

Monitoring of glasshouse climatic processes with the proposal of their control

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Abstract: The aim of this project was to carry out measurements of climatic process occurring in the glasshouse. This article describes the method of measuring the glasshouse microclimate using the Control WEB 2000 software and the ADAM 4000 series input/output modules. Control WEB 2000 is a graphic development environment to create measuring and control applications. Data acquisition was made by using the ADAM modules of 4000 series which ensure the conversion of data and their transmission from the sensors to the control computer. Soil temperature, glasshouse indoor and outdoor air temperatures and air humidity were analyzed during two summer months. The measuring application is further extended by a proposal for microclimate control in the glasshouse.

Keywords: Control WEB; ADAM module; measurement; automation

In the process of society development the humans first began to liberate from hard and repeated physical labour according to their abilities, opportunities and interest (mechanization). Later on, with a further technical development and growing demand of control activities, they also came up to get free from the demanding and labourious control brainwork (automatization).

A key role in the control systems is played by software. It is the software that makes the whole system unique and specific, tailored to user needs.

The primary job of all measurement systems is to measure and/or generate real-world physical signals. Measuring instruments help us to acquire, analyze, and present the measured data. Through the data acquisition physical signals are obtained such as voltage, current, pressure and temperature that are further converted into digital formats and as such transferred into the control computer. Recent methods of data acquisition include plug-in DAQ and instrument devices, GPIB instruments, PXI (PCI eXtensions for Instrumentation) instruments, and serial communication instruments.

Control WEB 2000 is a general-purpose tool for the development and use of visualization and control applications, applications of data collection, storage and evaluation, and manmachine interface applications.

MATERIAL AND METHOD

The goal of this project was to build a small gauging station for the assessment of glasshouse climatic con-

ditions. This measurement application was extended with a proposal for the microclimate control.

Whole metering was proceeding in private glasshouse in Třebíč. The glasshouse sizes were 4 × 6 m whose northern and eastern side is brick and southern and eastern side glassed – in. The glasshouse height was 1.8 m. Glasshouse was equipped by two ceiling manual operated dormer. Airing dormer was operated manually by staff experience (LUTZ 1987).

Metering sensor for inner air temperature and humidity were placed horizontally below ceiling in lengthwise axis of glasshouse.

The measuring station was based on the personal computer with AMD – K5 processor (frequency of 90 MHz, installed operating memory of 40 MB). The machine was operated on the Microsoft Windows 95b operating system. The old computer was deliberately used to show that it would be sufficient for the simple measurement. Other facilities installed on this computer model were supports for the ADAM modules of 4000 series made by Advantech and a development version of Control WEB 2000 software from Moravské přístroje.

Intelligent modules of the ADAM series ensure the measurement and data transmission from individual sensors to the control computer. The modules are equipped with inbuilt microcontrollers and they are remote-controlled by simple ASCII commands. Instructions are transmitted via the standard communication interface RS-485. The ADAM modules do the adjustment of input signals, their isolation,

