The Influence of Different Absorbed Coatings on Thermal Effect of Prefabricated Solar Collector Panels

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Abstract. Prefabricated solar collector panels is a kind of new permeability structure of collector panels. For this test, we adopt a certain proportion of copper oxide, magnesium oxide and iron oxide to enamel paint as absorbed panel coating and make two kinds of collector panels for different forms of color by dark green coating and black coating. By the methods of comparison, the two kinds of panel collector efficiency and heat loss coefficient U_L were tested. The results showed that there was a slight difference between the heat loss coefficient of prefabricated solar collector panels, using the panel with dark green coating's comprehensive thermal effect is well than the panel with black coating. The beautiful appearance color is more suitable for building requirements.

1. Introduction

Prefabricated solar collector panels is a flat type solar collector which combining with architectural. Through the prefabricated design, it can effectively guarantee collector structure parameter and collector efficiency. It can be used in solar building; it can be used in the trumbo wall structure of passive solar houses; it also can be embedded in the external walls of buildings. It can improve effectively the collector efficiency and improve the effect of building energy saving[1].

The design of Prefabricated solar collector panels includes: Complex frame, Glass cover plate, endothermic board ,V type of metal mesh, Insulation backplane, Air inlet pipe ,Air outlet pipe and so on (shown in Figure 1). The collector panels shell uses steel profiles which is processed into composite frame structure, it has the function of thermal insulation. Glass cover plate is made of double ordinary glass, which is placed in the double-layer steel profiles stacked composite frame. It can reduce the heat loss .The endothermic board of material uses galvanized iron plate materials as heat collector plate. In order to increase the collector efficiency of the heat exchanger and enhance the heat transfer effect of the air flow. It is designed a V-shaped metal mesh of permeability structure on the board. The Corrugated Angle of metal screen is 90 DEG. The even space of metal mesh made the

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heated air flow arbitrary on the endothermic board.

Non-selective coating material is used to cover the panel, to strengthen its thermal effect. We adopt a certain proportion of copper oxide, magnesium oxide and iron oxide to enamel paint as absorbed panel coating. The ratio of absorbed coating shows that theory of absorbed rate is bigger; launch rate is smaller; coating production is simple; material price is reasonable.

In order to determine the different absorbing coatings influence on the thermal efficiency. By the method of comparison, the two forms of Prefabricated solar collector panels with the dark green coating and black coating are separately carried out the collector efficiency and heat loss test.

2. Prefabricated solar collector panels trial design and test methods

2.1 Test system

The test system of the prefabricated solar collector panels is shown in Figure 2. Test system mainly includes: test bracket, solar collector, the sky radiation table, the average temperature of the heat-collecting panels, import and outlet temperature, hot wire anemometer, environmental anemometer, rotary cup anemometer and Temperature meter.
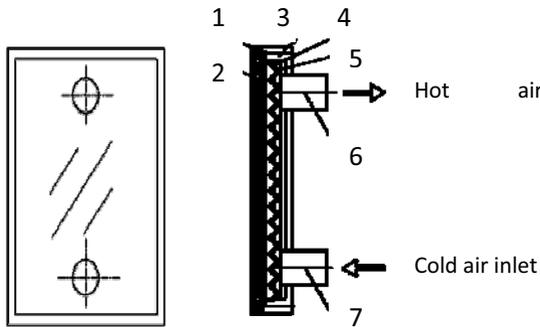

Fig.1 The structure of the heat-collecting panels

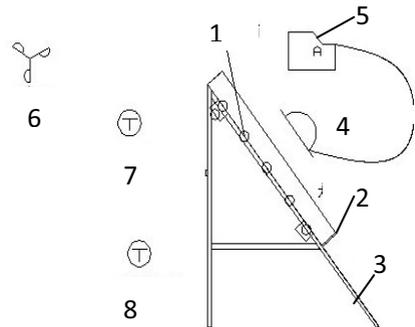1.Complex frame 2.Glass cover plate 3.Absorber plate type of metal mesh 5. Insulation backplane 6.Hot air outlet 7. Cold air inlet

Fig.2 The test pattern of the system

1.Measuring temperature distribution 2. Solar collector panels 3.Testtrestle 4. Sky radiometer 5. Radiation meter 6. Anemometer of environment 7.Temperature sensor 8. Ambient

2.2 The determination of collector efficiency

This experiment uses the method of comparison. In the test, two kinds of prefabricated collector panels are placed side by side, which guarantee the temperature of the two sets, the same temperature of the heating plate, the same wind speed, the same solar radiation and the same solar radiation angle. The test of time is four consecutive days of sunny weather; the period of time is from 9:30 to 15:30; the average wind speed of the external environment is 3m/s. It gathers temperature of inlet outlet T_0, outlet temperature T_1,

daylight area A, working flow m, solar total radiant intensity I, ambient temperature T, ambient wind speed V etc.

