Jurnal Sains Teknologi Transportasi Maritim
Volume 5 No. 2, November 2023, pp.67-76
DOI: 10.51578/j.sitektransmar.v5i2.73
e-ISSN 2722-1679 p-ISSN 2684-9135

SOLENOID VALVE CONTROL DESIGN USING ARDUINO ON FRESHWATER GENERATOR PROPERTIES

Aditya Prasetyo[1], Amad Narto[2], Febria Sujarman[3], Riyadini Utari[4*]

[1,2,3,4] Semarang Maritime Polytechnic

*Email: riyadini.utari@pip-semarang.ac.id

ABSTRACT

In the modern era of the maritime world, the learning process related to ship machinery is essential and crucial for students to master. So many effective learning methods are used, one of which is the learning method using machining aids on ships. Therefore, making ship machining aids is an exciting thing to work on in this modern era. The type of teaching aid made by the author is a solenoid valve controlled by Arduino on a freshwater generator teaching aid. The method used is research and development, a process or steps to develop a new product or improve an existing product, both hardware and software. The model in this development research is a procedural model, which outlines the manufacturing steps exposed sequentially and gradually from the beginning to the end. The solenoid valve control model by Arduino on the freshwater generator teaching aid utilizes two electronic modules: the Arduino Uno type module and the one-channel timer delay relay module. The two modules are programmed directly with the buttons on the module. The working system in this prop is that the heater is filled with water and then heated, and then the water vapor is flowed through the transfer pipe and condensed using a condensor and holding tank. This system can run because of the automation control system in the electronic module.

Keywords: *props, freshwater generator, electronics module, timer delay relay*

INTRODUCTION

At the Sailing Academy, especially in the Engineering field, improving facilities in the teaching and learning process really needs to be paid attention to, to improve the quality of cadets' understanding of teaching and learning, especially in the Engineering study program regarding freshwater generator systems on ships, different media and methods need to be used. The use of learning media and experimental methods must be able to create motivation to carry out an effective learning process to achieve learning goals (Muhtar et al., 2020).

Teaching aids are tools used to support the teaching and learning process, play a significant supporting role in teaching and learning activities, and support the instructor or teacher's teaching and learning activities (Arsyad, 2013). According to Anderson, props are media or equipment used to help teachers (Anas, 2014). Making teaching media in the form of teaching aids helps improve cadets' understanding of the material to be studied. With the help of media, teaching aids also increase the creativity of cadets to be more innovative, significantly further developing the use of technology in the current era of globalization .

Water is one of the most critical resources in our world. The existence of water that is clean and safe for consumption is a significant factor in maintaining human and ecosystem welfare. In many places,

*Corresponding Author

adequate fresh water should not be taken lightly. Therefore, developing technology to produce fresh water that is clean and suitable for consumption is very important (Juwono et al., 2022). One of the technologies used to produce fresh water is the Fresh Water Generator (FWG). FWG is a device used on ships and other marine industries to create fresh water from seawater. Efficient operation of the FWG requires precise control of various components, including the Solenoid Valve that regulates water flow in the system (Hanif, 2018).

A freshwater generator is an aircraft that produces fresh water by evaporating sea water in an evaporator, and the sea water vapor is cooled by condensing inside the plane. In new water generators, most of the freshwater is produced using the evaporation method. So fresh water is produced by evaporating seawater using heat from a heat source (Wiranata et al., 2021). Generally, on ships, the available heat source is taken from the main engine's water jacket, which cools main engine components such as the cylinder head and liner of the main engine. The resulting temperature from the water jacket is around 70 °C. But at a temperature of 70 °C, water evaporation is not optimal, as we generally know that water evaporation occurs at 100 °C under atmospheric pressure. So, to produce clean water at a temperature of 70°C, we need to reduce the atmospheric pressure by using a vacuum in the chamber where evaporation occurs. As a result of vacuum cooling, sea water evaporates at a lower temperature, then the water is cooled and collected, then transferred into a tank (Osaka Sasakura Engineering Co., LTD, 2014, p. Osaka).

This prompted the author to design a freshwater generator on a ship. The results of this design can later be used as a practicum tool or learning media at the Semarang Maritime Science Polytechnic to improve the quality of cadet learning in the Diploma IV program majoring in engineering at the Semarang Maritime Science Polytechnic and later the freshwater generator system teaching aids can be archived on the Semarang Maritime Science Polytechnic campus.

This research aims to design and implement a Solenoid Valve control system using Arduino on the Fresh Water Generator teaching aid. Arduino was chosen because of its proven ability to control various automation devices. With this system, it is hoped to increase the efficiency of FWG operations, reduce resource waste, and ensure reliable freshwater availability.