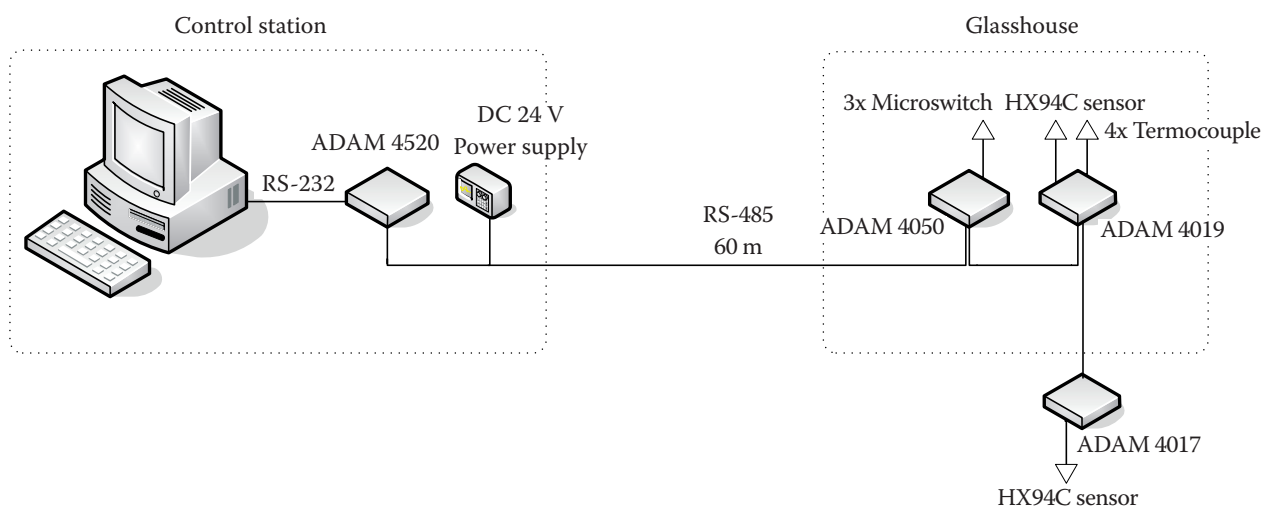


Figure1. The general wiring diagram

selection of input ranges, A/D and D/A conversions, data comparison and transmission to the pilot computer. Digital signals suitable for the relay operation or for the operation of other TTL logic facilities are available in some modules.

The ADAM modules can be connected to the control computer and to all other devices by standard communications interface RS-485. Communication between the modules takes place by means of transmitted and received ASCII commands. The command set for modules of any type contains approximately ten different commands.

The RS-485 network with a high resistance to interference provides for the safe data reading from individual sensors, which makes it possible to place the modules very near to signal sources. With the use of repeaters, one RS-485 network can be connected to as many as 256 ADAM modules with a maximum distance between two modules being 1200 m. The control computer can be connected to the RS-485 network by one of its COM communication gateways through ADAM RS-232/RS-485 or ADAM USB/RS-485 converters.

Modules ADAM 4000 series used in our case were as follows:

ADAM – 4520 – RS-232 to RS-485 isolated converter,

ADAM – 4050 – Digital I/O module with 8 digital inputs and 8 digital outputs,

ADAM – 4019 – 8 channel universal analogue module with 8 analogue inputs,

ADAM – 4017 – 8 channel analogue input module.

Temperature sensor used was a T-type thermocouple manufactured by Omega Engineering, Inc. Company. We also used HX94C sensors with the current output to monitor temperature and humidity made also by Omega Engineering, Inc. Digital inputs monitoring the opening of doors and ventilation dormer windows were controlled by microswitches.

The general wiring diagram of the gauging system is presented in Figure 1. The computer was connected to the ADAM 4520 module by serial interface. The module transferred the communication to the current loop of RS-485 network. In addition to the module ADAM 4520 there was also a 24V 50W DC power supply installed in the same switchboard.

Table 1. A specimen of the database file (1 August)

Time	Te_T_IN1	Te_T_IN2	Te_Soil1	Te_Soil2	Te_In_HX	Hum_In	Te_Out	Hu_Out	Vent_1	Vent_2	Door
0:00:19	20.30	20.1	19.6	19.6	20.59	97.24	18.3	78.62	F	F	F
0:00:49	20.30	20.1	19.6	19.6	20.59	97.38	18.3	78.60	F	F	F
0:01:19	20.30	20.1	19.6	19.6	20.59	97.40	18.3	78.65	F	F	F
0:01:49	20.30	20.1	19.6	19.6	20.58	97.38	18.3	78.42	F	F	F
0:02:19	20.30	20.1	19.6	19.6	20.57	97.34	18.3	78.55	F	F	F
0:02:49	20.35	20.1	19.6	19.6	20.58	97.47	18.4	78.61	F	F	F
0:03:19	20.35	20.1	19.6	19.6	20.57	97.60	18.4	78.68	F	F	F
0:03:49	20.35	20.1	19.5	19.5	20.57	97.70	18.3	78.65	F	F	F
0:04:19	20.35	20.1	19.5	19.5	20.56	97.73	18.3	78.60	F	F	F

