11th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

AUTOMATION SYSTEM OF SOLAR-HEATING-COOLING PLANT

Frantisek Hruska
Tomas Bata University in Zlin, Faculty of Applied Informatics
Mostni 4511, Zlin
Czech Republic

ABSTRACT
The situation of temperature rise of the Earth asks for some radical solving. One of its is our project of Solar-Heating-Cooling (SHC) system. The SHC system uses solar energy to change it into heating or cool energy. The SHC system requires a quality control system. Important basic function of control system is to accumulate maximum energy from solar radiation into warm water and chilly water. The secondary function is to control of heating or cooling processes in air condition equipment. The control system contents some devices for temperature, flow, pressures and solar radiation measurement. Central unit of system is built of an industrial computer with communication via the Internet. Actuating elements are valves, pumps and motors. A special category is a application software. It is programmed in a SCADA. There is built a html server for client communication too. The optimization algorithms give a possibility to save electricity energy used for present classical air condition and in the end to reduce by CO_2 in environment.
Keywords: measurement, heating-cooling system, control, automation

1. INTRODUCTION
Utilization of solar energy for heating and cooling requires at solving and designing of solar supply to use specific control system. This is given requirements for heating and cooling application. There is control according to optimum criteria as a basic requirement [1,2,3] Maximum of solar energy, accumulation of surplus of energy, accumulation the cool energy, minimum of utilizing of secondary source. Other specific is utilizing of extreme control of position of collector and its rotation according to sun.

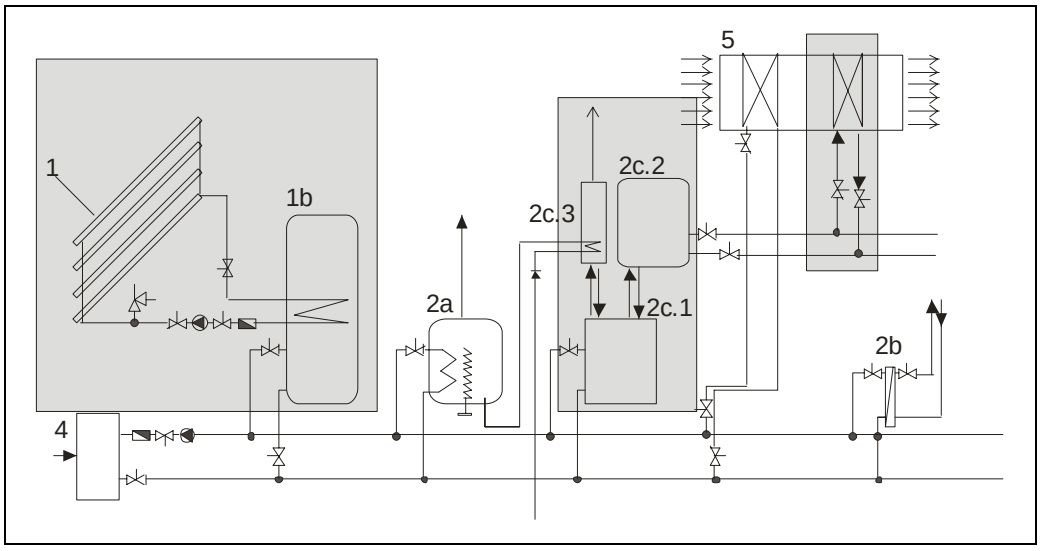

Figure 1. Scheme of SHC system

The solar energy presents a big energy source on the Earth. Therefore is a question, how to take it in maximum value and to use it for utilizing of people. The important is energy efficiency of solar heating system and now cooling system too.
In the industry there is much areas, where possibility is to use heating liquids in range about 40 to 95 °C for heating and for cooling too. In some application there is to use a air heating system. In summer when sun shines the most is needed cooling, in the industry and in the living houses. This specific solving about solar heating and cooling system (SHC) and its control system is described in this paper.
On figure 1 there is scheme of SHC system. Equipment (1) is a solar hot water supply as solar thermal collectors. The output of water has temperature about up 95°C. The solar energy is accumulated in tank (1b) in volume according to requirement power. The hot water out from the tank flows in pipeline system to come in different consumption units. They are: (2a) heater of service water, (2b) heat exchanger for technological plant, (2c) absorption cooling unit. The cooled water (range about 6 to 16°C) is achieved in tank (2b) and then is used in air condition exchanger (5). The exchanger (4) is separating unit for other pipeline system with hot water.

2. AUTOMATION SYSTEM

The automation system of SHC is planed with function of control, visualizing, archiving and communication on the Internet. The scheme of the system is on figure 2.

