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Design an automated computerized cooling system for controlling and recording the temperature in the tropical protected houses

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Abstarct
Increasing the internal temperature in tropical protected houses is a major problem for better crop growth and development. Eventhough, some remedies are in practice to control the temperature in protected houses, they are not very effective and efficient. The research was carried out to design, develop and evaluate performance of an automated, computer operated cooling system with the ability of storing and displaying temperature data in the report form in a protected house. This system was designed to operate it electronically and the system is easy to install. An electronic sensor (LM 35) is used to measure the internal temperature of the protected house. This data is transferred to the computer via COM port by converting the data to digital signals. Data conversion and port communication was done using an electronic circuit with a microcontroller. This system could be set either manually or automatically. If the user select automatic mode, the software compares the internal temperature value with the user defined temperature value. When the internal temperature increases above the defined value, the mist system automatically starts and works until internal temperature drops below the defined value. When the system is operating manually, there are "on" or "off" buttons in the system to operate as the user wishes. To check the accuracy of the sensor used in the system, a test was conducted under the laboratory condition and it was found that there was no significant difference between the data obtained by manually and by the sensor. Under protected house condition the internal temperature of the protected house was dropped down by 2-3^{0}C per minute with the system. Further studies are needed to control other climatological parameters such as relative humidity, light intensity etc. in protected houses.

Keywords: Protected house, Temperature control, Data recording, Computerized cooling system

Indroduction

The concept of growing plants under controlled environmental conditions is more popular in all over the world today. This concept is originated in cold climate zones of the world to provide adequate climatic conditions for crops. These houses are more popular as the grower can control the environment inside of these houses by using mechanical methods up to some extent to gain optimum crop production level.

This system is well adapted for tropical regions as well for regions where no suitable land exists for crop production and crop cultivation regardless of seasonality. More efficient use of water and fertilizers and minimal use of land area are the principal advantages of soil-less culture in combination with controlled environment agriculture. Another major benefit is that the possibility of obtaining pesticide free products, which fetch higher prices at the increasingly ready markets.

However the main drawback of protected houses in tropical background is the increase of the internal temperature of the protected house during the day time. Some remedies are taken to control this problem but they are not much effective and efficient due to constrains such as: Lack of labor, high wager rates and lack of trained and skilled labor (Department of Agriculture, 2008). Due to rapid development of information technology and electronics, fully automated protected houses are presently available. They are controlled by computers and all the work inside the protected house are done by special machines known as "robots". In Sri Lanka there is a limitation to install these systems due to high installation and maintenance costs as well as lack of skilled personnel to do the maintenance of these systems.(Benton, 1930)

Therefore, the main objective of this research was to design an automated computerized cooling system with easy installation, data storing, reporting and displaying abilities.

Materials and Methods

The Working Principal of the System

The temperature sensor senses the internal temperature inside the protected house and compares with the user specified temperature. When internal temperature increases above the threshold value, the cooling system automatically starts and works until internal temperature matches with the user defined temperature. The computer application also writes the necessary data into a text file. Also user can run this system manually. If user selects manual option, the system will work or stop according to the commands of the user.

The Cooling System Desigin

The proposed cooling system was designed by dividing the main system in to following sub-systems.

1. Mist spraying unit
2. Ventilation unit
3. Electronic circuit
4. Computer software application

Mist Spring Unit

This unit consists of a water pump, water storing tank, water sprayers and pvc pipes. Water that needed for generating mist was stored in a storing tank. The storing tank was used to make a continuous flow to the water pump. The water pump was a centrifugal pump of 0.5 horse power which is driven by 230V and 2A (single phase). Double-side knap-sac sprayer nozzles were used for the system and they were mounted in the center line of the roof of the protected house at the height of 12 m from the ground level.

Ventilation Unit

This unit consisted of ventilating fans and connecting wires. The diameter ventilating fan was 250 mm in size with 1400 R.P.M. speed. The fan was driven by 230 V and 2A (single phase). According to the specifications of the fan the air delivery was $11.4m^3/min$. This fan was mounted at the height of 6 m from the surface.

Electric Circuit

The main electronic circuit was designed to fulfill following requirements:

- The circuit acted as the bridge of communication between the computer and other mechanical devices.
- A convertor was used for the communication between the computer mechanical devices as computers are accepting digital signals and mechanical devices accepting analog signals.
- The circuit detected the internal temperature inside the protected house and compared it with user specified value.
- It had a facility to send required data to the computer for the inspection by the user.