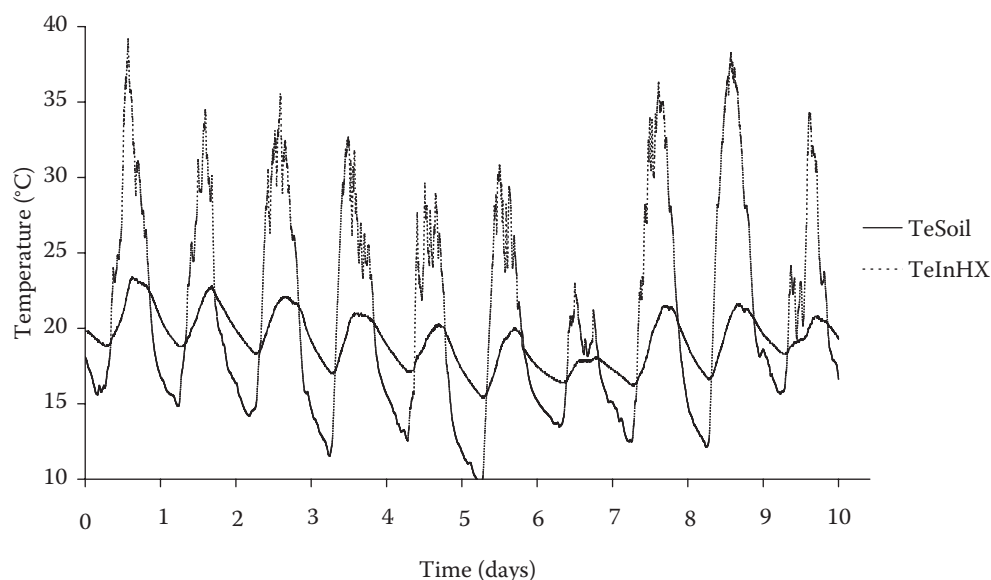


Figure 2. The course of soil and air temperatures in the glasshouse (23 July–1 August)

The switchboard was cabled to other switchboards situated right at the places of measurements, i.e. inside and outside the glasshouse. Distance of the switchboards was 60 metres. The cable contained two pairs of twisted wires of which one was for power supply to the remote modules and the second one served for the communication via the RS-485 network.

In the switchboard located inside the glasshouse there was an ADAM 4050 module for the ensurance of digital data acquisition with 3 microswitches connected to it to monitor the opening of doors and ventilation dormer windows in order to take into account all factors possibly affecting the measurement. The second module installed in the switchboard was ADAM 4019 for analogue signal acquisition. The ADAM 4019 module was connected to four T-type thermocouples and to the HX94C sensor with the current output. The ADAM 4019 module enables connection of sensors with different signal types to each of its analogue inputs. The thermocouples were arranged so that they would measure 2× soil tem-

perature and 2× temperature inside the glasshouse. One HX94C sensor measured temperature and humidity inside the glasshouse, the second one was connected to the ADAM 4017 module to measure temperature and humidity outside the glasshouse. Internal sensors were arranged along the entire length of the glasshouse.

DISCUSSION

The goal of this project was to build a small measuring station for the monitoring of climatic processes in the glasshouse. The need of building up the measuring station arose from the requirement of agricultural research worker who had to monitor the course of temperature and humidity and to subsequently evaluate the effect of microclimate on the grown plants.

This simple measuring station worked more than 2 months without errors. The measured data were processed and graphically displayed in Microsoft®

