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Research on Heat Dissipation of Photovoltaic Inverter based on Micro Heat Pipe Array in Lhasa

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Abstract

Aiming at the current situation of high altitude, thin air, poor insulation of electronic components and poor heat dissipation of photovoltaic inverter in Lhasa, a photovoltaic inverter radiator based on micro heat pipe array is designed, and its heat dissipation working principle is introduced. By comparing the heat dissipation performance of micro heat pipe array radiator filled with acetone, water and R141b, it is found that the heat dissipation performance of micro heat pipe array radiator filled with acetone is better than that of water and R141b, and its heat flux density is 142.8W/cm2 when the hot end temperature is 65 ℃; At the same time, after installing the micro heat pipe array radiator, the average ambient temperature in the photovoltaic inverter box decreases by about 2.8 ℃, and the average surface temperature of IGBT module decreases by about 3.2 ℃, which verifies the actual performance of the micro heat pipe array radiator.

Keywords

Lhasa Region; Micro Heat Pipe Array; Photovoltaic Inverter; Dissipate Heat.

1. Introduction

With the increasing prosperity of Tibet's economy and society, the increasing improvement of material living standards, the increasing demand for energy supply and the increasing proportion of solar energy year by year. The market share of photovoltaic inverter, as the heart of photovoltaic power station, also increases rapidly. As the key equipment of solar photovoltaic power station, its actual comprehensive use performance determines the solar energy utilization efficiency, conversion efficiency and construction cost of the whole photovoltaic power station. Therefore, it is particularly important to improve the comprehensive use performance of photovoltaic inverter. According to data statistics, the core components of photovoltaic inverter will convert active power into a large amount of heat energy during normal operation, and the conversion ratio is about 1% ~ 1.5%. The converted heat energy will not only increase the junction temperature of the core components, affect the overall operation stability of photovoltaic inverter, but also greatly shorten its service life [1]. For example, when the temperature of core components increases by 2 ℃, its reliability decreases by about 10%. When the temperature rises to 50 ℃, the service life of photovoltaic inverter will be only 1 / 6 of the operating temperature of 25 ℃ [2]. Therefore, it is necessary to release this part of heat timely and effectively, so as to achieve the purpose of not affecting the service performance of core components, improving the reliability of stable operation of photovoltaic inverter and reducing the burnout probability of core components.

The main heat dissipation core component of photovoltaic inverter is IGBT (insulated gate bipolar transistor), which is the heart of photovoltaic inverter and plays the role of power conversion and energy transmission. If the internal ambient temperature of photovoltaic inverter is too high and the heat dissipation is poor, IGBT will fail [3]. Shanhaijian [4] introduced

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the power and heat dissipation structure of IGBT, the core component of photovoltaic inverter, gave the calculation method and results of the thermal resistance of IGBT's radiator in the normal operation process, and briefly described the general criteria that should be followed for air-cooled heat dissipation through natural convection; Yang xiongpeng, Zhou Xiaodong and others [5] introduced the optimization design and optimization screening of photovoltaic inverter heat dissipation system by putting forward the basic idea and theory of Flotherm software simulation, and studied the influence and correction of altitude on photovoltaic inverter heat dissipation performance by using CFD numerical simulation and measured data; Zhang Guodong, Gao Miaoxiang and others [6] used Icepak to establish the numerical simulation of power module loss, radiator design, fan selection and thermal simulation, studied the reliability of the distribution of velocity field and temperature field in the internal environment of photovoltaic inverter on thermal simulation, and verified the accuracy of ICEPAK software on the thermal simulation of photovoltaic inverter; Tao Gaozhou, Lu You and others [7] reasonably simplified and equivalent treated the photovoltaic inverter by using the natural convection heat dissipation method, and established the simulation model through ICEPAK to verify and optimize the prototype.

The heat dissipation of photovoltaic inverter has increasingly become a key factor affecting its operation reliability and stability, and the requirements are gradually improved. In this paper, the heat dissipation research of photovoltaic inverter based on micro heat pipe array is carried out in Lhasa. Using the super thermal conductivity of special micro heat pipe array, the design, research and analysis of enhanced radiator are carried out on the basis of existing photovoltaic inverter heat dissipation devices.

