DESIGN AND FABRICATION OF SEA WATER DESALINATION SYSTEM

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MAY, 2024

CERTIFICATION

This is to certify that this project, **Design And Fabrication Of Sea Water Desalination System,** was carried out by **MOMODU SHERRIF JEFFERY (ENG1805254), ABURIMEN P. HAPPINESS (ENG1805223) SAMUELSON EMMANUEL OSAHON (ENG1805285) IKEKPEAZU CHERISH OGOCHUKWU (ENG1805246),** in the Department of Marine Engineering , Faculty of Engineering, University of Benin

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ACKNOWLEDGEMENT

First and foremost, we want to give thanks to God Almighty for strength and wisdom throughout this project.

Our sincere gratitude goes to our wonderful and highly esteemed supervisor Dr. Mrs. Unueroh for her contribution, time, and disciplinary actions which inspired us to put more effort and ensure this project was a success, She is more than a supervisor. Our profound gratitude goes to our parents, for their love and financial support throughout this project.

DEDICATION

This project is prayerfully dedicated to God Almighty who has made everything possible.

ABSTRACT

This project proposes a sustainable solution for sea water desalination through the utilization of water and air intercooling systems. The method aims to address fresh water scarcity on a ship by harnessing distillation method in evaporating sea water. The evaporated water is condensed and collected as fresh water leaving behind salts and impurities.

The design incorporates efficient heat transfer mechanisms and innovative materials to enhance the distillation process while minimizing energy consumption and environmental impact

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CHAPTER ONE

INTRODUCTION

1. 1 BACKGROUND TO THE STUDY

Access to freshwater is a critical factor in maritime operations, particularly for ships sailing on vast expanses of seawater. Traditional methods of freshwater production often involve the transportation of large quantities of water or reliance on shore-based sources, both of which pose logistical challenges for extended sea voyages. The need for self-sufficiency in freshwater production has led to the exploration of onboard desalination methods as a viable solution for maritime applications.

One promising approach is the utilization of distillation, a well-established process in which seawater is heated to induce evaporation, followed by the condensation of vapor to produce freshwater. This method not only addresses the challenge of sourcing freshwater at sea but also capitalizes on the abundance of seawater as a readily available resource.

With the world's water demand rising, this study intends to highlight the urgent need for creative and effective desalination methods. Given the energy and cost constraints of current technologies, distillation research becomes an important direction to pursue. This research highlights the possibility of distillation to provide a workable solution by clarifying the difficulties presented by traditional desalination techniques, satisfying the requirements of both environmental sustainability and resource efficiency.

This background establishes the framework for a careful investigation of distillation as a revolutionary technique in the desalination industry through a thorough assessment of the body of current literature. Through a knowledge of the existing condition of freshwater scarcity and the limitations of commonly used desalination technologies, this research seeks to provide important insights for a future in which water is more accessible and sustainable.

1.2 STATEMENT OF THE PROBLEM

A distinct set of issues arises in the maritime environment, as ships and offshore buildings frequently struggle with restricted access to freshwater resources. The operational effectiveness of these marine entities is also impacted by this scarcity, in addition to the daily requirements of the personnel.

The use of conventional desalination techniques, which are frequently energy- and cost-intensive, is one of the main problems at hand. The increasing demand for freshwater globally and the desire to lessen the environmental impact of maritime activities highlight the need for creative and sustainable solutions.

Certainly, here are the key problems that this project aims to address:

1. Freshwater Scarcity at Sea: Addressing the challenge of limited access to freshwater resources for marine operations.
2. Energy-Intensive Desalination: Mitigating the energy-intensive nature of traditional desalination methods commonly used in maritime environments.
3. Financial Burden: Providing a cost-effective alternative to existing desalination technologies to alleviate financial strain on marine entities.
4. Operational Efficiency: Enhancing the overall operational efficiency of ships and offshore structures by ensuring a reliable source of freshwater.

5. Environmental Impact: Reducing the environmental footprint associated with freshwater production at sea, aligning with sustainable practices in maritime activities.

