UNCONVENTIONAL HEAT GENERATING SYSTEMS FOR THE ADJUSTMENT OF THE MICROCLIMATE FROM THE PROTECTED CULTURE SPACES

SISTEME NECONVENȚIONALE GENERATOARE DE CĂLDURA PENTRU REGLAREA MICROCLIMATULUI DIN SPAȚIILE DE CULTURI PROTEJATE

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Abstract. *This paper presents new materials used in the extension of the vegetable crops growth season. To ensure the microclimate conditions regarding humidity, temperature and solar radiation, there are presented the indicators of ventilation capacity of materials and the electrical properties of these necessary in the establishment of the generated heat flux.*
Key words: *unconventional systems, protected cultures;*

Rezumat. *Lucrarea prezintă noi materiale utilizate în extinderea sezonului de creştere a culturilor de legume. În vederea asigurării condițiile de microclimat privind umiditatea, temperatura şi radiația solară, sunt prezentați indicatorii capacității de ventilare a materialelor şi proprietățile electrice ale acestora necesare în stabilirea fluxului de caldură generat.*
Cuvinte cheie: *sisteme neconventionale, culturi protejate*

INTRODUCTION

The assignation of the correlations between the microclimate factors and the biological requirements of plants is necessary for the design of textile materials with controlled heat potential.

The heat exchange on the surface of the textile material can be realized both by convection and by radiation. The natural convection is determined by the variable consistencies field of the air related to temperature(Munteanu, 2008; Korner,2007). When appear forces that generate a difference of baric pressure (wind) we can talk about forced convection that altogether supposes the intensifying of the thermal losses on the textile material surface. In the heat exchange on the surface of the textile material, we will also take into account the presence of a contiguous air layer whose characteristics determined by its position of partitionary wall between the microclimate and the outside environment, offers it a certain role of thermal protection according to the vegetable culture. The radiation represents a particular form of heat exchange where the energy carrier is featured according to the theory of electromagnetic waves. According to this theory we can say that the thermal radiation has a dual character, with the

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properties of the continuous field of electromagnetic waves and the discreet properties of photons. In green houses take place complex thermal phenomena of the warm and cold air exchange. In their inside, the solar radiation contributes to the general exchange of heat, to the steadfastness of caloric and radiation balance (complex phenomena where participate also temperature and humidity, evaporation and condensation) (Munteanu, 2008; Stan, 2003; Rodríguez, 2002).The temperature control is essential in green houses because too low temperatures prolong the vegetation and fructification duration.

MATERIAL AND METHOD

Structure of proposed materials

The studied knits have been made on flat knitting machines having as knit structure rib 1x1, with inlaid yarn, every structure being crafted in three stitch densities (NP=9.0; NP=9.5; NP=10). The inlaid yarn from the knit structure is copper and manganin type necessary for the heat production. Towards that, for the tested knit variants have been determined the following properties: permeability to air of knitted materials and the necessary electrical properties in the establishment of the generated heat flux.

RESULTS AND DISCUSSIONS

1. The assessment of air permeability for the studied knit variants

The gas exchanges between the proposed microclimate and the environment take place both ways, regarding the quantity of carbon dioxide and oxygen, so the studied materials must optimise the continuous or almost continuous air exchange.

By definition, the permeability to air represents the quantity of air that passes through material, at a certain pressure difference in the time unit and through the surface unit.

The general formula of air permeability adaptable to any type of apparatus is:

$$P_{ap} = \frac{V}{t \cdot A} \ (m^3/min \cdot m^2) \qquad (1)$$

where:

V – represents the air volume that passes the textile surface, between whose faces a pressure difference is created $p = p_1 - p_2$ (m^3)

t – represents the time needed for the passing of the air through the material (min, s)

A – the analysed sample surface (m^2)

If we take into account the definition relation of the air flow, q=V/t, then the air permeability formula becomes:

$$P_{ap} = \frac{q}{A} \ (m^3/min \cdot m^2)$$

For the establishment of all parameters that characterize the air passing through the knitted material we need the apparatus type ATL 2 for the determination of the air flow that passes through the textile material.
For the determination of the air permeability the apparatus type ATL-2 has been used, using the following calculus relation:

$$P_{ap} = \frac{q \cdot 10^3}{60 \cdot A \cdot 10^{-4}} = \frac{q}{6 \cdot A} \ (m^3/min \cdot m^2) \qquad (2)$$

where:
q – represents the air flow that passes the analyzed textile material.
A – the surface of absorption hatch (cm^2)
The values of the air permeability for the studied knit variants are presented in Table 1.