2. Experimental Device and Principle

2.1. Experimental Micro Heat Pipe Array

The micro heat pipe array used in the experiment in this paper is shown in Figure 1. The shape is rectangular flat plate and the material is aluminum. There are two sizes of micro heat pipe array, whose sizes are 900 mm respectively × 50 mm × 3 mm (Long × Wide × Thickness) and 500 mm × 50 mm × 3 mm (Long × Wide × Thickness). The transverse and longitudinal sections of the micro heat pipe array are shown in Figure 2 and figure 3. The interior of the two micro heat pipe arrays is composed of a certain number of independent micro heat pipes with the same size, and each micro heat pipe is equipped with micro channels. This structure can effectively improve the overall reliability of the micro heat pipe array. Even if a certain part is damaged, it will not affect the overall service capacity of the micro heat pipe array. At the same time, the experimental research shows that the flat plate micro heat pipe array has very good temperature uniformity and fast thermal response speed [8]. The internal working fluids of the two micro heat pipe arrays are filled with water, acetone and R141b respectively, and the liquid filling rate is 50%.

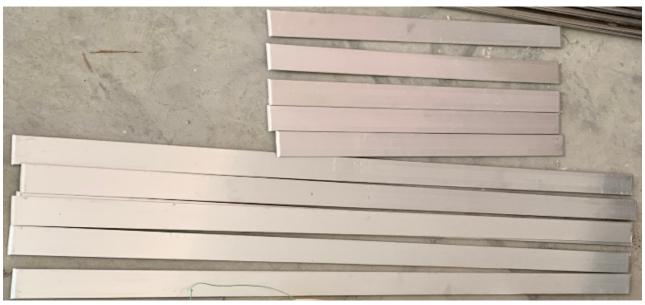

Fig 1. Physical diagram of micro heat pipe array

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Fig 2. Cross section of micro heat pipe array

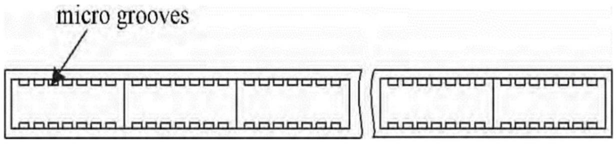
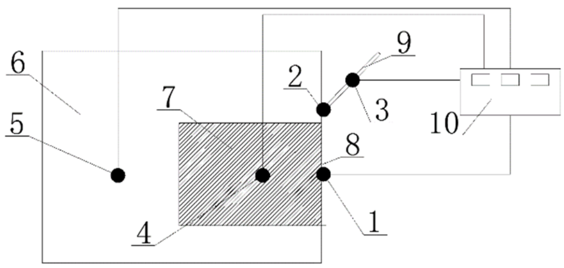


Fig 3. Longitudinal section of micro heat pipe array

2.2. Experimental Device

The experimental device is shown in Figure 4, which is mainly divided into three parts: core components, micro heat pipe array radiator and data collector. A micro heat pipe array radiator is externally installed on the PV Inverter in normal operation, which is directly attached to the shell corresponding to the core components of the PV inverter through thermal conductive silicone grease, and the whole radiator is divided into two parts: the lower hot end and the upper cold end, with a ratio of 2:1 and a vertical included angle of 45 ℃. The working principle of the whole set of experimental devices is as follows: the heat generated by the core components of the photovoltaic inverter flows to the shell of the inverter box through heat conduction, and the hot end of the micro heat pipe array radiator absorbs the heat. The internal working medium evaporates from the liquid state to the gaseous state, and the heat is transmitted from the hot end to the cold end of the micro heat pipe array radiator. The cold end carries out natural convection heat exchange with the outside air, and the gaseous working medium releases the heat to the air, and then becomes liquid again, Under the action of gravity, it flows back to the hot end, so repeatedly, so as to take away the heat generated by the core components of the photovoltaic inverter. In this paper, the calibrated high-precision K-type thermocouple is used to transmit the environmental temperature in the photovoltaic inverter box, the surface temperature of core components, and the temperature data of the hot end and cold end of the micro heat pipe array radiator to the data collector.



