Management of Power Supply System for Civil Aircraft

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Management of Power Supply System for Civil Aircraft

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Abstract. A control method based on Kinect for robots is proposed in this paper. For the motion control system of two-wheel robot, the method, which is combined with Kinect and DTW gesture recognition, is referred to the field of robotic control, and it can be applied in human-computer interaction system. A series of experiments indicate that this method can realize the dynamic gesture recognition and it has a good performance of real-time and robustness.

1. Introduction

Civil aircraft have developed rapidly towards MEA (More Electrical Aircraft) in the past decades, and large companies such as Boeing Airbus have launched their own new generation of multi-electric aircraft. IPS (Ice Protection System), ECS (Environment Control System) and Actuation System of Electric Aircraft are gradually moving towards electric drive. While providing higher energy utilization and fuel efficiency, they are also facing more problems of weight loss and power management brought by electric power equipment. In order to improve the above problems, advanced power management technology emerged as the times require. This paper will discuss some feasible power management technologies at the present stage, and make some prospects for its future development trend.

2. Introduction of Power Supply System for Typical Civil Aircraft

Electric power management is closely related to the generation/distribution system of aircraft power system. Although different types of aircraft have different power system schemes, a typical power system generally consists of the following parts:

- Power supply: composed of main generator, auxiliary power device, external power supply and emergency power supply.
- Power supply controller: used to control and monitor power supply devices.
- Power converter: used to realize power conversion.
- Bus and feeder: used to connect power supply, power converter and power load.
- Switch: composed of contactor, circuit breaker, relay and so on. The design of power supply system for multi-electric aircraft needs to meet the requirements of MIL-STD-704, so as to ensure the quality of power supply under different working conditions.

2.1. Balance analysis of lithium batteries and nickel-cadmium batteries

Battery system usually consists of battery, battery controller, related contactor, fuse and so on. Battery and battery contactor are the core components of the system. Battery controller can judge the working state of the battery according to the configuration of the power supply system. The battery controller controls and protects the battery by measuring and controlling the output voltage, charging and discharging current and temperature of the battery. In addition, the battery controller also transmits the measured values to other systems on board for system display.

Usually, aircraft have the following requirements for battery systems:

- In order to operate and maintain conveniently, the corresponding contactor and control switch should be set in the battery circuit.
- The battery controller needs to monitor and control the charging current of the battery so as to ensure the fast charging of the battery without damaging the power module in the battery.
- The installation design of storage battery should consider enough maintenance space for maintenance personnel to facilitate rapid disassembly and installation.
- Because of the chemical reaction, the gas will be generated when the battery is working: the nickel-chromium battery will decompose water to produce hydrogen and oxygen, while the lithium battery will also expand the gas in the battery because of heating. Therefore, it is necessary to design appropriate ventilation ducts for storage batteries so that the gas can be discharged and the potential safety hazards can be eliminated.
- Battery systems need to meet the requirements of CCAR-25 1353 airworthiness clause.

At present, most of the main batteries/APU batteries used in civil aircraft are nickel-cadmium batteries and lithium batteries. There are great differences in power density, charge and discharge characteristics between them.

It should be noted that the discharge curve of lithium batteries will change after multiple charges and discharges due to their active chemical properties. In addition, although lithium batteries do not have memory characteristics, excessive charging and discharging will cause irreversible permanent damage to lithium batteries. Therefore, lithium batteries require more battery controllers.

2.2. Page Numbers

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Table 1. Comparison of Charge and Discharge Parameters between Nickel-cadmium Batteries and Three Kinds of Lithium Batteries

Parameter	Nickel-cadmium	Lithium-cobalt	Lithium - manganese	Lithium iron phosphate
Maximum Charging Rate	1C	0.331C	1C	1C
Maximum continuous discharge rate	1C,2C	1C	10C	35C
Maximum discharge rate	20-25C	5C	40C	100C
Power Discharge Ranking of Cell Batteries	3	4	2	1
cycle index	1000	300-500	300-500	7000
Average life span	6.8	3	10	Greater than 10
Self-discharge (initial 24 hours)	10-15%	5%	5%	5%
Self-discharge (per month)	10-15%	5-10%	5-10%	5-10%
Maintenance	2500 flying hours	Seldom repairing	Seldom	Seldom repairing

interval	per time		repairing	
Security ranking	1	4	3	2
Use type	A300,310,320 330,340,380 B737,747,767 777, A400M, AR121, Dassault Falcon 900	A350XWB, B787 F35	None	Military aircraft; Unmanned aerial vehicle.
Note 1:1C indicates charging and discharging efficiency, such as C = 800 mAh, charging rate of 1C means charging current of 800 mA. Note 2: The maximum discharge rate mentioned above is calculated under the assumption that the output voltage of the battery is reduced.				

