Modeling and simulation of hybrid auxiliary energy unit based on fuel cell/storage device

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Abstract: Traditional aircraft auxiliary power plant noise, large carbon emissions, low efficiency, has been unable to meet the multi-electric/Full-power aircraft development requirements. The fuel cell has the advantages of high energy density, zero emission, long service life, low noise and high efficiency. In this paper, a fuel cell model is established and optimized to better reflect its steady and transient performance in. A hybrid system composed of fuel cell and super capacitor is established as a model of aircraft auxiliary Energy Unit, which verifies that the power quality satisfies thejgb181a-2003Standard, and compares with the traditional auxiliary power plant, showing its response speed. Efficiency and work-weight ratio have obvious advantages.

Keywords: fuel cell, super capacitor, auxiliary power plant, multi-electric plane

in an aviation power supply system, typically powered by an engine or a fuel turbineTheForce device (APU) starts the generator to provide power to the aircraft power supply system. Conventionalturbo engines that fly machinesAPU have problems with A high level of noise, more fuel, greater carbon emissions, a lower efficiencyrate, and short service life. In aircraft flight, the main engine and the auxiliary hairmotor(apug)power supply maximum efficiency is 10%~20% while the fuel efficiency of the auxiliary power unit is less than when the ground, send motive shuts down 10% and the fuelbattery Clean non-polluting, long service life, high efficiency, high energy density, meet more than power/development requirements. With the development of fuel cell research in various countries, the technical level of the IS gradually improved. The research of fuel cell hybrid system in the field of aerospace has great foreground. Currently, Europe has developed a fuel cell/Lithium-ionBattery Driveto move a small aircraft and test flight successfully.

in fuel cell system modeling methods, mainly divided into mathematical modeling sidemethod, equivalent circuit modeling method and electrochemical modeling method[2], different modeling methodsThe has pros and cons. In this paper, the mathematical modeling method based on the electrochemical principle is adopted after the comparison and analysis of various models.

This article takes a cryogenic fuel cell and a storage device (battery)/Super Capacitor in parallel asapug[3,4], through the simulation of the steady state and transient performance of fuel cell system, based on fuel cell/Energy storage devices replace tradition in performance Apug the possibility of a.

1. fuel cell system Architecture

Currently, fuel cells have 3 type of application: Cryogenic fuel cell/Storage PackSetsystem, high temperature fuel cell/Turbo Generator system and Renewable fuel battery system. Among them, low temperature fuel cell/energy density of storage system is lowest[5]. This article takes a cryogenic fuel cell/Energy Storage System as an object, according to the B787 The generation requirements for the APU are shown in the design architecture as illustrated in the diagram1. Consider the volume,

Weight, cost, efficiency, and performance requirements:
(1) in the case of constant output power, fuel cell and battery pack/SuperThe grade capacitor is fixed in weight.

(2) Battery Group/the super capacitor is external charging and discharging device only depends on the system unified dynamic performance and energy requirements.

(3) Battery Group/The super Capacitance access position affects the power of the inverter's front level change converter, thereby affecting its weight.

fully, select Diagram1 the configuration in the fuel cell through aDC/DC Change Intandem with the Super capacitor Apugan alternate object for the.

2. Fuel Cell Model Research

2.1 Comparison of models

the fuel cell models are mainly equivalent circuit models and mathematical empirical models and electrochemical models[6]. Proton exchange membrane fuel cell (pemfc) models of the fuel cell heap is byNfue cell monomer in series, battery heap power pressure can be expressed as a monomer voltageVFcThe sum of the, assuming the fuel cell monomer voltage phase Same, heap voltageVStExpressed as:

the has the lowest precision; The mathematical empirical model, although the simulation is high precision and the model is simple, the main If you rely on empirical parameters, many parameters are not physically meaningful and cannot be reflected in

PEMFC Ideal Standard potential when reacting to liquid water formation E0 For 1.229V, there are 3 The polarization of the action causes PEMFC Irreversible loss of voltage.

Theis based on the electrochemical principle of the fuel cell and on a certain assumption, using the Basic Conservation Law, mass transfer equation and electrochemical reaction equation[7], combining batteries The mathematical model obtained by the internal characteristics is more responsive to the internal characteristics of the fuel cell.

