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Design of high efficiency energy power system for hydrogen fuel cell cruise ship

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Abstract: With the increasing depletion of fossil fuels, combined with the worsening of the Earth's living environment, the global warming of carbon dioxide emissions, the frequency of extreme weather around the world, people's eyes began to turn to a variety of clean and renewable alternative energy resources. The International Maritime Organization and numerous countries and regions are actively taking various effective measures to reduce pollution from ships. Fuel cell is a power generation device that converts the chemical energy stored in fuel and oxidizer directly into electrical energy, and it is the only electric unit with high efficiency, no pollution, no noise, modularization and continuous operation at present, which has been widely concerned.

1. Introduction

Studies have shown that 4% per cent of total global greenhouse gas emissions come from CO_2 emissions from the global shipping industry, in addition to the annual NO_x and SO_x generated by global shipping instruments accounting for 15% and 10% of total human pollution sources. Due to the increasing environmental pollution caused by the shipping industry, the International Maritime Organization and many countries and regions are actively taking various effective measures to reduce pollution from ships.

Under this background, the application of clean renewable energy in ships undoubtedly has good prospects for development. In recent years, the cruise tourism industry in China has developed rapidly, and the people have begun to pursue the satisfaction at the spiritual level while satisfying the demand of material life. Among them, diesel engine and gasoline engine as the power of the cruise ship, its noise, soot and oil leakage and so on not only caused great damage to the ecological environment of the water, but also affected the travel experience of tourists, to a certain extent hindered the development of the high-end trend of cruise ships. Therefore, it is very necessary to study and design cruise ships with green and efficient cleaning as the main power.

2. Material and Methods

2.1. Research programmes adopted

2.1.1. Theoretical analysis

- Through the analysis of the physical and chemical characteristics of the working water of fuel cell, and referring to the existing fuel cell utilization technology, the reasonable design process of the waste heat utilization of the working water of fuel Cell is designed, and the complete piping system and the selection or design of each equipment are devised on this basis.



- After designing the complete comprehensive utilization system of waste heat of marine fuel cell reaction water, the parameters of each node are analyzed and calculated theoretically, and the knowledge of fluid mechanics, engineering thermodynamics, heat transfer and so on needs to be used in the calculation. Through the above calculation, we can get the parameters of each node under the ideal situation, so as to provide theoretical basis for the control of each valve. The approximate steps for node analysis are as follows:
- The known parameters are the power of the engine, the temperature of the working water, the flow rate of the working water, and the thermal efficiency of the relevant piping and working parts;
- through the above can first analyze the heat of working water and the heat required for ship refrigeration heating;
- Secondly, the relevant state parameters of the heating and refrigeration state of the waste heat utilization system can be analyzed.
- The flow of working water required to achieve the relevant refrigeration heating effect can then be analyzed;
- Then the flow distribution of the fuel cell working water in the pipeline can be analyzed.
- On the basis of the above analysis, the state of each valve and work piece under various working conditions can be obtained, so as to provide the basis for the design of the control program of the single chip microcomputer.

2.1.2. Simulation

Using fluent in Ansys can simulate the reaction process of fuel cell, and through the analysis of simulation results, we can further understand the reaction process of fuel cell, which is of reference significance to the design of structure and parameters.

The Simulink in MATLAB can be used to simulate the state parameters of each node, so as to provide a more specific basis for the design of the control system, at the same time, the state response under the change of boundary conditions can be studied, so as to know the fluctuation of the main parameters, and further propose measures to reduce the fluctuation. At the same time, the abnormal working conditions can be studied in order to perfect the control system, while ensuring the safety problem and improving the stability of the system.

2.2. Technical Route

2.2.1. Adsorption refrigeration Design

As an environmentally friendly refrigeration method and an effective tool for utilizing low-grade energy, adsorption refrigeration has been paid more and more attention, and has made important progress in adsorption refrigeration cycle mode under the unremitting efforts of scholars from all over the world. Starting from the actual situation of the adsorption refrigeration system driven by the waste heat of the fuel cell vehicle, the following principles should be met: The waste heat generated by the fuel cell can be fully utilized for continuous refrigeration, the structure is simple and compact, and the refrigeration efficiency should be improved as far as possible under the premise of ensuring sufficient refrigeration capacity.

From the above three principles, in order to achieve continuous refrigeration, combined with the existing technology, it is proposed to take a two-bed continuous return cycle.

