Fuzzy Logic Implementation For Incubator Prototype With Temperature And Humidity Control

Arief Marwanto
Master of Electrical Engineering Dept.
Universitas Islam Sultan Agung
Semarang, Indonesia
arief@unissula.ac.id

Kuat Supriyadi
Student of Master of Electrical Engineering Dept.
Universitas Islam Sultan Agung
Semarang, Indonesia
kuatmarjuki@gmail.com

Suryani Alifah
Master of Electrical Engineering Dept.
Universitas Islam Sultan Agung
Semarang, Indonesia
suryani.alifah@unissula.ac.id

***Abstract*— Premature infant and young baby born with low body weight has potential to be in high risk and critical condition to survive. Medical equipment functioned as uterine is required, so the infant will have the similar condition as in the womb of its mother. There is a need to control surrounding temperature, humidity, oxygen supply, sound and light level to support the development of the infant's weight. Infants with low weight have possibility to feel cold and have body heat loss. The use of additional supporting equipment such as incubator is absolutely necessary and vital to create a stable surrounding environment for infant to keep the body temperature in range of normal and relatively constant value. In this paper, the fuzzy logic is implemented as the role of controller for an incubator equipped with temperature and humidity sensor. The propossed incubator prototype was tested in DR. Sardjito Hospital, Yogyakarta Indonesia. The experiments showed prospected results to get a stable temperature and humidity which are suitable for premature baby.**

Keywords— Microcontroller, Fuzzy Logic, Sensor noise, temperature and humidity.

I. INTRODUCTION

The prevalence of premature babies born with low body weight are increasing recently which also bring several risks for these babies [1,2]. Babies with very low birth weight have a high risk especially when they feel cold. When the baby's heat is lost, it creates physiological response which exceeds the normal baby; physiological balance will be terribly disrupted [3]. This is because the baby needs to expend energy and metabolize oxygen to generate its own heat. Imparity of temperature can cause heat loss and cascading condition in baby's body for long period of time and inflict the effect such as hypothermia. Hypothermia can cause a reduction of the systematic arterial pressure, plasma volume, blood circulation into heart, and peripheral resistance. If this condition is left alone, it can induce the damage of permanent tissue, brain or even death. For fragile neonate, the circumstance which is less than one degree can be interpreted as the difference among succeed and decline [4].

To overcome this problem, a medical equipment is required that can replace the function of womb which has similar condition with mother's womb. he temperature, humidity, oxygen, and the light level for developing the baby's low body weight is crucial. It is not only the baby's temperature, humidity, and noise factors that must be considered, but also other problems that can interfere the baby health such as; factor of skin contact among the family members directly also contribute to cause a disease for the baby, because baby skin is still more sensitive, and it potentially will be infected [5].

The purpose of using incubator is to create a greatly stable circumstance so when there is a birth baby with low body weight can maintain a constant body temperature. In designing the incubator must consider a condition of humidity in the chamber, for sensitivity of the chamber temperature is more relative easier, but if the humidity condition is dry will greatly influent the baby's health. The forfeit of ideal humidity will cause the transepidermal weight loss (TEWL) of the baby temperature [3].

Most of the previous research [5-11] only controls and monitors temperature and monitors humidity. This study will develop previous research by including monitoring the level of noise in the chamber incubator. Because in previous studies only control and monitor temperature and humidity only.

II. SMART INCUBATOR MODEL

A.Architectural Design

Architectural design in this study is designed in several parts, namely; temperature, humidity and noise in the incubator room, sensors as detectors with DHT 22 for temperature and humidity, KY-037 sensors for noise sensors, Arduino data processing, Fuzzy logic control system controls, and displays. The objects taken in this study are temperature, humidity, and noise in the baby's incubator space. Then the data goes into data acquisition to change the signal from analog signal to digital signal and the data will enter Fuzzy logic temperature control software. The results of the control system will regulate the heat variable generated from the heater work, to obtain the temperature corresponding to the setting, as well as the humidity level and the level of noise in the incubator room, the results of the processing will be displayed in the dispatch.

The system prototype in this research is designed using Arduino Mega as main microcontroller. Fig 1 is the diagram of the overall equipment block.

