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Integration of Water Heaters into Residential Renovation Based on Solar Energy Ionization Reaction Conversion

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With the computer simulation technology, the wall-mounted solar heater with ionization reaction in the greenhouse reconstruction test is analyzed, and the thickness of the existing dwelling wall (≥ 370mm) well fit the bill for the full loads of the collectors and water storage tank. The water heater and solar collector can be installed at the wall between window, the windowsill wall and the parapet wall. The installation of the solar collector and the storage tank does not impact the indoor temperature and humidity. Water storage tank can be mounted in the outer wall chamber near the solar collector; pipeline from the storage tank to the water point can penetrate the wall surface, run under the ground the shed, and can be hidden by the decorative members. It is found via the experiment that the wall-mounted solar water heater can be installed and integrated in the existing residence for meeting basic living conditions. This experiment provides the clues to the installation of wall-mounted solar water heaters for greenhouse reconstruction, and contributes much to the expansion of the use of clean renewable energy resources.

1. Introduction

In the greenhouse project, the existing multi-dwelling has a limited roof area, and there is no surplus load for the solar heater to be installed in the house. The new solar heater converts solar energy into heat energy by chemical ion reaction. In this test, solar collector is attached onto residential wall in an attempt to discuss the façade effect; the maximum wall loads; especially whether it will bring disaster to the original building structure; whether it will inflict the damage on the energy conservation of existing multi-storey residential; as well as the arrangement of pipelines, etc. The layout of the solar collector should guarantee that sufficient sunshine time will be available to satisfy the requirements for test design. In the test, the installation site of the solar collector is used to simulate the positions of the wall between window, windowsill wall, parapet wall, etc. on the facade of the multi-storey residential buildings (Zhou, 2018).

2. Test scheme design

2.1 Test house

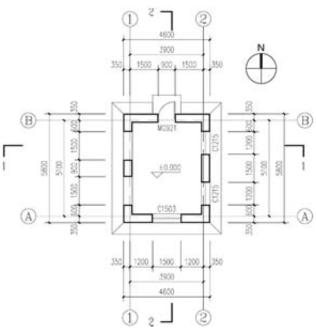

Figure 1: The floor plan

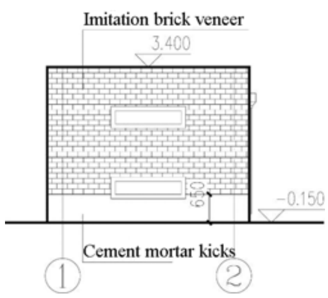

Figure 2: The south elevation

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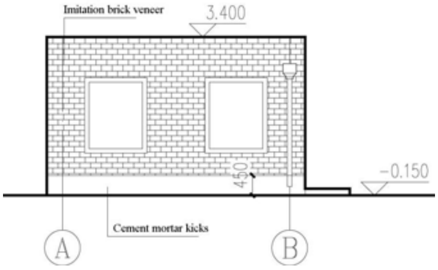