2.2.2. Design of working water circulating heating system

Fuel cell power generation at the same time also produces heat, with PAFC as the most commonly used traffic fuel cell, its working water temperature of about 80°C-100°C, can be used in the use of hot water in the ship heating, drinking, domestic water and so on. Its working process is as follows: In the state of heating, the high temperature hot water produced by the fuel cell no longer as the adsorption bed, but directly into the waste heat recovery device for heat transfer, resulting in hot water directly into the

ship's circulating water distribution system, through the system temperature distribution and flow distribution system supply to the different positions of the ship.

2.2.3. Control system Design

The whole system controls the opening and closing of the valve through a single chip microcomputer and the start and stop of the pump, realizes the switching of the working mode of refrigeration, heating and normal temperature, and monitors the state of each part of the system in real time to ensure the safety and stability of the whole system operation.

3. Results

Fuel cell is a power generation device that converts the chemical energy stored in fuel and oxidizer directly into electrical energy, and it is the only electric unit with high efficiency, no pollution, no noise, modularization and continuous operation at present, which has been widely concerned. With the promotion in the automotive and other fields as well as the support of national policies, the future mainstream development of marine fuel cell systems is imperative. Through the design and research of fuel cell system module, fuel cell system on board, and fuel cell related supporting system, this project designs a set of hydrogen fuel cell power system applied to cruise ship according to the requirements of fuel cell system configuration, and realizes zero emission and 0 pollution by improving the comprehensive utilization efficiency of hydrogen fuel cell, compared with the traditional power cruise ship, the energy saving and emission reduction effect of the project is very obvious.

Based on the analysis of the reaction process of fuel cell and the reference to the existing technology, the preliminary method of comprehensive utilization system of waste heat of marine fuel cell reaction water is designed, the preliminary design is analyzed and studied, the existing problems are solved, the design is further optimized, and the parameter design of the system is carried out on the basis of structural principle design. , the process of working water flow and the state of each node are analyzed by means of theoretical analysis and simulation simulation, and the design is further modified until the theory is feasible, and the control method of the whole system is formed and perfected on the basis of the above, and the control system is designed by single chip microcomputer, which is compiled and debugged. ; The economic analysis of cost and benefit of the actual use of the system.

4. Discussion

Marine applications introduce a set of requirements for fuel cell (FC) systems. These reflect the special conditions experienced at sea (such as movement due to waves, saline air etc.) and the need to be compatible with the conventional power systems on board the vessel. The latter puts certain restraints to the FC system with regard to power quality and dynamics. Further, any installation should be in compliance with current regulations.

4.1. Fuel processing system

A natural gas processing system (reformer) may be required unless MCFC or SOFC will be used. This unit should be specified together with the fuel cell.

4.2. Refueling system

In general the refueling system shall be easy to operate and no needs for specific operations shall be required. The refueling system is dependent on the fuel storage system. During refueling no spill of ignitable gas is allowed.

4.3. Safety

All safety measures shall be included in a fuel cell installation to ensure safe operation. This includes operational procedures, design and auxiliary system as inert gas system.

4.4. Rules and regulations

The ferry shall comply with existing rules and regulations for new-buildings of conventional ferries in Norway. In addition, the ferry shall comply with NMD regulations “Regulations for building and operation of gas-powered passenger vessel” .

The ferry shall also comply with IAC 60079-10, part 10: “Classification of hazardous areas”, (see description in §6 –6.1.5 in above NMD regulations).

4.5. Fuel processing and transfer system – general arrangement

The fuel transfer system connects the fuel storage tank to the fuel cell system, and shall comply with existing regulations from NMD. Main components in this system are: piping, valves, alarm system, shut-off system, inert gas system, etc. The piping shall go through existing casing for pipes if the storage is below main deck.

A double piping system is required for transfer of gaseous fuel. In case of leakage, the double pipe system shall be ventilated to the top of a mast beam above highest point on the ship. In all spaces and voids, which may be exposed to gas leakage, a gas detection and alarm system is required.

The original natural gas piping system on board will be used. This system will supply natural gas at a delivery pressure of app. 4 bar to the fuel cell system.

5. Conclusion

Taking inland river cruise ships as the object, the design and waste heat utilization of fuel cell hybrid ship are carried out, and a set of small ship integrated power system controlled by DC/DC is established, which is mainly based on hydrogen fuel cell and supplemented by lithium battery, and the temperature control is carried out under the flow control of single chip microcomputer by using power system to generate residual heat. To realize the multi-stage utilization of residual heat, it provides a new feasible scheme for improving the efficiency of energy use.

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