**CHAPTER 1**

**INTRODUCTION**

* 1. **HISTORY**

The problem of premature and congenitally ill infants is not a new one. As early as the 17th and 18th centuries, there were scholarly papers published that attempted to share knowledge of interventions. Doctors took an increasing role in childbirth from the eighteenth century onward. However, the care of newborn babies, sick or well, remained largely in the hands of mothers and midwives. Some baby incubators, similar to those used for hatching chicks, were devised in the late nineteenth century. In the United States, these were shown at commercial exhibitions, complete with babies inside, until 1931. Dr. A. Robert Bauer MD at Henry Ford Hospital in Detroit, MI, successfully combined oxygen, heat, humidity, ease of accessibility, and ease of nursing care in 1931. After then, more resources became available: The first unit had been set up with £100. Most early units had little equipment and relied on careful nursing and observation. Incubators were expensive, so the whole room was often kept warm instead. Cross-infection between babies was greatly feared. Strict nursing routines involved staff wearing gowns and masks, constant hand-washing and minimal handling of babies. Parents were sometimes allowed to watch through the windows of the unit. Much was learned about feeding—frequent, tiny feeds seemed best—and breathing. Oxygen was given freely until the end of the 1950s, when it was shown that the high concentrations reached inside incubators caused some babies to go blind. Monitoring conditions in the incubator, and the baby itself, was to become a major area of research. Although incubators provided oxygen and warmth, science in the 1950s was limited and it was not until later that technology played a larger role in the decline of infant mortality. The development of pulmonary surfactant is the most important development in neonatology to date, allowing the oxygenation and ventilation of underdeveloped lungs.

* 1. **EVOLUTION OF THE CONCEPT**

By the 1970s, NICUs were an established part of hospitals in the developed world. In Britain, some early units ran community programmes, 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. By the 1980s, over 90% of births took place in hospital. The emergency dash from home to the NICU 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, centralised NICUs. On the downside was the long travelling time for frail babies and for parents. A 1979 study showed that 20% of babies in NICUs for up to a week were never visited by either parent. Centralised or not, by the 1980s few questioned the role of NICUs in saving babies. Around 80% of babies born weighing less than 1.5 kg now survived, compared to around 40% in the 1960s. From 1982, paediatricians in Britain could train and qualify in the sub-specialty of neonatal medicine. Not only careful nursing but also new techniques and instruments now played a major role. 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 babies' lungs and gentler techniques with smaller pressure changes were devised. The many tubes and sensors used for monitoring the baby's condition, blood sampling and artificial feeding made some babies scarcely visible beneath the technology. Furthermore, by 1975, over 18% of newborn babies in Britain were being admitted to NICUs. Some hospitals admitted all babies delivered by Cesarian section, or under 2500 g in weight. The fact that these babies missed early close contact with their mothers was a growing concern. The 1980s saw questions being raised about the human, and the economic costs of too much technology. Admission policies gradually changed. In addition, treating low-birth-weight infants is expensive, especially when there are much cheaper ways of ensuring healthy babies. The key is prevention. Money can be spent on programs educating mothers on staying healthy during their pregnancy. One program (one that encourages women to stop smoking) is one-third the price of neonatal intensive care and has been proven to work. During this program, a significant number of women often quit.

**1.3 NEED OF THE PROJECT**

The average cost of incubators in most hospitals is still more than just a few thousands. This price, may be reasonable to hospitals in the developed countries, is impossible for third world countries. Before price, there is also the question of accessibility. Even if developing countries were to obtain incubators as a donation from developed countries, it would be hard for them to learn an entire system of operations of these new machines. Also, because these machines are built elsewhere, it is virtually impossible to find the same parts for replacement or fix-ups in these developing countries if anything were to go wrong with these incubators. The purpose of this project is to strike a balance between price and functionality, to invent an incubator that’s good at what it must do -- to keep baby warm and healthy, but does not cost a whole village’s fortune. Also, the incubator must be built with materials that are readily accessible in the home country so that trained staff can easily replace and rebuild.

