Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics
August 2024, Vol. 6, No. 3, pp. 20-27, e-ISSN: 2656-8624, https://ijeeemi.ijahst.org
https://doi.org/10.35882/jeeemi.v6i3.5

RESEARCH PAPER OPEN ACCES Check for updates

Desain Three Dimension Baby Incubator Using SketchUp Application Based on Indonesia National Standards

Icha Fatwasauri[1], Anshari Ahmad Zaini[2]

[1] Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia
[2] PT Wego, Jakarta Indonesia

ABSTRACT

Premature birth is one of the causes of perinatal death. Premature babies have a higher risk of death because babies have difficulty adapting to life outside the womb due to the baby's immature organ system. The medical device used to care for premature babies is called an incubator. In making an incubator, usually before making it, a prototype must be tried first. In addition, it must also be simulated so that the results of the incubator are in accordance with the standards. The purpose of this study is so that the incubator that is made can be simulated first in a 3-dimensional application. This is done to minimize errors in component assembly. Various studies related to simulators have been carried out, such as using matlab. This takes a relatively long time to learn. Therefore, the author designed a 3-dimensional design of the incubator, namely by cutting. Sketchup is easier to learn for beginners, this software is also free. The research method used by researchers is research and development. Researchers directly review examples of incubators, after which they begin to design the 3-dimensional shape of the incubator according to recognized requirements. The researcher conducted several stages, namely literature study, initial design, 3-dimensional design, validation, and discussion. From the design results that have been made and given a questionnaire to material experts, a value of 67% was obtained or said to be feasible. Validation was also carried out by direct measurement and the results were not much different. The conclusion of this study is that the 3-dimensional incubator results made are declared feasible or in accordance with the original.

PAPER HISTORY

Received April 02,2024
Revised May 31,2024
Accepted May 31, 2024

KEYWORDS
Incubator;
SketchUp;
Validation;

1. INTRODUCTION

In medical terms, newborns are called neonatal. The neonatal period is calculated from birth until the baby [1][2] is 28 days old. Data in 2017, the Indonesian Health Demographic Survey (IDHS) explained that the neonatal mortality rate (AKN) in Indonesia has decreased. In 2012, NMR in Indonesia reached 19 cases of death out of every 1000 births. And in 2017 it decreased to 15 cases of death from every 1000 births [3]. Premature birth is one of the causes of perinatal death. Premature infants are at risk of developing serious complications after birth [4]. Premature babies have a higher risk of death because babies find it difficult to adapt to life outside the womb due to immature organ systems of the baby's body. Throughout 2015 worldwide, there were 15 million (more than one in ten) babies born prematurely and more than one million died from premature complications. The birth rate of premature babies in Indonesia is also at a high number of around 675,700 per year, and in world order Indonesia is the fifth highest country [5].

Medical devices used to maintain babies born prematurely are called incubators or neonatal infant incubators [6]. A baby incubator is a medical device in the field of life support used to treat premature babies or BBLR (Low Birth Weight) [7] [8] born weighing less than or equal to 2500 grams. A baby incubator is very necessary to help premature babies adapt to their new environment. An incubator is a health care tool for critical/premature neonates that provides warmth and humidity according to the needs of newborns under controlled conditions [9]. The first incubator is credited to French Obstetrician by Stephane Tarnier, who was looking for a way to warm infants who commonly died of hypothermia [10].

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

Research has been conducted on the Design and Manufacture of Incubators Based on Temperature Distribution [11]. The study used a mathematical approach based on average physical data of newborns. After designing the incubator dimensions, the heat transfer parameters of the incubator are determined. Such heat transfer parameters are used for the simulation approach. After simulation, a prototype of the incubator will be made. From the simulation results, the temperature distribution in most areas in the incubator ranges from 31 - 35 ºC, so it is in accordance with the temperature needed by the baby. The control of humidity is extremely important to thermal comfort and in the case of the neonatal incubator survivability [12].