Figure 3: The east elevation

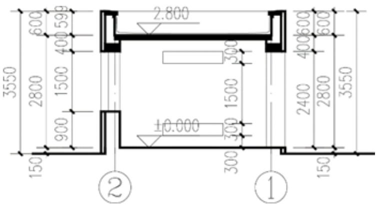


Figure 4: 1-1 Section

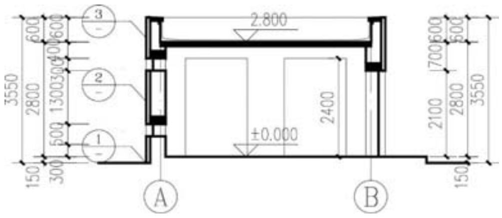


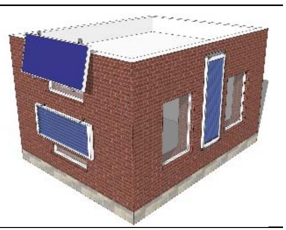
Figure 5: 2-2 Section

In order to simulate the greenhouse renovation process of multi-storey residential buildings in the practical projects and restore the real site situation, we specially design a suite of house for the test, see Fig. 1 - 5 for drawings. In the south wall surface of the test house, upper and lower holes should be retained, 1500mm*300mm, the distance between the two holes is regarded as the height between the windowsill walls; on the east side, there are two windows (1200mm in width * 1500mm in height), and the distance between them serves as the width of the wall between window. A solar collector will be positioned at the windowsill of the south wall and at the wall between window of the east wall (Benhouia et al., 2018; Gu et al., 2001; Kezza et al., 2018).

2.2 Solar collector installed on the wall

Two different types of solar collectors are installed on the south wall of the test house. A flat type solar collector, 2400mm*900mm*80mm, can be mounted on the parapet wall, and a vacuum tube type solar collector, 2200mm*800mm *90mm, on the windowsill wall. The last one can be installed in two ways. As shown in Table 1, the installation tilt angle is set to 90° for Scheme 1, and 75° for Scheme 2 (Chen & Jiang, 2003). Comparing the two schemes, it is observed whether the solar collector will shelter the daylighting of the window below and the wall loads (i.e. whether cracks will occur after the solar collector is installed on the wall). The vacuum tube type solar collector is installed vertically on the east wall at an inclination angle of 90°. Observe and record how the loads on the walls change, especially at the installation nodes (Fan, 2009).

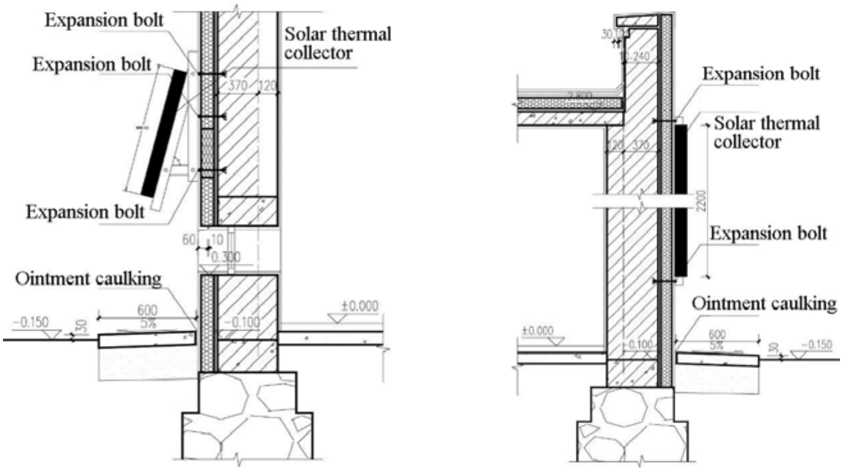
Table 1: The design plan of the collector

	Plan A	Plan B
Effect picture		

2.3 Large sample node

Large sample design of solar collector: After communication with solar collector manufacturers, it is also known that expansion bolts are used as the most common fixation method for installing solar heaters in multi-storey residential buildings now. When designing the large sample nodes of the solar collector and the storage tank, refer to the user manuals provided by the solar heater manufacturer.

Whether it is inclined or upright wall-mounted type, the number of expansion bolts required for installing the solar heater is determined based on the parameters of the water heater provided by the manufacturer. After the bracket is mounted with expansion bolts drove into the holes in the wall, the solar collector is installed again, as shown in Fig. 6. Repeat the above procedure for the large sample of the storage tank, and the expansion bolts are also required.



