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HUMIDITY CONTROL SYSTEM IN NEWBORN INCUBATOR

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Abstract - In this work they were developed a microcontrolled system devoted to the newborn incubator, in order to check the conditions of the environment provided to the premature newborns, a humidity control system and software that carries out the reading of the sensors. Two microprocessed, similar newborn incubator were used, for the realization of the measurements, being that one of the newborn incubator used distilled water and other one was valued without water. The measures were collected to each 2 minutes during 96 hours. The relative humidity inside newborn incubator without water and with water but, without humidity control, goes out from the band of comfort established by standard. With water and humidity control, if it kept inside established band of comfort by standard. One checked that the newborn incubator used in this inquiry does not provide to the premature newborns a totally appropriate environment taking into account the requisites of the standard NBR IEC 601-2-19.

Keywords: newborn incubator, humidity, control

1. INTRODUCTION

The clinical conditions of the premature newborns require special attention as a result of their difficulties to survive, demanding so, intensive cares. The high rate of mortality between them became a serious problem for the public health. In addition, there are serious the social consequences associated to the risk of desertion provoked by the long time of removal between mother and child and high financial cost for the cares with the health of them. These premature newborns must be maintained in thermo-neutral environment, in which, they consume the minimum of calories and oxygen, presenting a low metabolic rate to maintain the corporal stable temperature [1].

The newborn incubator is medical equipment used for life to maintain of premature newborns, in which, these find a thermo-neutral environment, whose conditions are likened to those considered ones in the motherly womb. The premature newborns disposes of an environment where the temperature and the relative humidity are controlled, being able to develop quickly with less risk of contracting diseases [1]. In Fig. 1 we can see a microprocessed newborn incubator.

Fig. 1. Microprocessed newborn incubator

The losses of water for premature newborns, with 25 weeks of gestation, treaties in ambient with relative humidity in 20 %, exceed 200 ml/kg/day [2]. The increase of the relative humidity inside newborn incubator reduced the loss of water for the skin of the premature newborns with fewer 30 weeks of gestation and contributed to the maintenance of his corporal temperature [3].

In the first days of life, the daily evaporative loss from premature newborn can reach up to 20% of body mass. Such loss can be reduced by increasing the air humidity inside the incubator. The skin evaporative exchanges between the neonate and the environment are directly proportional to the water vapour partial pressure difference between the newborn's skin and the air [4].

Standing out the importance of the newborn incubator in the treatment of newborn the some cares they are necessary to keep it in perfect functioning, therefore, this equipment has a tendency to suffer a natural deterioration, and consequently, it can stop being satisfactory to the requisites of the standard NBR-IEC 601-2-19 [5]. The checking of the main requisites of the standard [5], made a list to the security of the patient, must be carried out after corrective maintenance or in the preventive maintenance [6]. These equipments, during the transport between the nosocomial unities, it can receive unsuitable treatment and his physical conditions are compromised, in such a way that, periodic inspections can point to defects that bring risks to the newborns [7].

The humidity control system of the newborn incubator can be presented under two aspects:

1.1 Active humidity control system

This system is formed by an ultrasonic vaporizer, in which, the vapor is controlled for a control system that has a humidity sensor, what it causes a control of closed mesh, therefore, the relative humidity of air is measured and compared with a value of reference and this difference it is used as way of control.

1.2 Passive humidity control system

This system consists of a reservoir with water whose surface is crossed on the part of the air flow generated for weathercock. A greater or minor humidity of air can be gotten regulating the air flow. This humidity of air occurs for the passive diffusion of the water for the air that passes for the reservoir, not existing a shut mesh control mechanism because the relative humidity of air is not measured nor controlled, as can be seen in Fig. 2.

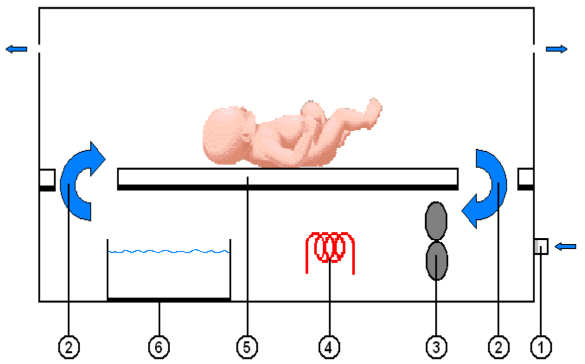

Fig. 2. Passive humidity control system. 1-air filter, 2-air flow, 3-weathercock, 4-heater element, 5-mattress, 6-water reservoir

The disadvantages of the use of this system inhabit in low the quality of the humidity control rate and the necessity of a very rigorous asepsis. This system used in most of the newborn incubator cannot reach high and constant levels of humidity [8].

