Smart Infant Incubator

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Abstract

Infant incubator was made for keeping infants in a suitable environment for them as their cases need of temperature and humidity, In our project we make a control include classic incubator addition to more vital functions such as (SpO2 and Heart rate) and other technical functions which keep infants more safe like (air quality mode, motion alarm sensor, water level in tank system and UV therapy control (Photo therapy). This papers deals with the cost-worthy design of an embedded device for real time monitoring of newborn babies in the incubator. In smart incubator a child's medical data can be checked through mobile phones or computers by the doctors or nurses from the place where they are accessing by the cloud storage through the internet. The smart Incubator is a one which monitors the newborn baby continuously and which sends the medical data directly to the cloud storage and the data's are stored. The medical data can be viewed from mobile phones and computer systems from the place where they are and from they can take actions.

Keywords-Neonatal incubator, Neonatal Intensive Care Unit (NICU), Low cost incubator, Smart temperature control, Premature Baby, Kangaroo Mother Care (KMC).

I. Introduction

A neonatal incubator is a device consisting of a rigid box-like enclosure in which an infant may be kept in a controlled environment for medical care. The device may include an AC-powered heater, a fan to circulate the warmed air, a container for water to add humidity, a control valve through which oxygen may be added, and access ports for nursing care. It may also contain a servo control to help regulate incubator air temperature [1]. The servo control uses a temperature sensing thermistor, which is taped to the child's abdomen [2].

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In infants born before 31 weeks' gestation, evaporative water loss is the single most important channel of heat loss [5]. This is due to inadequate keratinization of the skin, which allows a high permeability of water to the skin. The permeability drops rapidly in the first 7 to 10 days after birth unless the skin becomes traumatized or secondarily infected. In that 7 to 10- day period, the absolute humidity must be monitored so that evaporative heat loss is kept to a minimum as well as water lossthrough the skin [6].

There have been significant advances in thermoregulation since the 1960s. These advances have reduced mortality in small babies by 25%. Although this is a great accomplishment, research continues so that the mortality in small babies is reduced even more. Premature babies are not always put in incubators [7].

. If a baby is in danger of going into respiratory arrest or other significant problems, they are put in an overhead radiant cradle so that they are easily accessible to nurses and doctors. The radiation from overhead puts the heat back into the baby while the baby is losing heat by other means. Heat losses and gains are difficult to monitor. The only way to monitor the baby's temperature is with a thermistor and servo controlled heating unit [8]. The overhead radiator can account for the heat lost by other means, but cannot account for the water lost through the skin, which is critical to maintain for the first 7 to 10 days after birth to prevent dehydration [9].

II. Background

A neonatal intensive care unit, usually shortened NICU (pronounced "Nickyoo") and also called a newborn intensive care unit, and special care baby unit (SCBU - pronounced "Skiboo"), is a unit of a hospital specializing in the care of ill or premature newborn infants [10].

NICUs were developed in the 1950s and 1960s by pediatricians to provide better temperature support, isolation from infection risk, specialized feeding, and access to specialized equipment and resources[11].

Infants are cared for in incubators or "open warmers." Some low birth weight infants need respiratory support ranging from extra oxygen (by head hood or nasal cannula) to continuous positive airway pressure (CPAP) or mechanical ventilation. Public access is limited, and staff and visitors are required to take precautions to reduce transmission of infection[12].

By the 1970s SCBU's were an established part of hospitals in the developed world. In Britain, some early units ran community programmers, sending experienced nurses to help care for premature babies at home. But increasingly technological monitoring and therapy meant special care for babies became hospital-based [13].

By the 1980s, over 90% of births took place in hospital anyway. The emergency dash from home to SCBU with baby in a transport incubator had become a thing of the past, though transport incubators were still needed. Specialist equipment and expertise were not available at every hospital, and strong arguments were made for large, centralized SCBUs. On the downside was the long travelling time for frail babies and for parents [14]. A 1979 study showed that 20% of babies in SCBUs for up to a week were never visited by either parent [15].

Centralized or not, by the 1980s few questioned the role of SCBUs in saving babies. Around 80% of babies born weighing under 1.5kg now survived, compared to around 40% in the 1960s[16].

From 1982 in Britain pediatricians could train and qualify in the sub-specialty of neonatal medicine. Not only careful nursing, but also new techniques and instruments now playeda major role [17].

As in adult intensive care units, the use of monitoring and life support systems became routine. These needed special modification for small babies, whose bodies were tiny and often immature. Adult ventilators, for example, could damage baby's lungs and gentler techniques with smaller pressure changes were devised.

III. METHODS

This project emphasizes on developing an infant incubator especially for premature babies. Entire chamber of the incubator is constructed using Acrylic sheet as it is more advantageous over glass and plastic. This material is less dense. its density can range from 1100-1200 kg/m3 It is very much less than the density of glass which ranges 2420 to 2790 kg/m3Transportation and assembling of acrylic materials are consequently easier and cheaper. Main chamber consists of twocompartments.