1.3 RELEVANCE OF THE PROJECT

These are the main points of its applicability:

1. Sustainable Water Supply: The project's goal is to give marine habitats a steady and sustainable supply of freshwater, enhancing the health and functionality of offshore structures and ships.
2. Energy Efficiency: By emphasizing distillation techniques, the project aims to provide a more energy-efficient substitute for traditional desalination technologies, in line with international initiatives to lower energy usage and advance sustainability.
3. Cost-Effectiveness: For maritime activities to remain financially viable, particularly in isolated or resource-constrained places, the development of a cost-effective freshwater conversion system is essential.
4. Operational Resilience: By decreasing reliance on outside resources and limiting interruptions brought on by freshwater shortages, a steady supply of freshwater improves the operational resilience of marine entities.
5. Environmental Stewardship: The project supports ecologically conscious practices in the maritime sector by reducing the environmental impact of freshwater production.

To summarise, the project is relevant since it has the power to tackle current issues, boost productivity, and encourage sustainability when it comes to freshwater supply in the marine engineering domain.

1.4 AIMS AND OBJECTIVES

Develop an energy-efficient and cost-effective distillation-based desalination system for maritime applications, with a focus on:

1. System Design and Fabrication: Engineer a scalable and adaptable machine tailored for maritime environments.
2. Energy Efficiency Improvement: Conduct an energy audit and optimize the freshwater production process for sustainability.
3. Cost-Effective Solution: Perform cost analysis to identify and implement measures for financial efficiency.
4. Integration with Maritime Operations: Ensure seamless integration with existing infrastructure, minimizing operational disruptions.
5. Scalability and Adaptability: Design a system capable of meeting varying freshwater demands in different marine settings.

1.5 SCOPE OF THE PROJECT

The scope of the project encompasses the design, development, and implementation of a distillation-based desalination system for converting seawater to freshwater in maritime environments. The project will focus on addressing specific challenges related to freshwater scarcity at sea.

1.6 METHODOLOGY

A methodical approach has been developed for this project in order to methodically attain the goals that have been stated. The process proceeds as follows:

1. Literature Review: A thorough analysis of the body of research is conducted, focusing on energy-efficient technologies, distillation-based desalination systems, and affordable solutions tailored to maritime conditions.

2. System Design: The creation of a thorough design for the distillation-based desalination system gives the project its shape. Scalability, flexibility, and smooth integration with maritime activities are prioritized.

3. Fabrication: Putting theory into practice, the system is carefully constructed in accordance with engineering requirements and maritime norms.

4. Energy Audit: To find ways to maximize efficiency throughout the freshwater production process, a critical analysis of energy usage patterns is carried out.

5. Cost Analysis: The financial landscape is thoroughly explored through a comprehensive cost analysis, seeking areas for cost reduction without compromising system reliability.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Fresh water is fundamental to human health and well-being at sea. It serves as the primary source of hydration for crew members, essential for maintaining cognitive function, physical well-being, and overall morale during long voyages. Additionally, clean drinking water plays a vital role in preventing waterborne illnesses, safeguarding the health of seafarers who depend on it daily.

Operational requirements onboard ships heavily rely on freshwater. It facilitates the preparation of meals essential for crew sustenance and ensures cleanliness onboard, preventing the spread of infectious diseases. Routine tasks such as washing dishes, bathing, and laundry become challenging without adequate freshwater, compromising both comfort and efficiency.

Beyond human consumption, freshwater is crucial for the operation of machinery and equipment onboard ships. Cooling systems for engines and generators rely on freshwater to prevent overheating and maintain optimal performance. Moreover, freshwater is utilized in steam production for propulsion and power generation, powering the vessel's movement and electrical systems.

In the event of emergencies, such as fires or accidents, freshwater is essential for firefighting efforts. Fire suppression systems, including sprinklers and hoses, require a readily available source of water to contain and extinguish flames swiftly. Adequate freshwater supply ensures that vessels can meet safety regulations and respond effectively to onboard emergencies, safeguarding both crew and cargo.

Distillation is a simple technique of converting liquid (water in this case) to gas(vapor) by heating the liquid and consecutively condensing it back to liquid after the vapor comes in contact with a cooler surface (cooling medium). Simple distillation methods may not be efficient for certain modes of treatment; therefore, advanced distillations treatment methods such as fractional distillation for petroleum refining and multi-effect distillation (MED) for desalination re employed. Generally, distillation is usually applied to separate a homogenous fluid mixture using the differences in the volatility or boiling point of the mixture's components.