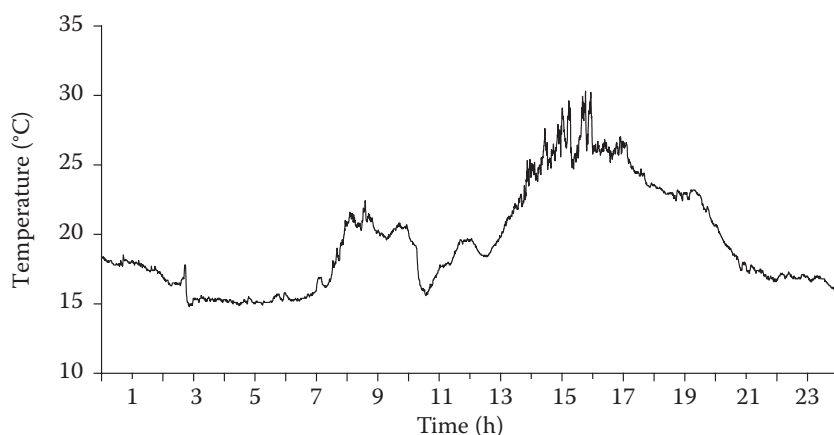


Figure 3. The course of temperature on 1 August (with a storm at 10 AM)

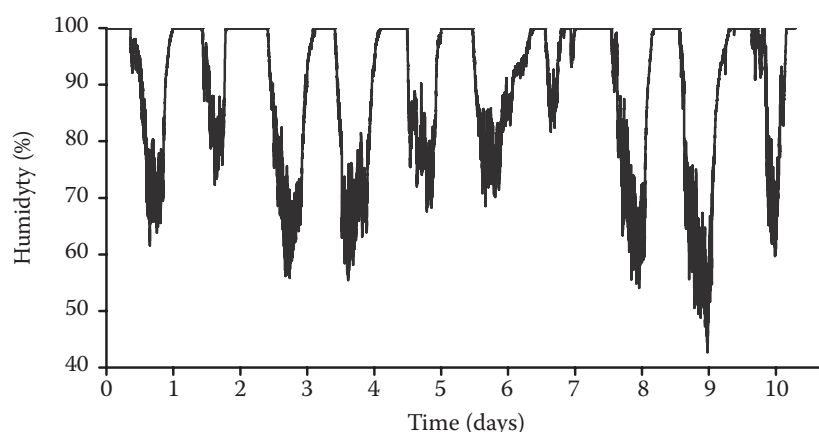


Figure 4. The course of humidity in the glasshouse (23 July–1 August)

Excel. There were some problems with plotting the resulting data row. Microsoft® Excel is limited by 32 000 values for 2 D graph. This is in our case roughly a period of 10 days. If we would wanted to display whole months, then different software would have to be used for data analysis or less values.

Table 1 shows a part of the database file from 1 August. Figure 2 illustrates the dependence of air and soil temperatures inside the glasshouse. Figure 3 presents a one day temperature course with an excellent example of temperature change at about 10 AM when a storm arrived. Figure 4 presents a ten day course of humidity.

RESULTS

A simple application was created in the Control WEB 2000 programme to read data from ADAM modules and to display and store the measured data in

the database file. The measurements were made from 22 July to 12 September without any problems or programme stoppage. To ensure a trouble-free work and smooth programme running, the commercial power supply was backed-up with a battery power supply. The data were measured two times per minute, i.e. 2880 measurements (communications with modules) per day. A total number of measurements carried out during the whole period of 53 days was 152 640 and there were nearly 1.7 million values measured. The subsequent analysis and evaluation of measured values were made in Microsoft® Excel application.

The measured values were used to prepare graphs illustrating the bioclimatic conditions existing in the glasshouse in this particular period of the year. Data from the microswitches on the opening of doors and ventilation dormer windows were used to take into account the impact of ventilation and air flow on the course of temperature inside the glasshouse.

