The Arduino controlled incubator to control temperature and humidity

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Introduction

The incubator with the aid of a tungsten bulb to maintain the temperature and the water and a desiccator to maintain humidity was developed. The aim here is to enhance the ability of maintaining accuracy in temperature and humidity to keep them in desired value with bulb, water, and copper sulfate desiccator. Obtained results show a tolerance of 2% in temperature, and 3% in humidity inside the incubation area for a finite range. Incubators are widely used for hatching the eggs, food preservation, and laboratory purposes. Overall the incubator was made to study the ability to maintain humidity simultaneously with the temperature and also the accuracy of the both factors in relation to the expected output values. There were ways to maintain a temperature with a reduced error percentage but not clear ways exist to maintain the humidity with minimized error. The system is a closed loop one with feedbacks of the outputs time to time to check and reduce the error percentage. The controller is an on-off controller and the system is controlled by Arduino programming board (Arduino Mega – AT Mega 2560). Since the system is a simple on-off controller system the accuracy of the system is not perfect as well as a fuzzy logic controlled system or Proportional-plus-integral-plus-derivative controller system. Anyway the system suits for normal purposes in agriculture, food preservation, and egg hatching where a range of the temperature or humidity is only required. The system uses sensors to sense the temperature and humidity. The use of heat emitted from a bulb in temperature change is studied in this setup. The effect of exposure of water in adding water vapor to a space to increase the humidity, and the effect of copper sulfate desiccator in absorbing the water vapor to decrease the humidity are also studied throughout the research.

Methodology

A wooden box was made and the lower part of the box was separated by a wooden plate. In the separated lower part a water containing basin was fixed under the separation plate. The plate was drilled and an opening was created to make an interface between the face of water and the upper part of the area. The opening was closed by a plastic door and a 5.0 voltage gear motor was fixed with the door in order to control the opening and closing of the door. A tube like structure was created in the upper surface of the wooden plate and 100grams of dehydrated copper sulfate was added inside the tube. The opening of the tube towards the upper area of the incubator was closed by a plastic door and another 5.0 voltage gear motor is fixed with the door in order to control the opening and closing of the door. A 220 voltage, 100 Watts Tungsten bulb is fixed inside the upper part of the incubator which was the incubation area. Two sensors DHT22 humidity sensor, and LM35temperature sensor were fixed in the incubation area in order to measure the humidity, and temperature values. Adequate wirings were made to connect the motors, bulb, and sensors with the control circuit. The control circuit was created using PCB wizard software. A Relay (125VAC, 5VDC), ULN2003A integrated circuit, and L293D motor controller were used to create the circuit. The circuit was connected to an Arduino Mega development board and adequate wiring was made to connect the circuit board with Arduino Mega development board. The Arduino Mega development board was programmed to maintain the system with the desired values of temperature, and humidity.

Figure 01: The top view of the incubation area of the incubator

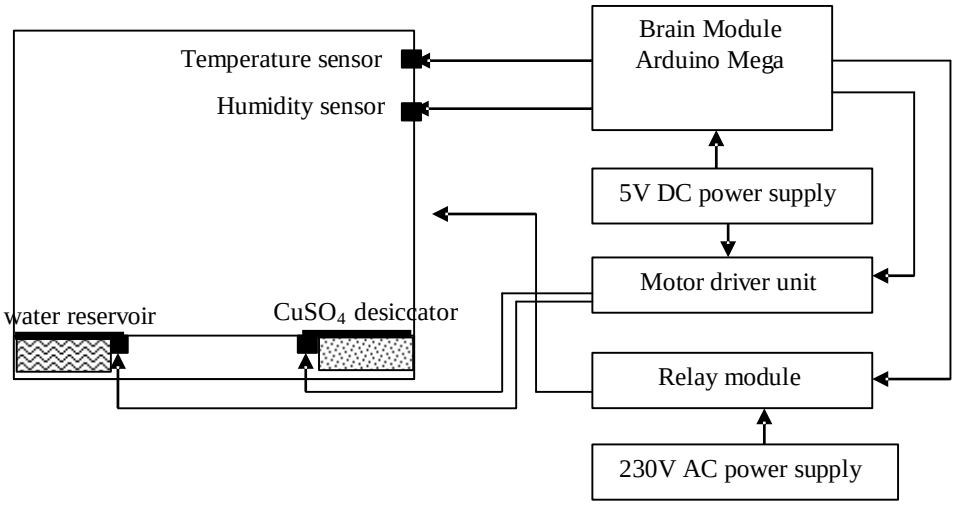

Figure 02: Block diagram for the incubator unit

Results and Discussion

Table 01: Obtained temperature and relative humidity values

Desired temperature (ºC)	Desired humidity (%)	The range of obtained temperature (ºC)	The range of obtained relative humidity (%)
35	62	33.20 - 35.16	61.90 - 62.70
45	70	43.69 - 45.76	69.50 - 71.00
50	75	49.00 - 50.60	74.00 – 75.70