Type: VAct for active polarization overvoltage, VOhmohm polarized overvoltage, VContoconcentration polarized overvoltage, E, for thermodynamics predictive voltage[8].

by Diagram4 PEMFC The simulation result of the electrochemical model and the voltage dynamic model show that the improved voltage dynamic model on the electrochemical model can better interpret the smooth response of the battery voltage characteristics when the load changes.

2.2 Model Optimization

There are some defects in the electrochemical model, and the electrochemical model can not reflect the combustion of the. the smooth response process of the output voltage of the material cell with the load change[8]. a voltage dynamic model can be established on the basis of the electrochemical model, and an equivalent capacitor C and soon Effect resistance in parallel. As shown in the figure 3, Eis the ideal voltage source, R0 For battery Omne

Blocking, Uthe is the battery-side voltage. Make the R1 the total polarized overvoltage on the isvD, the battery sheet

The dynamic properties of the body can be expressed by differential equation:

(2) in fuel cell loading time, the fuel cell does not meet the load required the power is supplied by SC.

3.2 Simulation Results Analysis

start performance as shown in 6, 0~5s internal fuel cell end voltage is constant (cold starts), Super Capacitor fast response discharge (response time in 0.1s), 5s after Super Capacitor current is reduced to zero, powered by a fuel cell load.
steady-state performance as shown when the load is a constant resistive load, \( P_L \) always Theremains around 2.7 kW, and the voltage remains on the 270 V bus voltage.

Transient performance as shown in (a) shown, fuel cell output power with load demand power changes have a good following effect. Because the fuel cell output power can follow the negative

The load, which almost provides all the load power, the super capacitance of the SOConly minor subtraction

3. Fuel Cell system simulation Analysis

The main devices of the fuel cell system include: fuel cell stack, DC/DC Change Converter, super capacitor (SC) and High-voltage DC bus load (DC motor). As shown in (5), 90/3 kW fuel cell through a high power DC/DC Converters and 270 V/1000 ft. The Super capacitor parallel in 270 V High voltage DC bus, DC load rated power is 2.7 kW.

Less (0.03%), the voltage remains in 2001 bus voltage around, as shown in Figure 9. Reference plane power supply power quality standard GJB 181a-2003, Burning

The performance index of the material battery system is qualified. Table 1 to fuel cell APU vs. traditional APU. The comparison of metrics has the following advantages:

1. In terms of dynamic response speed, due to the addition of the millisecond response time. The Energy storage component of the, at startup time, than the traditional APU the is greatly reduced.

2. In the power generation efficiency, although the addition of high-power converters but also the efficiency of is much higher than the traditional APU, at present, fuel cell efficiency international Advanced Level has reached 90%.

3. At the energy density, calculated at the current fuel cell level, when APU run time greater than 1.37 h, fuel cell system weight can be lower than the traditional APU; as fuel cell technology, especially hydrogen storage, increases, the fuel cell system is expected to replace tradition in the future APU instead of running enough hours to prevail.

3.1 System control Policies

5 after the fuel cell provides all the power to load (2.7 kW), Super capacitor charge the status (SOC) remains unchanged, stopping the discharge. If the load's steady power is greater than the 50% of the burning material battery's steady output power, load must be in accordance with the rated current of the 20%

(max) increases the current at a time, with each current increasing at intervals of 30 s [11]. This, although the simulation of the fuel cell output power can also achieve load following, but the actual in the use of the fuel cell damage, the system control policy to make the following modifications:

1. Detecting load power, if greater than 1.5 kW's sudden, load demand power \( P_L \) with fuel cell power \( P_F_c \) make difference, that is \( \Delta P = P_L - P_F_c \). If

\[ \Delta P < 0.6 \text{kw}, \text{fuel cell output power increased} \]

\[ \Delta P > 0.6 \text{kw}, \text{Fuel battery output power increased} 0.6 \text{kw}, \text{Delay} 30 \text{s}, \text{and then} P_L \text{and} P_F_c \text{Make a bad, heavy} \]

The model of fuel cell and energy storage element is established in this paper.

The simulation results show that the steady and dynamic characteristics of the system are simulated, and the result shows that the combustion Thematic battery system can meet the power quality standards for aircraft power Systems GJB 181a-2003 requirements. The comparison of efficiency and performance with the traditional APU shows that the APU system of the battery based on the burn in dynamic performance, Efficiency is much higher than the traditional APU, and is expected to replace the traditional APU in the future, thus verifying the fuel cell based

/ / The Hybrid Auxiliary Energy unit of a storage device replaces tradition in performance Apugcan Energy.
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