In 2015, research was conducted on Redesigning Grashof Incubator with Alternative Heating System and Ergonomic Aspects [13]. The redesign of the grashof incubator was carried out to overcome the lack of electricity, so a new heating system was created that resembled a light bulb system. Hot water-based heat exchangers are used to generate heat inside the incubator cabin. In 2021 research on Smart Baby Incubator [14] the research goal is to make a smart baby incubator that can detect baby's condition and in case anything goes wrong, the system can trip itself so that the conditions can return to a normal state. We will integrate it with IoT and a mobile app so that doctors can check the baby's condition remotely. It can be easy to think of an incubator as just a bed for a sick baby, but it's so much more than a place for sleeping. An incubator is designed with such techniques and care that it can provide a safe and sound atmosphere for a newborn baby to rest until its vital organs are still in a development stage.

In 2019, two studies have been conducted. First, research entitled Product Design, Prototyping, and Twin Incubator Testing Based on the Grashof Incubator Concept [15] [16]. The research used 3D modeling software, a product design development that focuses on the current functions of grashof incubators into twin grashof baby incubators, such as maintaining infant cabin temperatures at 33°C-35°C by enabling natural convention and natural circulation. In addition to key functionality, the design also focuses on ergonomic aspects as well as material considerations to improve usability and efficiency. The expected result of the study is the ability of the developed twin incubators to achieve mandatory temperatures, as mentioned above, inside the cabin using a 4 x 15 W light bulb as a heater. Second, a study entitled Analysis of Temperature Stabilization in Grashof Incubators with Environmental Variations Based on Indonesian National Standards (SNI) [17]. In this study, the temperature measurement [18] method used the DS 18B20 sensor to measure temperature and the DHT22 sensor to measure relative humidity. Both sensors will be integrated with the Arduino board and software for data reading. Temperature measurement procedure based on Indonesian National Standard (SNI). The purpose of this study is to determine the temperature stability point in the baby's cabin and determine the characteristics of temperature changes in the incubator following the ambient temperature. Data collection was carried out at ambient temperature variations of 25 °C -30 °C and <25 °C in some conditions, 2x25 watt and 2x40 watt heater lamps, and thermostat use. The test results say that the level of temperature stability in the baby's cabin is very dependent on the ambient temperature.

Before making an incubator, a 3-dimensional design is needed to simulate the incubator to be made. Simulation is needed to minimize errors in the manufacturing process. Some of the studies above conducted simulations using MATLAB / Simulink. In using MATLAB [19][18][20] requires a long learning time process. This causes ordinary people to take a long time to do simulations because it takes time to learn MATLAB and MATLAB software is relatively expensive. For this reason, a 3-dimensional application is needed that is easy to learn and cheap. The application is Sketchup.

Sketchup is an application program based on 3-dimensional (3D) modeling image [21] design that is easy to use for everyone, even for beginners. Sketchup is not only 3D modeling software, but SketchUp is also able to calculate budget plans using the Quantifier Pro extension. SketchUp Make is free software. It is user-friendly and easy to learn. It can be downloaded from the Internet for free and, most importantly, it can be used without an Internet connection [22]. Quantifier Pro is a SketchUp extension for cost estimation work by combining 3D SketchUp models that immediately provide accurate calculation results.

Based on previous research, computer-based design technology, such as the SketchUp application, has been used in various engineering and design fields to produce more accurate and efficient three-dimensional models [23]. In the context of infant incubators, good design must meet strict technical and safety requirements [24], as stipulated in the Indonesian National Standard (SNI), to ensure the safety and comfort of infants and ease of use by medical personnel.

The use of SketchUp application in incubator design offers advantages in terms of detailed visualization and the ability to make design modifications quickly and efficiently. However, the main challenge is how to ensure that the resulting 3D model complies with established standards. Several international studies have shown that a computer-

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

based design approach can reduce design errors and accelerate the product development process [25].