METHOD

The method used in this research is Research and Development, which aims to produce a product through a research design process and development of research with references from manuals and designs of simple machining teaching aid models as practical and learning tools. The research process in this study is explained as follows.

1. Observation Stage

According to Kris H. Timotius & Putri Christian (2017), observation is a way of observing and studying something for a specific purpose, for example, to develop a particular product tool. So, generally, this stage is the initial stage used by researchers. This stage is the stage where the author must understand and study the tools that will be designed so that the number of materials and tools used, as well as the selection of types of materials, can be prepared to create a product design through sketches, which is the following process of the observation process.

2. Design of Tool Design

Design design is the creation of a design where the author considers the size and components of the electronic circuit used in creating the design model.

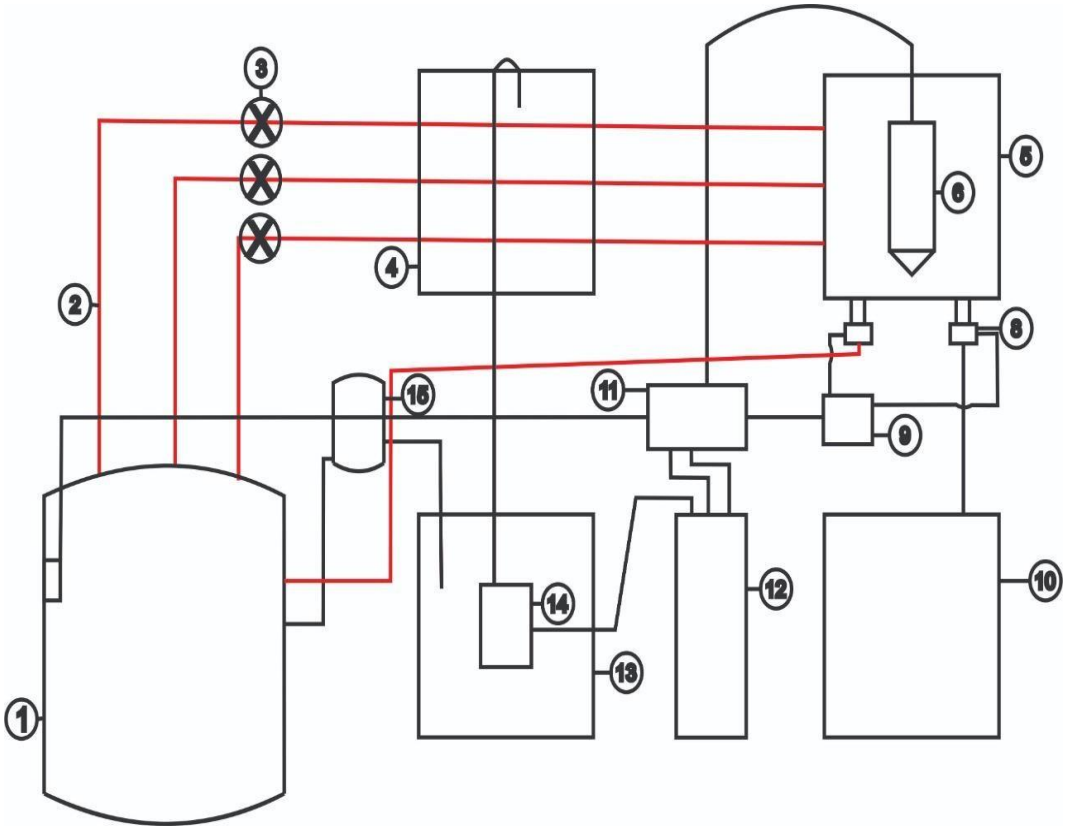

Figure 1. Fresh Water Generator Demonstration System Diagram on a Ship.

Information:

1	=	Heater	9	=	Relay 2 channels
2	=	Transfer pipe	10	=	Yield tank
3	=	Stop faucet	11	=	Arduino UNO
4	=	Condensor	12	=	Power supply
5	=	Calculation tank	13	=	Fill tank
6	=	pH measuring device	14	=	Circulation pump
7	=	pH sensor	15	=	Fill pump
8	=	Solenoid Valve			

3. Tool Design Stage

After making parts of the design model for the freshwater generator props, the next stage of the process is the writing stage. The author's writing is divided into two parts because there are alsogeneral parts of the model and parts of the electronic components.

3.1 Mechanical Design

The parts that have been completed are then designed together according to the design that the author created. Then, the installation process is carried out according to the design and system of the design model for the freshwater generator props.

