

## Test and application analysis of graphene electric heating mode

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**Abstract:** In recent years, many technical experts and personnel have conducted long-term research on “Energy saving and emission reduction”. Among them, graphene is a very environmental protection and anti-pollution of one of the new materials. Since it was developed, it has received great attention from all over the world. The academia has carried on the certain research to the graphene electric heating way, many demonstration results still need to be further short of person. This paper discusses the test and application of electric heating mode of graphene, the article will be combined with the analysis of graphene heating mode, and finally put forward some personal suggestions.

### 1. Introduction

With the increasing awareness of energy-saving in modern society, the research on energy-saving technology has become more and more in-depth. The so-called energy saving, in a sense, means to save the Earth's limited energy, through the introduction of new technology to reduce excessive energy loss and to minimize the energy consumption of the process of external emissions of pollutants. The ultimate goal of carbon reduction is to reduce carbon emissions, which usually means to minimize carbon emissions in normal life on the basis of meeting the needs of production, refers to the energy used should be as far as possible to reduce carbon emissions, in order to reduce the energy loss process of carbon dioxide emissions generated by the external. Graphene has attracted wide attention from all walks of life since it was studied and produced by scientists. The reason why this material can receive so high attention, mainly because the material has a high environmental protection and energy-saving value. The application of graphene in heating in the north of our country has a certain value, this material is still being studied.

### 2. Overview of graphene materials and characteristics of graphene materials

#### 2.1 Overview of graphene materials

Graphene, a two-dimensional graphite made of carbon atoms, is a new material in the field of chemical industry? The C bond length is about 0.142 nm. In 2004, Novoselov et al developed the material by using mechanical glass and other methods. It is composed of graphite, carbon nanotubes (CNT), fullerene (C60) and other basic units<sup>[1]</sup>. In graphene, each carbon atom is connected to its neighbors, forming a six-membered ring that extends to form a honeycomb-like planar sheet. The thickness of the material is about 0.335 nm<sup>[2]</sup>, and the thickness of the planar lamellar material is approximately equal to the diameter of carbon atom, which is the smallest known material.

#### 2.2 Characteristics of graphene materials

Graphene material has become a model of new environmental protection materials since it was developed. Because of its excellent electrical conductivity, it has been widely used in many fields. Graphene self-heating product is an important core heating material, so the material is also known as the “King of new materials in the 21st century”, its performance is very stable, energy-saving and efficient.

### 3. Winter heating needs in northern China

Energy-saving and carbon-reduction is an issue of great concern to all countries. Only by achieving efficient energy-saving and carbon-reduction can we further reduce energy consumption and at the same time reduce the adverse impact on natural resources in the process of carbon emission, at the same time, it would also reduce the impact of increased carbon emissions on the planet's greenhouse-gas benefits, such as carbon dioxide, thereby protecting the atmosphere and the natural environment on which our planet depends. In 1990, the sixth energy-saving office meeting of the State Council established the national energy-saving publicity week. The ultimate significance of this activity lies in vigorously promoting the national energy-saving and carbon-reducing education and publicity through the holding of the activities, improve the whole society's awareness of energy-saving and carbon-reduction, develop a good green low-carbon living habits, the full implementation of energy-saving and carbon-reduction strategy. By July, 23 years had passed since the 2023 began in 1990. Since then, the campaign has achieved great success on a social scale, with a gradual transition from the original theme to "Actively addressing climate change and promoting green and low-carbon development". Whether materials meet the requirements of energy conservation and environmental protection has been a matter of concern for many people, which is not only about the cost of knowledge, but also about people's health. In March 2022, the Ministry of housing issued the "14th five-year plan" for the development of energy-saving and green buildings, improving the energy-saving level of existing residential buildings. Compared with the southern cities, the northern cities are more cold, the northern families in the winter will take heating mode to resist the external cold, in order to live more comfortable. Urban central heating can solve the needs of northern cities for heating, can get more protection. How to improve the heating efficiency, energy consumption and the pollution caused by the energy consumption in the cold and extremely cold regions have become one of the topics concerned by many technical researchers. Since July 2018, four ministries have announced pilot cities to promote clean winter heating in northern regions after a series of performance evaluations, the strategy is of great significance in promoting clean heating in the region in winter, aiming to achieve the goal of maximum energy saving and carbon reduction. According to the data, after the four ministries promoted the plan in the pilot cities, the clean heating renovation area has reached 725 million square meters, and more than six million households have benefited from it, changed the traditional way of heating. Following the clean energy heating reform, air quality in the pilot cities has improved significantly, from 109.5 micrograms per cubic metre in 2016 to 76.4 micrograms per cubic metre in 2017, compared with before, and the decline of about 30%. There are various ways of heating with clean energy. Different places can adopt different energy sources to provide heating according to different conditions in their regions. For example, in regions with abundant sunlight and regions with large amounts of sunlight, solar energy can be used to generate electricity for heating, or adopt the auxiliary coal heating way to carry on the heating, thus, then made the clean energy heating plan to obtain the very good implementation. Among them, some northern areas rich in power resources, so the adoption of "Coal to electricity" approach to heating, and the adoption of such a clean energy heating pilot cities include: Beijing, Hebei, Zhengzhou and other cities. According to the literature reports, electric heating mainly includes: electric heating film, graphene heating devices, electric heating and other materials.