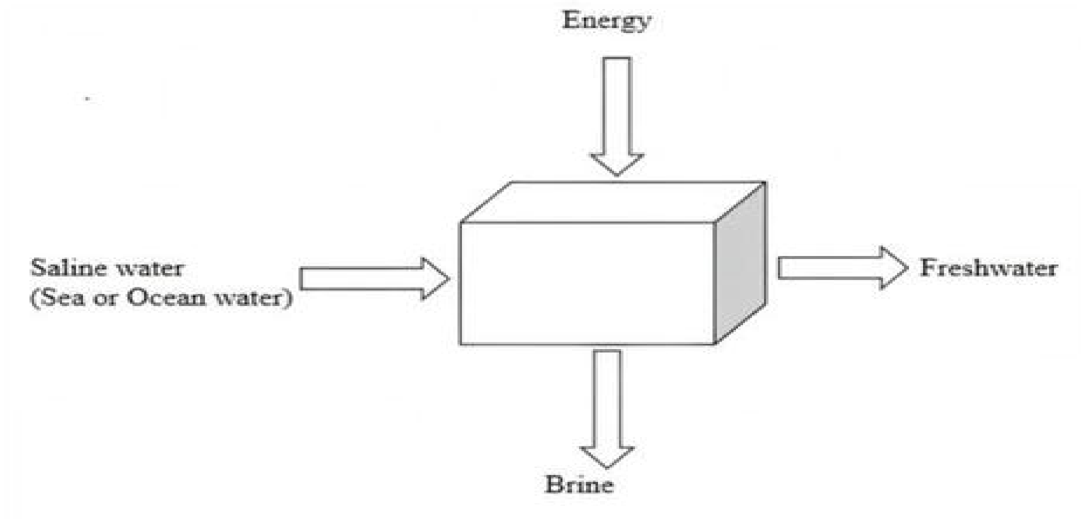


Figure 1. *Distillation process in desalination*

2.2 CHEMICAL AND PHYSICAL PROPERTIES OF SEAWATER

The six most prevalent ions in seawater are potassium (K+), magnesium (Mg2+), sodium (Na+), sulfate (SO24−), and chloride (Cl−). These ions comprise approximately 99 percent of all sea salts by weight. Because of the addition or removal of water locally (for example, through evaporation and precipitation), the concentration of these salts in a volume of seawater changes.

Salinity (S), which is defined as the quantity of salt in grams dissolved in one kilogram of saltwater and represented in parts per thousand, indicates the salt content in seawater. The open ocean's salinities have been found to vary between 34 and 37 parts per thousand (0/00 or ppt), which is equivalent to 34 and 37 practical salinity units (psu).

Seawater's other significant or major elements dissolved constituents are fluoride, inorganic carbon, boron, strontium, and bromide. Among the numerous minor dissolved chemical elements, inorganic nitrogen and phosphorus stand out the most because they are crucial to the development of marine organisms. Numerous dissolved air gases, primarily nitrogen, oxygen, argon, and carbon dioxide, are also present in seawater. Seawater also contains organic-rich particles and dissolved organic compounds like amino acids and sugars. These materials are mostly from the upper 100 meters (330 feet) of the ocean, where photosynthesis converts dissolved inorganic carbon to organic matter.

Many of the characteristics and constituent of seawater correspond to those of other water in general, because of their common chemical and physical properties. For example, the molecular structure of seawater, like that of fresh water, favors the formation of chemical bonds among molecules. Some of the distinctive qualities of seawater are attributed significantly to its salt content. The viscosity (i.e., internal resistance to flow of fluid between layers) and density (mass per unit volume of fluid) of seawater, is higher than that of fresh water because of its higher salinity (salt content). Seawater’s freezing point is lower than that of pure water, and its boiling point is higher.

2.3 HISTORY OF DISTILLATION IN DESALINATION

Although distillation is commonly used in various fields today, its earliest application for desalination dates back to the Babylonians in Mesopotamia, as evidenced by an Akkadian tablet from around 1200 BCE. Aristotle later theorized that evaporating saltwater produced vapor that turned sweet upon condensation, free of salt. Pliny the Elder described a method to purify Red Sea water using pearl barley leaves, which absorbed the salt. Sailors would spread these leaves around ships, let them absorb the seawater, and then extract clean water by squeezing the moist leaves.