1. Mechanical Design

At this development design stage, the author developed the writing of the parts of the central air compressor with existing electronic components. The electronic component is to move a heater, which can produce steam, and then the resulting smoke is channeled into an acrylic tub containing cold water. The water cools the hot vapor in the acrylic tub. Then, the pH is calculated using a pH-measuring device controlled by Arduino. If the freshwater pH is 6.9 - 8.0, the results will flow to the filling tank, and if the pH is above or below, the results will be returned to the heater.

2. Tool Making Stage

It was making the parts in the design model based on the sketches and designs made in the previous step. This is because, in this research and writing, the author created a freshwater generator design tool that the author made himself.

The tools and materials used in making freshwater generator props are listed in Table 1 and Table 2.

Table 1. List of tools used

Tool's name	Amount	Function
Saw	1	To cut pipes
Drilling machine	1	For drilling holes in acrylic
Lathe	1	For cutting and smoothing materials
Screwdriver	1	For fastening screws
Laser Machine	1	For cutting and trimming acrylic
Knife/Cutter	1	To cut and straighten materials
Pliers	1	To fasten specific size bolts
Ruler	1	To measure ingredients
Weld	1	For gluing pipes with heaters
Computer/Laptop	1	For coding sensors
Sandpaper	1	To smooth ingredients
Whiteboard marker	1	To mark size
Glue	1	To glue objects

Table 2. List of Ingredients used.

Material Name	Amount	Information
Heating	1 unit	Size 220 V 400 Watt
Iron pipe	1 unit	3 meters long
Acrylic	2 unit	Length 3 mm
Arduino	1 unit	1 unit
Solenoid Valves	2 unit	Size 12v, 4" thread
Screw	1 pack	Length 1.5 cm
Taftware Pump	1 unit	DC's current size is 12V 2.0 A
pH meter sensor	1 unit	Size 500 mAh
Open close faucet	3 unit	Three units
Water flow sensors	1 unit	Capacity 1 MHz
Power Supplies	1 unit	Size 12 V 20 A
Relays	1 unit	Size 12 V
Circulation Pump	1 unit	1 unit
Plastic Pipe	1 unit	1 meter long
Digital Meters	1 unit	1 MHz

4. Tool Testing Stage

After the tool has been made and the driving source can function adequately, the next step is the tool testing stage. Testing is carried out, starting with electronic components that work correctly. Starting from testing the heater and heat resistance produced by water vapor flowing in the pipe to prevent the line from burning, as well as accurate pH calculations so that the results from the freshwater generator teaching aid can be used as a learning medium.

5. Evaluation Stage

This evaluation stage is the conclusion stage, where after the author has carried out the testing stages of the teaching aids for designing the primary air compressor model, the author can conclude the results of testing the teaching aids. If, during the testing process, the results do not match what was expected or an error occurs in the system, then the author needs to conduct repairs on the mechanical

parts and the electronic system. The evaluation stage is also the final stage that the author carries out before a demonstration or publishing; finally, it is used as a learning medium.

RESULTS AND DISCUSSION

The results of this prototype research were in the form of teaching aids. The research carried out tests on the working system of the freshwater generator and observed the reaction process of seawater, which was heated using a heater so that it became steam and cooled utilizing a condenser so that the smoke could turn back into fresh water (condensation) and saw the results using a new water pH sensor. The benefit of testing is knowing the working system of the freshwater generator using teaching aids, which will be used as practical learning for cadets and training participants, specifically in the Engineering department, so that research into the design of teaching aids for the tube-type fresh water generator system on ships creates tools by the author's expectations.

The first part of making props is preparing the tools and materials used. Tools and materials must be designed well because this affects the smooth production of teaching aids. Hence, the researcher carried out experiments to support the writing system that the author uses. The next stage of making the teaching aids is to create a freshwater generator system design, initially using a sketch of the tool as minimally as possible using simple tools and materials. In making the freshwater generator system design, the designer makes props with a simple shape.

In determining the construction of a freshwater generator system, the author used materials; the main jacket cooling engine was replaced with a used lamp bulb filled with water and heated with a wick filled with kerosene, while the condenser was replaced with a 1-liter aqua bottle filled with water which was circulated so that the temperature Water in a 1-liter Aqua bottle can cool the steam produced by burning used light bulbs. The author uses a small water hose to transfer water vapor so that the moisture will become water after being cooled by an aqua bottle containing circulating water. The resulting fresh water after the condensation process will be collected in a glass. The author created a simple tool design to develop the previous teaching aids into more optimal teaching aids in the process and results.