1 - hot end temperature acquisition point; 2 - intermediate section temperature acquisition point; 3 - cold end temperature acquisition point; 4 - surface temperature collection points of core components; 5 - ambient temperature collection point in the box; 6 - inverter box; 7 - core components; 8 - hot end of micro heat pipe array; 9 - cold end of micro heat pipe array; 10 - data collector

Fig 4. Experimental device

3. Experimental Results and Analysis

3.1. Effects of Different Working Fluids on Heat Flux

For the size of 900 mm × 50 mm × 3 mm (Long × Wide × Thickness) and 500 mm × 50 mm × 3 mm (Long × Wide × Thickness) micro heat pipe array, respectively filled with three different working fluids: water, acetone and R141b, and when the filling rate is 50%, test its heat flux, and then analyze the heat dissipation performance of micro heat pipe array radiator. The experimental data are shown in Figure 5 and Figure 6. The heat dissipation performance of micro heat pipe array radiator filled with acetone working medium is better than that of water and R141b. It can be seen from Fig. 5 that when the hot end temperature of the 900mm long micro heat pipe array radiator is 65 ℃, the heat flux density of the micro heat pipe array radiator filled with acetone is 142.8W/cm^2, while that of water is 122.3W/cm^2 and that of R141b is 121.5W/cm^2. This is because with the rise of the hot end temperature of the micro heat pipe array radiator, the phase transformation of its internal working medium intensifies. In Lhasa, the boiling point of acetone is about 50.3 ℃ and that of water is about 89 ℃, Therefore, compared with water, the phase transition of micro heat pipe array radiator filled with acetone will be more intense in practical use. At the same time, the boiling point of R141b in Lhasa is about 28.6 ℃. In the 900mm long micro heat pipe array radiator, the evaporation section is 300mm long, the length of the evaporation section is relatively small, and the heat cannot be taken away in time under the influence of poor natural ventilation. As a result, the heat flux of the micro heat pipe array radiator filled with R141b begins to reach the maximum state when the hot end temperature reaches 45 ℃, and the linearity tends to be flat, It is basically maintained at about 125W/cm^2. Compared with the 500mm long micro heat pipe array radiator, the 900mm long micro heat pipe array radiator has greater heat flux, so the heat dissipation effect is better.

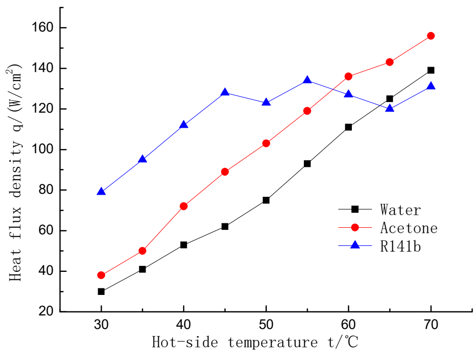


Fig 5. Heat flux density of 900mm long micro heat pipe array radiator filled with different working fluids

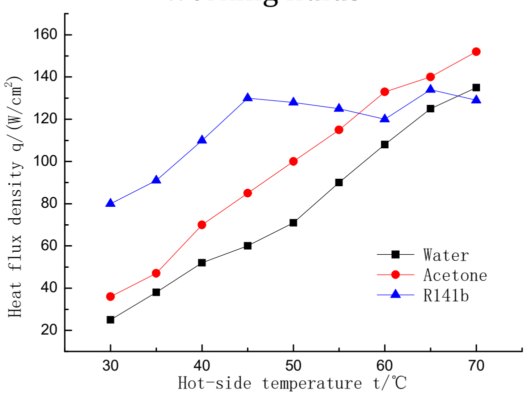


Fig 6. Heat flux density of 500 mm long micro heat pipe array radiator filled with different working fluids

3.2. Heat Dissipation Performance Experiment

Based on the existing 50kW normal operation photovoltaic inverter, the size of 900 mm is selected in this paper × 50 mm × 3 mm (Long × Wide × Thickness) micro heat pipe array radiator filled with acetone and with a liquid filling rate of 50% is evenly placed outside the outer casing of IGBT module at a plane spacing of 1cm, and the contact part between them is filled with high-efficiency heat-conducting silicone grease to make it compact and contact. Through the calibrated high-precision K-type thermocouple, comparative tests are carried out respectively: The ambient temperature in the photovoltaic inverter box with / without micro heat pipe array radiator and the surface temperature of IGBT module with / without micro heat pipe array radiator. The experimental data are shown in Figure 7. The average ambient temperature in the PV inverter box without micro heat pipe array radiator is about 51.5 ℃, and the average surface temperature of IGBT module is about 72.3 ℃. After installing the micro heat pipe array radiator, the average ambient temperature in the photovoltaic inverter box is about 48.7 ℃, the average temperature decreases by about 2.8 ℃, and the temperature decrease ratio is 5.4%; The average surface temperature of IGBT module is about 69.1 ℃, the average temperature decreases by about 3.2 ℃, and the temperature decrease ratio is 4.4%. Therefore, the micro heat pipe array radiator filled with acetone can really strengthen the heat dissipation effect of photovoltaic inverter. At the same time, it can be clearly reflected from Figure 7 that the thermal response time of the micro heat pipe array radiator is about 90s, and it is basically in a stable state after 90s, so the micro heat pipe array radiator can achieve a faster cooling effect.

