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Salt House Prototype Design to Optimize Drying Time

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Abstract
Salt is a food ingredient that cannot be separated from human life. The process of making salt begins by evaporating seawater until salt crystals remain over a period of 3-4 months. However, there are still some problems that occur throughout the process, which impact the quantity and quality of the product. Weather factors such as rainfall, sea waves, environmental temperature, limited sea water resources, limitations of traditional technology, and the need for human labor to supervise and control each salt production process. Based on these problems, the design and manufacture of a prototype salt house based on the internet of things was carried out. The method used in this research is the Pahl and Beitz method, the stages in the Pahl and Beitz method include the following: a) designing and explaining tasks, b) designing product concepts, c) designing product shapes, d) designing details. The results of the internet of things based salt house prototype design were obtained: The geometric size of this tool is 70 cm x 30 cm x 30 cm. with supporting dimensions: PTC heater, Eps 32 microcontroller, DHT22 sensor and DS18B20 sensor. Simulation results of the salt house prototype showed that the fastest salt crystallization process at a minimum sea water volume of 20 ml with a temperature of 29,30,31 and humidity 80.3%, 82.7%, 84.1% was 22 hours, at a maximum seawater volume of 135 ml with temperature 29,30,31 and humidity 96.6% 91.7%, 96.6% is 27 hours.

Keywords: Salt House Prototype Design, Internet Of Things, Pahl And Beitz.

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Introduction

Foodstuffs that cannot be separated from human life are salt. Salt is a halide mineral with a chemical composition as NaCl (Sodium Chloride) consisting of various Na (sodium) content of 39.3%, and Cl (chloride) consisting of 60.7%. Every day humans need a minimum salt intake of 0.3 grams in the metabolic process in the body. In addition, salt is also needed by industry for the processing of materials and the CAP (Chlor Planant) industry such as textiles, leather, cosmetics and others require salt with a higher NaCl content (NIDA, 2019). According to the Ministry of Industry (2002), the need for consumption salt is 1.2 million tons/year, while for industrial salt it reaches 2.4 million tons/year. Based on the Decree of the Minister of Industry Number 29/M/SK/2/1995 concerning the Indonesian National Standard (SNI) for industrial salt includes a NaCl content of 98.5 db.

The salt-making process begins with evaporating seawater until salt crystals remain for a period of 3-4 months (Central Bureau of Statistics, 2020). However, there are still several problems that occur throughout the process, which have an impact on the quantity and quality of the product. Weather factors such as rainfall, sea waves, environmental temperature, limited seawater resources, limited traditional technology, and the need for human labor to supervise and control each productive process of changing seawater into salt are some of these problems (Kurniawan et al., 2019).

Lack of supervision and control of salt production is one of the problems that is the focus of this study. Products that do not meet the desired quality and quantity standards can be produced due to failure in the production supervision and control process. Simple and traditional technology is an important influence in the supervision and control of salt house prototypes. Currently, the technology commonly used by salt farmers in Indonesia is traditional Madurase technology. However, this salt production technique still often produces poor quality salt. The application of simple technology in people's salt businesses often results in the salt produced not meeting the SNI standard set by the government of 97.46% (SNI 4435:2017). In addition to the low NaCl content, the salt produced is often not white and mixed with dirt because the base of the salt pond is soil. In addition, production ineffectiveness often occurs because the water contained in the media is lost through the pores of the soil (Nur et al., 2013) in (Kurniawan et al., 2019). Data from the East Java BPS shows that salt production has decreased significantly. For example, in Sumenep Regency, salt production decreased from 6,706 tons in 2022 to 3,051 tons in 2023. Similar declines also occurred in other areas in Madura, such as Pamekasan and Sampang (East Java BPS).

The use of technology using greenhouse prisms and the use of plastic mulch or geomembranes during the production process are some of the solutions that have been implemented to overcome these problems. A greenhouse prism is a greenhouse design made with crystal production technology that can absorb heat and retain heat (Muntalim et al., 2020). The greenhouse prism prototype has the potential to increase the efficiency and productivity of salt production because it can handle the failure of the salt production process due to weather factors. The use of plastic mulch can help crystallize salt and speed up the production process. From the results of laboratory tests on the quality of salt from the Greenhouse Prism, the NaCl content on a wet weight basis (adbb) was 87.56%, the Mg content was 2.15%, the Ca content was 3.45% and the water content was 5.86%. These results indicate that the quality of prism salt produced through the application of the Greenhouse Prism method in Sedayu Lawas Village, Lamongan Regency is included in the category of K1 quality salt.