**1.4 OBJECTIVE**

An infant has a relatively large surface area, poor thermal insulation, and a small amount of mass to act as a heat sink. The newborn as little ability to conserve heat by changing posture and no ability to adjust their own clothing in a response to thermal stress. To provide the similar environment as in the womb infants have to be kept in a device known as incubator. An infant incubator provides stable levels of temperature, relative humidity and oxygen concentration. Air temperature has to be maintained around 37ºC. The relative humidity should follow set values according to the number of incubation days.

**1.4.1 PRIMARY OBJECTIVE**

**TEMPERATURE**

The infants have very low thermal regulation and temperature regulation is one of the most important factors which affect the preterm. It is not possible for the feeble body to cope with the thermal loss. This requires the body of the infant to be in a moist heated environment. Therefore temperature is one of the most important factors that need to be maintained with minimum variations.

**HUMIDITY**

Many problems like hypothermia, dehydration will occur in infants if they have less humidity. These problems can be reduced if the preterm infants are nursed at high relative humidity. Also the skin temperature increases and the distribution of surface temperature will be more if an infant is nursed at a high relative humidity

**OXYGEN SATURATION**

Oxygen in the atmosphere is brought into the lungs by breathing. Each lung contains nearly 300 million alveoli which are surrounded by blood capillaries. Since alveolar walls and capillary walls are very thin, oxygen passing into the alveoli immediately transfers into the blood capillaries. (Usually in adults, the transfer would take about 0.25 seconds while resting.) A large proportion of the oxygen diffusing into the blood binds to hemoglobin in the red blood cells, while a part of the oxygen dissolves in the blood plasma. Blood enriched with oxygen (arterial blood) flows through pulmonary veins, then into the left atrium and left ventricle, and finally circulates throughout the body’s organs and their cells. The amount of oxygen transported around the body is determined mainly by the degree to which hemoglobin binds to oxygen (lung factor), hemoglobin concentration (anemic factor), and cardiac output (cardiac factor).

Oxygen saturation is an indicator of oxygen transport in the body, and indicates if sufficient oxygen is being supplied to the body, especially to the lungs.

**1.4.2 SECONDARY OBJECTIVE**

Even though we get the readings at a continuous rate from the microcontroller through liquid crystal display, we additionally tried and could interface with LabVIEW tools. This will be highly useful for remote monitoring of the baby without nursing it all day.

**1.5 SCOPE OF THE PROJECT**

**1.5.1 EMBRACE INFANT WARMER**

The design looked something like a sleeping bag. It wrapped around a premature infant, and a pouch of phase-change material (PCM) kept the baby’s body at exactly the right temperature and maintained this temperature for up to four hours. After four hours, the PCM pouch could be “recharged” by submerging it in boiling water for a few minutes.

The Embrace Incubator is small and light, making it easy and inexpensive to transport to rural villages. The entire sleeping bag can be sanitized in boiling water. It is far more intuitive to use than traditional incubators, and fits well into the recommended practice of “Kangaroo Care,” where a mother holds her baby against her skin. Finally, compared to the $20,000 price of a traditional incubator, the Embrace incubator only costs $25.The product uses an innovative wax incorporated in a sleeping bag to regulate a baby’s temperature. It stays warm without electricity, has no moving parts, is portable and is safe and intuitive to use. The Embrace Infant Warmer can be used in a clinical setting, for transporting babies, and in a community setting.



**Fig. 1: Embrace Infant Warmer**

**1.5.2 SUITCASE INCUBATOR**

Another incubator that was developed for use in Haiti, after the devastating earthquake this past winter was the suitcase incubator. Although there is not much information on how it was made, there are many advantages and disadvantages that can be determined based on this idea. First of all, it is extremely portable, which is more convenient for short term use, as opposed to a more long-term use in a developing country's hospital. It must be relatively cheap since you would simply use a suitcase as a shell. It is unclear how well insulated this could be, or how well it could circulate the air while preventing infections. Above is an image of these incubators being used at the Project Medishare/University of Miami Field Hospital, in Port Au Prince, Haiti, on Friday, March 19, 2010.



**Fig. 2: Suitcase Incubator**

**1.5.3 CAR-PART INCUBATOR**

This incubator, while low-cost (still $1,000/incubator), requires working parts from vehicles (and no one wants to take parts from a working vehicle). It also has not been tested for its ability to prevent infections and does not allow direct access to the infant through “sleeves,” as does many current incubators. It is also fairly complicated to build and does not have a humidifier. The main advantage of this system is that all of the parts should be locally available.

