Journal of College of Education for pure sciences(JCEPS)
Web Site: http://eps.utq.edu.iq/ Email: com@eps.utq.edu.iq
Volume 7, Number 4, December 2017

Wireless Controland Monitoring Systemfor Premature Infant IncubatorEnvironment

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Abstract

Majority problems related to climatic conditions within the infant incubator. Premature birth is from world-wide problem. control of incubator environment is a more important than others in premature infants. Premature infants are often care for infant incubators give convective heating. Where control of the oxygenconcentration,temperature, and relative humidity using Wireless Sensor Networks (WSNs) are the main objectives of this system. Achieving the proper climatic conditions to ensure a suitable environment within the infant incubator target a lot of investigations for some time. Various plans of control theories have been applied in this area to solve the above problems.Thispaperis submitted to the "Al-Habboubi Teaching Hospital" maternity hospital in Nasiriyah. The proposed system technique by using Fuzzy Logic Controller (FLC) that is used in order to simulate the infant incubator monitoring.

Keywords: Incubator, Premature Infant,WSNs, and Fuzzy Logic Controller.

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نظام التحكم والمراقبة اللاسلكية لبيئة حاضنة اطفال الخدج

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الخلاصة

ان معظم المشاكل ترتبط بالظروف المناخية داخل حاضنة الاطفال حديثي الولادة، والولادة المبكرة هي من المشاكل العالمية. ان السيطرة على بيئة الحاضنة هو من أكثر من الأمور أهمية في حاضنة الاطفال حديثي الولادة. السيطرة على تركيز الأكسجين ودرجة الحرارة والرطوبة النسبية باستخدام شبكات الاستشعار اللاسلكية هي الأهداف الرئيسية لهذا النظام. إن تحقيق الظروف المناخية المناسبة لضمان بيئة مناسبة داخل حاضنة الاطفال حديثي الولادة هدف الكثير من الابحاث. وقد تم تطبيق خطط مختلفة من نظريات السيطرة في هذا المجال من أجل حل المشاكل المذكورة أعلاه. يتكون النظام المقترح والذي تم تقديمه الى "مستشفى الحبوبي التعليمي " للولادة في الناصرية، من تقنية النظام المقترحة باستخدام وحدة تحكم المنطق الضبابي التي يتم استخدامها من أجل محاكاة لرصد ومراقبة أفضل لحالة المناخ داخل حاضنة الاطفال حديثي الولادة.

الكلمات المفتاحية: حاضنة الاطفال حديثي الولادة، أطفال الخدج، شبكات الاستشعار اللاسلكية، وتحكم المنطق الضبابي.

1. Introduction

One of the most significant elements in a newborn's survival is the infant's temperature state. Mammals have the benefitof being homoeothermic, significantthat they be capable of outputheat allowconstant body temperature to be repaired [1]. Moreover,a preterm premature infant incubatorof necessityspecificcare since some vital organs and/or biochemical/enzyme systems cannot have developed sufficiently, or because the growth of the fetus may have been disturbed, with the result that the infant incubatoris doubtfullyto survive uninjuredunless care. An infant incubatoris called preterm [2], if it is born next a gestation period of time of less than 37 weeks. The preterm infant incubatorhas variousdisadvantages in terms of thermoregulation.

The information is transmitted in a wireless manner to a central computer to be processed and a decision is made by using a simple system of fuzzy logic controller on the input to send suitable command to adjust digital parameters infant incubator within acceptable limits. The data that have been collected and control commands that have been applied are displayed in one control screen located at in the incubator and the other is displayed on the central computer screen to be analyzed for purposes of improving the incubator environment and thus improve the health status of the newborn.

2. Statement of the Problem

During study of the system phase, requirements of Infant Incubator were categorized into user requirements system, software and hardware requirements, outline to control and monitoring system of Infant Incubator study, Feasibility study and use case. The requirements of the temperature controller inside the incubator will be analyzed and, subsequently, designed and implemented. The purpose of this study is to design and implement a closed loop control fuzzy logic system to regulate the temperature, humidity, and oxygen concentration,inside a neonatal incubator. The use of software in the loop technology enables hardware-related work to be minimized and increasing the design flexibility since software changes are easier to introduce than hardware modifications. A simulation of the incubator thermodynamics to be implemented will be presented.