According to the obtained results it is not possible to keep the temperature or humidity in desired fix value but it can be kept within a range differing with a value percentage from the expected values. This kind of result is obtained because the system is an on-off system. If the fuzzy logic system or PID system is used here it might have been possible to maintain a fixed value with a less percentage of error. Moreover, the system deals with a real world issue. The water vapor added inside the incubation area absorbs the heat from the area if it is in a lower temperature than the area's temperature. It will lead to a fall in the temperature. And once the temperature is raised to the level using the bulb, now since the temperature has changed the relative humidity may change. Now again the humidity has to be controlled. Therefore, the system has to be doing some actions all the times to maintain our desired output. This real world problem may affect the results of the system and this

issue cannot be solved electronically. Another problem faced here is related to the desiccator. Here the copper sulfate has to be replaced periodically once it reaches its maximum level of absorbing water. Otherwise we may not be able to decrease the humidity if it goes beyond the preferred level. The exposed area of the desiccator affects the effectiveness of absorbing water. If the area is increased the rate of absorbing water will increase. Hence the effectiveness of the system will also be increased. The copper sulfate desiccator being a chemical is somewhat poisonous. It can cause the food items to be poisoned if they are kept to be incubated. Therefore the food items should be prevented from being incubated using the system. This is one of the important limitations of the developed system. The water molecules can spread very quickly into the incubation area once the door is opened. Therefore it is wise to keep the area of the opening as small as possible. Else the humidity increases so quickly before the sensors sense and identify the values. It is also important to keep the doors air tightened to maintain the humidity value stable. Moreover, some plants need to have a specific light density for their growth. In that case also this system may not be used since a light emitting bulb is used here to control the temperature. The light emitting bulb works depending in the temperature value; not in the light intensity value. In order to reduce the conduction of heat to the outside the wooden part of the incubator was painted in white color inside and outside. White color does not either absorb or emit any rays. Therefore this technique was used to keep the system working in an effective way. When it comes to the issues with the electronic devices, gear motors are not most suitable to the door system. Generally for any door system, servo motors are ideal. They can be brought to any position and we can easily state the positions of opening, and closing at any time. But, gear motors are not such ideal. We should know which terminal should be given high, and which should be given low to open and close the door. And it is important to consider whether the door is opened or closed at each moment. Therefore here I forcefully kept the system to close the door immediately after a delay of each time of opening. Then again the sensor has to inform the humidity value and if it is higher than the stated value the procedure will be repeated. Another factor to be discussed is the time delay of relay. The relay coil takes some time to get charged, and discharged when the command is given. This time delay also affects the effective function of the system in a minor way. It is wise to use optocoupler instead of relay since it is much quicker than the relay. The future direction of the incubator system can be focused on controlling the temperature of the water kept for humidity purposes in order to prevent it from absorbing heat from the incubation area. The incubator is less expensive and it can be considered as a main advantage related to the system.

Conclusions

The temperature values can be kept in a range including the desired value and the error can be reduced to a small value in this incubator. But, humidity maintaining has a much higher error percentage and it is not stable for a long time also. And the humidity controlling was found to be effective within a finite range of humidity values and not for all humidity values desired. Change in each value affects the other variable itself. The incubator is acceptable for temperature controlling purposes but not suitable for long term purposes related to humidity.

References

DHTArduinoNerd (2013). The Arduino Chicken Incubator. Retrieved August 17, 2014, from the World Wide Web: http://www.instructables.com/id/The-Arduino-Chicken-Incubator

WWC (2013). Arduino LCD Thermometer with LM35 Temp Sensor. Retrieved August 19, 2014, from the World Wide Web:
http://www.instructables.com/id/Arduino-LCD-Thermometer-with-LM35-Temp-Sensor/