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**Fig. 3: “Car-Part” Incubator**

**CHAPTER 2**

**LITERATURE SURVEY**

**2.1 REVIEW OF LITERATURE**

We had been given a week of time to go through various resources like journals and magazines to arrive at a conclusion on this project. We went through an ample number of IEEE journals and could elect this particular topic based on its novelty and newness.

Lyon, Andrew. (2006) "Applied physiology: Temperature control in the newborn infant." Current Pediatrics 16, 386-392

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Beck, Stacy, et al. “The Worldwide Incidence of Preterm Birth: A WHO Systematic Review of Maternal Mortality and Morbidity.” Bulletin of the World Health Organization (2009): 10.2471.

Beck, Stacy, et al. “The Worldwide Incidence of Preterm Birth: A WHO Systematic Review of Maternal Mortality and Morbidity.” Bulletin of the World Health Organization (2009): 10.2471.

Day, Richard L., et al. "BODY TEMPERATURE AND SURVIVAL OF PREMATURE INFANTS." Pediatrics 34.2 (1964): 171-81.

Design That Matters. Web. <http://www.designthatmatters.org/news/dtm-blog/project/incubator/>

HEBI Hemel Baby Incubator. Web. <http://www.hebiincubator.org/templates/heb/global/index.php?lngid=2&sqlmode=1&fid=144>

Relevant literature was identified by querying scholarly databases for the terms “Infant incubator” and “Neonatology”. Returned results were read. The scholarly databases queries included:

* ABI/INFORM Global
* Academic Search Premier
* ACM Digital Library
* jscholarship
* Applied Sciences & technology Full Text (EBSCO)
* IEEE Xplore
* Google Scholar

**CHAPTER 3**

**METHODOLOGY**

**3.1 TYPE OF PROJECT**

The main notion of this project is to provide an overview of infant incubator, architectures, and vital technologies and their usages. However, this manuscript will give good comprehension for the new researchers, who want to do research in this field of neonatology and facilitate knowledge accumulation in efficiently.

**3.2 TARGET RESPONDENTS**

In 1983 an extensive scientific study resulted in a list of physical properties which an incubator should satisfy. The HEBI incubator was reviewed against these requirements and only minor modifications were advised (like some energy saving recommendations). The HEBI Incubator is kept as simple as possible. This results in a low cost and ease of maintenance.

In 1988 an inspection was made of 20 hospitals in Uganda and Kenya. This inspection revealed that many incubators with more than 15 years of service were still functioning, even in hospitals where no maintenance whatsoever was applied. A similar review in 2002 showed the same. 900 to 950 grams was repeatedly mentioned as the lowest birth weight for children who were saved. Recorded growth curves for six small prematures in Uganda show the same weight. The growth speed has been compared with six small incubator children from Amsterdam. In the first 14 days, the weight drop is congruent with the children from Amsterdam. And in professional incubators the newborn is continuously exposed to sound of the electromotor. The HEBI incubator does not use a motor.

**3.3 CONSTRAINTS AND ASSUMPTIONS**

**3.3.1 ASSUMPTIONS**

We designed an incubator that meets the following criteria: low cost, temperature adjustable (achieves temperatures between 35.5 – 37.5°C), reinsulated (drops only 2°C over 45 minutes in case of power loss), easy to operate, repair, and clean, accessible (can be easily fabricated in country), and has automatic temperature adjustment.

**3.3.2 LIMITATIONS**

In low-resource settings, incubators tend to be much simpler and more affordable than in the developed world, but often lack necessary features, such as temperature feedback and safety precautions. The Hot Cot is the current incubator standard in Malawian hospitals. Inexpensive incandescent light bulbs act as the heating element costs less than 100 INR to produce. However, the device programmed with microcontroller offers automated temperature feedback- that is user need not manually change the temperature by adjusting the bulbs, and the use of the bulbs is a fire hazard without constant supervision.

**3.4 SAMPLING METHODOLOGY**

**3.4.1 Features of the Proposed System**

**3.4.1.1 TEMPERATURE SENSOR**

The Thermistor communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of -50°C to 150°C and is accurate to ±1°C at about 25°C. It is highly sensitive to changes in temperature and suitable for temperature measurement, control and compensation.