The main circuit was developed using the PIC18f452 high performance, enhanced FLASH microcontrollers with 10-Bit A/D. This microcontroller was programmable (built with EEPROM) and self-reprogrammable under software control. It operated under a wide voltage range (2.0V to 5.5V) and temperature ranges. The microcontroller was programmed using C programming language.

Computer Software Application

The software application for the protected house was developed using Visual C#. The application needed Visual studio.NET framework 2.0 to execute it inside the computer. The application allowed user to select the control mode; either "Manual mode" or "Automatic mode".

When the system is in manual mode the user need to switch on or switch off both pump and ventilating fans by clicking "On" and "Off" buttons. Both pumps and fans are working until user is clicking the "Off" button.

When the system is in automatic mode the user needs to specify the pump on and off threshold temperatures in relevant text boxes. Then the system works automatically by comparing threshold temperature with the temperature readings.

The interface also displayed the "current temperature" inside the protected house with the "thermal readings" in the "Reading sections" and calibrated temperature range with "minimum" and "maximum temperatures" and respective "thermal reading" values in the in the "calibration section".

Data Recording

The application created a text file which was having temperature values inside the protected house. The temperature values have been saved with relevant date and time. User has ability to view this text file later by using text editor and could use it for further analysis.

The Mechanisam of the System

A software application was developed for better communication between the computer and electronic circuit. Furthermore it helps to control the system and allows to store temperature records as well. The flow diagram of the new system is shown in Figure 1.

The main window of the application is shown in figure 2. User needs to run the "greenhouse.exe" file to get the user interface. Then user can select either manual mode or automatic mode.

Performance Test of the Cooling System

Following tests were done to test the performance of the new system.

- Laboratory test
- Field test inside a protected house with plants

Laboratory Test

Laboratory test was done to evaluate performance of the sensor under the room conditions. The temperature was measured using the thermal sensor and the thermometer. The circuit was attached to the computer and the temperature value detected by the sensor was recorded using the new software that was developed. At the same time the temperature values were also recorded in every five minutes time interval.

Field Test inside a Protected House with Plants

A field test was conducted to evaluate performance of the system under the actual field conditions. The electronic system was attached to the computer and then pump and blowers also attached to the electronic circuit.