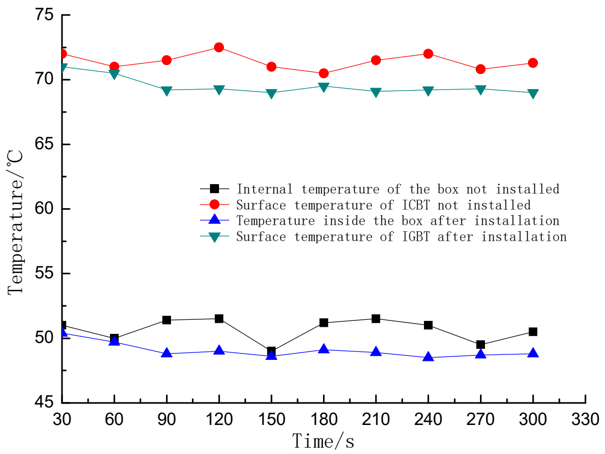


Fig 7. Heat dissipation effect of micro heat pipe array radiator

4. Conclusion

In this paper, aiming at the high altitude and thin air in Lhasa, the existing 50KW photovoltaic inverter has limited heat dissipation capacity. By effectively coupling the heating status of photovoltaic inverter with micro heat pipe array heat dissipation technology, a micro heat pipe array radiator is specially designed to strengthen the heat dissipation effect of photovoltaic inverter. Combined with relevant research, the conclusions are as follows:

(a) The heat dissipation performance of micro heat pipe array radiator filled with acetone working medium is better than that of water and R141b. For example, when the hot end temperature is 65 ℃, the heat flux density of micro heat pipe array radiator filled with different working fluids is 142.8w/cm2 for acetone, 122.3w/cm2 for water and 121.5w/cm2 for R141b. Therefore, micro heat pipe array radiator filled with acetone has better heat dissipation effect.

(b) Through comparative experiments, the micro heat pipe array radiator filled with acetone can really strengthen the heat dissipation effect of photovoltaic inverter. If the micro heat pipe array radiator is installed, the average ambient temperature in the photovoltaic inverter box will drop by about 2.8 ℃ and the temperature drop ratio will be 5.4%; The average surface temperature of IGBT module decreases by about 3.2 ℃, and the temperature decrease ratio is 4.4%.

(c) Combined with the experimental data, the micro heat pipe array radiator can achieve a faster cooling effect, and its thermal response time is about 90s.

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References

[1] Billings K. switching power supply manual [M] Translated by Zhang zhansong, Wang renhuang, Xie Liping Beijing: People's Posts and Telecommunications Press, 2006: 500-501.

[2] Yu Jianzu Thermal design and analysis technology of electronic equipment [M] Beijing: Higher Education Press, 2002.

[3] Zhang Honggen, Zheng Xinyan Thermal design of high heat chassis [J] Applied world, 2007, 8 (10): 55-56.

[4] Mountain and sea construction Thermal design of photovoltaic inverter power unit [J] Science and Technology Forum, 2011, (18): 35.

[5] Yang xiongpeng, Zhou Xiaodong, et al Heat dissipation design of photovoltaic inverter based on Flotherm analysis [J] Electric power technology, 2013, 3.54-47.

[6] Zhang Guodong, Migao Xiang, etc Heat dissipation analysis of centralized photovoltaic inverter based on Icepak [J] Mechanical design and manufacturing engineering, 2019, 48 (7): 104-107.

[7] Tao Gaozhou, Lu You, etc Study on natural convection heat dissipation of low power photovoltaic inverter [J] Electromechanical engineering, 2014, 30 (3): 19-23.

[8] Wan Li, Pu zewei, etc Experimental study on heat transfer performance of floor heating system based on micro heat pipe array in plateau area [J] Sichuan Institute of architectural science 2019, 45 (06): 90-96.