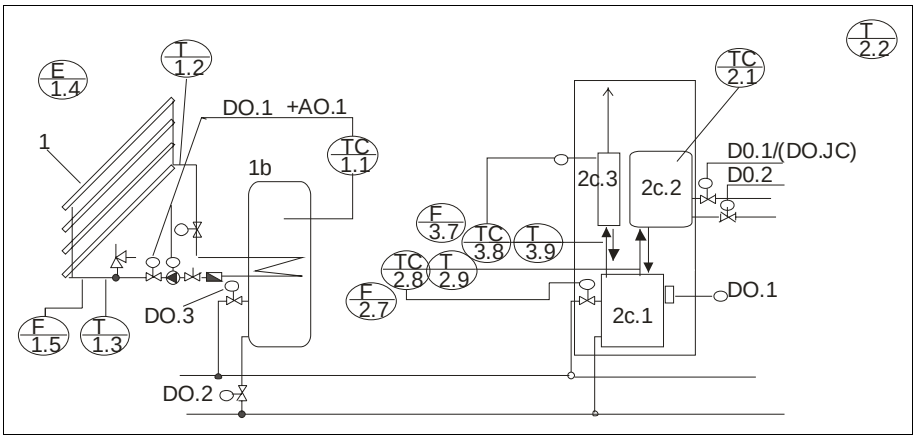

Figure 2. The scheme of the automation system

The automation system is realizing for measurement and control parameters according to table 1.

Table 1: list of measurement inputs and control outputs

	Describing	Range	Output
TC1.1	Accumulating temperature of hot water	0-100°C	0-10V
T1.2	Output temperature of collector	0-200°C	0-10V
T1.3	Temperature of back flow into collector	0-200°C	0-10V
E1.4	Radiant power	0-1100 W/m2	0-10V
F1.5	Flow of water 130°C	0-3 m/s	impulse
DO1.1	Pump control	0/I	contact
DO1.2	Valve V2 control	0/I	contact
DO1.3	Valve V3 control	0/I	contact
TC2.1	Accumulating temperature of cool water	0-100°C	0-10V
T2.3	Input of hot water into unit (2c1)	0-100°C	0-10V
T2.4	Output of hot water from unit (2c1)	0-100°C	0-10V
TC2.8	Output of cool water from unit (2c2)	0-100°C	0-10V
T2.9	Input of cool water into unit (2c2)	0-100°C	0-10V
TC3.8	Temperature of cooling water into (2c3)	0-100°C	0-10V
T3.9	Temperature of cooling water from (2c3)	0-100°C	0-10V
DO2.9	Control of (2c1)	0/I	contact

DI2.1	Valve V2.2 position	0/I	contact
DI2.2	Valve V2.3 position	0/I	contact
F2.2	Flow of hot water 130°C	0-3 m/s	0-10V
F2.7	Flow of cool water	0-3 m/s	0-10V
F3.7	Flow of cooling water	0-3 m/s	0-10V
T2.2	Ambient temperature	0-100°C	0-10V

The Automation system has three control loops. The temperature loop (TCA1.1) controls temperature in accumulating tank via run of the pump and valve in pipeline of flow through collector. The action units are a valve (V1) and pump (C1).
The temperature loop (TCA2.1) controls temperature in accumulating tank of cool water. The action unit is run of absorption unit (2c1). The unit makes cooling to be archiving the most cool water.
The third temperature loop is (TCA2.8) and controls temperature of input hot water for precise function of cooling process.
The temperature loop (TCA3.8) controls temperature of input cooling water from absorber. The action unit is run of cooling unit (2c3). The unit makes cooling to be coming away heat energy from absorber.
The automation system measures other parameters for visualizing and registration:

- (T1.2) *Output temperature of collector*
- *(T1.3) Temperature of back flow into collector*
- (E1.4) *Radiant power*
- (F1.5) *Flow of water through collector*
- (T2.3) *Input of hot water into unit (2c1)*
- (T2.4) *Output of hot water from unit (2c1)*
- (T2.9) *Input of cool water into unit (2c2)*
- (T3.9) *Temperature of cooling water from (2c3)*
- (F2.2) *Flow of hot water 130°C*
- (F2.7) *Flow of cool water*
- (F3.7) *Flow of cooling water*
- (T2.2) *Ambient temperature.*

2.1. Central unit of system

The SHC-Control system has central unit of IPC (Industrial Personal Computer) unit. The decision about the using of IPC was done according to new trends automation technique. The unit is compatible with office PC. But it has got a part for inputs from measuring loops and outputs to action units.
The all system has preferring (figure 3):

