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Research Article

Investigation of the Influence of Environmental Thermal Characteristics on Thermal Modes of Transparent Boxes

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Keywords: Ambient temperature; Transparent box with polyethylene walls; Transparent box with glass walls; Greenhouse; Thermal regime; Air humidity

Abstract

This paper presents the results of experiments to investigate the influence of thermal characteristics of the environment on the thermal modes of transparent boxes. To conduct experiments on the non-stationary thermal model of solar greenhouses developed by us, two identical transparent boxes with dimensions of 0.80 x 0.65 x 0.80 m were constructed. The transparent boxes have rectangular shapes. One transparent box has glass walls and the other with polyethylene walls. The influence of the thermal characteristics of the environment and the thermal conditions inside the transparent boxes with film and glass transparent walls are investigated. The experimental results show that at a maximum ambient air temperature of 42 °C on 27.06.2024 at 13:48 hours, the air temperature increases to 10% and 23% in transparent boxes with polyethylene and with glass walls, respectively, and at 05:10 hours, the humidity decreases to 8% and 11%, respectively.

Thus, the influence of the thermal characteristics of the environment on the thermal conditions of transparent boxes with glass walls, at the maximum ambient temperature, is greater by 1.2 times than in transparent boxes with polyethylene walls, and humidity decreases by half.

Introduction

Energy-saving issues are relevant in construction (buildings and structures), in solar thermal installations, and in greenhouses. To solve energy-saving problems, in particular, it is necessary to create non-stationary thermal models of such objects, taking into account their main parameters to the maximum extent possible. The multifactorial nature of the problem leads to the fact that currently simplified methods of their computational analysis, mainly based on stationary models, are mainly used [1-4].

In works [5,6] a non-stationary unified thermal model of a solar water heater is considered, which allows for investigating the dynamics of heating temperatures of the main elements of the solar water heater (transparent enclosure, receiver, heat-insulating ground bottom).

The study of the main design parameters of energy-efficient solar greenhouses and their main components for determining the light transmission coefficients of the transparent fence are considered in [7].

The study of the thermal regime of solar greenhouses for individual purposes, taking into account their design features, is considered in [8,9].

The automatic control system in a greenhouse and calculations of heating temperatures of transparent screens and their technical and economic indicators are considered in [10-14].

Experimental setup

The study of the influence of the thermal characteristics of the environment on the thermal regimes of transparent boxes was carried out at the research site of the National Research Institute of Renewable Energy Sources under the Ministry of Energy of the Republic of Uzbekistan.

To conduct experiments the following measuring

instruments were used for the experiments: pyranometer 'SR20 pyranometer 1' - to measure the scattered solar radiation falling on the surface, DUAL CHANNEL THERMOMETER - a two-channel thermometer with 4 thermocouple probes, temperature measurement ranges from -50 to 1300 °C. Thermometer for measuring air temperature. Moisture analyzer TRIME-ES with probe T3/22, the composition of the moisture analyzer complex includes two devices: the actual moisture sensor - probe T3/22 cylindrical shape and the electronic unit - transducer TRIME-ES, designed for processing and displaying the results of measurements and data exchange with external devices. Using thermal potentials to analyse territories, this method allows us to move from a set of spatial data to an accurate numerical assessment at each point of the territory.

We carried out experiments on the developed unsteady thermal model of solar greenhouses, we have constructed two identical transparent boxes with dimensions 0.80 x 0.65 x 0.80 metres. The transparent boxes have rectangular shapes. One transparent box has glass walls and the other with polyethylene walls. The influence of thermal characteristics of the environment and thermal regimes inside the transparent boxes with film and glass transparent walls is investigated.

Schemes and designs of transparent boxes with film and glass transparent walls are presented in Figure 1.

Research results

Experiments to study the influence of thermal characteristics of the environment on the thermal regimes of transparent boxes began to be conducted from 1 July 2024 and are conducted to this day, in closed transparent boxes with film and glass transparent walls. The general view of the test site, from the place of conducting experiments with transparent boxes, measuring instruments, and equipment is given in Figure 2.

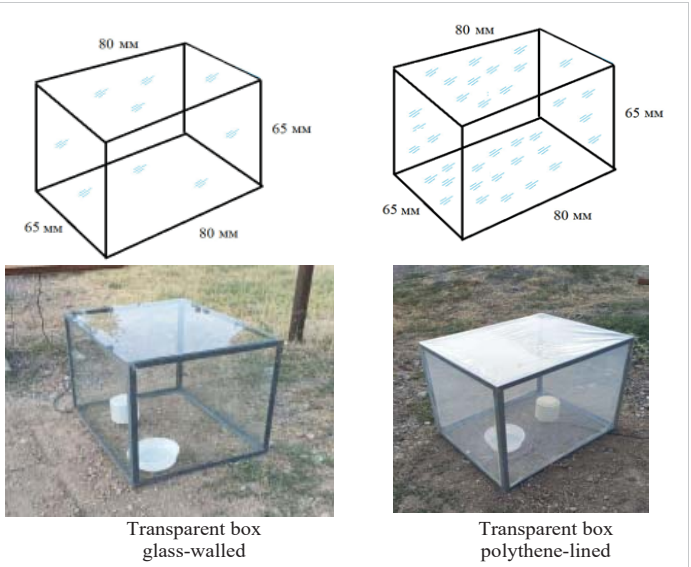

Figure 1: Diagrams and constructions of transparent boxes with film and glass transparent walls.