For the accomplishment of this study they had been developed a microcontrolled system devoted to the newborn incubator, in order to check the conditions of the environment provided to the premature newborns, a humidity control system and software that carries out the reading of the sensors. In this case was boarded the humidity control system.

2. MATERIALS AND METHODS

The Committee of Ethics in Research Involving Human Beings of CISAM/UPE (Integrated Health Center Amaury of Medeiros/University of Pernambuco), through the research protocol CEP/CISAM 002/07 approved the conduct of research.

The analyzed equipment is a microprocessed newborn incubator that possesss a humidity control system of the passive type, as can be seen in Fig. 3.

Fig. 3. Newborn incubator with passive humidity control system

Two microprocessed, similar newborn incubator was used, for the realization of the measurements, being that one of the newborn incubator used distilled water in the humidity reservoir, associated to the silver nitrate with the finality of inhibiting the proliferation of bacteria, and other one was valued without water. The fact of the measurements they were carried out with and without water it is due to some assistance establishments of health that they do not use water in the humidity reservoir of the newborn incubator, alleging that the use of this favors the proliferation of bacteria [1].

Each parameter (temperature, humidity, sound level, oxygen concentration and velocity of air flow) was measured in the point A, situated to 10 cm above the surface of the mattress with the same in the horizontal low position (item 5 – Fig. 2), as can be seen in Fig. 4.

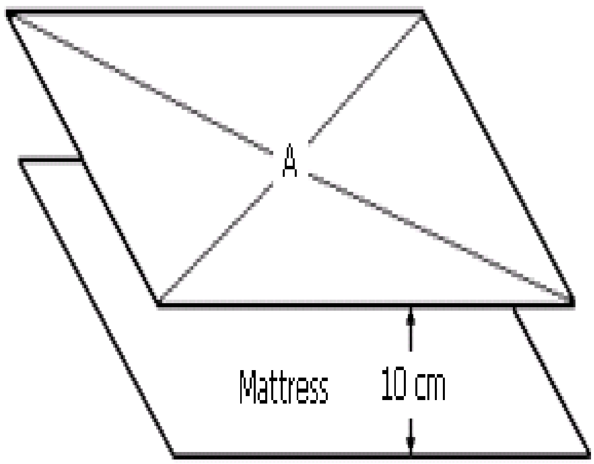

Fig. 4. Location of the point of measurement on the mattress in accordance with the standard NBR-IEC 601-2-19

The data acquisition system developed is based on the microcontroller PIC18F4520 of the Microchip. A sensor SHT11 manufactured by the Sensirion was used to measure the relative humidity of the air and the temperature of the newborn incubator. A software was developed in Delphi to carry out the reading of the sensors.

The measurements were carried out on basis of the requisites of the standard [5] and were collected to each 2 minutes during 96 hours. To effectuate the measurements, a microcomputer is communicated through an interface RS-232 with the sensor properly positioned inside of the newborn incubator, as can be seen in Fig. 5.

Fig. 5. Data acquisition system

3. DEVELOPED SYSTEM

The humidity control system is based on the microcontroller PIC16F628A of the Microchip, was developed for newborn incubator using a step motor, to maintain the relative humidity inside a band of comfort established by the standard [5] (40 % to 60 %), turning in a shut mesh control system. In Fig. 6 can see the block diagram that system.

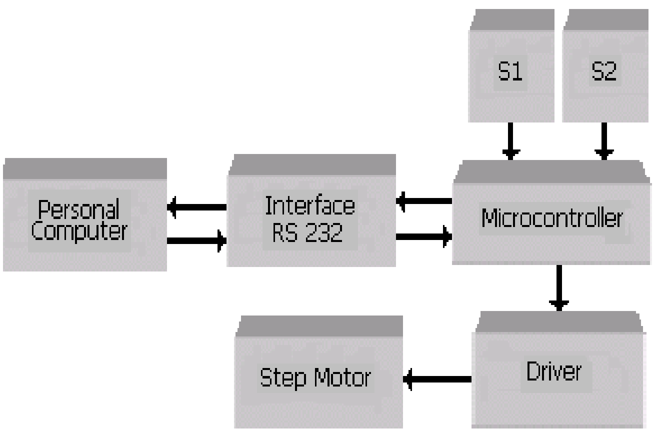

Fig. 6. Block diagram of humidity control system

The driver is the interface that makes switching voltage of 24 volts required by the motor from the voltage of work of the microcontroller that is 5 V.