- IPC:
    a. Microprocessor VIA EDEN 600 MHz
    b. Memory 256 MB DDR 266SDRAM with shared video memory
    c. Watchdog
    d. Interfaces for VGA, PS/2, RS232, RS485, 2x 10/100 MBps Ethernet, 4xUSB
    e. Slot for CF Card Type 1
    f. Audio in/output
    g. Standard 2,5” IDE HDD
- Analog input interface (ADI3):
    a. 8 analog inputs
    b. 16 bit Delta-Sigma ADC
    c. galvanic isolation of inputs
    d. voltage inputs from 0+/-0.1 to 0+/-10V
    e. current inputs 0-20/4-20 mA
- Analog output interface (AO1):
    a. 8 analog outputs with common ground
    b. 12 bit DAC

c. galvanic isolation of outputs
d. voltage outputs from 0+/-10V
e. current inputs (only four) 0-20 mA

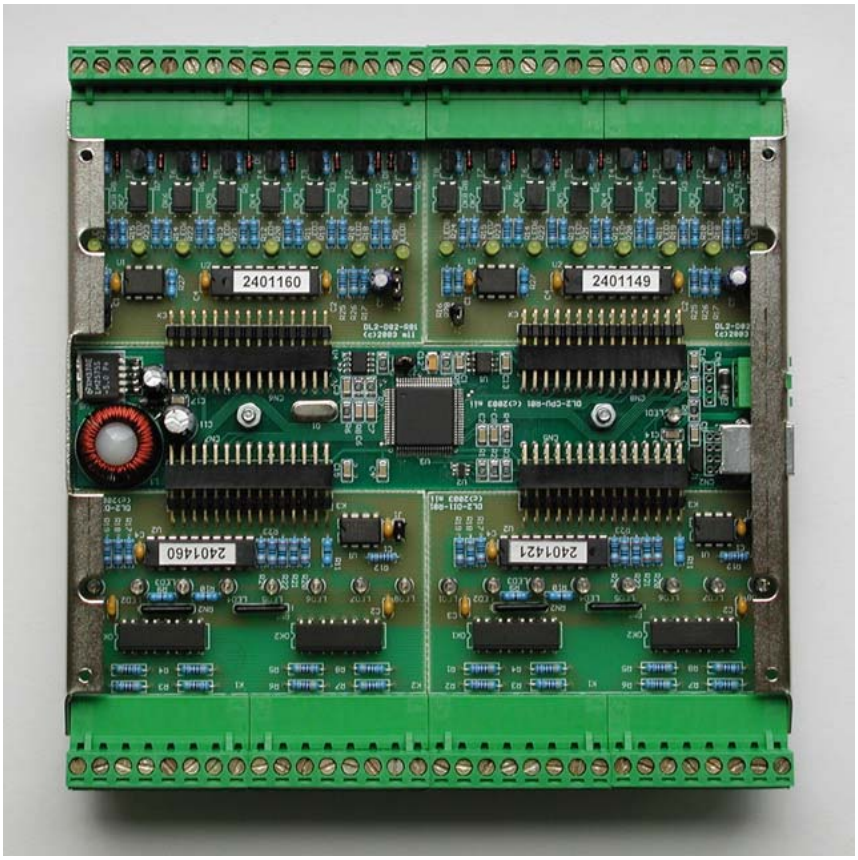

Figure 3. Photo of analog interface of central unit

3. CONCLUSION

The automation system is a result of development and solving the SHC system. Next the local automation system is being a possibility to connect into the Internet and to remote access. The all project has theme of pilot plant.

4. ACKNOWLEDGEMENT

This work was supported in part by the Ministry of Education, Youth and Sports of the Czech Republic under grants MSM 281100001: Automation of technologies and product processes and MSM 7088352102 : Modeling and control of processes of natural and synthetic polymers.

5. REFERENCES

[1] HRUŠKA F.: The solar heat system for industry technology. In: Proceedings of 7th International Conference CPHS ´06, p. 20, ISBN 80-7318-409-5, May 16-18.2006, Zlin, Czech Republic.

[2] HRUŠKA F.: Solar Heating Control System. In: Proceedings of the 17th International DAAAM Symposium “Intelligent Manufactoring &Automation” DAAAM 2006, pp. 167-168. ISBN 3-901509-57-7. Vienna, Austria, 8-11.11.2006.

[3] HRUŠKA F.: Industrial Control System of Heat Solar Supply. In: Proceedings of the 10th International Research/Expert Conference “Trends in the Development of Machinery and Associated Technology” TMT 2006, pp. 977-980. ISBN 9958-617-28-5. LLoret de Mar, Spain, 11-15.9.2006.