The temperature abdomen the mother’s womb is 38ºC [3]. Departing the warmth of the womb at birth, the wetness new born finds itself in a very colder environment and without delay begin wasting heat. About5-25 minutes, the new born who is not even caloric defended may lose sufficient heat for the body temperature to descend around 2ºC -5ºC, with level make great falls in the next time if correct care is not granted [4]. 60%-80% for humidity [5].At the time of the oxygen concentration falls lower down 30%, oxygen is supplying from the oxygen is ensured [6].If heat loss is not

impeding and ispermitted to keep on, the newborn will grow hypothermia and is at raised risk of improving health problems and end of life.Hence,an infant incubator is requirement which attempts to produce the necessary environment for the infant incubator continuation of life [7].

3. Development Simulation Model of Infant Incubator

The systemconsists of two stations: sensor station and central station to allow for better monitoring of the state of climate inside the infant incubator sensor station has been provide with the required equipment and several sensors, such astemperature and humidity. This is attaining establish communication between the sensor station and central station through a wireless network. Several changes exist in the model. The system is able to collect information on key environmental parameters, such as; Oxygen concentration and Magnetic door sensor to the open door illegally inside the infant incubator, Monitor the sudden motion of the newborn by using camera inside infant incubator, and treatment the incidence of jaundice through lighting of jaundice.

3.1.Design of Control and Monitoring System

The control of the digital temperature/humidity in DHT11 and other sensorsin the operation of the Infants Incubator Heater (water)/Fan (air filter) at the high and low temperature/humidity conditions, oxygenconcentration, and door status were controlled with relays. Figure (1) show flowchart of the proposed work system beginning for receive the data from the remote node to last step when the user turns off the system.

Fuzzy logic is used to decidethe error between the data that acceptedwith set values,Figure (2, 3, and 4), respectivelyshow membership function of temperatureerror, oxygen concentration, andhumidity error values.