In the first century, Alexandria the Chemist detailed how sailors boiled seawater in bronze vessels covered with sponges to collect condensate. In ancient cities of the Indian subcontinent, such as Taxila, Charsadda, and Shaikan Dheri (now in Pakistan), evidence shows that distillation was practiced with devices known as Gandhara stills, which produced weak liquor due to inefficient vapor collection methods. The first recorded use of distillation specifically for water was by Alexander of Aphrodisia in 200 CE. By the third century, Zosimus of Panopolis had expanded the process to other liquids in early Byzantine Egypt.

In the eighth and ninth centuries, the distillation of wine was developed by Arabic scholars like Al-Kindi and Al-Farabi, with notable references in the 28th book by Al-Zahrawi (Abulcasis). Medieval chemists such as Jabir ibn Hayyan (Geber) and Abu Bakr al-Razi (Rhazes) conducted extensive distillation experiments with various substances. By the twelfth century, a well-known recipe for aqua ardens (ethanol) emerged from distilling wine with salt, becoming commonplace among Western European chemists by the late thirteenth century.

In China, distillation began during the Eastern Han Dynasty (first to second centuries), continued during the Southern Song (tenth to thirteenth centuries), and was later practiced during the Jin Dynasty (twelfth to thirteenth centuries). These processes predominantly focused on beverage distillation, with evidence of widespread use in Qinglong, Hebei Province, during the Yuan Dynasty (thirteenth to fourteenth centuries).

2.4 DISTILLATION DESALINATION

Distillation desalination is a process used to convert seawater or brackish water into fresh, potable water by separating salt and other impurities through distillation. This method relies on the principles of boiling and condensation. Other minerals and impurities as major or trace constituent or composition in seawater or any related impure water also removed during desalination and this treatment process can be extended to industrial water, rivers, streams, pond, wastewater, and groundwater/wells. . Two products are majorly obtained after desalination which are freshwater and brine, which is the waste or byproduct.

Desalination can significantly reduce the strain on water resources and is capable of supplying ample clean water, particularly to coastal regions. It is increasingly being recognized as a viable alternative for both domestic and industrial freshwater needs. Although desalination demands a considerable amount of energy, the versatility in energy sources enhances its feasibility. The diagram below illustrates various energy sources applicable for desalination, divided into two categories: nonrenewable and renewable. Nonrenewable energy sources encompass nuclear, coal, petroleum, natural gas, and hydrocarbons. In contrast, renewable energy sources include wind, geothermal, solar, and biomass. Nonrenewable sources are sometimes costly and often not environmentally friendly. Conversely, renewable energy sources like solar, wind, and geothermal can serve as substitutes for nonrenewable energy. They are abundant and cost-efficient to harness, particularly solar energy, which can be effectively utilized even in rural areas.

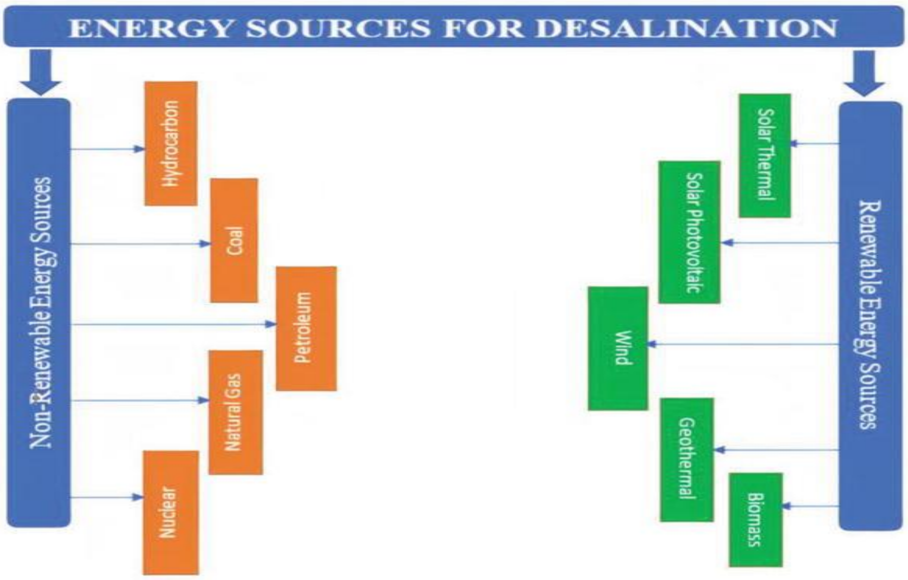


Figure 2. *Energy sources for desalination*

2.5 DISTILLATION AND FRESH WATER GENERATION

Distillation is an ancient method of desalination. It is a phase change process where the liquid known as feedwater, which is mostly seawater or brackish water, is heated to the gaseous state known as vapor and then condensed back to liquid. The condensed water is separated leaving behind brine (byproduct) during the process of evaporation and condensation. There are different distillation types in desalination, namely, solar distillation, multi-effect distillation, multi-stage flash distillation, vapor compression distillation, and membrane distillation.