Instantaneous thermal efficiency of the collector panel η calculated by the following formula:

$$\eta = \frac{mc_p(t_o - t_i)}{AI}$$

Where :   m — Mass flow of heated media，kg/s;

Cp — The heat capacity of air，J/kg·℃ ;

t, — Inlet temperature，℃;

t,— Outlet temperature，℃。

2.3 The determination of heat loss coefficient UL

The heat loss coefficient U_L of collector panels is tested under conditions of no sunlight, dark green coating panels for test board, black coating panels for contrast panels. The influences on heat loss coefficient U_L of two different color coating can be known.

The heat loss coefficient U_L is calculated by the following formula:

$$U_L = \frac{C_P m(t_1 - t_2)}{A(t_m - t_a)\Delta T}$$

Where: t_1—Initial temperature of collector plate，℃;

t_2—end temperature of collector plate，℃;

t_m—air temperature of in the collector plate，℃;

t_a—The average ambient temperature，℃;

△T—Test time，h.

2.4 Test results and analysis

This test was operated in 4 following days and 4 groups of 4 times, we tested collector efficiency and heat loss coefficient U_L of dark green coating panel or black coating panel. The thermal efficiency curves of the two kinds of collector are obtained by the experimental datas.

2.5 Thermal efficiency of panel with dark green coating

After finishing the collection efficiency of the dark green coating panel test, which the Instantaneous collection thermal efficiency curve is shown in Figure 3. After linear regression that we obtain the dark green coating panel of instantaneous collector efficiency equation: y=-12.602x+0.9551, Correlation coefficient is -0.90758.
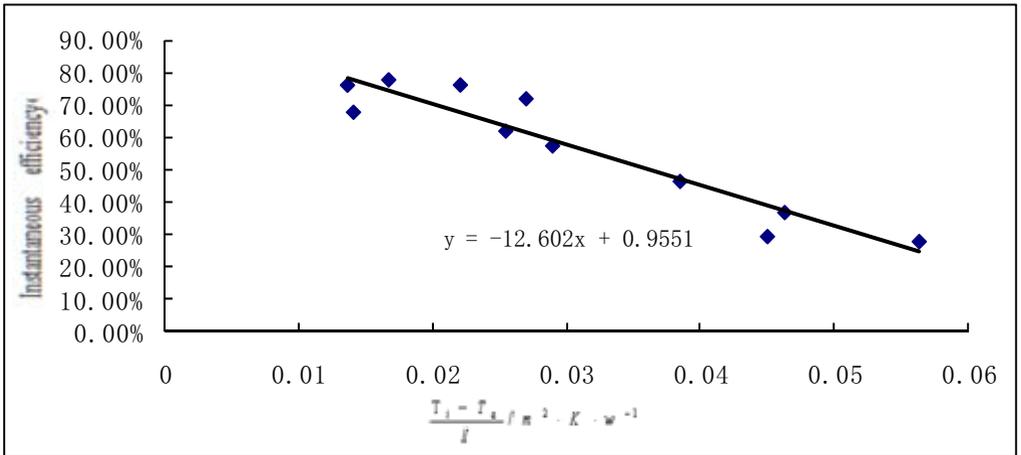
Fig.3   The instantaneous thermal efficiency curve of the dark green coating panel

