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Application of semiconductor refrigeration and heating system in sportswear

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Abstract: *Solar clothing is a kind of clothing which usually uses sunlight as its energy source, converts solar energy into electricity based on the principle of photovoltaic power generation system and Peltier action, and outputs electricity through the design of clothing itself or the electronic devices it connects. This paper studies the combination of solar heating and semiconductor refrigeration systems. The team designed a solar suit similar to the design of the assault suit. The garment is mainly composed of a solar heating device, a semiconductor refrigerating device, a temperature sensor, a solar panel, a storage battery and the like. The liner design of the assault jacket effectively realizes the conversion of the heating and refrigeration system. By collecting information and making models, we have completed the research of our team project.*

Keywords: *solar energy, semiconductor, refrigeration, heating, sportswear*

1. Introduction

Solar energy is a kind of renewable green energy. China began to use solar energy to make fire as early as 3000 years ago, and the history of its use as green energy is only a few decades. At the same time, the advantages of semiconductor refrigeration are light weight, small size, no noise, low risk and so on. As people pay more attention to the functionality of clothing and the concept of environmental protection, the research on solar clothing will gradually increase. This paper mainly designs a solar clothing to realize the function of cooling or heating at different temperatures. By consulting relevant information and referring to the knowledge of human mechanics in the process of exercise, different solar panels and mosaic sewing methods are selected at different positions, and fabrics with strong air permeability and fiber strength are selected to achieve the highest conversion rate of light energy and refrigeration and heating efficiency.

1.1 Research background

With the rapid development of society, the evolution of clothing has been accelerated, and people's attention to the functionality of clothing has been aroused. According to the evolution of clothing and people's living needs, the next fashion trend that is sought after by people has a great opportunity to integrate technology and function like "solar clothes". Clothes using solar energy for cooling and heating, with renewable green energy-solar energy as the energy source, are environmentally friendly, which makes it of great research significance.[1]In this paper, a system using solar photovoltaic power generation to provide direct current for semiconductor refrigerator is designed. The system has the advantages of low pollution index, high safety performance and easy installation. At present, the domestic and foreign research on the application of solar semiconductor refrigeration has always focused on small devices such as refrigerators and ice machines, and the semiconductor refrigeration and heating technology has not been organically combined.

1.1.1 Current Research Focus on Semiconductor Refrigeration

Nowadays, energy conservation and environmental protection have become the main criteria for evaluating new technologies, and semiconductor refrigeration technology is known as the "green refrigerant" in the 21st century, which has a wide range of development, great research significance and a wide range of application prospects. Because the convenience and other values of semiconductor refrigeration technology are much higher than traditional refrigeration technology, and the semiconductor industry is developing rapidly, many researchers in the world have begun to study semiconductor

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refrigeration technology in depth.

In the application of semiconductor refrigeration technology, it is necessary to adjust measures to local conditions, design the unused performance according to the use requirements, in order to expand the application field of the technology. It can be predicted that the future development of semiconductor refrigeration technology will be more and more rapid, and the scope of application will be more and more extensive.[2]

1.1.2 Half Necessity of the Development of Conductor Refrigeration

Because of the geographical location, the electricity bill in some marginal areas of our country is very high, and it is even impossible to evaluate the convenience of using electricity in some areas. Solar energy plays an important role in these places. The advent of semiconductor materials with improved thermoelectric properties has also greatly increased the efficiency of the thermoelectric effect, making thermoelectric refrigeration an experimental technology. Compared with the traditional vapor compression injection and absorption integrated cooling mode, the advantages are as follows:(1) Zero use of refrigerant is realized, which is friendly to the environment.(2) The cooling position can be specified, and it has the function of positioning cooling.(3) That volume is small, the occupy area is reduced to a certain extent, and the weight is light.(4) There is no mechanical rotation, so there is no noise, no wear, reliable operation and convenient maintenance.(5) Two different purposes of cooling and heating can be achieved by changing the current direction.(6) It has the ability to generate electricity, and if the temperature difference is established between the two sides of the refrigeration component, it can generate direct current.(7) that cool speed is high, and the cooling speed can be control by adjusting a working power supply, so that the control is convenient.

Despite the current technical conditions, the efficiency of thermoelectric refrigeration is lower than that of compression refrigeration in the case of large capacity, and the price is expensive.[2]As a source of cold air for specific technical applications, the semiconductor cold plate has the following advantages.(1) The semiconductor refrigeration chip has two functions, both refrigeration and heating. The refrigeration efficiency is generally not high, but the heating efficiency is very high, always greater than 1. Thus, the use of the semiconductor can replace separate heating and cooling systems.(2) The reverse use of the semiconductor cooling chip is temperature difference power generation, and the semiconductor cooling chip is generally suitable for power generation in a medium and low temperature area.(3) The temperature range of the semiconductor cooling chip can realize a temperature difference from a positive temperature of 90.degree.C.to a negative temperature of 130.degree.C.

