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DESCRIPTION OF EXPERIMENTAL DEVICES IN GREENHOUSES AND EVALUATION OF ERRORS OF MEASUREMENT CONTROL DEVICES

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Abstract
Is to create energy-efficient hot air distribution equipment in order to ensure optimal microclimate conditions for the cultivation of organic genuine agriculture (fruit and vegetable) products in greenhouses.

Keywords: microclimate, optimal, greenhous, experiment, thermometer.

Introduction

The task of control measuring instruments has a special place within the scope of each experimental work. Control measuring instruments are selected within the defined parameters.

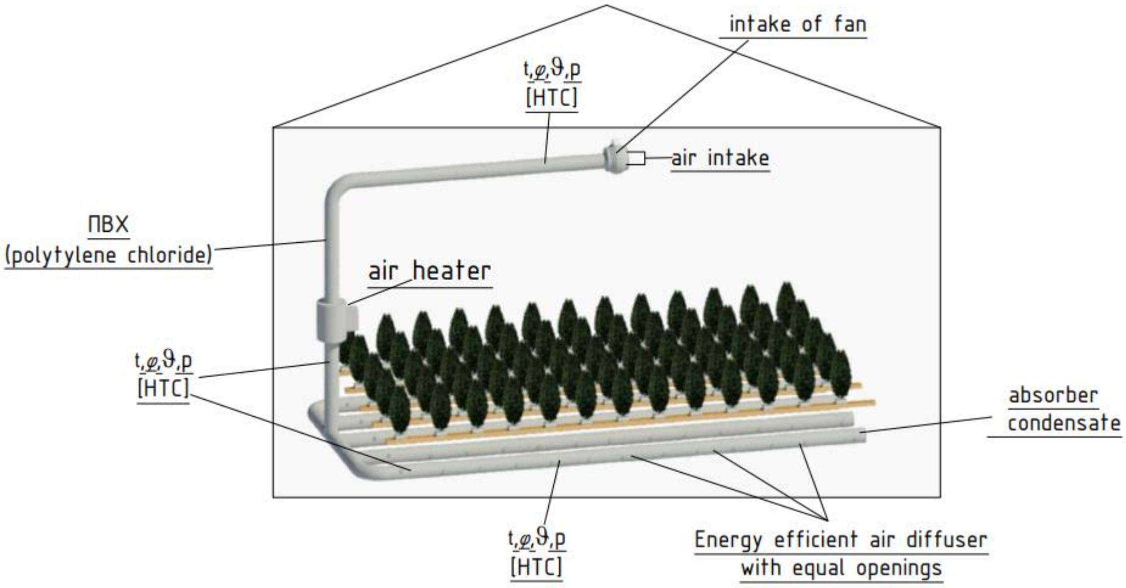

Figure 1. Schematic view of the measuring instruments and instruments in the system for conducting the experimental process in the greenhouse

In order to obtain accurate data during the experiment, we can get true readings without error by correctly placing the selected measuring instruments.

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Materials

HTC-2 electronic thermometer-hygrometer with LCD display and wired external temperature sensor. It shows the correct indoor and outdoor temperature as well as indoor humidity. Stores the minimum and maximum temperature and humidity values in its memory.

Figure 2. HTC-2 electronic thermometer-hygrometer with LCD display.

As an additional function, the device has an alarm clock.

- external temperature measurement width; ±10 ^{0}C ,-50~+70^{0}C, (-58~158°Φ)
- indoor room temperature measurement width; ±1 ^{0}C,-10~+50 ^{0}C, (-14~122°Φ)
- relative humidity; 10~99% ±5%
- size; 90 * 100 * 22 мм.

Moisture meter testo 925 accurately shows the humidity and temperature in the Kakapit bag where the plant is planted, i.e. inside the soil.

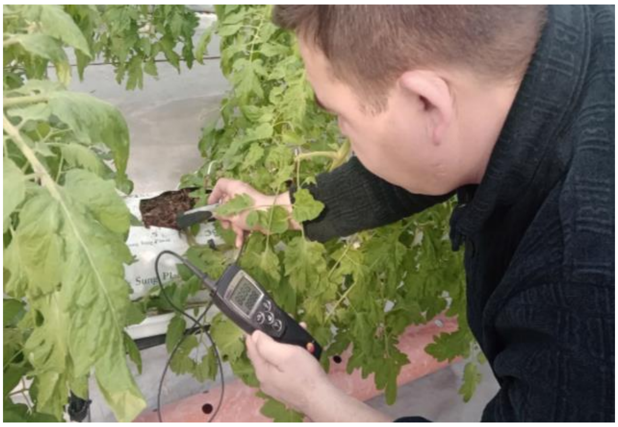

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Figure 3. Testo 925 measures soil moisture and temperature

Testo 925 model details, measuring range -50 to +1000 °C, accuracy - ±(0.7 °C + 0.5%) with intermediate sensitivity.