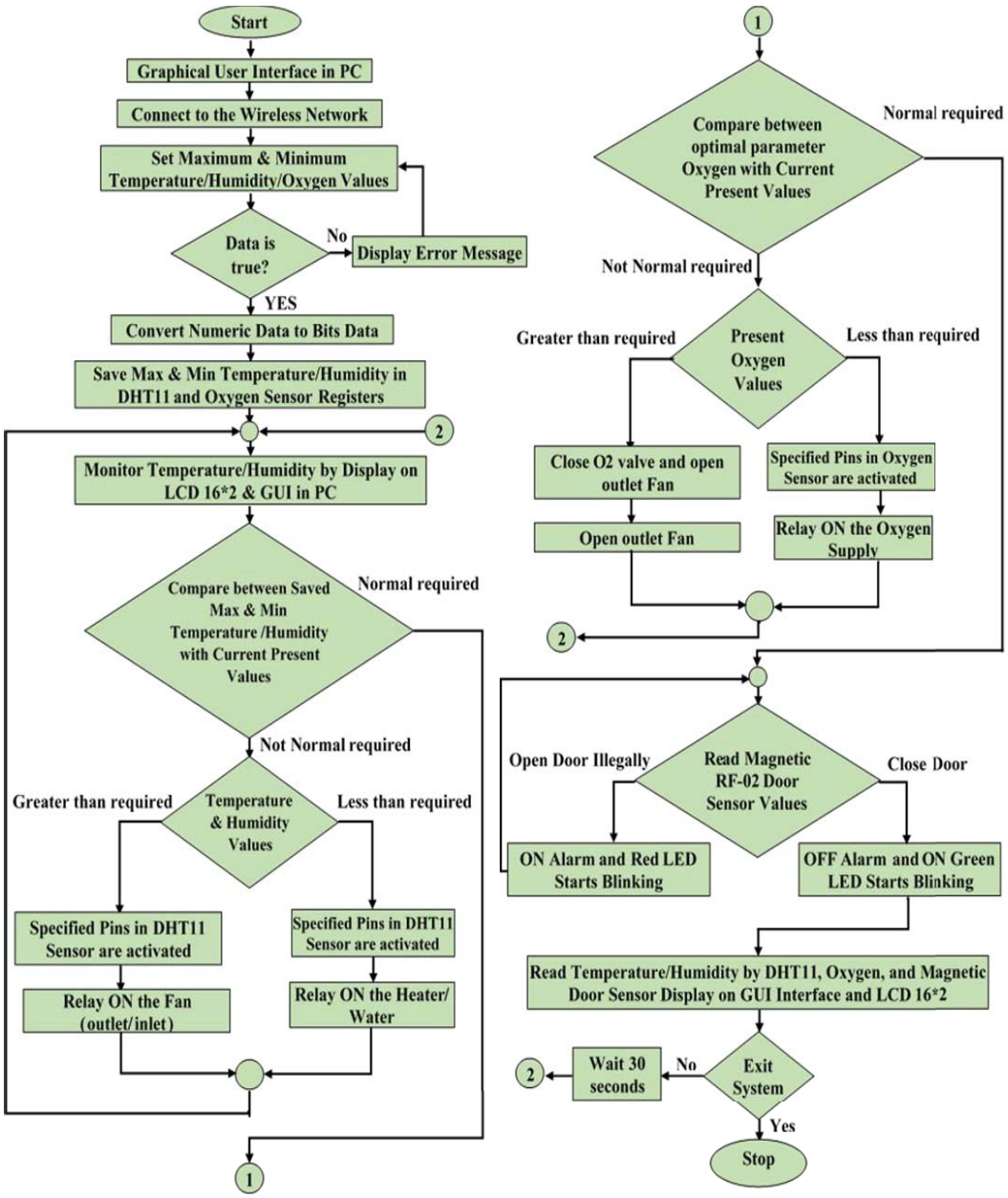

Figure 1: General Flowchart of depicting the Control and Monitoring System.

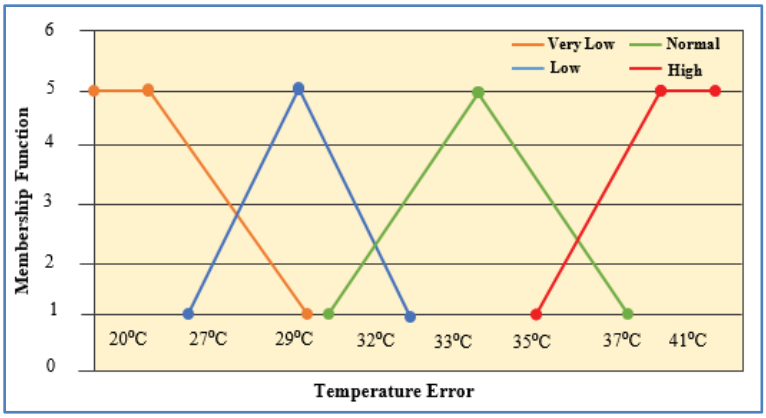

Figure 2: Membership Functions for Current Temperature Error.

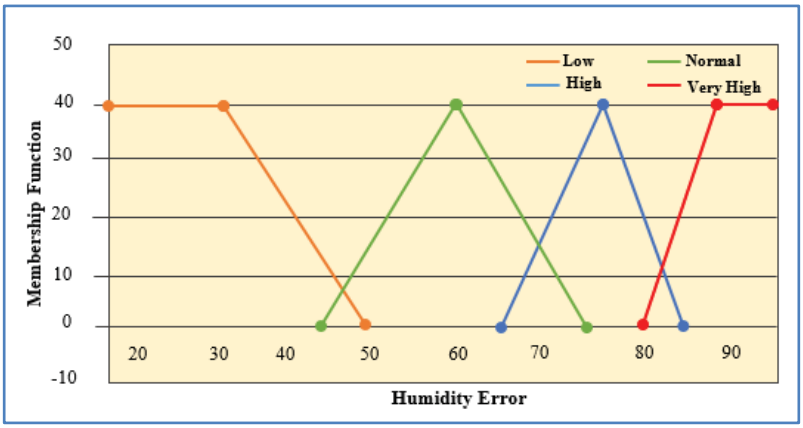

Figure 3: Membership Functions for Represented Humidity Error.