The transparent boxes used: 0.2 mm thick polyethylene film and 4 mm thick window glass.

The results of daily measurements of air temperature in the environment and inside transparent boxes with glass and polyethylene walls are presented in Figures 3,4.

As can be seen from Figure 3, the results of daily measurements of ambient air temperature and inside the transparent boxes with glass and polyethylene walls on 27.06.2024. At ambient air temperature at 13:48 has a maximum value of 42 °C, passing through a transparent box with polyethylene walls, has an average value of 47 °C, and the air temperature difference is 5 °C. This is explained by the

Figure 2: General view of the boxes with transparent walls during the experiments on the study of heat losses.

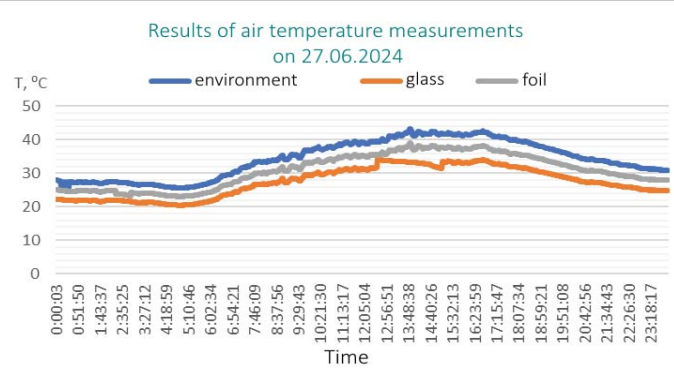

Figure 3: Results of daily measurements of air temperature in the environment and inside transparent boxes with glass and with polyethylene walls on 27.06.2024.

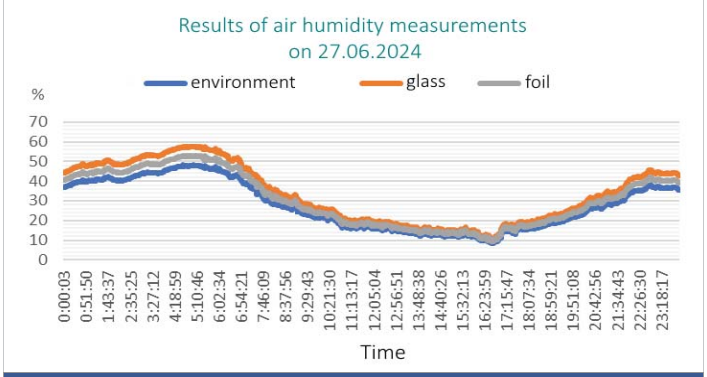

Figure 4: Results of daily measurements of air humidity in the environment and inside transparent boxes with glass and polyethylene walls on 27.06.2024.

fact that the polyethylene walls of the transparent box absorb part of the heat, which leads to a limitation of heat exchange through the air, and through the side walls of the transparent box there are heat losses that significantly affect the thermal regime, which leads to an increase in the temperature of the air inside the box by 10%. And passing through the transparent box with glass walls, the air temperature has a value of 34 °C, the difference in air temperature is 8 °C. This is explained by the fact that inside the transparent box with glass walls a greenhouse effect is formed with a part of heat absorbed by glass walls, which leads also to an increase in air temperature inside the box by 23%.

Results of daily measurements of air humidity in the environment and inside transparent boxes with glass and polyethylene walls on 27.06.2024. Figure 4 shows that the humidity of the environment at 05:10 hours has a maximum value of 46%, in a transparent box with polyethylene walls is 54%, and the difference in air humidity is 8%. In the transparent box with glass walls is 58%, and the humidity difference is 12%. This is explained by the fact that the walls of the transparent box with polyethylene film are more permeable to water vapour, which allows part of the moisture to escape from the rectangular box, unlike the walls of the transparent box with glass walls. It should be noted that glass is non-hygroscopic, i.e. it cannot absorb moisture from the air. Glass has a higher thermal conductivity than polyethylene film [15-18].

Conclusion

The experimental results show that at a maximum ambient air temperature of 42 °C on 27.06.2024 at 13:48 hours in transparent boxes with polyethylene and with glass walls, the air temperature increases to 10% and 23%, respectively, and at 05:10 hours the humidity decreases to 8% and 11%, respectively.

Thus, the influence of the thermal characteristics of the environment on the thermal conditions of transparent boxes with glass walls, at the maximum ambient temperature, is greater by 1.2 times than in transparent boxes with polyethylene walls, and humidity decreases by half.

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