HTi HT-9830 thermal anemometer with telescopic sensor is a measuring device equipped with a sensitive distant telescopic sensor for measuring in hard-to-reach places. It can measure air flow speed, volume and temperature. The sensor can be extended to any length up to 1 meter. The small diameter of the sensor allows us to enter and measure a narrow channel.

Figure 4. HTi HT -9830 thermal anemometer with telescopic sensor

Wired anemometer HTi HT-9830 (wind speed sensor, air flow speed meter) - a measuring device equipped with a sensitive remote telescopic sensor for measuring in hard-to-reach

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places.

- minimum airspeed sensitivity; 0,1 м/с

VOLTCRAFT DET1R Digital Hygrothermometer Sensor Handheld Thermometer has a wide measurement range (-10°C to +200°C), suitable for most practical applications.

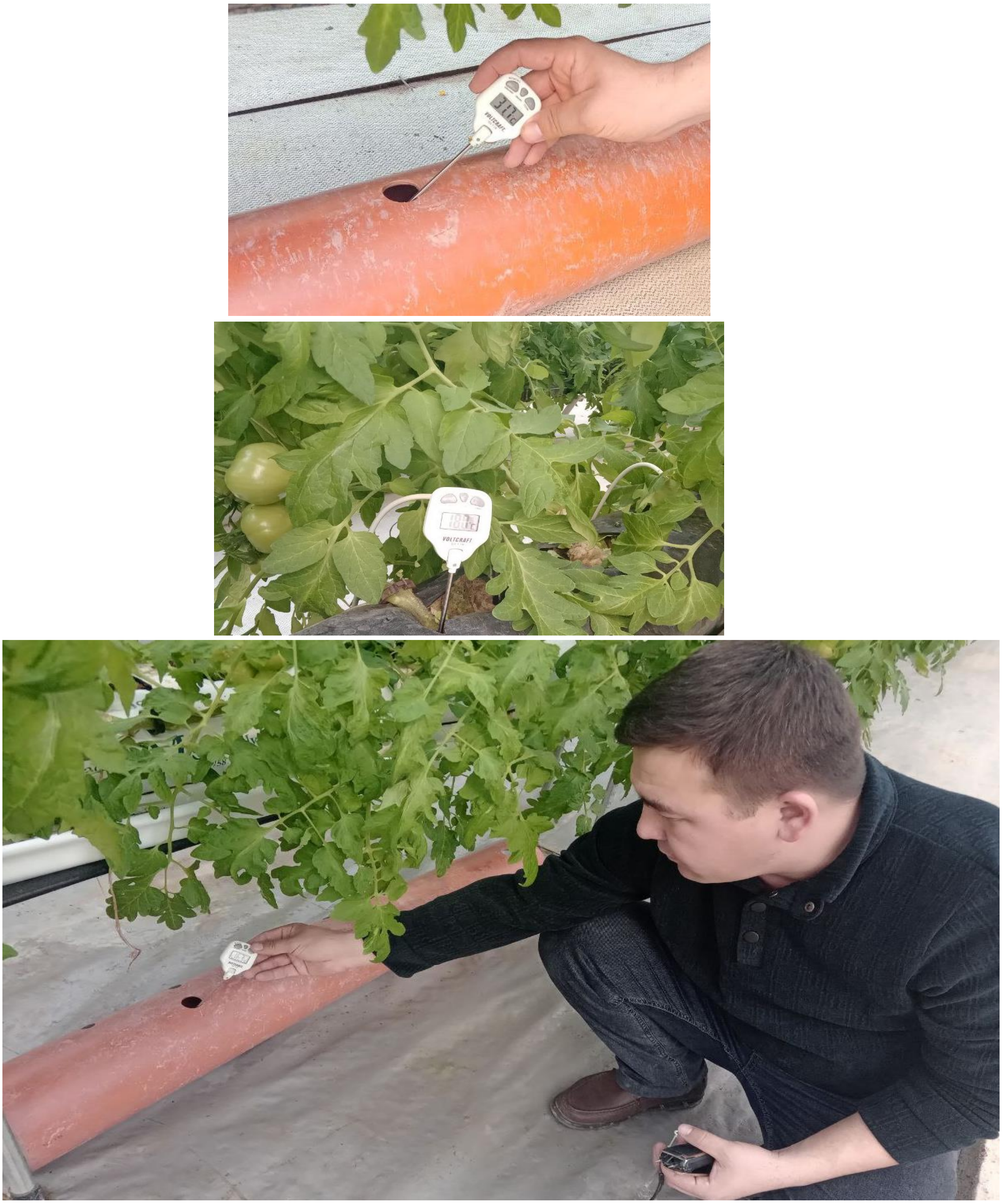

Figure 5. HTi HT -9830 thermal anemometer with telescopic sensor

The memory function allows you to remember the minimum and maximum measured temperature. VOLTCRAFT DET1R digital hygrothermometer is used to measure humidity

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and temperature both indoors and outdoors.

DC 12v V1209 digital thermostat and temperature control, that is, when the set temperature command is given, the suction fan located at the top of the greenhouse starts operation when the temperature reaches 20°C during the day, and turns it off when the temperature drops below 20°C at night.

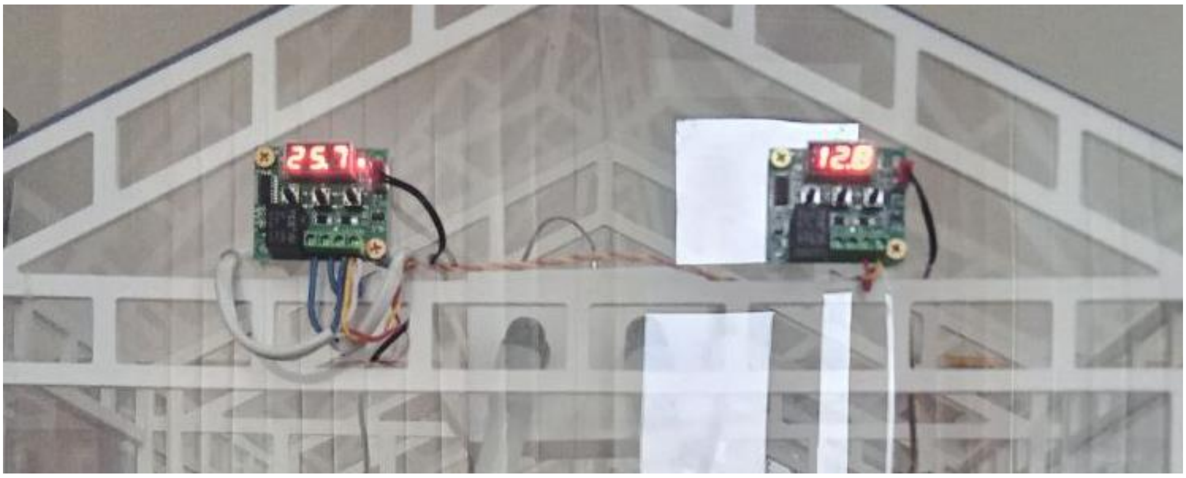

Figure 6. DC 12v V1209 Digital Thermostat and Temperature Controller

- Temperature control range: -50~110 ^{0}C
- Measurement accuracy: 0.1°C
- Accuracy of control: 0.1°C
- Power consumption DC12V