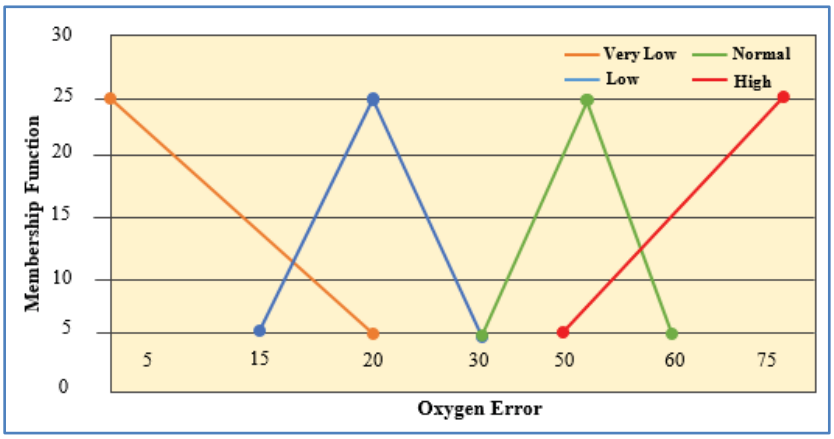

Figure 4: Membership Functions for Oxygen Concentration Error.

By using the rules base in Table (1) these table are built in themodelbecause the parameters occur in the premature incubatorlinked together. The system will accept the determination to turn ON/OFF the devices that appear the heating, fans,cooling, or oxygen valvesystems.

Table 1: The control ruleswith different adapt of represented temperature (ºC),humidity (%), and oxygen concentration occur in the premature incubator.

Temperature (ºC)		**Humidity (%)**		**Oxygen Concentration**	
Range	**Membership Function**	**Range**	**Membership Function**	**Range**	**Membership Function**
From 20 to 25	Emergency and open heater	From 0 to 20	Heater for Water	From 1 to 20	Emergency and open O_2 valve
From 25 to 30	Open outlet fan	From 20 to 50	Reduction the speed of fan	From 20 to 30	Open O_2 valve

From30 to 35	Almost acceptable	From 50 to 65	Almost acceptable	From 30 to 50	Acceptable
From 35 to 37	Acceptable	Almost 65 to 80	Normal	From 50 to 60	Tight O_2 valve and open outlet fan
From 37 to 38	Almost acceptable	From 80 to 90	Almost acceptable	From 60 to 75	open outlet fan
From 38 to 41	Emergency open cooling fan	From 90 to 100	Increase the speed of air to dehumidifying	Greater than 75	Close O_2 valve and open outlet fan

The system takes into consideration modeled for simplified equations. will be measured herethe order ***a***; ***b*** and ***c*** are the mode orders for the ***n*** and ***m***lateral directions[8], in which E_1=-E_2=E_3. The general case, in which $|E_1|\neq|E_2|\neq|E_3|$, can be establishsomewhere else.The system must be pretend a distance r_1 from both sides of the cavity center that hosts the beam waist, and their essential radius of air/core temperature:

$$E(r) = E = r + (a + b - 1) - \sum_{n=1}^{m} \left(c_n \tan\frac{n+c}{r}\right) \ldots\ldots\ldots\ldots\ldots (1)$$

$$\mathrm{E}(r) = r\left[\sin\theta\frac{1}{r}\left(r^2\frac{1}{c}\right) + \left(\tan\theta\frac{a}{b}\right)r^2 + \frac{1}{\sin\theta}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\eta(r) = sin\left[\sin\theta\frac{1}{r}\left(r^2\frac{1}{c}\right) + \left(\frac{a}{b}\right) = \frac{1}{\sin\theta}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

All of the equations are support on the fundamental to conservation of energy. Where ***E*** is calculated by setting Equation(1, 2,and 3) equal to each other and interchangethe request ***E*** for***r***. For ***n***of 25°C, the value of ***E*** is 0.728V.The values of ***a***, ***b***, and ***c*** must be selected[9].