a) Inclined *b) Upright wall-mounted*

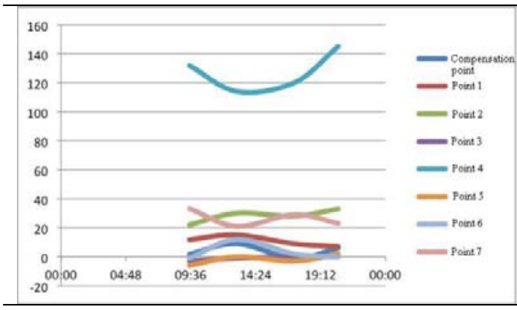
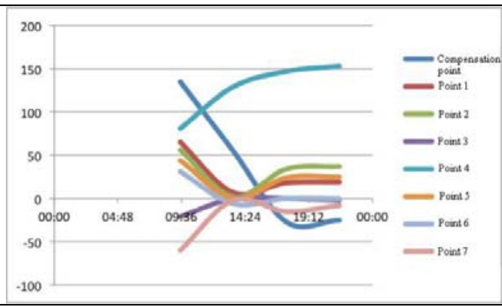
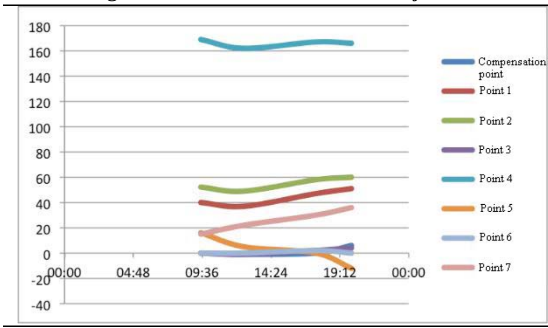
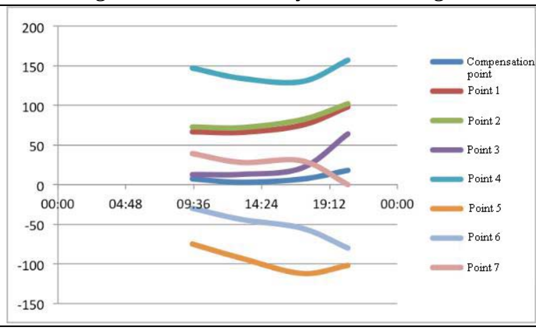
Figure 6: The installation of collector on the experiment room

3. Test procedure

3.1 Data acquisition

After installing the storage tank, select seven measuring points next to the three suspension points of the water storage tank, as shown in Fig. 7, test how the wall stress changes when the water storage tank is installed. The compensation point selected on the east wall plays a function to reduce the error. Stress is tested and recorded before the water tank is filled with water and after water injection, repeat the test after it is bled off water.

Table 2: The picture of the wall stress changes

	
The change of wall stress before water injection	The change in stress on the day after flooding
	
The change in stress on the first day after flooding	The change in stress the next day after flooding

As shown in Table 2, the stress at each measuring point fluctuates before and after the water storage tank is filled, but is stable. There is no any violent fluctuation with numerical changes in a tiny range. It is visible that the wall itself does not crack. As shown in the table, stress data measured on the day after the water storage tank is bled off shows fluctuations, but tends to be stable two days later. There is also a subtle change in the stress value after it is empty. In short, the stress fluctuations measured before and after water injection and discharge of the water storage tank are negligible, which demonstrates that the installation of the water storage tank on the wall does not damage the wall space.

Figure 7: The wall stress test

Figure 8: The temperature and humidity recorder between the water storage tank and the hole

3.2 Changes in the indoor temperature and humidity

Install the temperature and humidity recorder on the east, south, north and west walls of the test house and at the holes of the water storage tank, as shown in Fig. 8, observe how the indoor temperature difference changes before and after the installation of the solar water heater.