Distillation is an ancient method of desalination, involving a phase change process where feedwater, typically seawater, waste water and many more, is heated to produce vapor, which is then condensed back into liquid form with different means of cooling. During this process, the condensed water is separated from the remaining brine (a byproduct). Various types of distillation methods are used in desalination, including solar distillation, multi-effect distillation, multi-stage flash distillation, vapor compression distillation, and membrane distillation.

2.6 MULTI-STAGE FLASH DISTILLATION

This method resembles a continuous process used in solar distillation. Initially, the feedwater undergoes pretreatment, followed by heating and evaporation in the first chamber or stage of the separation system. The energy released from condensation in each stage is utilized to heat the water in the subsequent stage to increase the efficiency and optimization of the overall distillation system, continuing this cycle until the final stage, after which post-treatment occurs to yield freshwater. In this way, each flash process harnesses the energy from the preceding vapor. The process involves several series of flash chambers. Unlike multi-effect distillation, in multi-stage flash (MSF) distillation, both heating and boiling occur within the same vessel. As of 2018, the estimated unit cost of freshwater produced by MSF is $1.40 per cubic meter.

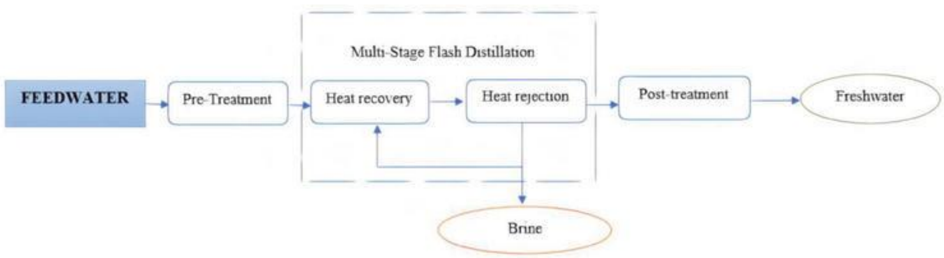


Figure 3. *Schematics of a MSF plant*

The advantage of this system is that it reduces operating costs by reusing the heat released from each stage (waste heat). Another benefit is that the quality of the feedwater does not significantly affect the overall quality of the produced freshwater, thanks to the multiple distillation processes in each chamber. Additionally, it produces a large quantity of freshwater. However, the disadvantage is scale formation during heating. Although the scale accumulates in the brine rather than on the heating surface, which primarily increases maintenance costs and frequency, it does not damage the system. Key features of MSF include stages (spaces), a heat exchanger, a distillate collector, and a brine heater.

Figure 4. *MSF plant*

2.7 MULTI-EFFECT DISTILLATION

The multi-effect distillation (MED) process involves spraying feedwater onto pipes to heat it and generate steam. This steam is then used to heat and evaporate the subsequent feedwater, producing freshwater and brine as byproducts. The energy for this process is sourced from solar collectors. For small-scale MED systems, flat plate collectors and evacuated tube collectors are used, while large-scale systems utilize parabolic trough collectors or other solar energy concentrators.

MED is an ancient process, where only the initial stage generates steam independently. Subsequent stages use vapor from the first and previous stages as their energy source.

Typically, MED systems have 8 to 16 effects, with more effects leading to higher efficiency. The goal of MED is to maximize the use of the same heat to evaporate more feedwater. The heat from the first stage aids in the evaporation in the second stage, the second stage aids the third, and so on. Each stage's evaporator also serves as a condenser for the previous stage. This method allows the large latent heat of vaporization to be reused multiple times before dissipating, although the temperature of the first effect is lower than that of the boiler heating steam. Solar energy sources, when harnessed, are converted to electrical energy to provide heat for the pumps.