Table 1

The calculus of air permeability for the studied knit variants

NP	DP = 5 mm col. water q(l/h)	Pa ($m^3/min \cdot m^2$)
9.0	5733	49
9.5	6225	53,2
10	6500	55.55

The overflow of optimal level of temperature and humidity of the air from microclimate can determine an unbalance of the plants metabolism and the reduction of the photosynthesis. The choosing of the value limits for the ventilation capacity indicators of the textile materials must be realized according to the requirements of the cultivated biological potential. According to table 1, the studied textile materials come under the value limits for the April-May period.

2. Electrical measurement system setup

In order to test the heating properties of the materials a measurement system was developed. The setup of the system is depicted in Figure 1. A personal computer is controlling the system using two USB ports (*USB0* and *USB1*). First USB port is used to command a programmable power supply. This device is a EA-PSI 6032 device and can generate up to 32 Volts and 3 Amps. The electrical heating wire is connected to the output of the power supply. This is the “power circuit” of the system. Two temperature transducers (*TS1* and *TS2*) are fixed within the heating conductor in order to measure the real wire-temperature. These sensors are AD590 type and they are integrated circuit temperature transducer that produces an output current proportional to absolute temperature. The temperature range is large (-55 °C to 150 °C) and the output current is linear (1µA/°C). A data acquisition board is used to measure the temperature sensors signals. This board is a National Instruments bus-powered M series multifunction board for USB and has up to 400 kS/s and up to 32 Analog Inputs. Secondary USB port of the computer is connected with the DAQ board.

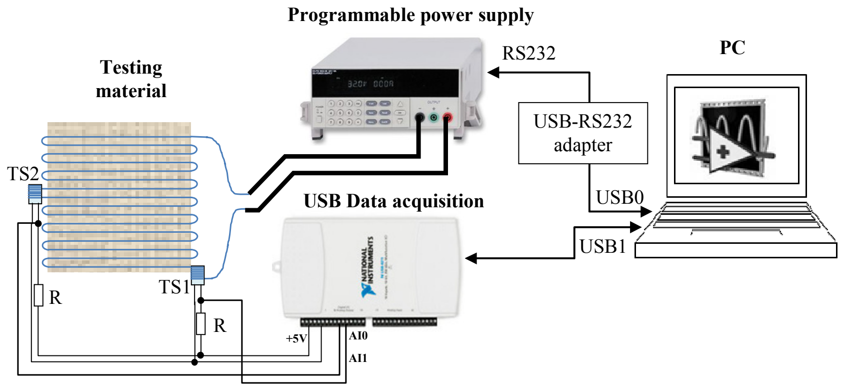

Fig. 1 - The measuring system setup

The system uses two temperature sensors because we needed the confirmation that the electrical wire is heated uniformly and the material texture has no influences in this. In the measurement results only one temperature is presented because these tow sensors indicated very closed values of temperature.

A virtual instrument designed in LabVIEW software platform is used to control the system and to collect the data from sensors. A screenshot of this instrument is presented in fig 2. As can be seen the instruments has two different tasks to do: to program the power supply and to collect the sensor's data. In order to control the supply voltage the operator must set the starting voltage, the stop voltage, the step voltage and the number of seconds to hold that voltage. The instrument displays the actual voltage and can be stopped anytime by pressing the "*STOP*" control button. The instrument read the sensors values every second and displays the data on the graphical indicator. All the data are also saved into a data file for further analyzing and processing.