1.2 Current application of solar energy in refrigeration

1.2.1 Compression type solar air conditioner

The air conditioner is completely the same as the host of the conventional air conditioner sold on the market at present, and the only difference is that the electric energy is provided by a solar cell, so that the air conditioner is difficult to popularize under the condition that the cost of the solar cell is high at present.

1.2.2 Olar metal hydride air conditioner

This system is a high and new technology developed in recent years, which is one of the hot research and development at home and abroad. Its endothermic and exothermic principle is based on the process of hydrogen desorption and absorption of metal hydride at different temperatures.

1.2.3 Solar absorption air conditioning

The principle of solar absorption air conditioning is solar absorption refrigeration, which is a common way of solar refrigeration. Its principle is to combine ammonia or lithium bromide absorption air conditioner with solar hot water system to realize the functions of cooling in summer, heating in winter and hot water supply throughout the year. At present, the technology of our country has not yet realized the assembly line production of low-power lithium bromide refrigerators, the main contradiction is divided into two aspects, on the one hand, the cost of refrigerators is too high, and the power of refrigerators produced is too large due to technical constraints, on the other hand, the area of solar water heating system is too large to be installed in normal residential houses, and the energy cost used in its manufacture is too high. Therefore, only by reducing the cost of the system and speeding up the production of commercialized low-power solar absorption chillers, can solar absorption air conditioning be popularized.

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1.2.4 Olar solid adsorption refrigeration

Solid adsorption refrigeration based on solar energy, which is a refrigeration technology without using Freon refrigerant, has become one of the most popular research topics in the refrigeration industry. Its advantages are simple design, high efficiency, no traditional energy consumption, low noise, long service life, high safety and no corrosion. Many studies have shown that many modern solid adsorption refrigeration cycles, such as continuous thermal cycles, have good performance characteristics, but the system performance cannot meet the requirements of practical applications. The solar adsorption refrigeration system usually operates under negative pressure, and after a period of time, its performance will decline and eventually stop.[3]

1.3 Current Application of Solar Energy in Heating

1.3.1 Direct expansion heating system

Replacing the air-cooled evaporator of the air source heat pump with a solar collector is the core design of the direct expansion solar energy heat pump heating system, which absorbs solar radiant heat as the main low level heat source and air energy from natural convection as the auxiliary low level heat source to meet the heat load demand of users.

1.3.2 Phase-change heat storage type heating system

Energy storage technology is one of the most effective ways to correct the instability of solar energy quality and the mismatch between peak load and off-peak heat load curve. Phase-change energy storage has a higher potential heat exchange capacity and is more efficient in regulating system performance than, for example, single-phase water energy storage. At present, the research on phase change solar hot air heating system mainly focuses on three aspects, namely, improving the direct expansion solar hot air heating system, developing the three-loop heat exchanger and implementing the phase change thermal storage water heater.[4]