Therefore, this study focuses on the design of a three-dimensional infant incubator referring to SNI using the SketchUp application, with the aim of producing a model that is not only visually aesthetic but also meets the technical specifications required in the medical device industry in Indonesia.

Based on the background above and some previous research, the author will conduct a study entitled "3-dimensional Design of Baby Incubator Using the Sketch Up ApplicMatlaation Based on Indonesian National Standards". The purpose of this study is so that the incubator that is made can be simulated first in a 3-dimensional application which is free access, and this application is easier to use than MATLAB, AutoCAD [26][27][28] and other applications. Research contributes as a reference for designing medical device designs.

2. MATERIALS AND METHOD

The research method used in this study is the research and development method. The purpose of this study was to make a 3-dimensional design of a baby incubator, and the design results were validated. According to research and development methods are needs analysis and research is needed to test the effectiveness of these products so that they can benefit the wider community. The object of the study is a baby incubator. The subject of the study is a material expert. Material experts here are incubator experts or electromedical lecturers. Data collection techniques [29] in this study by filling out questionnaires and documentation. A questionnaire is a data collection technique by providing a set of written questions to be answered by respondents. The questionnaire in this study serves to assess the feasibility level of design by material experts. This research instrument uses a Likert scale with 5 scales in the form of a check list. The lowest score used in the instrument is 1 and the highest score used in the instrument is 5. The rating scale of the instrument items is made at intervals of 1-5 with the following criteria in table 1.

Table 1. Questionnaire Instrumentation Measurement Scale

Alternatif Answer	Angka
Excellent	5
Good	4
Good enough	3
Not good	2
Very unkind	1

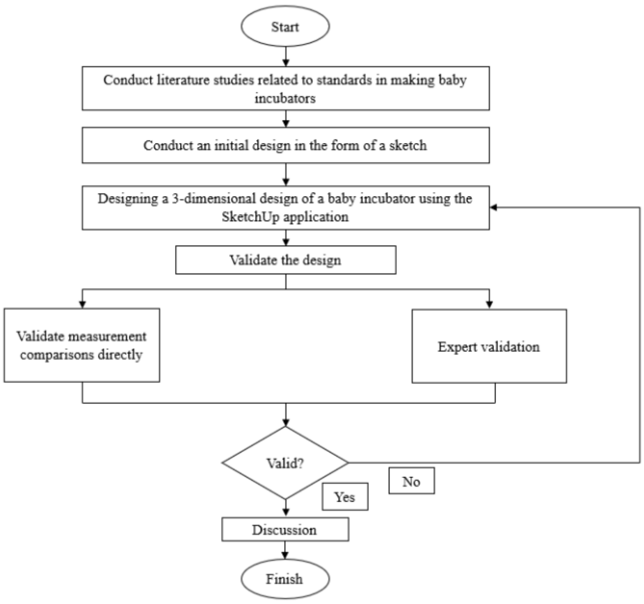

Fig. 1. Frame of Study

Data analysis techniques in this study will be carried out using percentage descriptive analysis techniques. The data was obtained from a questionnaire of feasibility test results by material experts regarding 3-dimensional design. Based on the feasibility assessment questionnaire by material

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

experts, it can be known the number of scores obtained through the following equation (1) [30]:

$$P = \frac{\sum n}{\sum N} \times 100\% \quad (1)$$

Where P is percentage of product suitability assessed, ∑n is total score obtained based on expert assessment, and ∑N is maximum score from expert assessment.

3. RESULTS

Making the 3-dimensional design of this baby incubator is carried out through five stages, namely: literature study, initial design, design with SketchUp, design validation, and discussion. In initial design, researchers already have an initial product (prototype). In prototypes have several types, one type that researchers use in this study is sketching or sketching. A sketch is a rough design of a composition or part of a composition made for personal satisfaction. In Figure 4, the sketch that the researcher made was in the form of lines only briefly to display the image of a sketch that had been completed.