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However, the use of greenhouse prisms also has several disadvantages, such as high initial costs, as well as ongoing maintenance and care costs. In addition, the use of geomembranes is still often disrupted by unpredictable weather conditions (Kurniawan et al., 2019). To solve this problem, researchers designed an Internet of Things-Based Salt House Prototype Using the Pahl & Beitz Method. The prototype is used to minimize manufacturing costs, ease of repair, security development capabilities, efficiency and service quality. The prototype can improve control over the room temperature in the salt house prototype automatically and efficiently, so that the salt making process can be easily controlled. This prototype is expected to help the productivity of salt making at night by using artificial heaters (heaters) as a substitute for heat sources controlled by Eps 32, so that it can maximize the use of time in salt production in the salt house prototype. IoT uses the Eps 32 device to control and monitor the salt house prototype.

This technology was chosen because IoT technology has proven effective in increasing the efficiency of control and supervision in various sectors. This study developed a tool used to conduct remote monitoring of water quality based on the internet of things. This system uses a Turbidity Sensor, TDS Sensor, pH Sensor, and NodeMCU as a microcontroller, and can send monitoring data via a website with a success rate of 86.6% and an error rate of 13.3% (Widya et al., 2023). By using IoT technology that utilizes Eps 32 as a microcontroller and sensor to monitor environmental conditions. The sensors used are water temperature sensors, as well as room temperature and humidity sensors. In addition, the microcontroller will turn on the heater as a substitute for solar heat when the temperature inside the salt house prototype is low. By using this technology, the salt house prototype can be adjusted automatically and reduce dependence on human labor. In addition, it is hoped that this prototype can also facilitate monitoring and monitoring of conditions in the salt house prototype remotely via an internet connection. Thus, supervision of the salt house prototype can be carried out more easily and efficiently without having to be physically at the production site.

Literature Review

Salt is a halide mineral with a chemical composition as NaCl (Sodium Chloride) consisting of various Na (Sodium) contents of 39.3%, and Cl (chloride) consisting of 60.7%. Salt is one of the needs that is a complement to food needs and is a source of electrolytes for the human body. Physically, salt is a white solid in the form of crystals which is a collection of compounds with the largest part of NaCl (> 80%) and other compounds such as CaSO4, MgSO4, MgCl2, and others (Marihati and Muryati, 2008). Salt has hygroscopic properties/characteristics which means it easily absorbs water and a melting point at a temperature of 801 ° C. Every day humans need a minimum salt intake of 0.3 grams in the metabolic process in the body. In addition, salt is also needed by industry for the processing of materials and the CAP (Chlor Planant) industry such as textiles, leather, cosmetics and others require salt with a higher NaCl content. Sodium chloride forms crystals in the dry state, but like other salts in the body, it readily dissolves in water. When salts dissolve in water, their components separate as particles called ions. These dissolved ion particles are known as electrolytes. The concentration (level) of each electrolyte in a solution of a dissolved salt can be measured and is usually expressed in milliequivalents per volume of solution (mEq/L).

According to IEEE (Institute of Electrical and Electronics Engineers), the Internet of Things (IoT) is defined as a network of physical objects embedded with technology that allows them to communicate with each other and interact with their surroundings. The technology contained in

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these physical objects usually includes sensors, software, and internet connectivity that allows for automatic data collection and exchange (Ang & Seng, 2019).

IoT architecture consists of several components, namely sensor devices, gateways, IoT platforms, and IoT applications. Sensor devices function to collect data from the surrounding environment. Gateways function to send data from sensor devices to IoT platforms. IoT platforms function to process data and store it in the cloud. IoT applications function to monitor and control devices remotely.

Smart water systems are one example of a system that uses IoT technology to monitor and control water usage intelligently (Junior et al., 2021). This system consists of hardware such as sensors, water pumps, and microcontrollers that are connected to the internet via wireless networks or using cables. Smart water system technology in this study is used to monitor or detect water availability in the salt house prototype and control water pumps.

Design is the initial activity of an effort to realize a product that is very much needed by the community. After the design is complete, the following activity is product manufacturing. Both activities are carried out by two people or two groups of people with their respective expertise, namely design is carried out by a design team and product manufacturing by a product manufacturing group team (Trilian & Jakaria, 2024)

Research Methods (Times New Roman 12 pt (Bold))

The type of research used in this study is Research and Development (R&D). Research and Development (R&D) is a process or steps to develop a new product or improve an existing product. Development research is a type of research that can be a link or breaker of the gap between basic research and applied research. From this description, it can be concluded that Research and Development is a research method that aims to produce certain products (Okpatrioka, 2023).

The prototype model is one way of developing a system that is done by creating a prototype or initial model of the system. The prototype is then tested and evaluated to see its performance, and repaired if there are deficiencies or weaknesses. This model is used to create a salt house prototype to produce salt. The materials for making the salt house consist of acrylic glass, water containers, PTC Heaters. The salt house material is made of acrylic glass with a thickness of 4 mm because it can be an insulator of solar heat into the house space and protection from the weather in the salt crystallization process optimally assisted by a heater that focuses heat on the salt house. The heater is used to accelerate the salt crystallization process through evaporation. Acrylic glass sheets are arranged into a double slope house.