2. Research methods

2.1 Object of study

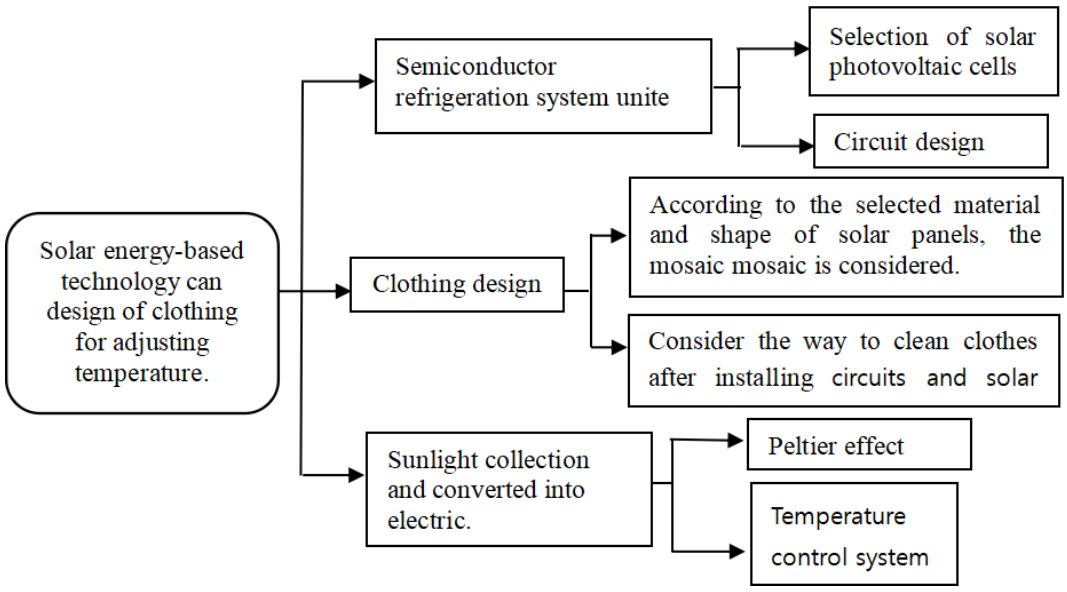

Figure 1: Mind map of solar clothing research

Solar clothing is usually With sunlight as the energy source, based on Action principle of photovoltaic power generation system and Peltier action.The solar energy is converted into electric energy according to the optical principle,Through Designed for or attached to the garment itself Electron Device Pieces Converting electrical energy into other energy(Such as charging,lighting,warning,alarm,etc.)Output Yes A kind of Clothing,most of the solar clothing studied now is solar charging clothing and solar thermal clothing.At present,there are few solar clothing in the market,and most of them are limited by weather

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conditions.Therefore,it is of great significance to develop new functional solar clothing to break through the industrial bottleneck and open up the solar energy market. In this paper,two systems of solar heating and semiconductor refrigeration are studied.Combined, the mind map is shown in Figure 1.

2.2 Research methods

2.2.1 Costume design

After designing, the team divided the whole clothing design into two parts in order to improve the conversion rate of solar energy and ensure the basic aesthetic of clothing. One part is the surface design, which is mainly used to install solar panels, and the main problem to be solved is the way of inlaying and sewing with solar panels and the choice of cloth. The other part is a liner design, which is mainly used for placing a control circuit device and effectively improves the designability of the garment.

2.2.2 Surface Design of Garment

Because of the particularity of the clothing designed, when designing the appearance of clothing, the team will consider both the aesthetic and functional nature of clothing. Aesthetics mainly focuses on the color of clothing, not only to pay attention to its individuality, but also to take care of its commonness, that is, popularity, so as to make it more aesthetic and social. The functionality mainly focuses on the mosaic position and stitching method of solar panels. In the design of clothing, the placement of solar cells needs to take full account of the dynamic movement changes of the wearer's body and clothing in different sports scenes. The designed clothing does not affect the normal activities of the human body, nor should it destroy the beauty of the clothing, according to the force relationship on the clothing when the human body moves, referring to the knowledge of human mechanics, different solar panels and mosaic sewing methods are selected at different positions to achieve the highest conversion rate of light energy. Solar cells are usually installed in areas that are less active and can receive sunlight to a large extent, such as the back, chest, etc.

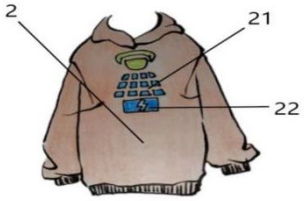

Figure 2: Solar clothing front view

The surface design sketch of the clothes is mainly to put some solar panels on the back, and the layout can be designed by yourself. The charging mark indicates the interface with the circuit device in the clothing liner, such as Figure 2.

2.2.3 Inner container design of temperature control system

Due to the design of the inner container, the temperature control system is closer to the human body; when the external temperature changes, the clothes start to heat or refrigerate correspondingly; because the inner container is more fitted with the human body, a better temperature control effect is achieved; meanwhile, the combination of the temperature control system and the inner container increases the functionality and aesthetics of the clothes; and the detachable design also makes the later cleaning of the clothes more convenient. According to the stress relationship on the clothes when the human body moves, the temperature control system consists of a semiconductor temperature control system controlled by a temperature sensor and is combined with an independent clothes liner, and is connected with a solar power supply system according to a designed circuit to provide refrigeration or heating according to corresponding requirements. As shown in the Figure 3.

The inner container of the clothes is similar to the design of the assault clothes. The inner container can be understood as the circuit device of the clothes, which is the hub of the alternation of hot and cold clothes. The semiconductor cooler is also in the inner container. The style of the back of the garment is shown in Figure 4.