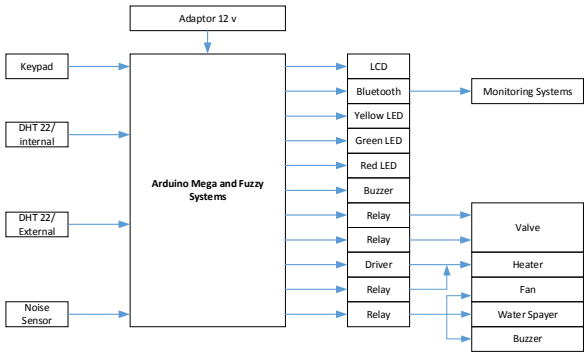

Fig. 1. Diagram of Baby Incubator

Firstly, the parameters were assigned. Parameter that must be noticed through the incubator is the parameters of temperature, humidity, and noise inside the incubator chamber. By discovering the appropriate condition, it is expected that the needs of the incubator chamber will be convenient as required which in the end baby's health will be better.

To gain the condition as expected, the heat source is obtained from the heating of the filament by electrical current controlled by the system, while humidity is provided by the water inside container. The gas valve will open and drain the fresh air when the temperature is too high exceeding the threshold determined by the setting. It happens if the condition is in an emergency that is caused by the outside factors of the system that affect the incubator space, for instance, it is influenced by the outside air, so that it needs reduction of the temperature and humidity inside the incubator properly.

Noise sensor will work when there is a noise inside the incubator exceeding 56dB. The cause of noise is possibly because of the rotation of the main fan which occurs continuously. The rotation of mechanical fan may potentially deteriorate which generates sound that exceeds a predetermined limit, i.e. a maximum of 56 dB, If this thing happened, the main fan will be off and it will be replaced by the second fan as the alternative which in this research is called as sprayer. It will be indicated by the indicator lamp that would be turn on, informed the user or technician to repair or replace the damage fan.

B. Fuzzy Mamdani Logic Method and Defuzzification

Mamdani method is also called as method of MAX-MIN, [14], To find out the output through 4 steps as follows:

1. Forming the set of Fuzzy
2. Applying the implication of function (rule) Mamdani uses Min Implication function
3. Composing the Mamdani rules could use 3 composition rules, that is : max, additive, or
4. Affirming (defuzzy) the result of composition set, need to be interpreted become crisp value as the final result.

A great way to map an input space into an output space, the Fuzzy concept itself is applies the value between 0 and 1. By aiming the result of the Fuzzy output related to the instinct or natural language which appropriate to the human ability.

The next step is defuzzification where it changes fuzzy output become crisp according to the function of affiliation that has been decided. If the temperature has not reached 360C it will be detected temperature and humidity again. However, when the temperature is ≥37ºC the heater will off, the fan is on and after that will automatically detect the temperature and humidity. Table 1 shows base role mode. Moreover, Fig. 2 show the form of temperature chart and Fig. 3 show the humidity chart.

TABLE I. BASE ROLE MODE

Internal Temperature / External Temperature	Cold	Cool	Normal	Warm	Hot
Cold	EC	W	RW	RW	C
Cool	W	W	RW	C	C
Normal	RW	W	C	C	EC
Warm	RW	RW	C	EC	EC
Hot	D	RW	EC	EC	EC

Note: EC: Extremely Cool; C: Cool; RW: Rather Warm; W: Warm; H: Hot

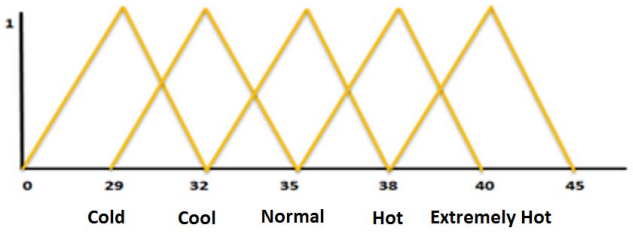

Fig. 2. Temperature Chart Diagram of Baby Incubator

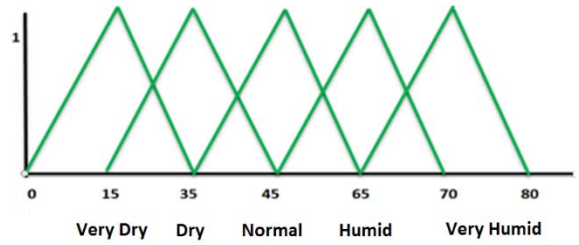

Fig. 3. Humidity Chart Diagram of Baby Incubator

C. Inference Model

The system of Fuzzy inference is an accounting framework based on the concept of the theory of fuzzy set, Fuzzy role if-then, and Fuzzy idea. This system of Fuzzy inference has succeeded to be applied in several fields.