The motor is powered with a step voltage of 24 V, 7.5 degrees for step, is bipolar, and operates in temperatures from -10 ºC to 50 °C and relative humidity of 20% to 90%.

In Fig. 7 can see each other the mechanism that was inserted in the water reservoir (item 6-Fig.2) of the newborn incubator with the objective to control the relative humidity. In this mechanism, the step motor receives a sign of the microcontroller and gives steps of 30 degrees moving the window of the humidity reservoir of coupled to his axle whenever the value of the humidity will be out of a belt prearranged with the finality of maintaining it inside the belt of comfort established in the standard [5].

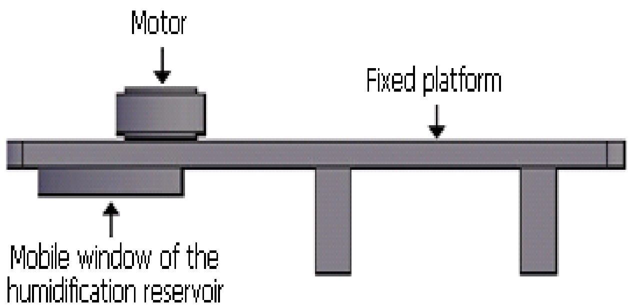

Fig. 7. Humidity control mechanism (front view)

As can be seen in Fig. 8, optical sensors (S1 and S2) were put in the fixed platform of way to indicate the location of the window of the humidity reservoir. The reflecting surfaces represent the positions taken by it in accordance with the angle of rotation. Each sensor consists of an infrared LED (transmitter) and a photo-transistor (receiver). The rays of light emitted by the LED are reflected to the photo-transistor.

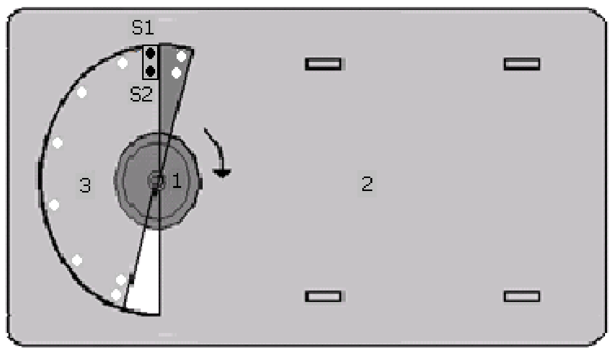

Fig. 8. Humidity control mechanism (superior view) 1. Step motor 2. Fixed platform 3. Mobile window of the humidity reservoir S1, S2 – Optical sensors.

In Fig. 9 can see the flowchart of the firmware for the micontroller PIC 16F628A.

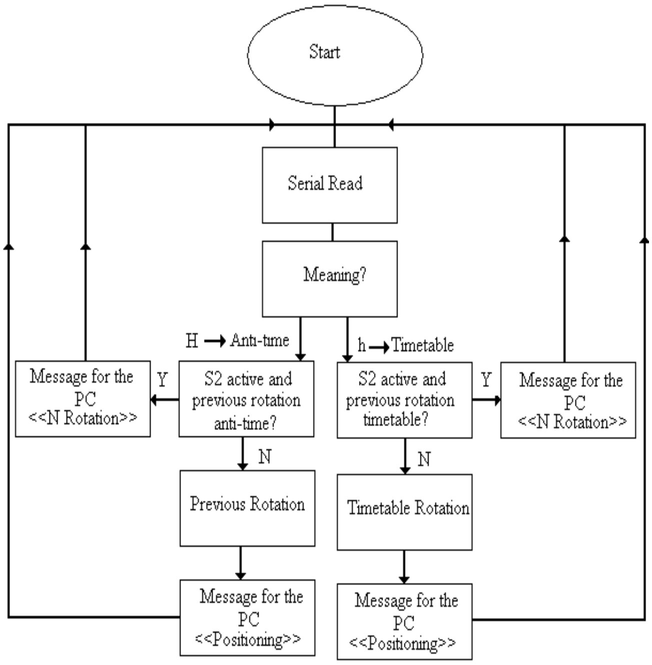

Fig. 9. Flowchart of the firmware for the micontroller PIC 16F628A.

In Fig. 10 can see the humidity control mechanism applied to newborn incubator.

Fig. 10. Humidity control mechanism developed for newborn incubator

We used the SPSS statistical package for the purpose of determining the average and standard deviation of the measures obtained by the acquisition system for temperature and humidity.

The software was developed in Delphi 7.0 language to unify the basis of time data collected by the acquisition system that collects information about the values of temperature and humidity inside the incubator neonatal.