3.2.Description of Incubator Structure

Premature Infant Incubator is affected by various factors, such astemperature, humidity, oxygen,and etc. In this work, we've been focused on design and implementation for monitored environment conditions and to control the different devices on output (Video Camera, Oxygen Supply, Wi-Fi shield, Heater Device, Light Jaundice, Air Filter,LED/AlarmIndications, Heater for Water, and Fan Motor). Various inputs (sensors) are installed and connected to PC via controller circuit (Arduino UNO) determined as data acquisition. Thesome I/O pins are configured to be used

as Analog–to–Digital converter (A/D signal convertor) to record the environmental parameters. These pins are connected to the four sensors.

Device development was done using DHT11 sensor which is a temperature-cum-humidity sensor. The Arduino UNO microcontroller development board is connected with the LCD display, DHT11, Oxygen, and RF-02 doorsensor. For acquiring the signal from the sensor a program in Arduino sketch was made. Processing of the acquired signal was done by providing the oxygen,temperature and relative humidity thresholds, these parameters were included in the program. When these parameters i.e. oxygen, temperature and/or relative humidity deviated or go out of range of the threshold values the monitoring system module which is connected with the Arduino board is activated. A process of sending data packet to a control computer which reports the current oxygen, door status, temperature and humidity. One additional connection is made to a second Arduino development board. Similarly, a program was made to acquire the signal to the microcontroller, as shown in Figure(5).

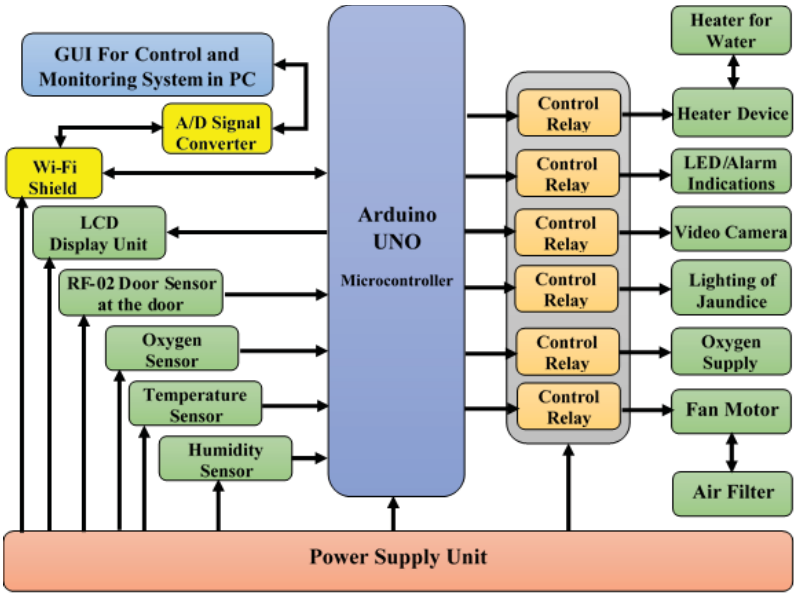

Figure 5: Block Diagram of Hardware Functional for the infant incubator.

The preterm infant incubatordesign can be prototype structure built from class. The describeincubator can be described in Figure (6). The structural carry the device that includethe other subsystems and the preterm infant incubator. The enclosure is reliablefor enclosing the heat exchanger and the electrical components requiredfor the incubator to work. The shell is dependablefor retaining the heated water/air, preventairborne infections from impressionthe preterm infant, and venting the standing air. The bed is intended to have an adaptable tendencyfrom 25°C-35°C, decreasethe noise exposure to the infant, and keep the preterm infant situated properly.

Figure 6: The Sample Experimental of infant incubator.

4. Performance Evaluation and Experimental Results

To implement the model,variousphysical properties must be famous, and also the incubator measure. The graphical user interface of the system was designed using Microsoft Visual Basic 2013 .NET as shown in Figure (7), it was improvedcarefully to serve the aim of thesystem.The design of the GUI (Graphical User Interface) is quite simple and convenient that even abeginner could efficientlyoperate the system in a matter of hours. By login to multiple authorized system, person who owns the account of already registered and given a username and password.The doctors will be able to supervise several of parameters remotely when needed with completely access control. The nurses have restricted access control. The parents will be to able just monitor the situation of infant incubator without access control but they will be able to notify the doctors or nurses if any problem is happening.In case ofsensors disconnected or stopping any device in incubator, the parameters ofthis sensor becomerejectedand the warning message willbe displayed.