The overall architectural design of the salt house prototype includes, firstly, hardware consisting of a DHT22 sensor, DS18B20 sensor and ESP32 sensor as a module. The module will collect data detected by the sensor and will send data to the cloud database as a place to store data. The cloud referred to here is the Firebase platform. Firebase will store data in real-time where if there is a change in data from the sensor side, the data in Firebase will be replaced directly. Users can interact with the desired room temperature using the Internet of Things system via a mobile application.

Results and Discussion

The design of the salt house prototype refers to market needs and demands. Identification of needs is done by conducting observations at conventional salt production locations, as well as by interviewing salt farmers. The next step is to create a functional structure of the salt house

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prototype which is separated into two parts, namely the overall functional structure and the sub-functional structure. The overall functional structure is characterized as the flow of energy, material, and signals, which can be represented by a function block with inflow and outflow, as shown in Figure 1. The type of energy used in the device in question is electrical or mechanical energy, marked with the symbol "E." The incoming material is seawater, and the resulting material is salt crystals, which is symbolized by the letter "M." The flow of information can be in the form of an electrical signal for this device, the on and off buttons are used as signals, which are represented by the symbol "S."

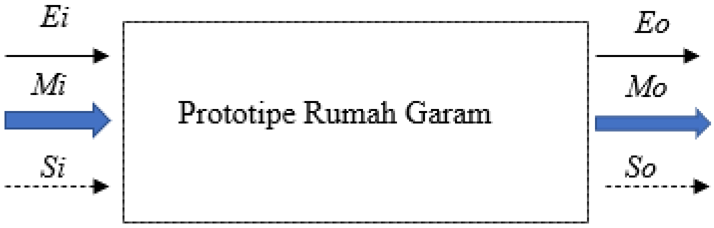

Figure 1. Functional structure of the salt house prototype

The sub-function structure can be called the second part to describe the flow of energy, material and signals, component signals, and processes that occur in the planned tool. From this analysis, the functions that make up the structure of this salt house prototype can be determined.

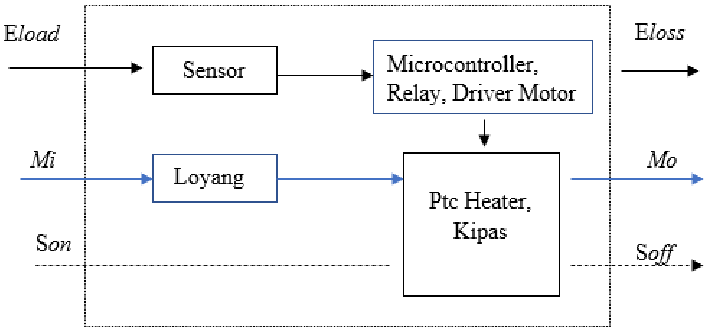

Figure 2. Function Substructure

After the requirements table, function structure and function tree diagram are created, the next thing to look for is the solution principles to fulfill the sub-functions, the method used in finding the solution principles is the morphology chart, which is a method that combines all existing solutions in matrix form. This method will allow variations in the combination of choices so that it will facilitate the process of realization and performance specifications in its design. The results of the combination of choices with design parameters will produce several alternatives.

These concept alternatives are then assessed by weighting based on the level of achievement of the expected performance specifications. The selection of a more effective salt house prototype concept is a prism shape because it has good stability, strong structural shape, design flexibility, and dynamic., for the frame profile used 4 mm acrylic which is stronger, lighter and has high design flexibility compared to glass, and can be chemical resistance, glue uses special acrylic glue to make it more durable, the water container used is a pan that has high conductivity properties to further assist in the process of accelerating the manufacture of salt crystals, the heater used is a PTC Heater as a substitute for the sun which can be set its temperature fluctuations and can work

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without being constrained by the weather, the Microcontroller used is esp 32 which has high connectivity, energy efficiency to make it easier in the system testing process.