2.6Thermal efficiency of panel with black coating

After finishing the collection efficiency of the black coating panel, which the Instantaneous collection thermal efficiency curve is shown in Figure 4. After linear regression that we obtain the black coating panel of instantaneous collector efficiency equation: y=-10.563x+0.7468，, Correlation coefficient is -0.90988.
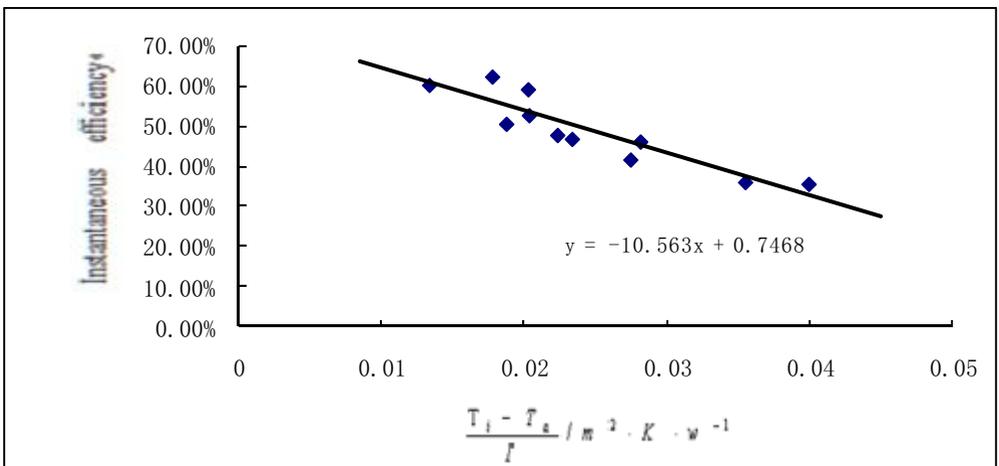

Fig.4 The instantaneous thermal efficiency curve of the black coating panel

The contrast of the dark green coating panel and the black coating panel of instantaneous collector efficiency is shown in Figure 5.
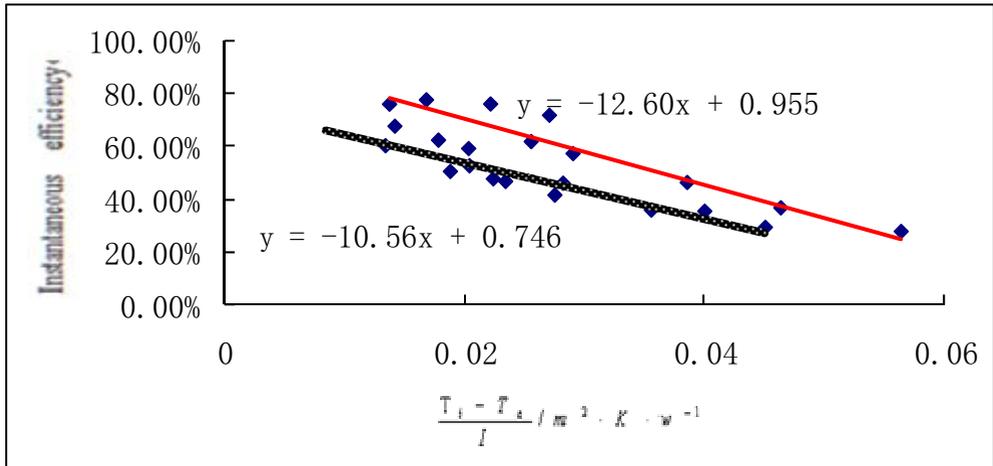
Fig.5 The comparison of instantaneous thermal efficiency curve of the

dark green coating panel and the black coating panel

2.7 The heat loss coefficient UL

The test of two kinds of collector panel of the heat loss coefficient U_L is contrasted . Calculation shows that the heat loss coefficient U_{L1} of dark green coating panel is $0.14 KJ/m^2 \cdot h \cdot ^\circ C$; the heat loss coefficient U_{L2} of black coating panel is $0.17 KJ/m^2 \cdot h \cdot ^\circ C$.

3. Analysis

The analysis of the test results shows that the dark green coating panel of instantaneous collector efficiency equation intercept is 0.9551; the black coating panel of instantaneous collector efficiency equation intercept is 0.7468. The thermal efficiency of panel with dark green coating is higher than panel with black coating. The two kinds of panels' heat loss coefficient U_L is little difference.

4. Conclusion

The test shows that adding a certain proportion of copper oxide, magnesium oxide and iron oxide to enamel paint as absorbed panel coating, its thermal effect is better, appearance is more suitable for building aesthetic requirements, the long wave emission rate is low, the heat preservation of effect is good, the preparation process is simple and feasible. It can content the design requirements of the comprehensive application effect, it is a better for the non-selective coating material of solar panel to popularize and appliance.

5. Acknowledgement

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