**3.4.1.2 HUMIDITY SENSOR**

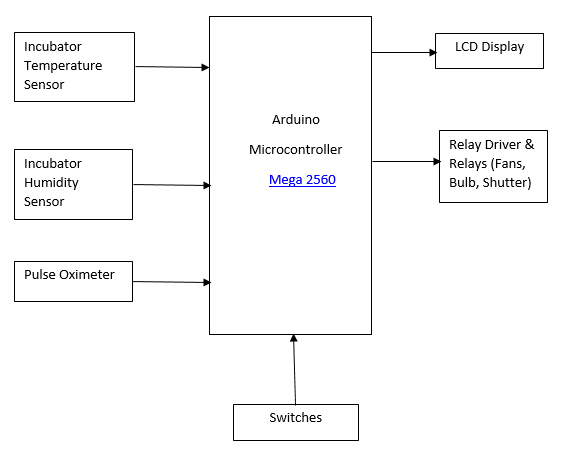
Humidity sensor should provide humidity level in the incubator in terms of relative humidity (%RH) in the range of 0-100%RH. The humidity sensor chosen for the present work is DHT11. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement device, and connected with a high-performance 8-bit microcontroller. DHT11 uses a simplified single-bus communication. Single bus that only one data line, the system of data exchange, control by a single bus to complete. Device (master or slave) through an open drain or tri-state port connected to the data line to allow the device does not send data to release the bus, while other devices use the bus, single bus usually require an external one about 5.1kΩ pull-up resistor, so that when the bus is idle, its status is high. Because they are the master-slave structure, and only when the host calls the slave, the slave can answer, the host access devices must strictly follow the single-bus sequence, if the chaotic sequence, the device will not respond to the host.

**3.4.1.2 PULSE OXIMETER**

Oxygen binds to hemoglobin in red blood cells when moving through the lungs. It is transported throughout the body as arterial blood. A pulse oximeter uses two frequencies of light (red and infrared) to determine the percentage (%) of hemoglobin in the blood that is saturated with oxygen. The percentage is called blood oxygen saturation, or SpO2. A pulse oximeter also measures and displays the pulse rate at the same time it measures the SpO2 level. The pulse oximeter emits red (R) and infrared (IR) LED light that passes through the body, receives data from a photodetector, and calculates the oxygen saturation by determining the ratio of the two waveforms. When the amount of HbO2 is greater, the absorption of red light becomes smaller and the absorption of infrared light becomes larger, resulting in a lower ratio of absorption of the two wavelengths. In contrast, when the amount of deoxygenated hemoglobin is greater, the absorption of red light becomes greater while the absorption of infrared light becomes smaller, resulting in an increased ratio of absorption of the two wavelengths. Thus, the pulse oximeter determines oxygen saturation by measuring the ratio of oxygenated hemoglobin to deoxygenated hemoglobin**.** Oxygenated hemoglobin absorbs more infrared light, while deoxygenated hemoglobin absorbs more red light.

**3.4.2 Description of Proposed Architecture**

An incubator is an apparatus used to maintain environmental conditions suitable for a neonate (newborn baby). It is used in preterm or for some ill f ull-term babies. The mattress where the baby lies is completely enclosed by a wooden canopy. In this temperature, blood oxygen level and humidity are the parameters which have to be controlled.The temperature in the incubator is increased by an incandescent bulb. A motor driven fan near the heater draws in fresh air and blows it past the heater, warming the air. The air is directed up through slots into the area above the mattress and circulated around. The air temperature is monitored by temperature sensors and is adjusted by switching the bulb on and off through a relay. The user can set the incubator to control the temperature of the air. If the temperature of the incubator increased above the threshold value then the fan will be on and it remains on till the temperature decreased to the threshold value. If the temperature of the incubator decreased below the threshold value then the bulb will be on and it remains on till the temperature increased to the threshold value. The humidity can be increased by the use of water bath. And a shutter mechanism is being used to maintain the amount of water vapor in the air.Light bulb heats air in all parts of the incubator. The air passes over a container with evaporating water, so that its humidity increases. The warm, humid air then flows upwards (chimney effect) into the compartment.



**Fig.1 Block Diagram of an Infant Incubator**