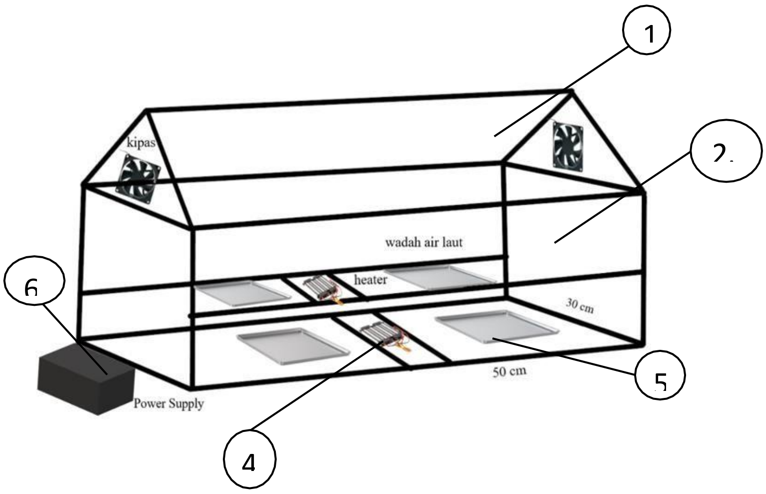

Figure 3. Sketch of the salt house prototype

The system used in this research uses the internet of things (IoT). This technology was chosen because IoT technology has proven effective in increasing the efficiency of control and supervision in various sectors. The architectural series of the system can be seen in the image below:

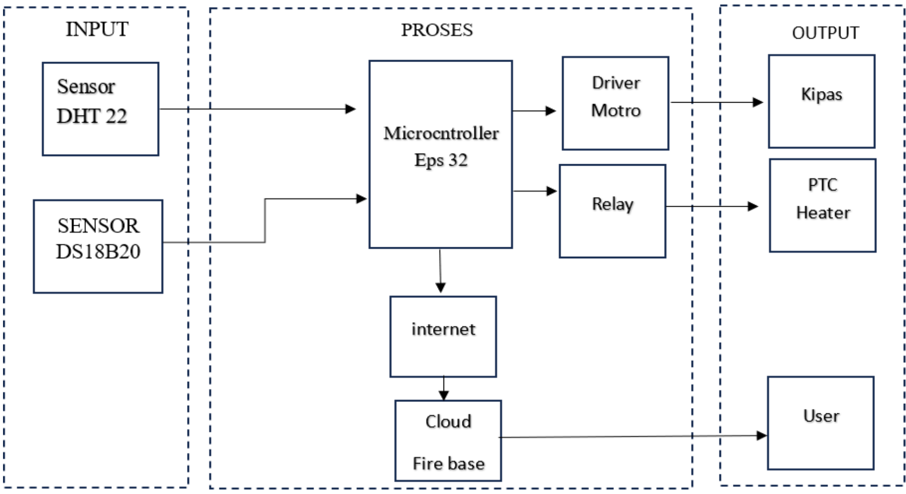

Figure 4. Block Diagram of Overall IoT System

The salt house prototype testing was conducted using acrylic blocks as the house material, the salt house application as the salt house monitoring, electricity as the fuel and the temperature set up equivalent to the conventional salt crystallization process which ranges between 30-40 degrees. The results of the test can be seen in the following test table:

Table 1. Experimental Testing

No.	Volume	Temperature	Duration (hours)
1	20 ml	30°	24
2	20 ml	29°	25
3	20 ml	31°	22
4	60 ml	29°	27

5	60 ml	30°	26
6	60 ml	31°	24
7	135 ml	29°	31
8	135 ml	30°	30
9	135 ml	31°	27

Based on table 1. from the nine experiments above, it was found that in the first experiment with a water volume of 60 ml, a temperature of 30° and a humidity of 80.3%, salt crystals formed for 26 hours, in the second experiment with the same temperature, a water volume of 20 ml and a humidity of 82.7%, salt crystals formed for 24 hours, and in the third experiment with the same temperature, a water volume of 135 ml and a humidity of 84.1%, salt crystals formed for 30 hours and so on.

Figure 5. Salt House Prototype

The results of the experiment, it can be concluded that the indication of the speed or slowness of salt crystal formation is found in temperature, humidity and water volume. The experiment proves that there is an innovation in the problem of the salt making process that is not threatened by weather conditions, and has a faster process compared to the conventional process. The following is a comparison of the results of NaCl content and the salt crystallization process:

Table 2. Comparison of NaCl content and salt crystallization process

Parameter	Conventional Method	Salt House Prototype
Nacl	81,78%	87,75%
Speed	3-4 month	27 hours

The NaCl content and the speed of salt crystallization obtained are the results of laboratory tests and tools carried out by researchers. From both comparisons it can be concluded that the results of the NaCl content obtained are both included in the k-3 salt results, but the results obtained from the prototype are higher and faster than the conventional salt process, so this prototype can help and can be used as a benchmark for a 1:1 scale.

Conclusions

The design of the salt house prototype went through many processes according to the Pahl & Beitz method, starting from finding data on community needs, making morphology charts, determining materials, making sketches, embodiment design, result phases to experimental testing. The results showed that the most optimal performance of the salt house prototype was the ninth experiment with a volume of 135 ml, a temperature of 31° and a humidity of 96.6%, salt crystals formed for 27 hours with a NaCl content of 87.75% which is included in the quality of K-3 salt. This shows that the salt house prototype is more effective than conventional salt making because it has a faster process and a higher NaCl content.

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