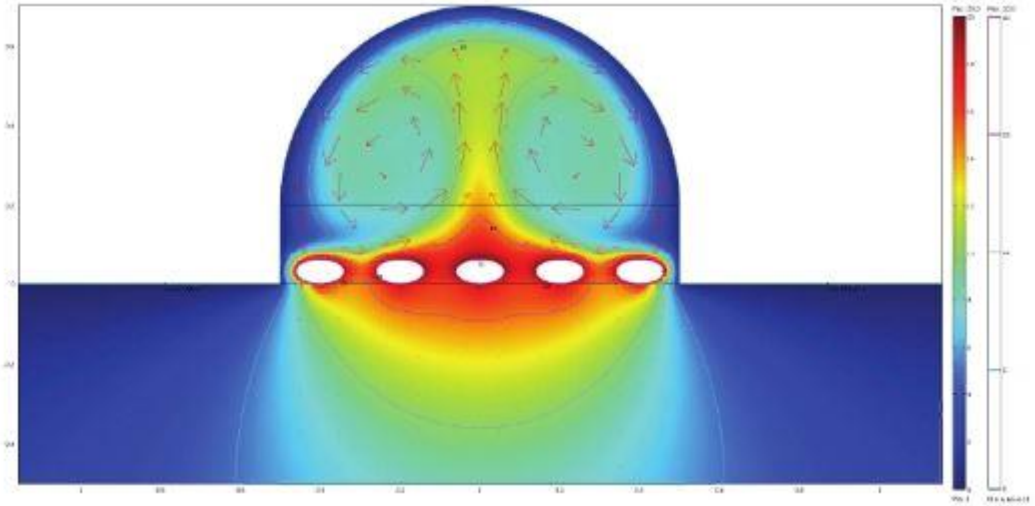

Figure 7. View of the heat flow from the outside of the greenhouse using a thermal imager

Methods

For a technical thermometer, we can only determine the range in which the actual temperature value lies:

(346±4) ^{0}C or 342-350 ^{0}C, known correction values for laboratory thermometer, so it can be determined by experiment.

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T_d =352+(-1)+(+0,5)=351,5 ^{0}C
From here we can observe that the actual error of the technical thermometer exceeds the permissible limits.
As a result of observations, the indicator arrow moves from the previous link to another based on the signal power DU that entered the measuring device.

$$\Delta U = \frac{(Uk\ - Hh)}{N} = \frac{10-(-10)}{50} = 0.4\ мВ$$

Therefore, K=0.4 mV should be

If we consider the movement of the pointer arrow as the change in the output value of the device over one interval, then it is easy to see that the sensitivity ^{0}C and the interval coefficient K are reciprocal quantities.
S=1/К=1/0,4=2,5
S- coefficient of sensitivity reshaping.
The input signal of the thermometer is the temperature and the output signal is the electrical resistance of the thermometer. The coefficient is relevant for a copper thermometer with a sensitivity range of 250 kPa.
S_m =dR/dt=R_0·α
for a platinum thermometer
$S_п$= dR/dt=R_0·(A+Bt)
Thus, the conversion factor for a copper thermometer does not depend on temperature, but for a platinum thermometer, its temperature changes.
The shift of the indicator from 0°C to 10°C corresponds to degrees XK. the value of thermo-EMF changes by 0.65 mV.
34,12+(0,65)=33,47 мВ
Determination of the temperature value T=442,75°C
Let's determine the estimate of the most likely value of the difference corresponding to the end points of the scale.

Results

$$\Delta p = \frac{84{,}15+84{,}06+83{,}80+83{,}90+83{,}94+84{,}10+84{,}02+84{,}03}{8} = \frac{672}{8} = 84\ кПа$$

Let us estimate the most likely value of a voltage drop of 10%:

$$\Delta p^* = \frac{83{,}85+83{,}73+83{,}82+83{,}76+83{,}84+84{,}82+84{,}83+84{,}75}{8} = \frac{670{,}4}{8} = 83{,}8\ кПа$$

Thus, we can find an estimate of the largest error value at the end point of the scale, where a change in the tension of the measuring system will result:
$\tilde{\Delta}=\tilde{\Delta p}^*$- $\tilde{\Delta p}$=83,8-84=-0,2 кПа
This error is called additive, because it occurs as a result of the deviation of one of the influencing quantities (supply voltage) from the normal value.
The change in barometric pressure is 4 kPa.
Since the measuring devices of manometric thermometers measure excess pressure, the device readings are overestimated by 4 kPa.
The scale of the thermometer is the same, the pressure range of the scale is 250 kPa.
Thus, the thermometer indicator is determined as follows.

$$100 * \frac{4}{250} = 1{,}6\ °C$$

Then we find the absolute error at 80°C.

$$\delta = \frac{+1{,}6}{80} 100 = +2\%$$

At a temperature of 24 0C, the main error occurs, since the normal operating conditions of the device are 20 ± 5 °C. At a temperature of 10 0C, in addition to the basic error, there will be an additional change in the instrument readings due to temperature changes.

Fixed margin of error - $\delta_0 = \Delta_0 / x_и$

The smaller the instrument reading on the scale, the greater the relative error.

Therefore, the measuring range of the device should be at the end of the measured value.

If there are no other metrological characteristics in addition to the potentiometer class, then only the permissible error limits can be estimated. The permissible margin of error in the experimental results of measuring instruments is determined by the measurement range x_k-x_n of the measuring instruments of the K class and the potentiometer:

$\Delta_0 = ((x_к - x_н)/100) \cdot K$

For potentiometers, the error is expressed in millivolts.

