, proposed improvements to empirical controllers, optimal controllers.
Synthesis and validation of controllers: system usage models, optimization methods.

THERMAL MANAGEMENT
Thermal management of electrical components: battery, electrical machines, power electronics.

ELECTRIC & AUXILIARY POWER PRODUCTION
Consumer power: electric actuators, other consumers defrost, light.
Focus: Preparing for powering an aircraft. Preparation of the first flight.
The quality of the embedded network. Harmonics, power factor The outlook for the electrical system. Problem of carbon fuselages.

AIRCRAFT ENGINES ELECTRIFICATION
Electrical actuator: context, issues, technologies, application examples.