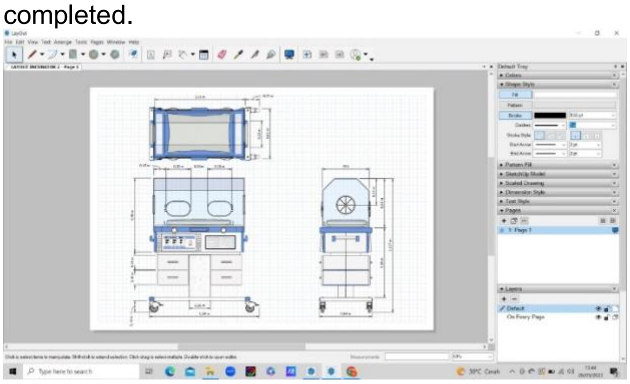

Fig 2. Baby Incubator Sketch

In the 3-dimensional design stage of the baby incubator, researchers have designed using the SketchUp application. Figure 3 is the result of the 3D design of the baby incubator.

Fig 3. *Baby Incubator 3D Design Design*

Direct measurements on figure 4 are made by comparing the results of designs made using sketch ups with the original incubator. Here's a picture of the incubator I've taken measurements of.

The following are the results of direct measurements and design measurement results show in table 2:

Table 2. Comparison of Direct Measurement and Design Measurement

No	Design Size Results (m)	Direct Measurement Results (m)
1	Bad Base 1,11 x 0,61	Bad Base 1,0 x 0,60
2	Closing 0,57 x 0,60	Closing 0,56 x 0,58
3	The entire incubator from engine to cover 1,34 x 0.90	The entire incubator from engine to cover 1,32 x 0.90
4	The entire incubator from wheels to cover 0,64 x 1,637	The entire incubator from wheels to cover 0,62 x 1,633

Fig 4. Direct Incubator Measurement

Expert validation was carried out by five people in the electromedical field, namely three electromedical lecturers, one hospital technician and one person

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

from the company. Material experts provide an assessment related to the 3-dimensional design of baby incubators. The results of the assessment given through research instruments were identified using a Likert scale with a score range of 1 to 5. The following are the results of the assessment given by material experts.

Based on table 3, it is known that in 6 questions covering aspects of components and sizes, they received an assessment from material experts in the decent category with a total assessment score of 67%. From 6 questions, there are 2 questions that get a very decent category, namely at the bottom there is an electronic component of the baby incubator that meets the standards and on the upper front side of the tool made of transparent acrylic. While the other 4 questions get a decent category from experts. The category at the top there is a baby place equipped with an incubator cover get score 72%. The category the size of the incubator is in accordance get 64% score. The catagory size of the carpet base used is in accordance with the standard, namely (PxL) (1,11m x 0,61m) get 64% score. There are four incandescent light bulbs as a source of heat or heating get 52% score.

Table 3. Material Expert Validation Results

Assessment Instrument	A1	A2	A3	A4	A5	Score	%	Ket
1. At the bottom there are electronic components for the baby incubator that meet standards.	3	5	3	4	4	19	76%	very worthy
2. At the top there is a baby place equipped with an incubator cover.	3	4	4	3	4	18	72%	worthy
3. The size of the incubator is in accordance with standards, namely (PxLxT) (1,34m x 0,64m x 1,637m).	4	4	3	3	2	16	64%	worthy
4. The size of the carpet base used is in accordance with the standard, namely (PxL) (1,11m x 0,61m).	3	4	3	3	3	16	64%	worthy
5. The top front side of the tool is made of transparent acrylic.	5	3	3	3	5	19	76%	very worthy
6. There are four incandescent light bulbs as a source of heat or heating.	3	4	2	2	2	13	52%	worthy
The total assessment score	**21**	**24**	**18**	**18**	**20**	**101**	**67%**	worthy
Expected score	**30**	**30**	**30**	**30**	**30**	**150**		
Percentage (%)	**70%**	**80%**	**60%**	**60%**	**66%**			