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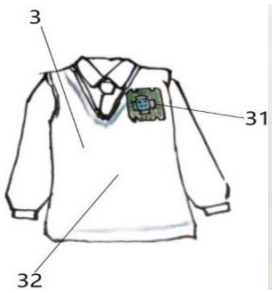

Figure 3: Solar clothing liner front display

Figure 4: Solar clothing back display picture

2.2.4 Selection of Clothing Fabric

Clothing fabric is the basis of clothing. To design a garment, we need to choose the appropriate fabric according to the corresponding season and style. When choosing fabrics, the team needs to consider the sewing degree between fabrics and solar panels, the comfort and aesthetics of fabrics, and the convenience of cleaning in the future. Generally speaking, the wear resistance of synthetic fiber fabrics is higher than that of natural fiber fabrics, so designers often use synthetic fiber fabrics when choosing sportswear fabrics. The fabrics with better waterproof performance are mainly made of nylon and polyester, such as nylon, memory-like fabrics, etc. The performance of these fabrics is more in line with the requirements of this paper.Moreover, the solar thermal system needs to be more fully exposed to the sun in order to function more effectively, and the ultraviolet rays in the sun are also a little destructive to the non-coding RNA substances in the long fiber chain, so it is also necessary to consider the sun-resistant characteristics of fabrics, such as polyester is better than nylon.[5] In addition, the material has high strength and toughness, the shorter fiber is 5.6 ~ 5.7 cN/dtex, and the higher strength glass fiber is 5.6 ~ 8.0 cN/dtex. Therefore, polyester as clothing surface cloth can be well sewn with solar panels. In addition, the easy washing and quick drying of polyester fabrics also bring great convenience for daily wear.

2.3 Study the principle

The working principle of the 0.5 conductor central air conditioning device driven by sunlight is mainly the working principle of the solar photovoltaic power generation system and the Peltier effect. Photoelectric effect is that when the solar light reaches the p-n junction surface of the 0.5 conductor radio, a new hole center-electron pair is formed. Under the influence of the p-n junction electric field technology, the hole center first enters the p region from the n region, and then the electron enters the n region from the p region. When the grid is connected, an output current is formed. The Peltier effect can also be simply expressed as that under the influence of the electric field, when the atoms move in the direction, part of the internal energy is pushed to the end of the external electric field technology. The device has the advantages of simple and compact structure, convenient carrying, simple and convenient operation, high safety and stability, and capability of dispersing electric energy, so that the energy storage device is simple in design and high in stability. It does not need to change the current mode to change from the cooling state to the heating state.

2.3.1 Calculation of System Transformation Method

Light energy/photoelectric conversion efficiency: nominal electric power per square meter/1000 W

Nominal electric power density: product power/product area

Experimental data are as shown in the Table 1.

Table 1: Experimental data of solar panel output power

Intensity = 1.88w/M D^2 = 25 cm

Load resistance R/Ω	0	15	30	45	60	75	80	85	90
Output voltage U/V	0.03	0.35	0.64	0.99	1.29	1.680	1.69	1.84	1.87
Output current I/mA	21.2	21.1	21.1	21.2	21.2	21.2	21.0	20.8	20.7
Output Power P/mA	0.64	7.39	13.50	20.99	27.35	35.62	35.49	38.27	38.90

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Table 2: Solar radiation data by region in China

Level	Area	Annual total radiation (kcal/em²)	Local annual average sunshine duration H (H) under standard irradiance	Average daily power generation Actual load usage (kWh)	Average daily reduction CO^2 emissions (kg)
1	Northern Ningxia and western Gansu Ministry, Southeast Xinjiang, Qinghai West of the sea and west of Tibet	160~200	7.15~8.93	47.30~59.07	41.15~51.39
2	Northwest Hebei and northwest Shanxi Ministry, Inner Mongolia Southern Ningxia and central Gansu Ministry, Eastern Qinghai Southeastern Tibet and southern Xinjiang Edge	150~160	6.69~7.15	44.25~47.30	38.50~41.15
3	Yunnan, Shandong, Henan,Southeast Hebei Southern Shanxi and northern Xinjiang Ministry, Jilin, Liaoning, Shaanxi Northwest and southeast of Gansu Ministry of Agriculture, Northern Anhui, Guangdong Southern, southern Fujian, Jiang Northern Soviet Union	120~140	5.35~6.25	35.39~41.34	30.79~36.00
4	Hunan, Guangxi, Jiangxi, Zhejiang and Hubei Northern Fujian and northeastern Guangdong Ministry, Southern Shaanxi Southern Jiangsu, Heilongjiang,Southern Anhui	100~120	4.46~5.36	29.50~35.46	25.67~30.85
5	Sichuan and Guizhou	80~120	3.57~4.46	23.62~29.50	20.55~25.67

To sum up, the specific consumption of batteries and solar panels in the system can be selected according to the figure in Table 2.