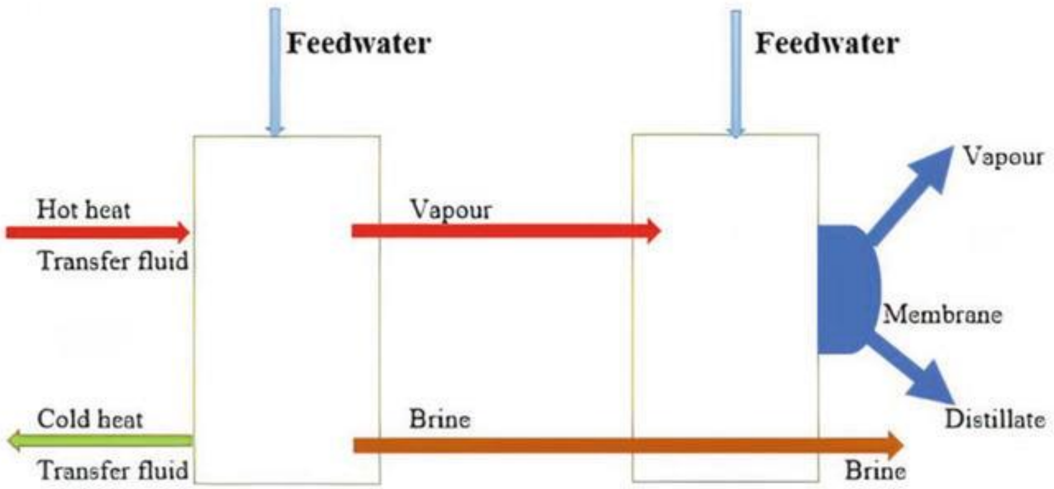
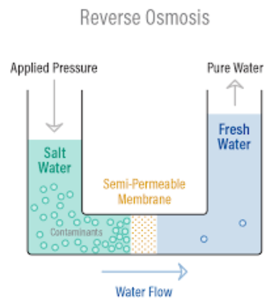


Figure 5. *Schematics of MED plant*

The advantages of MED include lower energy consumption compared to other thermal techniques. It operates at low temperatures and concentrations, which helps to minimize scaling and corrosion, and it does not require extensive pretreatment. Additionally, it is highly reliable with low maintenance costs. However, a drawback of this process is that it experiences heat and pressure losses at each stage since the process is not adiabatic, which can reduce the freshwater yield. There is also the risk of corrosion and erosion at the contact surfaces between the brine and the heat exchanging surfaces. In 2003, the average cost of freshwater produced from MED worldwide was found to be $1.00 per cubic meter, which is lower than the cost for MSF. Features of MED include a heat source, heat sink, stages, distillate collector, and membrane.

2.8 REVERSE OSMOSIS



Another method for generating fresh water from seawater, commonly used on ships for producing drinking and domestic freshwater, is reverse osmosis (RO). Reverse osmosis is a membrane-based process that does not rely on boiling or flash processes to generate water vapor. A simplified schematic of an RO plant is depicted below.