$x_к$=E(600°C, 0°C)=49,11 мВ;

$x_н$= э(200°C, 0°C)=14,59 мВ;

$\Delta_0 = \frac{49{,}11 - 14{,}59}{100} * 0{,}5 = 0{,}1726$ мВ.

Relative error margin at 550 °C

$\delta_0 = (\Delta_0/(E(550°C, 0°C))) \cdot 100 = (0{,}1726/44{,}71) \cdot 100 = 0{,}386\%$

The absolute margin of error is the same for everyone

scale marks, and the relative error margin increases towards the top of the scale. For example, around 300 °C

$$\delta = \frac{0{,}1726}{22{,}88} 100 = 0{,}75\%$$

Therefore, the measuring range of the device should be selected so that the measured value is at the end of the scale.

Let's estimate the error in measuring air temperature using the characteristics of a glass thermometer. A thermometer with a division value of 0.2 and a scale of 100-150 °C has a tolerance of ± 0.5 °C.

Thus, $\Delta t_v = \pm 0{,}5°C$ yoki $\Delta t_v / t_v = \pm 0{,}00416$. To estimate the margin of error in determining the heat transfer coefficient, we use the following formula to determine the absolute error. For additional calculations, we determine the derivatives:

$$\frac{\partial \alpha_к}{\partial Q} = \frac{1}{F(t_c - t_в)} = \frac{1}{3{,}14 * 10^{-3} * 80} = 3{,}98 \frac{1}{(м^2 * К)};$$

$$\frac{\partial \alpha_к}{\partial F} = \frac{Q}{F^2(t_c - t_в)} = \frac{1588}{(3{,}14 * 10^{-3})^2 * 80} = 2{,}013 \cdot 10^6 \frac{Вт}{(м^4 * К)};$$

$$\frac{\partial \alpha_к}{\partial t} = \frac{Q}{F(t_c - t_в)^2} = \frac{1588}{3{,}14 * 10^{-3} * 80^2} = 79{,}02 \frac{Вт}{(м^2 * K^2)};$$

$$\frac{\partial \alpha_к}{\partial в} = \frac{Q}{F(t_c - t_в)^2} = \frac{1588}{3{,}14 * 10^{-3} * 80^2} = 79{,}02 \frac{Вт}{(м^2 * K^2)};$$

$$\Delta\alpha_{к} = \mp\sqrt{(3{,}98 * 11{,}34)^2 + (2{,}013 * 16)^2 + (79{,}02 * 2{,}9)^2 + (79{,}02 * 0{,}5)^2} =$$
$$= \mp 239{,}06\ \frac{Вт}{(м^2 * К)};$$

Calculated heat transfer coefficient

$$\alpha_{к} = \frac{Q}{F(t_c - t_d)} = \frac{1588}{0.00314 * (200 - 120)} = 6321{,}7\ \frac{Вт}{(м^2 * К)};$$

Fixed relative error margin

$$\delta_0 = \frac{\Delta * \alpha_{к}}{\alpha_{к}} = \mp\frac{239{,}06}{6321{,}7} * 100 = \mp 3{,}78\%$$

It can be seen from the solution that the largest component of the error is due to the error in measuring the temperature of the pipe surface.

The decisive factor in the temperature measurement error itself is the error of the thermoelectric thermometer. If we consider that as a result of individual calibration, the error of the measuring set for temperature measurement can be brought to a value not exceeding ± 0.5 ° C, then the absolute error in measuring the heat transfer coefficient is reduced to the permissible limit.

$$\Delta\alpha_{к} = \mp\sqrt{2037 + 1037 + 1561 + 1561} = \mp 78{,}72\ \frac{Вт}{(м^2 * К)};$$

Or

$$\delta_0 = \mp\frac{78{,}72}{63{,}21} * 100 = \mp 1{,}24\%$$

Discussion

As a result of the calculations, the permissible margin of error in the measurement of the heat exchange coefficient was obtained. It is known that each component of the error does not go beyond the permissible limits, but the error is equal to the limit or several times smaller than the unknown. To estimate the error, we need to know the possible values for each of its components with corresponding confidence intervals. These values can be obtained by repeated measurements and subsequent statistical processing of the results.

Conclusion

Increasing the accuracy of determining the heat exchange coefficient is done by using high-class measuring tools. In this case, we estimate the value of the maximum permissible error, which is naturally smaller for measuring devices with a higher category, and accordingly the error falls into a narrower range. It should be noted that the calculation does not take into account a number of factors that affect errors, so the actual errors (limits of permissible values) will be more.

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