Table 3: The picture of temperature and humidity changes inside the room

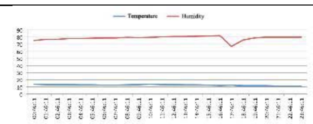
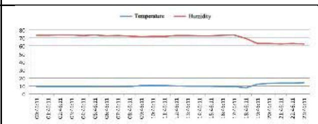
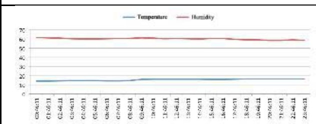
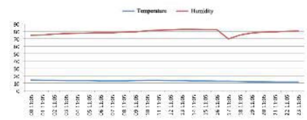
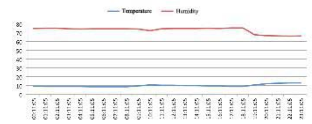
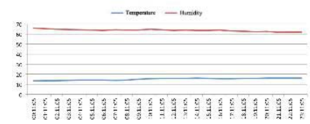
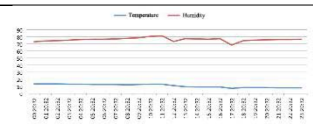
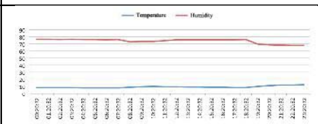
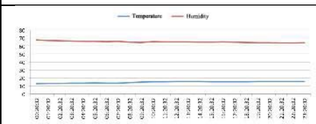
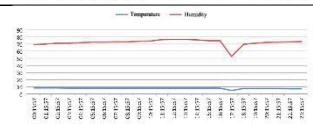
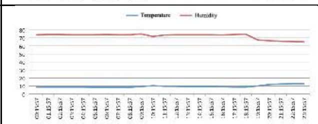
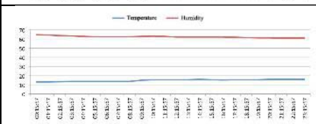
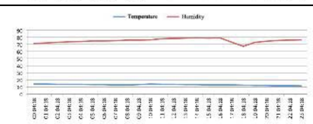
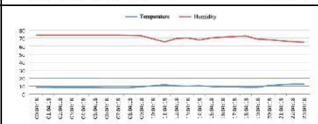
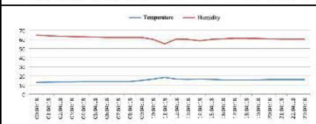
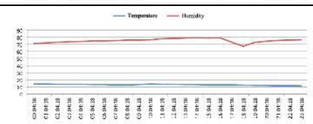
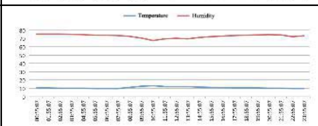
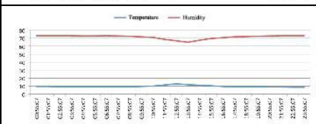
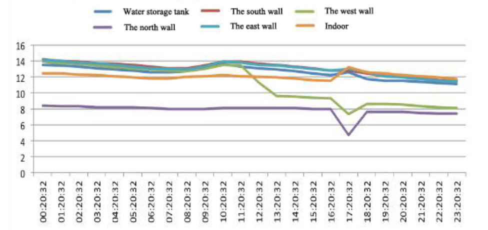
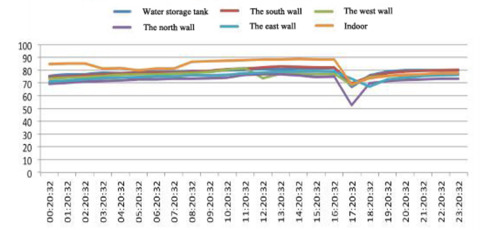
	Changes in temperature and humidity before installing solar water heaters	Changes in indoor temperature and humidity on the first day after installation of solar water heaters	Changes in indoor temperature and humidity for the second day after installation of solar water heaters
Water storage tank			
The south wall			
The west wall			
The north wall			
The east wall			
Indoor			