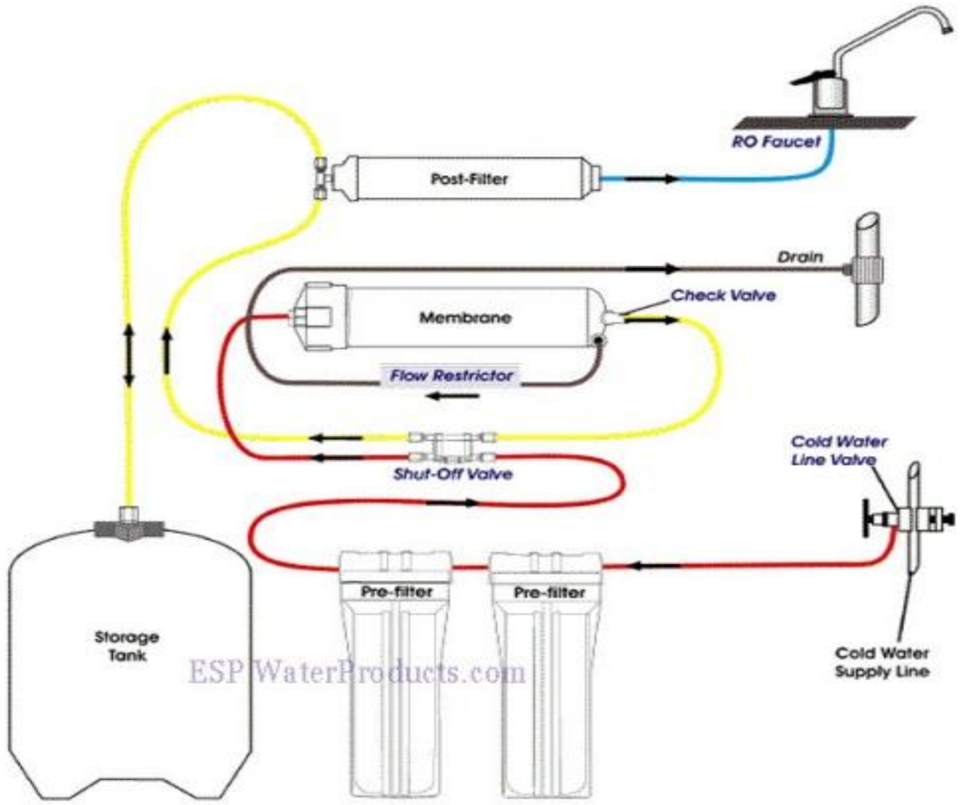


Figure 6. *Schematics of Reverse Osmosis plant*

As the name suggest, this methods works on reversing the osmosis principle.

When a chemical solution is separated from pure water by a semi-permeable membrane (which allows water but not salt to pass through), pure water flows through the membrane until either all the pure water has passed through or the hydrostatic pressure of the salt solution becomes high enough to stop the process.

Reverse osmosis utilizes this phenomenon in the opposite direction. In this process, water is forced through the membrane from the concentrated solution toward the more dilute one by applying pressure greater than the osmotic pressure of the concentrated solution.

Figure 7. *Reverse Osmosis plant*

2.9 SUMMARY

Historical evidence indicates that distillation has long been a technique used for water purification. In the context of desalination, distillation has proven to be an effective method for producing freshwater. Various types of distillation yield similar quality distillate, but they differ in the quantity of distillate produced. The method of distillation can also impact the quality of the freshwater yield, as demonstrated in laboratory settings where the active mode produced cleaner water.

Each type of distillation used in desalination comes with its own advantages and disadvantages. Therefore, the choice of distillation method depends on the required quantity and quality of the distillate. Ongoing research aims to enhance the distillation process for desalination. Technological advancements are needed to improve yield in solar distillation and reduce costs, particularly in vapor compression desalination.

One promising development is the use of carbon nanotube membranes, which have shown potential for improving membrane desalination processes. Overall, desalination has proven to be an effective and efficient solution to supplement conventional clean water supplies. With continued focus and development, it could become a sustainable long-term solution for providing clean water.

CHAPTER THREE

DESIGN METHODOLOGY AND ANALYSIS

3.1 MATERIALS AND METHODS

The design was targeted towards achieving the following: producing a continuous supply of fresh water for various purposes onboard which has a higher efficiency and cost can be maximized, availability of locally sourced materials and cost of the machine.

3.2 PROPOSED CONCEPTS

During the course of this project, two distinct concepts were proposed.

3.2.1 CONCEPT ONE: REVERSE OSMOSIS: This process involves the application of high pressure applied to force sea water through a semi-permeable membrane. This membrane allows water molecules to pass through while blocking salt and other impurities.

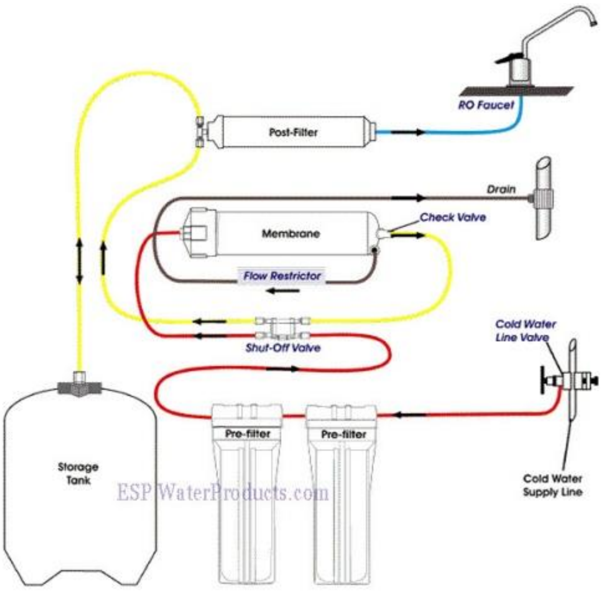


Figure 8: *Concept 1 Schematics of a reverse osmosis*

3.2.2 CONCEPT TWO: DISTILLATION PROCESS: This process relies on evaporation to purify water. Contaminated water is heated to form steam. Inorganic compounds and large nonvolatile organic molecules do not evaporate with the water.

