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TESTING SYSTEM OF THERMAL INSULATION PERFORMANCE ON VACUUM GLAZING

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ABSTRACT

This paper shows a special test system, and it is applied to thermal performance study of vacuum glazing. Firstly, the heat box device are defined and realized. Secondly, the control and text strategy of temperature, voltage, current, power, electrical energy are described in detail. Thirdly, the soft system sketch and principle are shown. Experimental results demonstrate that the proposed scheme satisfies the requirement for insulation thermal performance of vacuum glazing testing with high accuracy parameter value gotten. The proposed scheme has been used in evaluating the insulation performance of vacuum glazing.

Keywords: *Computer Test system, Insulation Thermal Performance, Vacuum Glazing,*

1. INTRODUCTION

Heat loss through building windows is one of the major effects on the energy efficiency of the buildings. To reduce the heat loss through the windows, double glazing with a sealed cavity filled with air, or inert gases and internal glass sheet surfaces coated with low-emittance (low-e) coatings have been widely used. In gas filled double glazing, gaseous conduction and convection still exist. To eliminate these kinds of heat transfer, the concept of double vacuum glazing (VG) with an evacuated gap was firstly presented by Zoller [1, 2]. The new energy-saving constructer -VG possesses excellent thermal performance, thinner thickness, and lighter weight compared with other glass sheets.

The Thermal performance modeling and simulation of VG is the hot research topic since the 1990's[1-2]. At first, the 2D analytical model is well adopted to evaluating the insulation performance. Then the 3D numerical simulation method has been the powerful design tool for VG [3-10]. But the 2D analytical model in references has some difference, and is not well evaluated. For example, the gas heat conduction is limited when the pressure is lower then 0.1 Pa. But in fact, the effect detail of pressure is not well studied. The 3D model of heat transfer for VG is all adapted the square pillar to similar the cylinder pillar. Some research is shown the effect of this method could be ignored [3]. But some author is noted, the heat transfer of the pillar is almost the same, but the total heat transfer of VG will be affected [7]. The detail is not well given.

The test of vacuum glazing thermal insulation performance is also the research topic[10,13]. It has several measurement methods. N. Ng, et. al compared three method: the small-area guarded hot plate apparatus gives absolute measurements of the different heat flows through the glazing due to radiation, gaseous conduction and thermal conduction through the pillars; In the transient technique, a step temperature increase is applied to one side of the glazing, and the resultant slow temperature rise of the other glass sheet is measured; In the cool-down method, one glass sheet of a glazing that is initially at high temperature is insulated, the opposite glass sheet is rapidly cooled, and the rate of cooling of the thermally insulated sheet is then measured. A guarded hot box calorimeter was designed and

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constructed to measure their heat transfer coefficients [14]. Experimental measurements of temperatures and rates of heat transfer were found to be in very good agreement with those predicted using a developed finite element model. A method for determining the heat trans-fer coefficient of the evacuated gap has been established.

This paper shows a special test system, and it is applied to thermal performance study of vacuum glazing. Experimental results demonstrate that the proposed scheme satisfies the requirement for insulation thermal performance of vacuum glazing testing with high accuracy parameter value gotten. The proposed scheme has been used in evaluating the insulation performance of vacuum glazing.

2. HARDWARE OF EXPERIMENT BED

The experiment bed of the thermal insulation performance includes heat box, measurement and control device, and sensor.

2.1 Heat Box Device

The hot box should have lower heat transfer coefficient. It includes two box, little and big box. The dimension of former is 600×600×600mm, and latter is 300×300×300mm. The little box is in the center of the big box (see Fig.1). The big box is cut some part on the side in schematic in order to clearly shown their poison.

On top of little box is coverplate. On top of big box is coverplate that has two kinds structure(see Fig.2). One is used to test heat transfer coefficient of hot box. The other is used to test heat transfer coefficient of vacuum glazing.

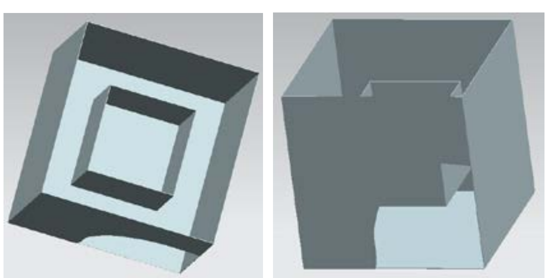

Figure 1: Box Installation Location Schematic

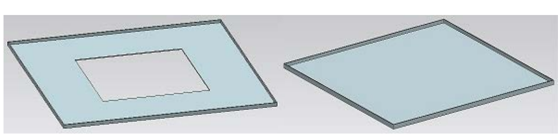

Figure 2: Top Cover Plate

Between big and little box, it is filled with glass fiber or lower the heat loss. The surface of glass fiber is covered by aluminum foil paper. The power cable and signal line is set with the hot box assembled.