4. RESULTS

The acquisition system for temperature and humidity and the humidity control system worked because all the prerequisites of the project.

In Table 1 are presented the results of the measures of temperature and humidity inside in newborn incubator without water in humidity reservoir in interval of 6 AM to 5.58 PM, during four days.

Table 1. Measures of temperature and humidity inside in newborn incubator without water in humidity reservoir in interval of 6 AM to 5.58 PM, during four days.

	Temperature (ºC)	Humidity (%)
Minimum	33.30	35.10
Maximum	37.40	52.60
Mean	35.40	42.59
Std. deviation	1.44	5.48

In Table 2 are presented the results of the measures of temperature and humidity inside in newborn incubator without water in humidity reservoir in interval of 6 PM to 5.58 AM, during four days.

Table 2. Measures of temperature and humidity inside in newborn incubator without water in humidity reservoir in interval of 6 PM to 5.58 AM, during four days.

	Temperature (ºC)	Humidity (%)
Minimum	34.90	40.90
Maximum	37.30	52.00
Mean	36.08	47.63
Std. deviation	1.12	3.93

In Table 3 are presented the results of the measures of temperature and humidity inside in newborn incubator with water in humidity reservoir but, without humidity control, in interval of 6 AM to 5.58 PM, during four days.

Table 3. Measures of temperature and humidity inside in newborn incubator with water in humidity reservoir but, without humidity control, in interval of 6 AM to 5.58 PM, during four days.

	Temperature (ºC)	Humidity (%)
Minimum	31.90	64.10
Maximum	37.30	76.90
Mean	34.59	69.32
Std. deviation	1.81	4.65

In Table 4 are presented the results of the measures of temperature and humidity inside in newborn incubator with water in humidity reservoir but, without humidity control, in interval of 6 PM to 5.58 AM during four days.

Table 4. Measures of temperature and humidity inside in newborn incubator with water in humidity reservoir but, without humidity control, in interval of 6 PM to 5.58 AM, during four days.

	Temperature (ºC)	Humidity (%)
Minimum	31.90	65.00
Maximum	35.50	76.90
Mean	33.47	73.40
Std. deviation	1.49	3.22

In Table 5 are presented the results of the measures of temperature and humidity inside in newborn incubator with water in humidity reservoir with humidity control during four days.

Table 5. Measures of temperature and humidity inside in newborn incubator with water in humidity reservoir with humidity control during four days.

	Temperature (ºC)	Humidity (%)
Minimum	34.90	45.10
Maximum	37.30	52.00
Mean	36.07	48.49
Std. deviation	1.11	2.99

5. DISCUSSION

5.1 Without water in reservoir

The analysis of the results, presented in Table 1, in the period of 6 AM the 5.58 PM, had evidenced a discomfort for the newborn, in view of, that the relative humidity of the air inside newborn incubator, without water in humidity reservoir, go out from the band of comfort established by standard [5] (40% to 60%).

However, in the period of 6 PM the 5.58 AM the results, presented in Table 2, had evidenced that relative humidity of the air inside in newborn incubator, without water in humidity reservoir, if it kept inside of the band of comfort established for the norm [5].

5.2 With water in reservoir and without control of humidity

The analysis of the results, presented in Table 3, in the period of 6 AM the 5.58 PM, had evidenced that the relative humidity of the air inside of the newborn incubator that used water in humidity reservoir, without control of humidity, go out from the band of comfort if it kept above of the greatest limit established by standard [5].

The analysis of the results, presented in Table 4, in the period of 6 PM the 5.58 AM, had evidenced that the relative humidity of the air inside of the newborn incubator that used water in humidity reservoir, without control of humidity, go out from the band of comfort if it kept above of the greatest limit established by standard [5].

5.3 With water in reservoir and controlled humidity

The analysis of the results, presented in Table 5, had evidenced that the relative humidity of the air inside of the newborn incubator that used water in humidity reservoir, with control of humidity, if it kept inside of a band preset in agreement with the norm [5], troughout the day, independently of the measurement interval.

6. CONCLUSION

It was verified, with this study, necessity of use water in the humidity reservoir of newborn incubator used in this work, as well as, to maintain humidity controlled.

The expectation is that the presented results will be able to provoke reflections in the professionals of the health area in the sense of using water in humidity system of the newborn incubator and that the control of this humidity could contribute to the thermo-neutral of the environment and to improve the quality of life of the premature newborns.

One checked that the newborn incubator used in this work does not provide to the premature newborns a totally appropriate environment taking into account the requisites of the standard NBR IEC 601-2-19 [1].

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