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 thegjb181a-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 flymachinesAPUhave problems withA 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 is10%~20%while thefuel efficiency of the auxiliarypower unit is less than when the ground, send motive shuts down10%[1].and the fuelbattery Clean non-polluting, long service life, high efficiency, high energy density, meet more thanpower/development requirements.With the development of fuel cell research in various countries,the technical level of the ISgradually improved.The research of fuel cell hybrid system in the field of aerospacehas 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 parallelasapug[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 performanceApugthe possibility of a.

1. fuel cell system Architecture

Currently, fuel cells have3type of application: Cryogenic fuel cell/Storage PackSetsystem, high temperature fuel cell/Turbo Generator system and Renewable fuelbattery 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, accordingtothe B787The generation requirements for theAPUare shownin the design architecture asillustrated 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/SuperThegrade 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/Thesuper Capacitance access position affects the power of theinverter's front level change converter, thereby affecting its weight.

fully, select Diagram1the configuration in the ③ fuel cell through aDC/DCChangeIntandem with the Super capacitorApugan 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 modelsand electrochemical models[6].Proton exchange membrane fuel cell (pemfc) models of the fuel cell heap is byNfuel cell monomer in series, battery heap powerpressure can be expressed as a monomer voltageVFcThesum of the, assuming the fuel cell monomer voltage phaseSame, heap voltageVStExpressed as:

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

PEMFCIdeal Standard potential when reacting to liquid water formationE0For

1.229V, there are3Thepolarization of the action causesPEMFCirreversible loss of voltage.

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

Type:VActfor active polarization overvoltage,VOhmohm polarized overvoltage,VContoconcentration polarized overvoltage,E,for thermodynamics predictive voltage[9].

by Diagram4 PEMFCThe simulation resultsof the electrochemical model and the voltage dynamic model showthat the improved voltage dynamic model on the electrochemical model can betterinterpret 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 capacitorCand soonEffect resistance in parallel.Asshown inthe figure3,Eis the ideal voltage source,R0For battery Omne

Blocking,Uthe is the battery-side voltage.MaketheR1the 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 requiredthe power is supplied bySC.

3.2 Simulation Results Analysis

start performance asshown6,0~5sinternal fuel cell endvoltage is constant (coldstarts), Super Capacitor fast response discharge (response time in0.1s),5safterSuper Capacitor currentIScReduced to zero, powered by a fuel cell load.

steady-state performance asshown7shown when the load is a constant resistive load,PLalwaysTheremainsaround2.7kW, and the voltage remains on the270Vbus voltage.

transient performance asshown8as shown, fuel cell output power with load demand powerchanges have a good following effect.Because the fuel cell output power can follow the negative

Theload, which almost provides all the load power, the super capacitance of theSOConly minor subtraction

3. Fuel Cell system simulation Analysis

the main devices of the fuel cell system include: fuel cell stack,DC/DCChangeConverter, super capacitor(SC)and High-voltage DC bus load (DC motor).Asshown in5,90v/3kwfuel cell through a high powerDCConverters and

270v/1000fthe Super capacitor parallel in270VHigh voltage DC bus, DC load rated power is2.7kW[10].

Less (0.03%), the voltage remains in2001bus voltage around, as shown in Figure9.reference plane power supply power quality standardGJB181a-2003, Burning

the performance index of the material battery system is qualified.Table1to fuel cellAPUvs. traditional

APUThe comparison of metrics has the following advantages:

(1) In terms of dynamic response speed, due to the addition of the millisecond response timeTheEnergy storage component of the, at startup time, than the traditionalAPUThe isgreatly reduced.

(2) in the power generation efficiency, although the addition of high-power converters but also the efficiency ofis much higher than the traditionalAPU, at present, fuel cell efficiency international Advanced Levelhas reached90%.

(3) at the energy density, calculated at the current fuel cell level, whenAPUrun time greater than1.37h, fuel cell system weight can be lower than the traditionalAPU;as fuel cell technology, especially hydrogen storage, increases, the fuel cell system

is expected to replace tradition in the futureAPUinstead of running enough hours to prevail.

3.1 System control Policies

5safter the fuel cell provides all the power to load (2.7kW), Super capacitor chargeThestatus (SOC) remains unchanged, stopping the discharge.If the load's steady power is greater thanthe50%of the burningmaterial battery's steady output power, load must be in accordance with the rated current of the20%

(max) increases the current at a time, with each current increasing at intervals of30s[11].This, although the simulation of the fuel cell output power can also achieve load following, but the actualin the use of the fuel cell damage, the system control policy to make the following modifications:

(1)detecting load power, if greater than1.5kW's sudden, loaddemand powerPLwith fuel cell powerPFcmake difference, that is$\Delta P=PL-PFc$.If

$\Delta P<0.6kw$, fuel cell output power increasedΔpif$\Delta p>0.6kw$, Fuel

battery output power increased0.6kW.Delay30s, and thenPLandPFcMake a bad, heavy

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

The simulationresults show that the steady and dynamic characteristics of the system are simulated, and the result shows that the combustionThematerial battery system can meet the power quality standards for aircraft power SystemsGJB 181a-2003requirements.Thecomparison of efficiency and performancewith the traditionalAPUshows that theAPUSystem of the batterybased on the burnis in dynamic performance,Efficiency is much higher than the traditionalApu, and is expected to replace the traditionalApuin the future, thus verifying the fuel cell based

/TheHybrid Auxiliary Energy unit of a storage device replaces tradition in performanceApugcanEnergy.

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