$$\mu_{Temperature-Cold[x]} \begin{cases} 1 & x \leq 30 \\ \frac{36-x}{6} & 30 \leq x \leq 36 \\ 0 & x \geq 36 \end{cases} \quad (1)$$

$$\mu_{Temperature-Hot[x]} = \begin{cases} 0 & x \leq 30 \\ \frac{x-30}{6} & 30 \leq x \leq 36 \\ 1 & x \geq 36 \end{cases} \quad (2)$$

$$\mu_{Humid-Dry[x]} = \begin{cases} 1 & x \leq 30 \\ \frac{90-x}{60} & 30 \leq x \leq 90 \\ 0 & x \geq 90 \end{cases} \quad (3)$$

$$\mu_{Humid-Humid[x]} = \begin{cases} 0 & x \leq 30 \\ \frac{x-30}{60} & 30 \leq x \leq 90 \\ 1 & x \geq 90 \end{cases} \quad (4)$$

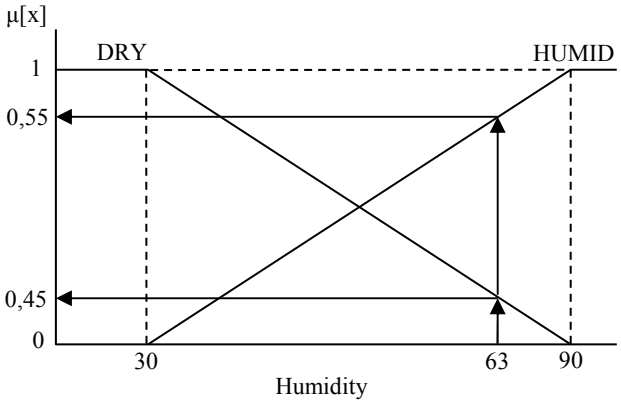

Fig. 4. Temperature and Humidity Role Base Graph

III. Result and Disscusion

This testing was aimed to discover the performance of whole series of the measurement between two temperature sensors to respond the control system in RSUP. dr. Sarjito on 23 April 2019.