Note: A: Materials Expert

4. DISCUSSION

The process of making this 3-dimensional design goes through several stages, namely conducting a literature study or literature review, conducting an initial design in the form of sketches, designing a 3-dimensional design, validating, and discussing. Based on the results of the literature review, it is known that there are 3 problems, namely the need for a 3-dimensional design in simulating an incubator before it is made; some studies conduct simulations with MATLAB whose learning process is relatively long; and students need interesting learning media. For this reason, it is necessary to design a 3-dimensional design of the incubator in accordance with the standard. Literature review is done as a basis of observation for the author. The author has also looked for references related to standards on baby incubators and made designs according to standards. In searching for references, the author has not found a journal that discusses making 3-dimensional designs of baby incubators using SketchUp. The next stage is to do an initial design as a sketch. At this stage the author has made sketches starting from the cover, bed, incubator body, components, drawers and incubator wheels. Sketches are useful for calculating the size of the incubator. In the sketch is displayed the size of the

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

length and width of the incubator. This sketching serves to minimize design errors and to conform to incubator standards. After the sketch is completed, the next stage is to make a 3-dimensional design of the baby incubator. Designs are made starting from the incubator holder, transparent incubator cover, machine parts, drawer parts, and various other accessories such as baby beds, baby pictures, and wheels.

The next stage is to validate the design. Validation is carried out in 2 stages, namely (1) by comparing incubators directly through measuring the length and width of the original incubator; and (2) making questionnaires to electromedical experts. Based on the results of direct measurement comparison, the incubator that the author made is almost the same as the original incubator example. The original incubator was taken by the author to take measurements at the Indramayu State Polytechnic Nursing Laboratory. The results show that there is a slight difference in length and width, but this is not a problem because the size in the incubator is basically the same. There is a slight increase in length and width due to the iron that supports the incubator. Based on expert assessment, it is included in the decent category with a total assessment score of 67%. Experts recommend that more detail be seen on the components of the baby incubator. Because of the short time of research, maybe the advice from this expert will be done in the future.

The design of a three-dimensional baby incubator using the SketchUp application is carried out by referring to the Indonesian National Standard (SNI) which applies to medical equipment, especially baby incubators. The design process begins with collecting data on the dimensions, functions, and main components that must be present in the baby incubator, in accordance with safety and comfort standards for babies. Through the SketchUp application, the 3D model of the baby incubator is designed in detail, including important elements such as a transparent room for baby supervision, temperature and humidity settings, and other safety features such as alarms and air vents.

From the design results, the baby incubator model produced can meet the specifications set by SNI according to research [17], both in terms of dimensions and function. The use of the SketchUp application has been proven to facilitate the design visualization process, allowing designers to see and correct potential errors from an early stage. In addition, the resulting 3D model also makes it easier to simulate component placement, test dimensions, and estimate the space needed for additional equipment. The designed incubator can also be adjusted to the needs of hospitals or health centers based on the parameters specified in the standard, thereby increasing flexibility and efficiency in the production of baby incubators in the future.

In this study, although the design of a three-dimensional infant incubator using the SketchUp application provides detailed visualization and is in accordance with the Indonesian National Standard (SNI), there are several limitations and shortcomings that need to be considered. First, the SketchUp application, although ideal for visual design, has limitations in functional simulation, especially related to thermal analysis and airflow which are very important in designing an infant incubator. This application is not designed to comprehensively test the thermodynamic performance or environmental response required by the infant incubator to maintain optimal temperature and humidity.

Second, another limitation is the dependence on the designer's skills in using the SketchUp application. Although user-friendly, this application requires a certain level of expertise to maximize design accuracy and ensure compliance with SNI technical specifications. Human error in the design process can lead to less precise results. In addition, the resulting 3D model does not directly include testing the feasibility of the materials or components used, which requires additional testing outside the software.