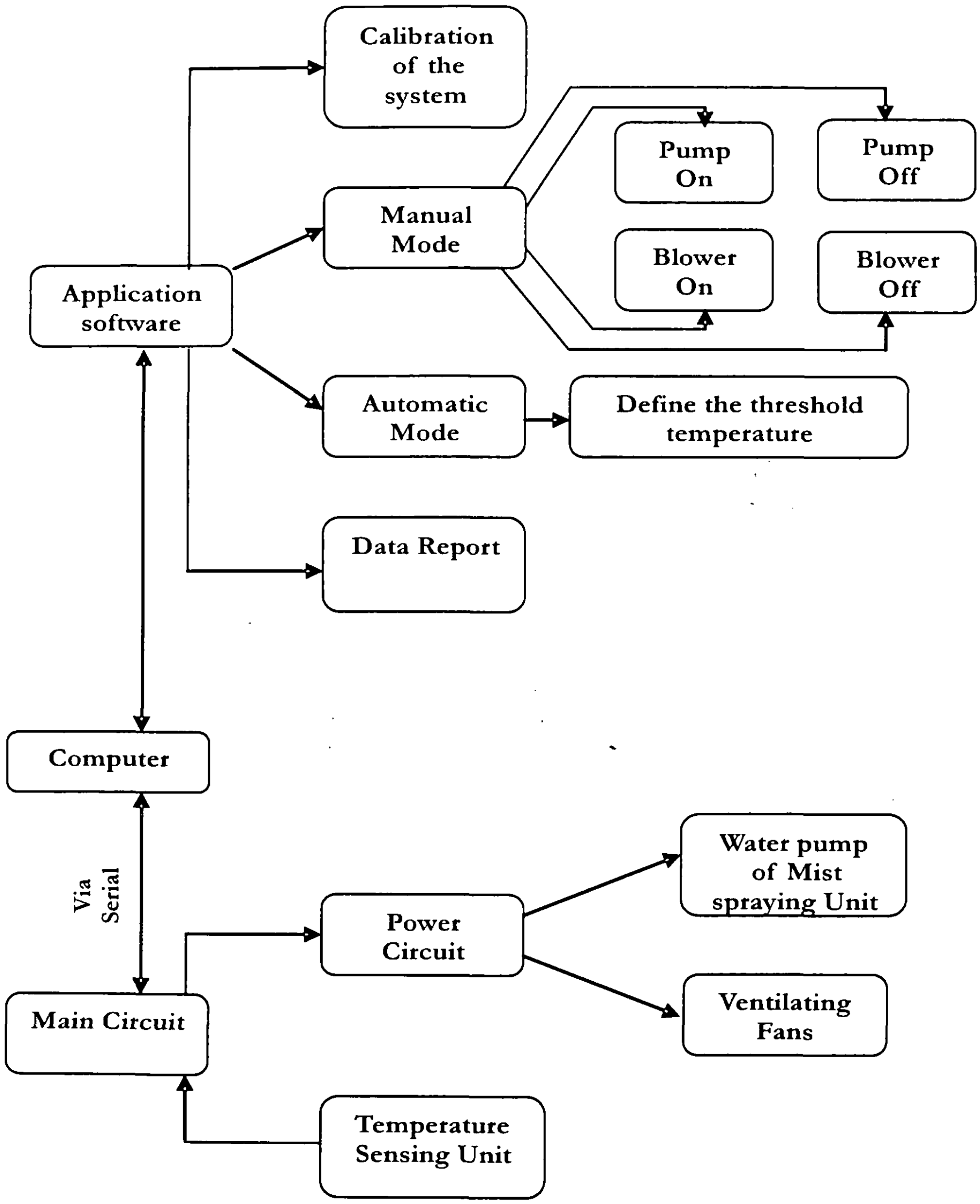

Figure 1- Flow chart of the developed automated system

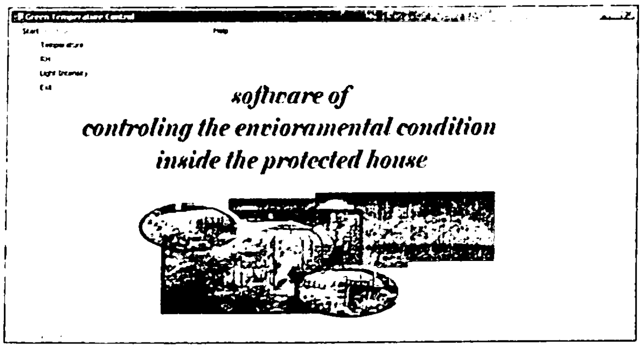

Figure 2 Main window of the application

Then automatic mode was selected from the supporting software and entered the pump on and off threshold values to the computer. Two thermometers were mounted inside and outside of the protected house. Time taken to reduce the temperature, time taken to increase the internal temperature back to its previous value and internal and external temperature values of the protected house were also recorded.

Analysis of Test Data

The results from the above test were statistically analyzed using T test to check whether any significant differences exist between observed thermometer values and thermo sensor values.

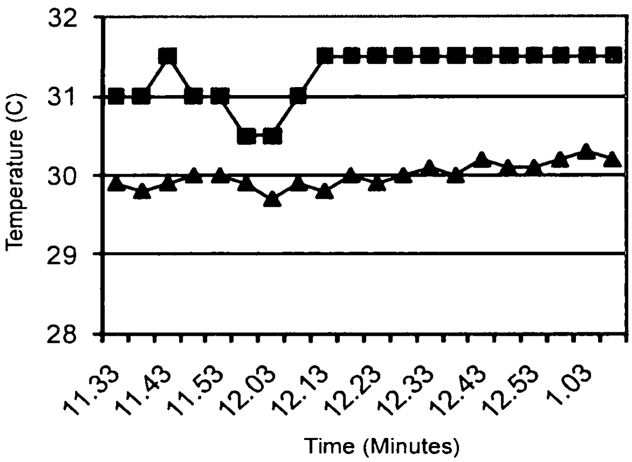

Figure 3 Temperature variation in the laboratory where squares are for thermometer and triangles are for sensor

Resultes and Discussion

Laboratory Test

Figure 3 summerizes the temperature values measured by thermometer and the thermal sensor in the laboratory. A corelation between the temperature values was identified.