The experiment hot box is in shown in Fig.3. The five face is made by the insulation material. The sixth face, top face is for test material. Its heat transfer coefficient need to get.

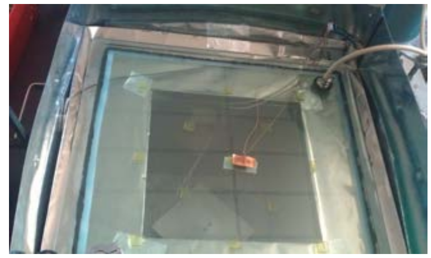

Figure 3: Hot Box

According heat transfer theory, the heat resistance of test material includes heat conduction, convection, and radiation resistance as Eq.(1).

$$R = \frac{1}{\alpha_i + \frac{q_{ri}}{(T_i - T_{wi})}} + \frac{d}{\lambda} + \frac{1}{\alpha_o + \frac{q_{ro}}{(T_{wo} - T_o)}} \quad (1)$$

Heat transfer coefficient is :

$$U = \frac{1}{R} \quad (2)$$

But the heat resistance of test could be gotten by experiment method,

$$R = \frac{Q_h - Q_5}{A(T_i - T_o)} = \frac{Q_h - \sum_{j=1}^{5} A_j (T_i - T_o) C}{A(T_i - T_o)}$$

(3)

The heat resistance of hot box wall could be gotten by experiment that the top face of hot box is also covered by wall material.

$$C = \frac{Q}{(T_i - T_o)\sum_{j=1}^{6} A_j} \quad (4)$$

2.2 Control and Measurement Device

Four temperature signals are monitored by thermal-couple. They are changed to digital signals by NUDAM MODULES (I-7018). And then they are transferred to host computer by RS485 cable through COM port. One pressure signals is monitored by vacuum gauge. And also the voltage, current, power and electrical energy signals of heater in heat box are recorded. The temperature

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signals are monitored by membrane vacuum gauge. It is voltage signals that changed to digital signals by NUDAM MODULES (I-7017). It is transferred to host computer by RS485 cable through COM port.

The signals of voltage, current, power, and electrically of heater in hot box are gotten by AMMETER MODULES (LCDG-113). It can output the digital signals, and communicate with RS485 bus

The temperature of hot box is controlled by the heater power, see Fig.4. The temperature controller adjusts the solid state relay that control angle of departure to give the appropriate heat power.

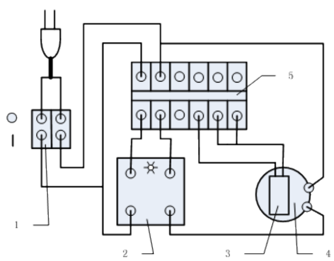

Figure 4: Automatic Temperature Control Circuit of Heater Temperature (1.Switch, 2.Solid State Relay, 3.Thermocouple, 4.Heater, 5. Controller)

The diagram of measurement control device is in Fig.5. The real system is in Fig.6.

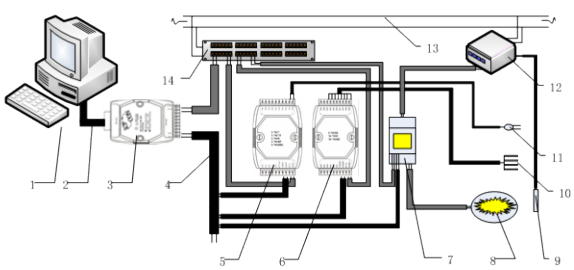

Figure 5: The Whole Assembly Diagram Of Measurement Control Device (1. Host Computer, 2. RS232 Bus, 3. I-7520 Module, 4. RS485 Bus, 5. I-7017Module, 6. I-7018Module 7. AMMETER MODULES 8. Heater 9. Temperature Sensor Of Heater 10. Temperature Sensor 11.Membrane Vacuum Gauge, 12. Temperature Controller 13.220V Power , 14. 5V And 24V DC Power)

Figure 6: Measurement Control Device

3. SOFTWARE DESIGN

The software of host computer should has the function of (1) recording the data in database (2) real-time display the temperature and other signals.