In making this prop, the author used acrylic as the material most widely used as a foundation and as a wall material. There are many considerations in determining the material to be used. There are several advantages to using this material.

1. Acrylic

Acrylic is used as a foundation because the acrylic material has heat resistance to prevent the props from burning in the steam heating process, and its texture is relatively smooth, so the author does not need to carry out the smoothing and smoothing process. Acrylic is a material that is strong enough so that the components in the props can be attached and do not fall off easily. Acrylic is also easy to obtain at an affordable price, which makes the author choose this material as the foundation for the props.

2. Heater

They are used in teaching aids as a main jacket cooling engine, adapted for steam production, or as a tool that can heat water until it becomes steam by modifying the top so that three pipes can be installed for the steam transfer process into the condenser. The method of heating the water in the heater takes a short time, so the author chose a heater, as in Figure 2.

Figure 2. Heater.

3. Iron pipe

Iron pipes (Figure 3) are used in demonstration equipment as a steam transfer medium from the heating process to the output of the freshwater generator system. This iron pipe has a diameter of 5 mm with a length of 50 cm, which faces upwards with a size of 20 cm and then bends towards and passes through the condenser with a height of 30 cm. These three pipes are side by side and have the same diameter and length as the others. The author chose iron pipes intending to reduce the risk of leaks due to hot steam from the heater. Installing iron pipes into the heater is more accessible, cheaper, and robust, so the author chose iron pipes as the transfer medium.

Figure 3. Iron Pipes.

4. Condensor

The author made a tool made from acrylic, as shown in Figure 4, which is filled with cold water as a condenser in the freshwater generator system, which functions to cool/condensate the steam in the pipe so that the haze can turn into the water after being cooled. The author chose acrylic base material as the condenser. Namely, acrylic is strong enough to withstand the iron pipe that enters the acrylic. It also has heat-resistant properties, preventing water leaks from occurring in the freshwater generator system.

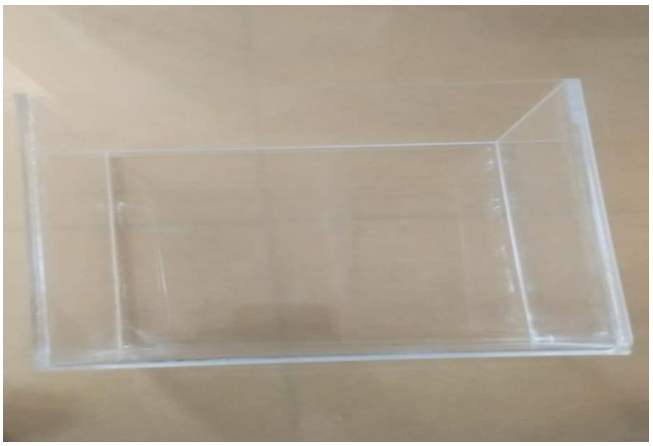

Figure 4. Acrylic.

5. Fill Pump

The author uses a Taffware brand pump to fill water, as shown in Figure 5, in a heater with a pressure of 0.48 MPa, DC 12 V with a current size of 2.0 A, which functions as an automatic heater filling pump with a water level sensor so that when the water in the heater runs out, the Pump runs out. Automatically fills water into the heater. The author carried out this process so that when the heater is low-level or empty, it prevents it from burning. The author chose this Pump because it is relatively small, affordable, and guaranteed good quality.

Figure 5. Fill Pump

6. pH of fresh water

The pH of fresh water is a tool for measuring the results of condensation water where seawater is converted into fresh water. The meter uses DROBOT brand new water pH with a voltage of 5 Vdc. The author chose this tool because the price is affordable, good quality, and is easy to obtain so it can speed up the design and construction time for the tube-type fresh water generator system props on ships.

7. Arduino

The author uses Arduino to calibrate the pH sensor with a pH meter to measure the results of freshwater entering the pH sensor. Then, the results of the freshwater will be read by Arduino so that the solenoid valve will open to the filling tank or return to the heater to be reheated. The author uses this method to get maximum results from changing seawater into fresh water.

8. Solenoid valve

The solenoid valve functions as an automatic valve that is opened via Arduino control after the pH sensor reads the pH of the freshwater. If the pH of the freshwater is below or above 6.9 - 8.0, then the freshwater will flow back to the heater to be reheated to get maximum results. If the pH of fresh water is 6.9 – 8.0, the solenoid valve will open, and freshwater will flow into the filling tank and be ready for consumption. Solenoid valves are easy to obtain, and the price is so affordable that the use of solenoid valves for this teaching aid is essential for the author.