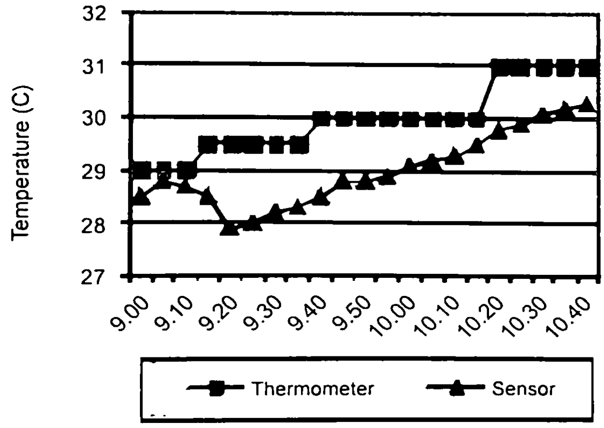

Figure 4 Temperature variation in the protected house on 22/06/2008

Field Test

Figure 4 shows the temperature values measured by thermometer and the thermal sensor at the protected house during the morning. A correlation between the temperature values of was identified except at the beginning.

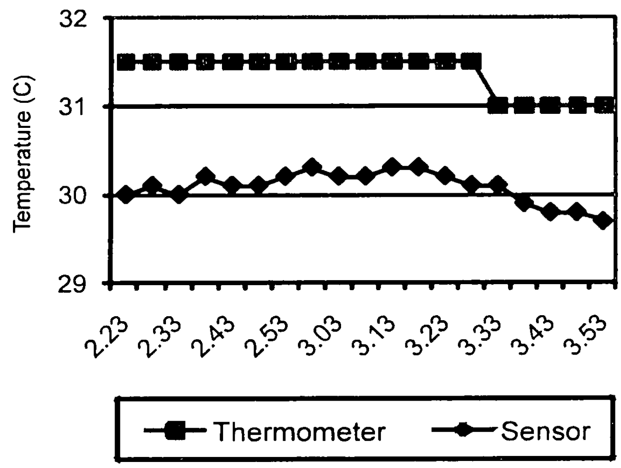

Figure 5 temperature variation in the protected house on 23/06/2008

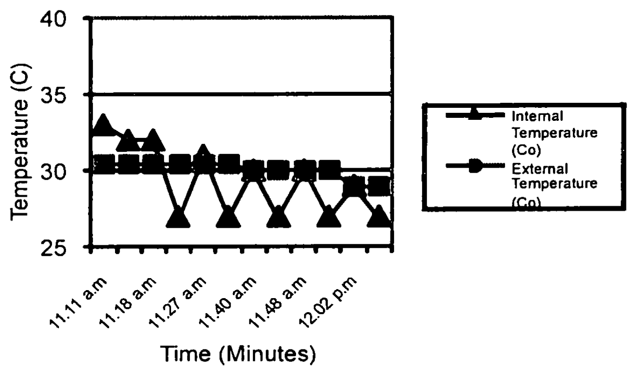

Figure 6: Performance of new cooling

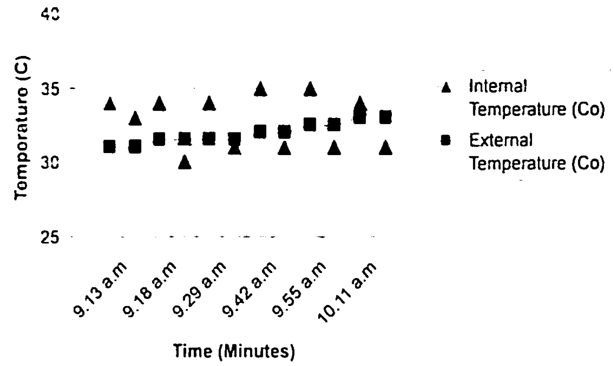

Figure 7: Performance of new cooling system checked on 31/07/2008

Performance Analysis

Figure 5 summarized the temperature values of thermometer and the thermal sensor at protected house during the afternoon. There was a positive correlation between these values. The summary of T-test for temperature values of thermometer and sensor shows that the observations are not significantly different from the expected value in 5% α level.

system checked on 28/06/2008

Figures 6 and 7 show the performance of the new cooling system. The internal temperature of the protected house changed with the variation of the external temperature. The system monitored the internal temperature and when it exceeded or below the critical temperature, system automatically starts and drops down or raised the temperature. Generally the new system decreases 2-3°C within one minute in a protected house under its normal field conditions. In this system amount of water discharged from the nozzles is 2140 ml/min. According to the results, 15-20 minutes were taken to settle the internal temperature back to its previous value without switch on the system again. It may vary with the environmental conditions of outside.

Conclusions and Recommendations

Designed automated computerized cooling system helps to decrease temperature by 2-3°C within one minute in a volume of 146.25 m^3 of space of protected house under its normal field conditions.

The new cooling system decreases the internal temperature inside the protected house up to some extent depending on the external environmental conditions.

The software has an ability to store temperature data inside the protected house with date and time.

The system can be operated automatically or manually.

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