2.3.2 Conversion efficiency of refrigeration system

The most important factors affecting the cooling efficiency of solar energy to the 0.5 conductor radio are the intensity of solar radioactivity, the photoelectric conversion efficiency of solar panels, the temperature of the hot end of semiconductor refrigeration and the way of heat dissipation. Therefore, this chapter will focus on the effect of solar irradiance on the cooling effectiveness of a 0.5 conductor radio. Through the test, it is concluded that the cooling rate of the solar 0.5 conductor central air conditioning device changes with the change of solar irradiance, and eventually tends to be stable and reaches a critical state. In practice, the best lighting rate can be achieved by properly adjusting the inclination of the solar cell, and the experiment shows that the inclination of the solar cell is only 0 °. The principle of the refrigeration plate is Peltier effect. One part of the electric energy is used to transfer heat, and the other part generates Joule heat. Therefore, one part of the heat generated by the refrigeration plate comes from the electric energy, and the other part comes from the heat absorbed by the cold end. Therefore, its refrigeration efficiency is only 50% ~ 60%.

2.3.3 Conversion efficiency of heating system

Through the relevant physical equations, it can be concluded that the Peltier heat generated from the heating end is inversely proportional to the output voltage, while the Joule heat is inversely proportional to the square of the current. The heat conducted by the heating end is independent of the voltage, so the heat generated will further increase with the increase of the voltage. According to the experimental data, the stable temperatures in the heating space are 0.5 ℃, 1.5 ℃.8 ℃, 4. ℃ and 5.5 ℃. In the experiment, when the current is 3A, the internal temperature of the heating space reaches 5. 5 ℃, which is 9. 5 ℃ higher than the ambient temperature, and the heating effect is ideal. According to the theoretical analysis of thermoelectric refrigeration, the heat released by the hot end is larger than the electric power consumed when the semiconductor refrigerator is used for heating, so the heating function is much easier to realize than the refrigeration function, and the heating experiment only needs to change the direction of the current flowing through the semiconductor thermoelectric refrigerator, and the heating efficiency is greater than 100%.[6]

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3. Results and analysis

Solar panels on clothing absorb solar energy and store it in batteries to start cooling or heating at any time when the weather changes. When the current normally passes through the semiconductor refrigerator, the semiconductor realizes the balance of heat dissipation and refrigeration by using the energy stored in the battery, thereby effectively and stably refrigerating; Accord to that direction of current conversion in theory, the semiconductor utilizes the photovoltaic effect and the Peltier effect to heat normally, so that the temperature of the semiconductor attache to the inner container is increased, and the temperature control effect in theory is achieve on the whole. A temperature display on the surface of the garment, connected to a semiconductor device, can observe the temperature change all the time. Under normal conditions, the temperature display is refreshed once a second. Through experimental observation, the effect of refrigeration and heating conversion is ideal.

4. Conclusions and recommendations

At present, with the gradual improvement of the world's development level, environmental problems are gradually exposed, and the speed of information transmission is also accelerated, which makes various industries begin to understand more environmental problems. The surface of clothing receives sunlight for a long time, which is a good carrier to use solar energy. Integrating it is an effective way to open up new green energy. Although there are many kinds of clothing and strange styles nowadays, the existing clothing can play two roles of decoration and warmth preservation. If decoration and environmental protection are integrated, the benefits will be greatly increased. People working in some special environments also increasingly hope that clothes can have these functions, such as heating, to make life more convenient. The significance of the research on solar clothing is as follows: (1) This research adheres to the concept of green clothing, which involves not only green clothing, but also the rational use of resources, the maintenance of the environment and other fields. Compared with clean energy such as wind power and tidal energy, the sun will not be destroyed in the process of research and use, and its reserves are unlimited, so it is an ideal alternative fuel for human beings. (2) The solar clothes utilize solar energy to provide heat energy and electric energy, meet different requirements of human bodies on temperature in different environments, and effectively improve the utilization rate of resources and the comfort level of human bodies. Through the circuit control device, the temperature of the clothes can be increased in cloudy days, and the temperature of the clothes can be decreased in sunny days, so that the clothes do not need to be reduced or increased, and the quality of life of audience groups is effectively improved.

At the same time, the ready-made clothes made by the team have the following shortcomings: (1) The conversion efficiency of solar panels is too low. In the following experiments, we can replace the original solar panel material by comparing the solar panels made of various materials, considering their comfort and conversion efficiency. (2) That volume of the solar panel and the circuit control device in the current finished product is too large. Although it is easy to install, there is a risk that the device will fall off during movement because of its large size and heavy weight. In subsequent experimental studies, the team wants to decompose the whole into chip-like connection devices to enhance its overall stability.

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