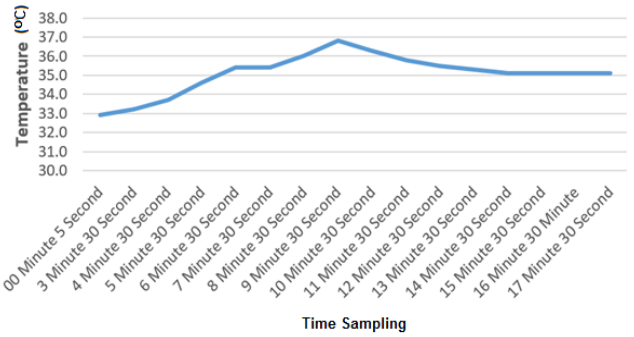

Fig. 5. Response of Fuzzy Control of Temperature

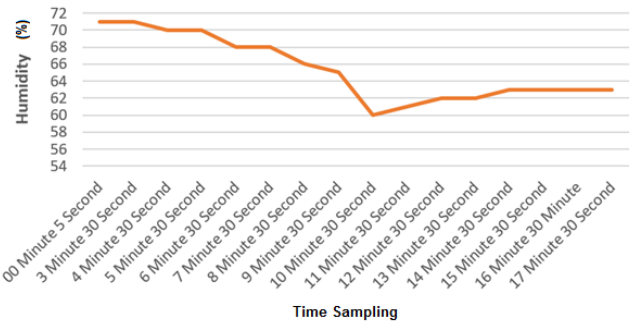

Fig. 6. Response of Fuzzy Control of Humidity

TABLE II. Measurement Result on Control System Response

No	Time (second)	Temperature (°C)	Humidity (%)	Fuzzy output	Crisp output
1	00 minute 5 second	32.9	71	175	50
2	3 minute 30 second	33.2	71	175	50
3	4 minute 30 second	33.7	70	175	50
4	5 minute 30 second	34.6	70	175	50
5	6 minute 30 second	35.4	68	168,45	56.55
6	7 minute 30 second	35.4	68	168.45	56.55
7	8 minute 30 second	36	66	162.86	62.14
8	9 minute 30 second	36.8	65	143.65	81.35
9	10 minute 30 second	36.3	60	125.28	99.72
10	11 minute 30 second	35.8	61	123.33	101.67
11	12 minute 30 second	35.5	62	122.42	102.58
12	13 minute 30 second	35.3	62	120.45	104.55
13	14 minute 30 second	35.1	63	120.19	104.81
14	15 minute 30 second	35.1	63	120.19	104.81
15	16 minute 30 second	35,1	63	120.19	104.81
16	17 minute 30 second	35,1	63	120.19	104.81

Table II shows the measurement result of control system response which was observed for 17 minutes at 10.30-10.47 WIB, 00 minutes 5 second with temperature sensor 32,9° C humidity 71% at Crisp output 50. The heater and fan were turn on while the Fuzzy output 175, the sprayer was turn off, whereas the fuzzy control system in Fig. 5 the fuzzy control system of temperature has already work properly. Then, in Fig. 6 the fuzzy control system of humidity has already work properly.

IV. Conclusion

Based on measurements results, fuzzy logic has been applied to the proposed incubator prototype to keep the system in accordance with the desired temperature and humidity setting point. By using temperature and humidity sensor, the incubator prototype is able to adjust the surrounding environment required by suitable conditions of

the baby. Monitoring system of the incubator prototype has been implemented by using android with Bluetooth.

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REFERENCES

[1] JR. Bloch, "Antenatal events causing neonatal brain injury in premature infants." Journal of Obstetric, Gynecologic, & Neonatal Nursing 34, no. 3, pp. 358-366, 2005.

[2] B. Rooney and BC. Calhoun. "Induced abortion and risk of later premature births." Journal of American Physicians and Surgeons 8, no. 2, p. 46-49, 2003.

[3] Ducker, D. A., A. J. Lyon, R. Ross Russell, C. A. Bass, and N. McIntosh. "Incubator temperature control: effects on the very low birthweight infant." Archives of disease in childhood 60, no. 10 (1985): 902-907.

[4] Matika, Ryan, Mohab Ibrahim, and Amol Patwardhan. "The importance of body temperature: An anesthesiologist's perspective." Temperature: Multidisciplinary Biomedical Journal, vol 4, no. 1, p. 9-12, 2017.

[5] TA Tisa, Zinat Ara Nisha, and Md Adnan Kiber. "Design of an enhanced temperature control system for neonatal incubator." Bangladesh Journal of Medical Physics, vol 5, no. 1, 2013.

[6] NYD Setyaningsih and AC Murti, "Control Temperature On Plant Baby Incubator With Fuzzy Logic", Simetris: Jurnal Teknik Mesin, Elektro dan Ilmu Komputer 7, no. 1, p. 273-282, 2016 .

[7] G.M. Amer and K.M. Al-Aubidy. "Novel Technique to Control the Premature Infant Incubator System Using ANN." In Proceedings of Third International Conference on Systems, Signals & Devices (SSD 2005), Sousse, Tunisia, pp. 21-24. 2005.

[8] SK. Singla and V. Singh. "Design of a microcontroller based temperature and humidity controller for infant incubator." Journal of Medical Imaging and Health Informatics, vol 5, no. 4, p. 704-708, 2015.

[9] H. Joshi and Dattu Shinde. "PIC Microcontroller Based Efficient Baby Incubator." Int. J. Adv. Res. Electric., Electron. Instrum. Eng, vol. 4, no. 2, p. 832-837, 2015.

[10] Purnomo, A. S. "Sistem Kontrol temperatur Tabung Inkubator Bayi Menggunakan Ic At89c51". Jurnal Unimus, p.16-19, 2006.

[11] Rozaq, N. Y. "Kendali Suhu Inkubator Bayi Menggunakan PID". Jurnal SIMETRIS, p.489-494, 2016.