Structure development of incubator It is better that the incubator is light in weight so that it can be portable at the same time provides strong support for the components used and can bear the weight of the infant. Isolation of the compartment where the baby is kept from the controlling unit is a necessary requirement. The incubator design can be divided into four subsystems: structural support, enclosure, shell, and bed. The structural support is the device that accommodate the other subsystems and the preterm infant. Design Parameters: Length 80 cm, Height 30 cm, Width 30 cm thickness of material 5mm.Control unit inside the box has a dimension of 10 cm x 30 cm x30 cm.

The control unit is responsible for holding the heat exchanger and the electrical components needed for the incubator to work. The shell is responsible for retaining theheated air, preventing airborne infections from reaching the preterm infant, and venting the stagnant air. The bed is intendedto keep the preterm infant in place. Fig. 1 depicts the rendered image of the 3D model of incubator structure designed by Computer Aided Design.

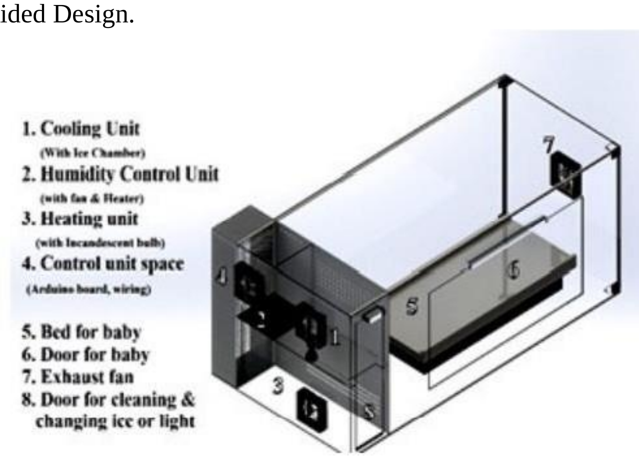

Fig 1. 3D model of the incubator

The temperature is sensed by DHT11 sensor. It is connected to the Arduino Uno. In the circuit arrangement of the control system. Signal pin of the sensor is connected to the analog input pin A0 of the microcontroller.

These are connected through relays with the digital output pin 10 and 9 of Arduino board. Each Relays are of 5 volts and are interfaced with the Arduino Uno through relay drivers. Here NPN transistors are used as relay drivers. Arduino Uno is the controller used here. The program is written to control the bulb and fans.

When the temperature in the chamber falls down below 36oC the bulb glows and fan associated with the bulb is turned ON so that that the hot air isblown to the compartment B through the slider.

The cooling unit consists of an Aluminum vessel containing ice and a 12 vdc fan. This fan is connected with the digital output pin 7 of the Arduino board through a relay. Whenever the temperature in the chamber goes beyond 37oC the bulb automatically switches off and the fan in the cooling unit turns ON.

Cool air is blown to the compartment B until the desired temperature is achieved. the constructed view of incubator’s temperature controlling unit. Fig. 2(a) and 2(b) are heating and cooling portions respectively.

2(a) 2(b)

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Lm35 to measure the skin temperature for baby.DHT11 to measure the hood's air temperature and control it anddetect the humidity of the incubator.Air quality sensor to measure the harmful gases in air like co2 and dust.Motion sensor (Ultrasound Sensor) to detect the place of baby in the incubator and worked with buzzer to make the baby more safe.Water level sensor to make sure the tank is full of water or not, that make the incubator and baby more safe.Pulse Oximeter

HARDWARE REQUIREMENTS AND ITS IMPLEMENTATION

The various hardware components are required forimplementing the proposed system:

- Temperature Sensor (LM35).
- Humidity Sensor (DHT11).
- Water Level Sensor.
- ECG Sensor (AD8283).
- SPO2 and Heart Rate Sensor (MAX30100).
- Ultrasonic (motion) Sensor.
- Air Quality Sensor (MQ135).
- Future Work.
- Bluetooth Module.
- Mobile App

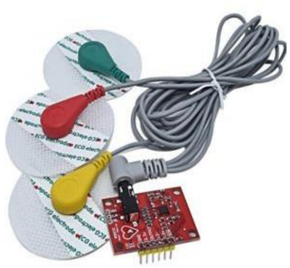
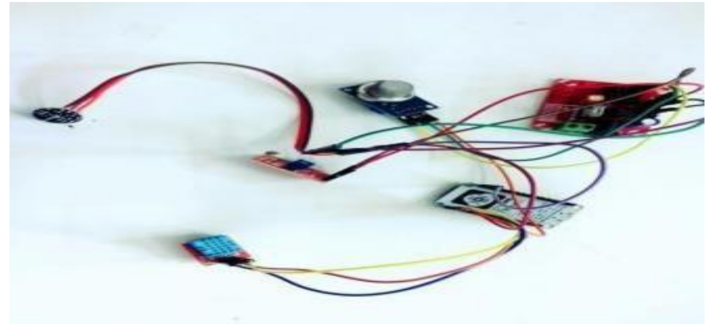


Fig. 3 ECG electrodes

Fig.5 Block Diagram of the System

IV.RESULTS



to detect Non-invasive blood pressure for baby (NIBP).ECG Module to detect the heart rate for baby in incubator. Phototherapy unit to treat the jaundice disease for baby.