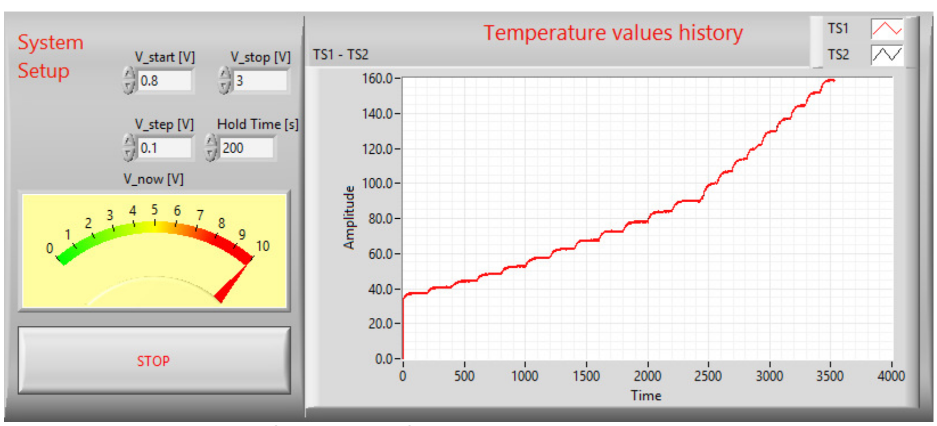

Fig. 2 - The front panel of the measurement Virtual Instrument

Two types of electrical heating conductor were tested: copper and manganin. The choice was made for these materials because of their electrical resistivity coefficient (16.78 nΩ*m for copper and 43-48 nΩ*m for manganin), small variation with temperature and because of their higher tensile strength (200-250 N/mm^2 for copper and 300-600 N/mm^2 for manganin). These tests are performed just to observe how the heating textile materials acts, for further tests and implementation other dedicated heating material (as Kanthal, Nichrome or Cupronickel alloys) will be used.

Figure 3 presents the measurement results for two conductors. In both cases the textile materials maintain their physical properties (dimension, elasticity and shape) even the higher temperature was around 160 °C.

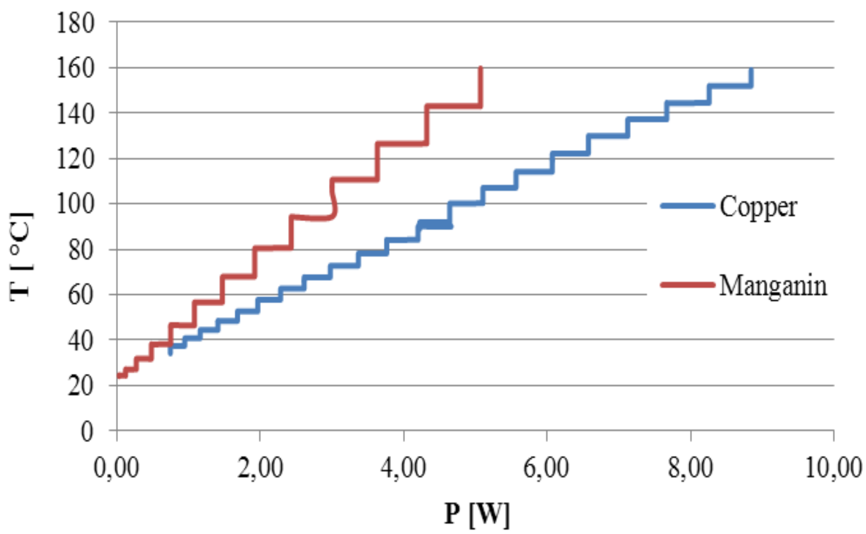

Fig. 3 - Temperature vs. absorbed power of heating materials

The above results show that both conductors can be heated up to 160 °C. The difference in supplying power values are because of the electrical resistance of conductors (0.86 Ω for copper and 33.33 Ω for manganin). The low resistance of copper impose greater supply power but at lower voltage values. The high temperature (160 °C) was achieved with a voltage of 3 V and 3.16 A current. In case of manganin because of a greater value of resistance, the same temperature was achieved with 13 V and 0.39 A. These values can be seen in next tables, where one can see that the heating material can be selected regarding the electrical parameters of the power supply. In case of a power supply that can provide more voltage with low current then manganin is appropriate material. In case of a power supply with low voltage but more current heating conductor based on copper are suitable.

CONCLUSIONS

In the design of heat generator textile materials, used in prolonging the growth season of plants, an important role is being taken by the absorption capacity and humidity transfer indicators, indicators of the ventilation capacity. The correlations between the air flow that passes through the textile material q(m^3/min) – the coefficient of permeability to vapors μ – the specific heat generated by the material through the heating elements contribute to the development of an optimal microclimate according to the biological needs of plants.

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REFERENCES

1. **Korner O., Aaslyng J.M., Andreassen A.U., 2007** - *Microclimate Prediction for Dynamic Greenhouse Climate Control.* HortScience, 42(2);
2. **Munteanu Neculai, s.a., 2008** - *Bazele tehnologice ale legumiculturii ecologice* Ed.Ion Ionescu de la Brad , Iasi
3. **Rodríguez F., 2002** - *Modelling and hierarchical control of greenhouse crop production*, PhD thesis, University of Almería, Spain;
4. **Stan N., Munteanu N., 2001** – *Legumicultura*, vol. 2. Editura "Ion Ionescu de la Brad" Iasi;
5. **Stan N., Munteanu N., Stan T., 2003** – *Legumicultura*, vol 3. Editura "Ion Ionescu de la Brad", Iasi;
6. **Voican V., Lacatus V., 2001** – *Cultura protejata a legumelor in sere si solarii*. Editura Ceres, Bucuresti;