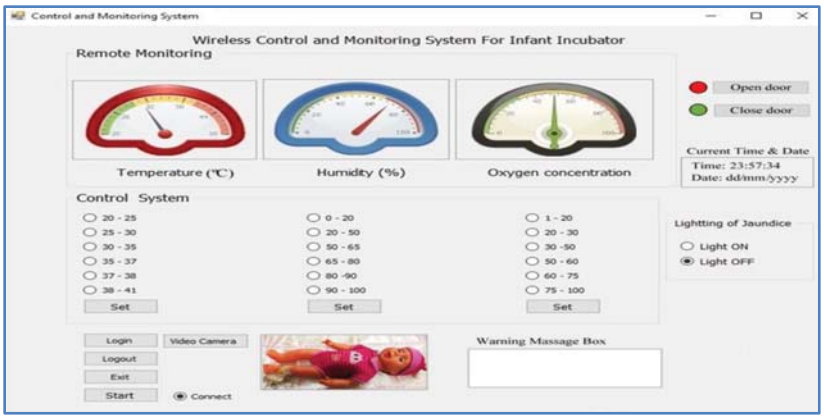

Figure 7: Main Page of Control and Monitoring System.

The suggestionmodel enhanced which work at simulate the infant incubator environment. The model usual a single wall rectangular infant incubator with require convection heating. The perfect preterm infant incubator system was divided into various homogenous compartments.A function of air/coretemperature and for simulationpurposes, exponential formula can be developed from Figure (8):

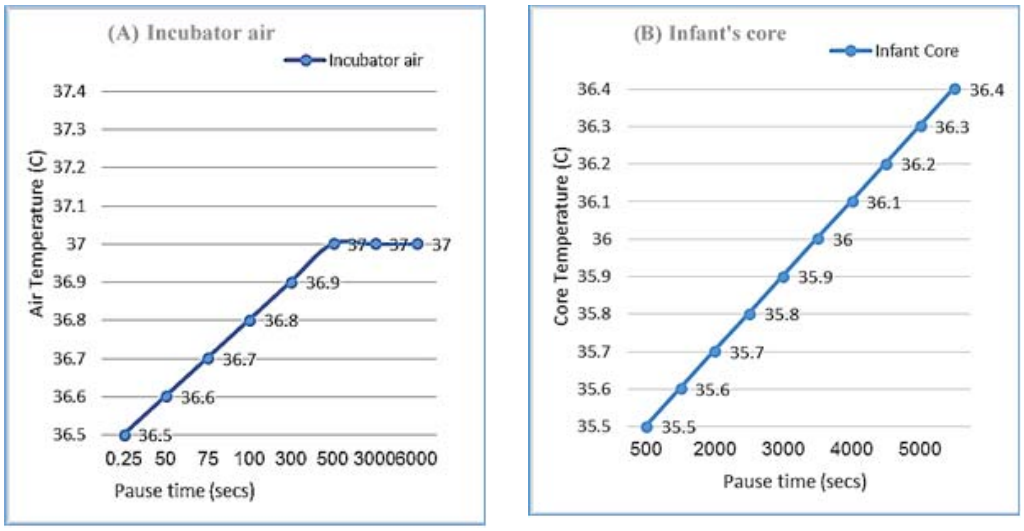

Figure 8: Temperature variation vs. Time.

There existsdoor in the incubator wall that possibly opened to clean out and feed the newborn. When these little piece are opened to nurse the newborn, much more coldness air at the environment temperature begin streaming into the incubator, air loses its heat to the environment,and irregular oxygen concentration. Due to this distraction there may be fluctuations in incubator systems. When door open to happen the simulated control system in incubatorwillbe off control.