Table 4: The picture of temperature and humidity changes inside the room

<table>
<tr><th></th><th>Temperature ℃</th><th>Humidity %</th></tr>
<tr><td>Changes in temperature and humidity before installing solar water heaters</td><td>
</td><td>
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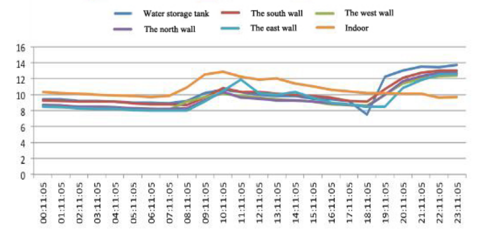
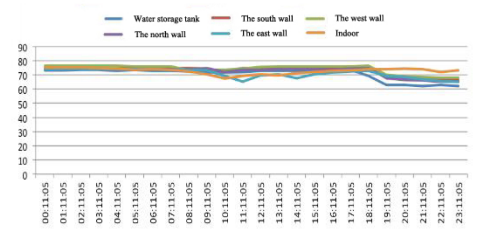
<tr><td>Changes in indoor temperature and humidity on the first day after installation of solar water heaters</td><td>
</td><td>
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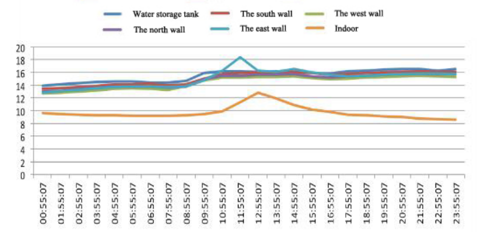
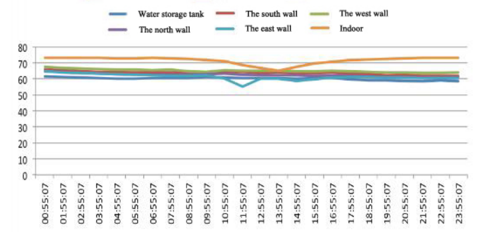
<tr><td>Changes in indoor temperature and humidity for the second day after installation of solar water heaters</td><td>
</td><td>
</td></tr>
</table>

A temperature and humidity recorder is installed under the water storage tank, at the center of the room, and on the east, south, north and west walls to record three sets of data of the indoor temperature and humidity before and after the installation of the water heater for comparison.

As shown in Tables 3 and 4, the temperature and humidity are relatively stable, and there is no obvious fluctuation, indicating that the insulation effect of the test house is still good, and is not affected by the installation of solar water heaters (Wan, 2011).

4. Analysis of test data

4.1 Load analysis of wall mounted solar water heaters

As shown in Table 2, after the storage tank is installed on the wall, the stress at each measuring point of the wall does not change significantly, indicating that the storage tank on the wall does not affect the wall.

After the storage tank is filled with water, the stress at each measuring point fluctuates, but within a tiny range, which can be neglected and does not cause damage to the wall.

As shown in Table 2, the curve at the measuring point does not fluctuate much. It is measured by a strain gauge that the water storage tank after water injection has no effect on the wall surface on the current day and two days later.

After testing, it is feasible to install a solar water heater on the wall without causing damage to the wall, and the wall can withstand the weights of the solar collector and the storage tank.

4.2 Analysis of temperature and humidity differences at the nodes

Temperature difference: Record the temperature data at 6 measuring points of the test house before and after installing the water heater. As shown in Tables 3 and 4, the temperature difference in 24 h a day is kept within a small range, and there is no significant temperature change at all points. It means that the installation of solar water heater has little impact on the indoor temperature. The solar collector and the storage tank can be installed indoors and outdoors (Yang, 2000).

Humidity change: As shown in Tables 3 and 4, the humidity in the test house before and after the installation of the water heater does not change significantly, and tend to be stable at various points in the test house, presenting the installation of solar water heaters does not affect the humidity in the room (Wang and Gong, 2011).

5. Conclusion

With the test house built here, this paper simulates the reconstruction process of multiple dwelling greenhouses in practical project. The real site situation is recurred again, and structure joints are designed for installing solar water heaters in the existing multiple dwelling. In addition, the test houses are also tested for the wall loads and indoor temperature and humidity variables before and after the installation of the solar heater is installed. Record and analyze test data. It is then concluded that the installation of the solar water heater has no impact on the wall loads, the indoor temperature and humidity. The layout of the storage tank and pipeline in the house has also been designed to provide the clues to the practical installation of solar heaters.

Acknowledgment

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