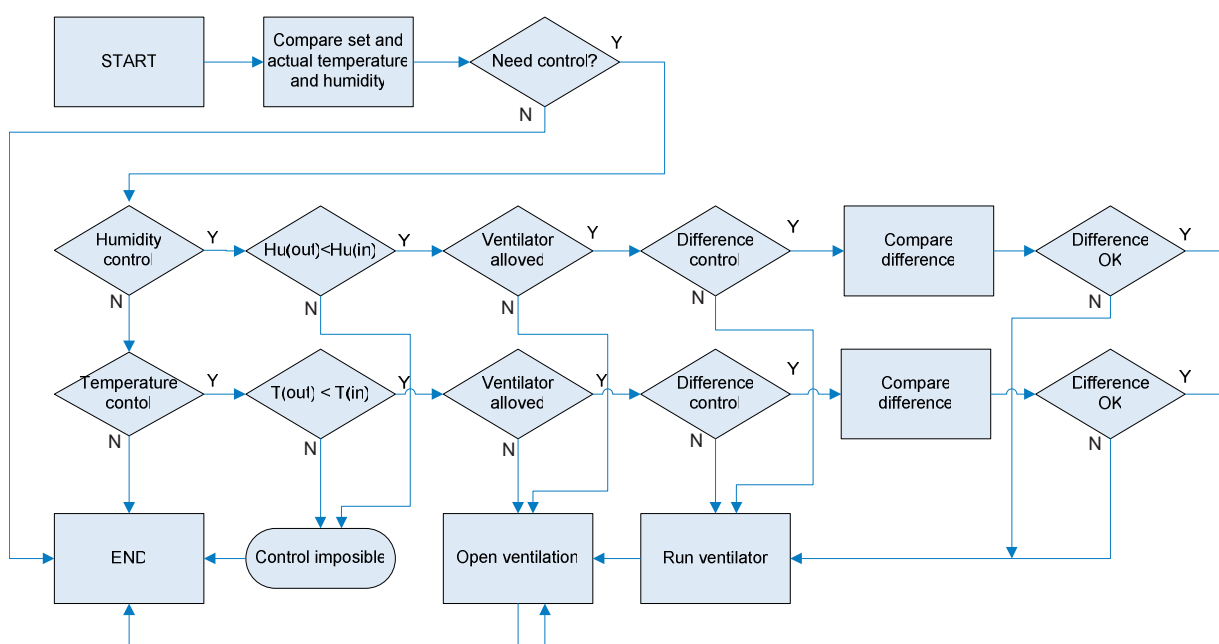


Figure 5. Flow diagram of control process

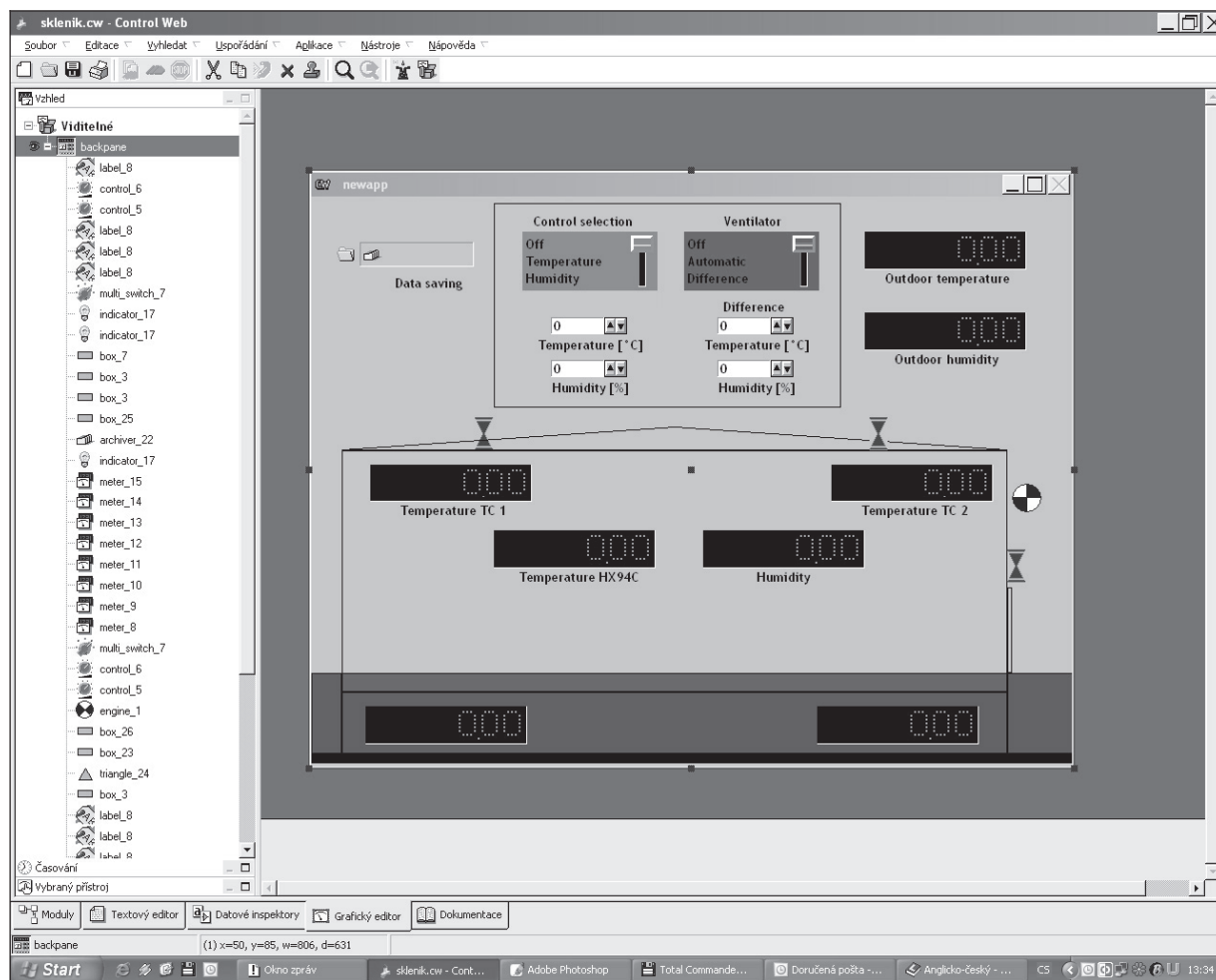


Figure 6. Development environment Control WEB 2000

Analyzing the measured data we arrive at all information concerning the climatic conditions and processes occurring in the glasshouse whose courses are presented in the graphic form in the following diagrams along with some interesting waveforms measured between 22 July and 12 September.

Proposal of glasshouse environment control

When the measuring application was proved, there were 4 digital inputs and 8 digital outputs remaining unused on the ADAM 4050 module and the measuring application was therefore extended by a simple climate management control. A comparison is made between the measured and set-up data and the regulation depends on the result of the comparison. For the regulation by ventilator it is only necessary to set-up a difference of temperature or humidity values at which the ventilator is to be switched on.

This easy control system is operated only by unused digital I/O of the ADAM 4050 module. No other control hardware is to be added. Figure 5 presents a flow diagram of the control process.

At the beginning, the programme will make a comparison of the measured and set up temperature or humidity data if it is necessary to control them. Should the control be required, the programme will find out what we want to control (temperature, humidity or both). Individual steps of the regulation are same for temperature and humidity. The programme will first make a comparison between indoor and outdoor temperatures. The regulation takes place only by the exchange of air. The following step consists in the adjustment of value to be controlled. Should we also wish to use for the regulation air circulation enforced by ventilator, it is necessary to set up a so called value difference at which the ventilator would switch on. Another possibility is that the ventilator is switched off and does not affect the regulation.

Figure 6 shows the Control WEB 2000 development environment. At the bottom working place you can see five flags for switching particular windows. You can switch between graphical and text programming mode. On another page you can read documentation or configure whole application.