From the above analysis can be known that the northern areas of the demand for motive heating is relatively strong, is a rigid heating. In the clean energy heating materials, there are many options, different heating materials have different characteristics, so these materials should be tested. Graphene material is one of the clean energy heating materials, which has been paid more attention in recent years, this kind of material is gradually applied to northern areas as winter heating materials.

## **4. Test and analysis of graphene electric heating mode**

### **4.1 Energy saving effect of graphene material**

Graphene has long been known as the “King of new materials” and is widely used in energy-saving and carbon-reducing ways. In the application of heating has a higher economic benefit of energy saving. The application of graphene materials to floor heating can rapidly increase the indoor temperature in winter through material conductivity and heat. Because the material has good electrical conductivity and is relatively stable, it can not only reduce energy loss, but also continuously heat the indoor room, making the whole room become warm as spring. To further promote China's energy conservation and emission reduction and improve the efficiency of energy use has a very large role. According to laboratory studies, the conversion rate of graphene electrothermal film is higher than that of common materials, and can reach more than 99% , this experimental data shows that graphene is an almost flawless environmentally friendly material.

### **4.2 FAR infrared low temperature radiation effect of graphene**

There are three basic modes of heat transfer, if only theoretically analyzed: heat conduction, heat convection, and heat radiation. The radiant heating can continuously heat the indoor room, and this kind of heating method consumes relatively less energy in the air, and the energy utilization rate is higher than other heating forms, therefore, the heating effect obtained is naturally better, which and convective transmission there is a greater difference.

The general forced convection heating method is relatively simple, according to the relevant heating air flow common sense, the air in the upper part of the heating room is mainly hot air, which can be explained from the principle of hot air upward flow, while the lower part of the room is a relatively low temperature, at this time, it will lead to the heating energy is completely wasted. This will lead to insufficient heating concentration, and the effect of heating will be even worse. The use of graphene electric thermal film heating system can solve the problem of insufficient heating in the room, such as: the material is mainly based on far infrared low temperature radiation for external heat dissipation, and this heat dissipation method is more in line with the needs of modern heating, such as: The use of floor heating for heating can make the heat mainly concentrated in the middle and lower position of the heating room, and people's lives are mainly on the ground, so that the human body can absorb heat more efficiently, remove the cold, and improve the human body's use efficiency of heat.

At the same time, convective heating generally draws heat from the heated air, so that the air in a room can get more heat, and the air temperature is higher than the surrounding objects in the room. Radiation heating and convection heating are very different, usually get heat energy directly from the source of radiation, can make the temperature of the indoor room rise rapidly, make the indoor air temperature get more heat energy, improve the efficiency of heat transfer. Some scientists have found that using radiant heating to save energy can achieve the goal of energy conservation and environmental protection, that is, for every 1 ° C reduction in indoor temperature, it can save about 10% of energy consumption. This is obviously superior to convective heating. For example, if the indoor temperature is 16 ° C under radiant heat, it is equivalent to the heating effect of convective heating from 18 ° C to 20 ° C, radiation heating has more environmental protection and energy saving characteristics.

### **4.3 Benefit analysis of graphene electric heating test**

Graphene electric heating is a kind of low-temperature floor radiant heating, which is different from traditional heating, but the heating effect is better and the energy-saving effect is better. Taking single household heating 80m<sup>2</sup> as an example, when designing graphene electric heating scheme, the total investment is 10830 Yuan, the capacity demand is 6.6 kw, the annual unit electricity consumption kWh, the annual running electricity cost is 19.62 yuan/m<sup>2</sup>. The annual heating cost is 1570 yuan, which is close to 1600-2500 yuan of traditional coal heating, and the coal consumption is 1t-2.5 t. Because according to the relevant research can be known, rural residents because of the impact of income problems, so the economic costs of heating a greater degree of

concern, the heating cost is usually influenced by the quality of house insulation and villagers; living habits, and the use of graphene electric heating can meet the needs of villagers; motive heating, which is about the same as their economic consumption level.