Fig.4 Hardware setup of proposed system

Our project achieved the required results and its efficiency reached 90%. We succeeded in measuring skin temperature, air and humidity, measuring the proportion of dust and harmful gases in the air. We were also able to add a jaundice treatment unit and measure non-invasive blood pressure and heart rate, and its efficiency in all of that was excellent. It is fit for use in hospitals.

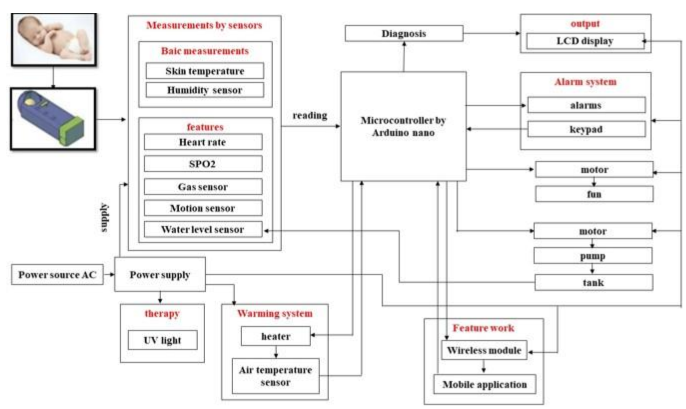


Fig.6 Final design of Smart Infant Incubator

A. Temperature Control Unit The major concern of this incubator is to control the temperature of the baby room and maintain it within the desired range 36oC to 37oC. Fig.
11 exemplifies the process control by Arduino UNO microcontroller. Here a whole day (24 hour) data of controlled temperature is inset with the ambient temperature of the same day.

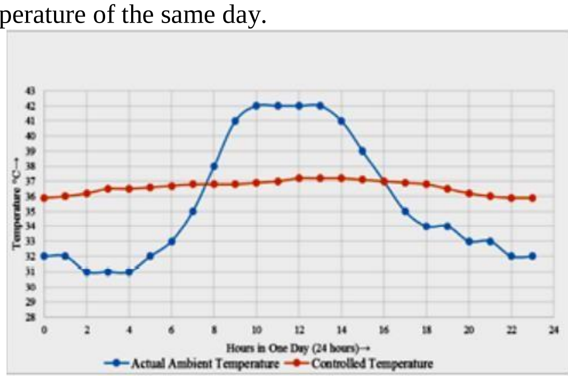


Fig.7 Temperature variation in the incubator for control system

At 00:00 am the temperature of atmosphere was low and almost constant up to morning 6:00 am. Then it rises with the day time and again lowered at and after 5:00 pm. But the system for keeping preterm baby safe and sound the temperature is needed to be constant within the range. The incubator constructed has been efficient at doing this and the graph shows that it kept the temperature of the baby compartment at 36oC to 37oC irrespective of ambient temperature.

B. Humidity Control Unit Humidity is another critical factor for preterm infants. Fig. 12 depicts the humidity control by Arduino microcontroller system and its variation with the ambient humidity.

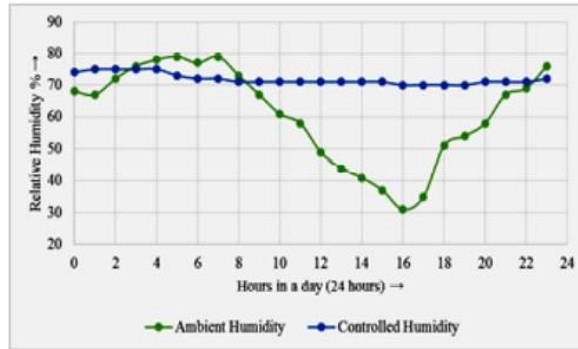


Fig.8 Humidity variation of the neonatal incubator and it's ambient

The baby room is maintained within the RH level of 70% to 75% though the humidity in the immediate vicinity of the incubator varies from 30% to 80% at different time of the day.

V.CONCLUSION

Every year, about 1 million infants in the developing world die due to prematurity complications. Premature infants are born before the developing organs are mature enough to allow normal postnatal survival. To provide a sound environment for the baby temperature in an infant incubator must be maintained at a proper level, generally set at 37oC. The developed system is one of the most practical solutions for addressing the lack of proper care for infants, affected preterm and other complications in impoverished regions. The system is capable of providing the most crucial aspects of patient care at a cost low enough. The prototype is capable of maintaining a proper environmental temperature (36oC-37oC) and humidity (70%-75%) for a patient, which are the primary functions of an incubator. Once set, the temperature and humidity are maintained automatically by the microcontroller based system which makes the system easy to operate. The proposed model can be further improved by using a voice detection system usingDSP to detect if the baby's crying. Emergency oxygen supply mechanism should be incorporated. Solar power can be used asan alternative power source.

In the conclusion of the paper, we would like to inform you that our project is a mixture of 6 different devices, which leads to reducing the child's transfer from one device to another, and this increases the child's harm and injury, and sometimes the situation is critical, so our project is one of the very important projects in the world of biomedicine Thank you.

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