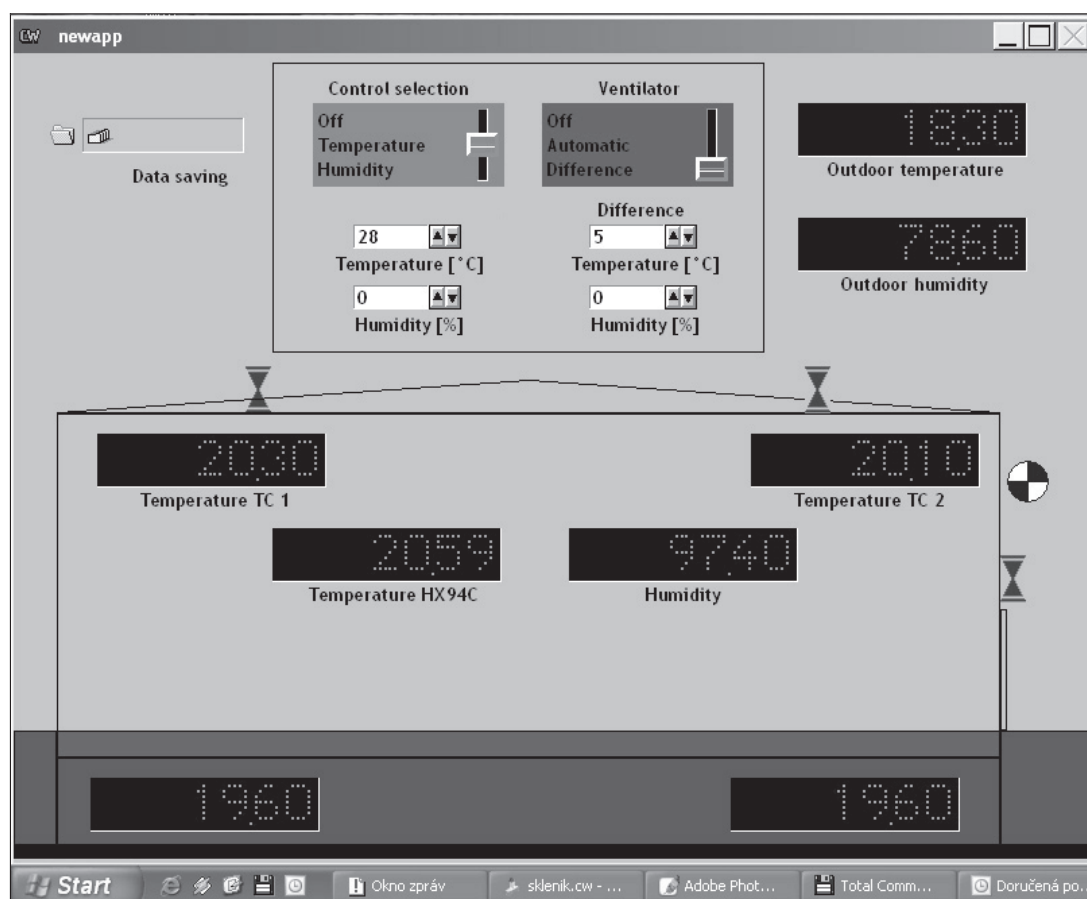


Figure 7. Finished running programme application

Figure 7 illustrates the finished running application. There are displayed measured values as temperatures and humidities. There is also control panel to set control type, define values of temperature and humidity and switching ventilator. All measured data are saved which is representing by icon in top left corner. Red symbols represent position of ventilation windows, their end position.

This application is further extendable with additional ADAM modules and it is possible to create a range of other measuring applications.

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Received for publication January 6, 2006

Accepted after corrections March 2, 2006

Abstrakt

HOLOUBEK L., KUKLA R., KADLEC R. (2006): **Monitorování klimatických dějů ve skleníku s návrhem řízení.** Res. Agr. Eng., 52: 48–54.

Cílem projektu bylo provést měření klimatických dějů probíhajících ve skleníku. Článek popisuje způsob měření mikroklimatu ve skleníku pomocí programu Control WEB 2000 a vstupně výstupních modulů ADAM řady 4000. Control

WEB 2000 je grafické vývojové prostředí pro vytváření měřících a řídicích aplikací. Pro sběr dat byly použity moduly ADAM řady 4000, které zabezpečují konverzi dat a jejich dopravu od senzorů do řídicího počítače. Analyzovali jsme teplotu půdy, vnitřní a venkovní teplotu a vlhkost vzduchu po dobu dvou letních měsíců. Měřící aplikace je dále rozšířena o návrh na řízení mikroklimatu v tomto skleníku.

Klíčová slova: Control WEB; moduly ADAM; měření; automatizace

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