9. Filling tank

The material used by the author is acrylic base material, which is cut and then shaped like a cube to function as a filling tank. The author chose an acrylic base material, namely a transparent material, so that the results can be seen directly, and a strong base material that does not easily collapse when subjected to heavy loads. Next, in the final stage, a pump is prepared in the filling tank to refill the heater.

10. Relay

The voltage from the Arduino pin can control the relay to switch the solenoid valve. There are three primary connections, namely COM, for input from other devices. NC (Normally Close) will be connected to the NC pin in regular circumstances. NO (Normally Open) is usually not attached. However, when the relay gets voltage from the Arduino, COM will move from NC and connect to NO.

The system in this relay determines the pH point, namely 6.8 – 8.0. Suppose the pH sensor reads above or below the predetermined pH point. In that case, the Arduino control of the relay, namely COM, will be connected to the NC (Normally Close) pin so that the solenoid valve in the filling tank will close. The solenoid valve returning to the filling tank will open. On the other hand, if the pH sensor reads a point that corresponds to the Arduino control, namely 6.8 - 8.0, then the Arduino control of the relay, namely COM, will be connected to NO (Normally Open) so that the solenoid valve on the filling tank will open.

11. Water level sensor

The performance of the water level sensor is to read the resistance of the water level in the heating tank so that when the water level in the heater points to a low level, the water level sensor will automatically be controlled by the Arduino Uno and give commands to the Pump in the tank—filling to pump water into the heating tank. The water level sensor has a more affordable price. It prevents the impact of the heater burning, so the author chose the water level sensor to be used in designing the freshwater generator system props.

The results of the design of the freshwater generator system demonstration equipment can be seen in Figure 6. Test results. The test results of the demonstration device show that no air leaks or other problems occur during operation, the solenoid valve turns off automatically if there is an emergency, such as overpressure or significant leakage, and the Arduino can send appropriate control signals to the solenoid valve.

Figure 6. Freshwater Generator System Demonstration Tool.

Corrections and improvements to the props are carried out repeatedly during the manufacturing and assembly process of the fresh water generator system. Reinforcements are formed with a tube type so that the bottom foundation is attached with a base of wood that has been smoothed at the same time to beautify and make the props stand up and will be used like iron in Figure 6.

CONCLUSION

From the results of the research and discussion that has been described, it can be concluded that acrylic, plastic, and stainless materials are most widely used in making and manufacturing these props using a manual manufacturing process, either using a laser machine as a material cutter or a drill as a material puncher. , and grinding to smooth this part of the props. The assembly process must be carried out carefully, and the placement of components must be correctly according to the sketch/drawing of the building design for the freshwater generator system as expected. Writing electronics is simpler using Arduino control with a two-channel relay module to move the solenoid valve. A pH sensor reads the pH results to find out where fresh water will be placed, and the power supply is more accessible for beginners to understand and practice. Based on the test results, this tool is suitable as a learning aid because cadets can see directly how Arduino controls the solenoid valve in a natural context. They can see how theory is applied in practice and understand how it works with their hands, enhancing their understanding and providing hands-on experience.

REFERENCES

Anas, M. (2014). *Alat peraga dan media pembelajaran*. Pustaka Education.

Andika, B. D., Narto, A., & Sujarman, F. (2021). Pembuatan Prototype Main LO System pada Sump Tank di Mesin Induk 2 Tak. *Majalah Ilmiah Bahari Jogja*, *19*(2), 112–126.

Arsyad, A. (2013). Media pembelajaran edisi revisi. *Jakarta: Rajawali Pers*, *24*(4).

Hanif, A. (2018). The decline in freshwater generator performance resulted in low freshwater production on MV DK 02.

Juwono, P. T., Subagiyo, A., & Winarta, B. (2022). Balance of Water Resources and Sustainable Urban Space. Brawijaya University Press.

Kris H. Timotius & Putri Christian. (2017). *Pengantar metodologi penelitian: Pendekatan manajemen pengetahuan untuk perkembangan pengetahuan* (1 ed.). ANDI.

Muhtar, N. A., Nugraha, A., & Giyartini, R. (2020). Pengembangan Media Pembelajaran IPA berbasis Information Communication and Technology (ICT). *PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *7*(4), 20–31.

Sasakura Engineering Co., LTD. (2014). *Fresh Water Generator*. Osaka, Jepang.

Wiranata, E., Rahman, M. S., & Sirman, M. (2021). Analisis Pengaruh Tingkat Kevakuman Terhadap Produksi Air Tawar Pada Fresh Water Generator di MV. HI 01. *JURNAL KARYA ILMIAH TARUNA ANDROMEDA*, *5*(1), 184–191.