3. Overview of Power System Safety Assessment

A subsubsection. The paragraph text follows on from the subsubsection heading but should not be in italic.

Power system FHA process is used to determine the failure state of power system, and to assess the severity of failure state, so as to determine the safety objectives; Power system PSSA process is to formulate the mitigation measures of failure state in FHA through qualitative and quantitative analysis, and design the system framework and installation according to the measures. SSA process of power supply system verifies FHA process and PSSA process, confirms the effectiveness of mitigation measures in PSSA, and verifies the implementation of mitigation measures.

These three processes can be carried out iteratively. If a non-conformance item is found in any evaluation process, the system design changes are needed. After the design changes are completed, the system security assessment is carried out again.

3.1. Target of Power System Safety Assessment

The objectives of power system security assessment (SSA) include:

- Verifying the security requirements established in power system level functional hazard assessment are met.
- Confirming the establishment of power failure status impact level is reasonable.
- Verifying the security requirements derived from design requirements and objectives are met.
- Verifying the security requirements are met. The design requirements identified in the process are met.

3.2. Development trend of Electric Energy Management Technology

Several existing power management technologies are described above. For multi-electric aircraft and even all-electric aircraft, the number of loads will be doubled, and the grid structure will become more complex. Therefore, there is an urgent need for a more advanced and intelligent means of power management to reduce system weight, improve power supply quality and improve power efficiency. This paper envisages the possible development trend of power management technology from the following aspects:

- In the flight process of aircraft with variable load priority, the priority of load can be dynamically adjusted to improve the efficiency of power utilization because of the difference in the importance of load.
- The power management technology of multi-electric aircraft usually has many main generators, APU generators and other power sources, which can be turned off to optimize the efficiency and performance of the whole system.
- Energy regeneration technology, as mentioned above, is gradually moving towards electric drive, such as the actuating system of multi-electric aircraft, which can be recovered and regenerated to maximize the use of primary energy when appropriate.

3.3. Comparison of safety, economic analysis and applicable standards

3.3.1. Safety. Among the existing safety models, there are abundant experience in the design, manufacture, forensics and use of nickel-cadmium batteries. The requirements of CCAR-25 1353 airworthiness clause can be fully met through battery charger, temperature monitoring and other measures. Because lithium batteries charge and discharge more than nickel-chromium batteries, they generate more heat. Therefore, a more reliable battery charger is needed to achieve more accurate control of the working state of lithium batteries. According to the design experience, the voltage precision of lithium battery charger should be less than 1%.

This will put forward higher requirements for the design and airworthiness verification of battery system, and also have greater engineering risk. In addition, due to the active chemical properties of lithium ion, the electrolyte of the battery is flammable. This also puts forward higher requirements for the installation of lithium battery system.

3.3.2. Economical. The cathode material of lithium battery is LiCoO2, which contains cobalt element at a higher price. In addition, it is difficult to store the electrolytes of lithium batteries in the existing process. As a result, the price of lithium batteries in the current market is about three times that of nickel-cadmium batteries. Considering that the maintenance characteristics of lithium batteries during the whole life cycle will be due to nickel-chromium batteries and the lighter weight of lithium batteries, which will save aircraft operating costs. The economy of lithium battery is better than that of nickel-cadmium battery.

4. Conclusion

In this paper, the selection of nickel-cadmium batteries and lithium batteries commonly used in civil aircraft is studied, and a comprehensive comparison is made from four aspects: power density and energy density, charge/discharge characteristics, maintenance and service life, safety, economic analysis and applicable standards, which provides a basis for the selection of batteries in civil aircraft development.

References

[1] L.Faleiro, “Beyond the more electric aircraft,”Aerospace America, September 2005, pp.35-40..
[2] Hua Wang. Highly Efficient Selective Assembly Method of Horizontal Stabilizer based on Metamodeling and Particle Swarm Optimization[J]. Journal of Aerospace Engineering, 2014.
[3] T. Schr6ter and D. Schulz,“Efficiency of the electrical system on large modern civil aircraft - status quo analysis,”in Deutscher Luft - und Raumfahrtkongress, 2010.
[4] Yiru Ren,Jinwu Xiang. Crashworthiness uncertainty analysis of typical civil aircraft based on Box–Behnken method[J]. Chinese Journal of Aeronautics, 2014, 27(3).