Finally, limitations also exist in the scope of the study which focuses more on visual design and does not include the manufacturing process or direct testing of physical prototypes. Thus, although the resulting 3D model is close to standard, the practical implementation of this design still requires further testing to ensure the quality and safety of the infant incubator when mass-produced.

Research on the design of a three-dimensional infant incubator using the SketchUp application based on the Indonesian National Standard (SNI) has significant implications in various aspects, especially in the health sector and the medical equipment industry. First, the success of detailed 3D design contributes to increased efficiency in the design and production process of infant incubators. By using the SketchUp application, designers and manufacturers can accurately visualize the shape and function of the incubator according to applicable standards, thereby minimizing design errors and shortening product development time. This can accelerate the innovation process and distribution of more affordable and safe incubator devices to hospitals or health centers.

Another implication is the potential for cost savings at the design and production stages. With a comprehensive 3D model, manufacturers can simulate and modify the design before producing a physical prototype, thereby reducing costs associated with repeated physical trials and development. In addition, SNI-based design ensures

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

August 2024, Vol. 6, No. 3, pp. 20-27, e-ISSN: 2656-8624, https://ijeeemi.ijahst.org
https://doi.org/10.35882/jeeemi.v6i3.5

that the resulting incubator product meets safety and health regulations, which are very important in its use for premature babies or babies with certain medical conditions.

In the field of education and research, this study opens opportunities for higher education institutions and medical design professionals to explore the use of 3D design technology in creating innovative solutions for medical devices. Thus, this research not only contributes to the development of the medical device industry, but also advances the quality of healthcare services in Indonesia.

5. CONCLUSION

From the results of the research and discussion of the 3D design of this baby incubator, the goal is that the incubator that is made can be simulated first in a 3D application that can be accessed freely, and this application is easier to use compared to MATLAB, AutoCAD and other applications. The creation of the 3D design of this baby incubator is carried out through stages consisting of literature studies, initial design in the form of sketches, 3D designs, design validation and discussion. The sketch is made using the sketch up application. In making the sketch, the size of the baby incubator is designed. The sketch results are designed as a 3-dimensional design of the baby incubator. The results of the feasibility test or direct measurement validation show results that are not much different or can be said to be the same. The results of the feasibility test or validity of the material expert are included in the feasible category with a total assessment value of 67%. It is hoped that in the future this research can calculate the cost budget plan (RAB) using the Quantifier Pro extension. Quantifier Pro is a Sketchup extension for cost estimation work by combining 3D Sketchup models that directly provide accurate calculation results. This research can be continued by simulating an incubator with the weight of a baby.

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Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

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AUTHOR BIOGRAPHY

Icha Fatwasauri was born in Pekanbaru, Riau. She received a Bachelor of Physics (Electronic Metrology and Instrumentation) from Universitas Ahmad Dahlan Yogyakarta in 2017. She received her Master of Biomedical Technology from the Universitas Indonesia in 2020. From 2020-2022, she has been a lecturer in electromedical at the Al Insyirah Institute of Health and Technology Pekanbaru. From 2022 to present, she has been a lecturer at the Politeknik Negeri Indramayu. Her current research interests include biomedical image processing, medical device calibration, health regulation and medical instrumentation.

Anshari Ahmad Zaini. He was born in Pekanbaru, Riau 23 years ago. He earned a bachelor's degree in Electromedical Engineering from MH Thamrin University Jakarta in 2023. He had an internship at BPFK Jakarta. Since 2023 until now, he has been a technician at PT. Wego Indonesia. Before at PT. Wego Indonesia, he had worked in a medical device assembly factory such as infusion pumps, patient monitors and others. He currently focuses on laboratory equipment.

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia

Corresponding author: Icha Fatwasauri, email: ichafatwasauri@polindra.ac.id, Department of Refrigeration and Air Conditioning Engineering, Politeknik Negeri Indramayu, Indonesia