The results in the figure (9-A)show two graphs for the incubator parameters (temperature and humidity) collected from the incubator without using any control by using monitoring system. The first line represented the temperature change without using control. Itis clear that the temperature decreasesproportional to the climate environment, andreach to 29ºC or under during this period. The second line represented the humidity from figure there is notnoteworthy changewithout using control inside incubator.The effect of control is clearwhich is increase by (10%-30%) using the small fans with same water. This reduction may reduce when using appropriatesize of fans.

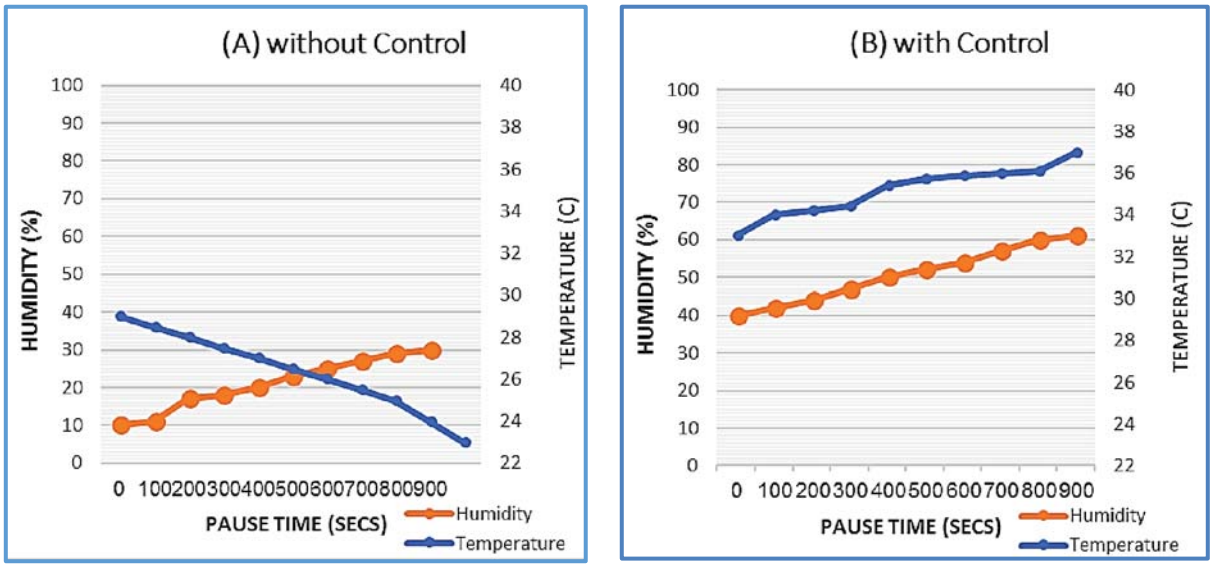

Figure 9: Temperature and Humidity Collected from Incubator.

The results in the figure (9-B)show two graphs to the incubator parameters (temperature and humidity) reading beginning first line thatrepresented the reading with control, it is clear that temperature was verylow and constant this because there is no air flow or whatevercausetemperature. If newborn in a dry environment can lose temperature overtime. Similarly, if temperature was above (38ºC) this willextend the risk, that will be processed by heater or fan on to increase/decreasetemperatureto reach the required degree. The second line represented the reading of humidity with control and howreading of humidity was double of the reading with control by using fan and pad system which provide suitable level ofhumidity from the water that pass through the fan filter.

5. Conclusions

In this paper, we presentedA fuzzy logic control of temperature and humiditybe occurringimproved successfully that uses both the core temperature and air temperature for control the incubator warming. We get least fluctuations in the air temperature when compared to ON/OFF heater control and ON/OFF fan.The value of errors in this system is rangedtemperature instability be low in fuzzy logic between0.15ºC-0.25ºC, humidity between 0.13%-0.18%, and oxygen concentrationbetween0.1-0.6, a control valve for oxygento make arrangements a stable environment interior the incubator.The appliance results show clearly which the monitoring/control system has tolerable efficiency in rapid response. The low-cost acquisition is the necessary equipment cost and the influence is lifesaving

one.The effectivenessaverage, for the system of fuzzy logic controller is about 99.85%.Large size of infant incubator required additional time to reaching the steady state level.

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