Graphene electric heating is widely used to improve the heating effect of the vast number of northern families, it is a low-temperature ground radiation heating, during the test showed that, the average radiant surface temperature of the room heated by electric heating with graphene is 29 ° C, and that of the room heated by electric heating is 19 ° C, this has undoubtedly greatly improved indoor air quality and reduced pollution. Graphene electric heating is suitable for small families in the northern regions, and it is necessary to take into account the increase of electric capacity during the heating period, as well as the economic costs during the various increase periods. This technology has a high promotion value.

In general, the annual energy consumption of electric heating with graphene is 3926 kwh, and the energy consumption per unit area of a house is 49 kwh/m<sup>2</sup>. The effect of different buildings on the heating capacity of the impact of large differences, if the heating of the house using 50 mm thick polyurethane wall insulation is in the middle energy-saving level. And if the house that did not take any heat preservation material is not recommended to use graphene electric heating scheme, but can use other heating scheme.

## **5. Application analysis of graphene electric heating**

### **5.1 Check the condition of the laying ground first**

In the installation of graphene electric heating process, the need to check the laying of the ground, and clean up, and then a ground leveling, you can use 1 m yardstick and wedge ruler to check, height gap > 3 mm, after leveling with cement, the ground should be air-dried once before laying the floor until it is completely dry.

### **5.2 Get the floor heating insulation ready**

Should purchase a good choice of thermal insulation materials, must choose regular manufacturers, because the choice of good thermal insulation materials to provide stable heating, and can improve the insulation effect of indoor houses, it is more environmentally friendly. If you choose inferior heating materials, then it will pose a great harm to human health because of the toxic substances contained in the materials. Moreover, these insulation materials are permanent use, during the period, almost no material will be replaced.

### **5.3 Lay the floor warm insulation layer**

In the process of laying the floor heating insulation layer, the area of indoor house should be accurately measured and well designed, the gap between different plates should not exceed 4mm, so as to improve the indoor thermal insulation effect. After laying the heat preservation board of floor heating, should use the adhesive tape to seal the gap between the plates completely, can reduce the heat to flow from the gap between. This can improve the insulation effect of indoor houses.

### **5.4 Laying of graphene electrothermal film**

In the completion of the insulation layer laid, the beginning of the graphene electric heating film laying, should be in accordance with the size of the room for uniform laying. The laying process can not be laid flat, can not pull and curl. During the installation, it is arranged between the reflecting film and the extruded plate. All operations must be laid in accordance with the relevant laying basic requirements, can be placed between the plate film group.

### **5.5 Prevent electric heating film and cement support contact**

In the laying process in order to prevent the direct contact between the electric heating film and the floor, as well as the electric heating film to add a layer of PE film protection <sup>[3]</sup>. After laying, laying a layer of full silicon mesh above, the main purpose is to prevent the back-filled layer due to thermal expansion and contraction caused by cracks. Non-electric heating film area should be fixed

treatment, pay attention to whether the fixed contact surface is tight..

## 5.6 Cement laying

In the completion of the above graphene electric heating installation and temperature detection, if there is no problem, you can fine cement will be laid. In this construction process should pay attention to cement slurry and not too thin. Secondly, in order to prevent damage to the electric heating film, leveling can be used when the non-stone bean paste sauce, as long as the cement will be laid requirements. After the completion of the installation, the heating system should be a secondary test, you can use a shake table to test, to achieve the rolling resistance value &lt; 2 Megohm is expressed as qualified <sup>[4]</sup> .

## 5.7 Installation and testing of graphene electric heating

At this stage, the installation and testing of graphene electric heating can adopt a flexible control system to debug the temperature of different rooms, which can realize separate households, separate rooms, and time sharing for independent heating, and can be flexibly adjusted according to the needs of users, so that the indoor room temperature can be in a more ideal state, which helps to improve the comfort of indoor space. Improving the overall operation capacity and effect of the indoor room heating system can effectively reduce the operation energy consumption and improve the energy saving effect of the indoor house.

## 6. Conclusion

As we all know, graphene electric heating can meet the needs of winter heating in the vast northern areas, is very popular one of the new point heating. According to the test of graphene electric heating mode, this heating mode has higher heating efficiency, good stability and strong electric conductivity. It can realize diversified, personalized and environmental protection functions, and is cheaper than the traditional heating mode, can reduce pollution, is to achieve energy-saving carbon reduction, reduce energy consumption on climate pollution one of the major ways. In the process of installing electric heating with graphene, laying according to the construction standard should be combined with the actual situation, which can improve the installation usability, safety, improve the heating effect and protect the health of family members.

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