The configuration software has the ready-made driver for NUDAM MODULES and temperature controller. They can be directly accessed to communicate. Also the configuration software has the good interface design superiority. But the AMMETER MODULES must be compiled the driver by Visual Basic (VB) or Visual C++ (VC) software. So, the software system is compiled with VB and configuration software. The VB software has the strong ability of data communication and treatment. Together with the VB and configuration software, the monitor system will be easily and Flexible. The software architecture is in Fig.7.

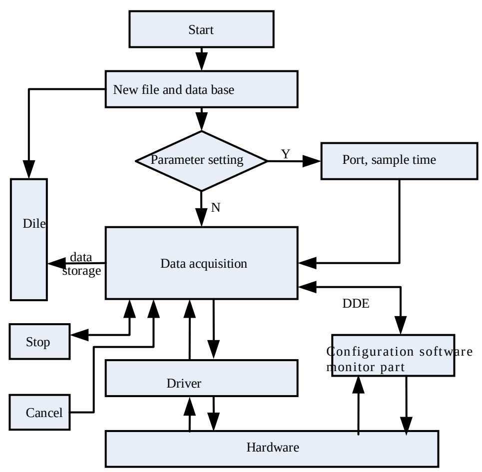

Figure 7: Program Flow Chart of VB and Configuration Software

The configuration software monitor system is in Fig.8. Very variable is shown, and the four curves are temperature curve real-time. The temperature and pressure signals are gotten by configuration software monitor system. The voltage, current, power and electrical energy signals is gotten by VB software. Another function of VB is as the data recording system, see Fig.9. VB system has a lot of dada exchange with monitor system. That is realized by DDE connection in background. The VB system is as the server, and configuration software monitor system is as the customer that asks for dada exchange.

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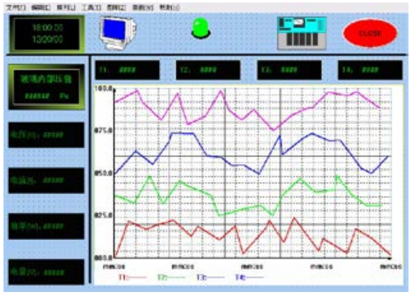

Figure 8: Configuration Software Monitor System

Figure 9: VB Data Recording System

4. TEST RESULTS OF SYSTEM

At first, the heat resistance of hot box wall is measured. The data is shown in Fig.10. The total test time is 10 hours. The temperature fluctuate is very little, and the quantity of heat is well stabilization. The heat transfer coefficient is C = 0.24292 W/(m^2K).

The heat transfer coefficient experiment of double glazing (DG) is similar above experiment. The glass thickness is 6mm and 8mm respectively. The gas gap thickness is 2mm. The pillar material is silica gel. Changed the gas pressure inner the gas gap, the heat transfer coefficient of DG is as Fig.13.

The heat transfer coefficient of DG is changer with gas pressure as 'S' curve. When the gas pressure of gas gap is lowered to 1 Pa, the heat transfer coefficient is not changed. It is because that gas is in molecular flow state, gas heat transfer is little. As the pressure lower to 1 Pa, it is eligible double vacuum glazing (DVG).

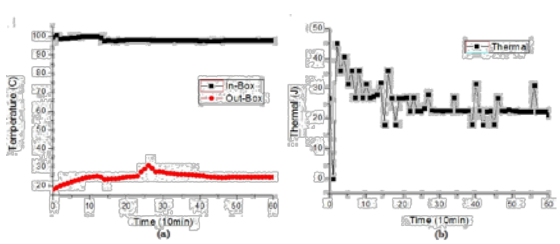

Figure 10: Heat Transfer Coefficient Experiment of Hot Box Wall

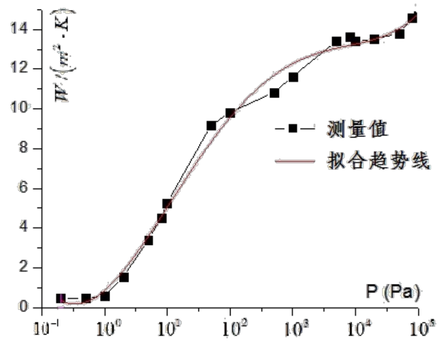

Figure 11: Heat Transfer Coefficient of Double Vacuum Glazing

5. CONCLUSION

This paper shows a special test system, and it is applied to thermal performance study of vacuum glazing. Firstly, the hot box device are defined and realized. Secondly, the control and text strategy of temperature, voltage, current, power, electrical energy are described in detail. Thirdly, the soft system sketch and principle are shown. Experimental results demonstrate that the proposed scheme satisfies the requirement for insulation thermal performance of vacuum glazing testing with high accuracy parameter value gotten. The proposed scheme has been used in evaluating the insulation performance of vacuum glazing.

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