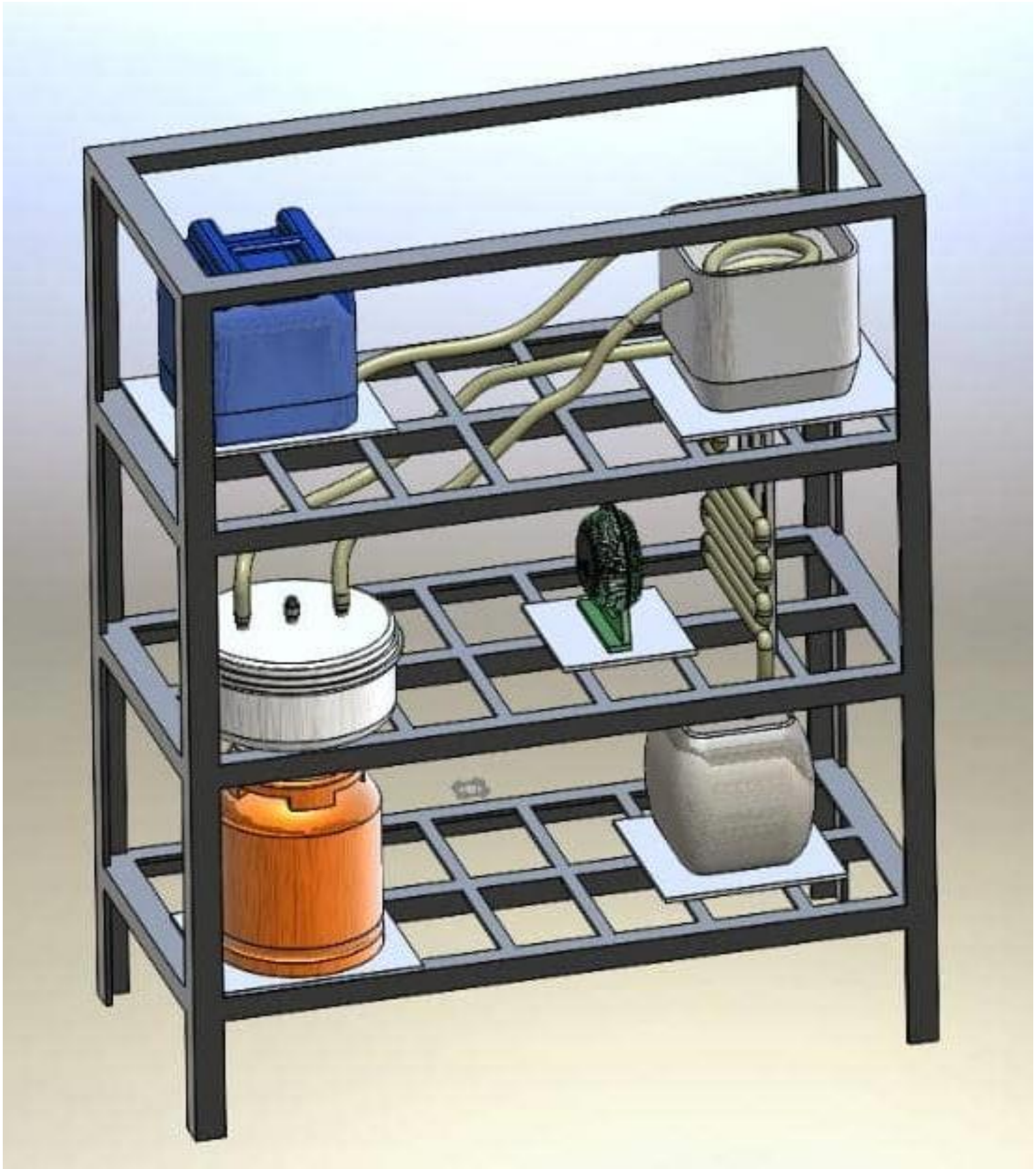


Figure 9*: 3D representation of concept two*

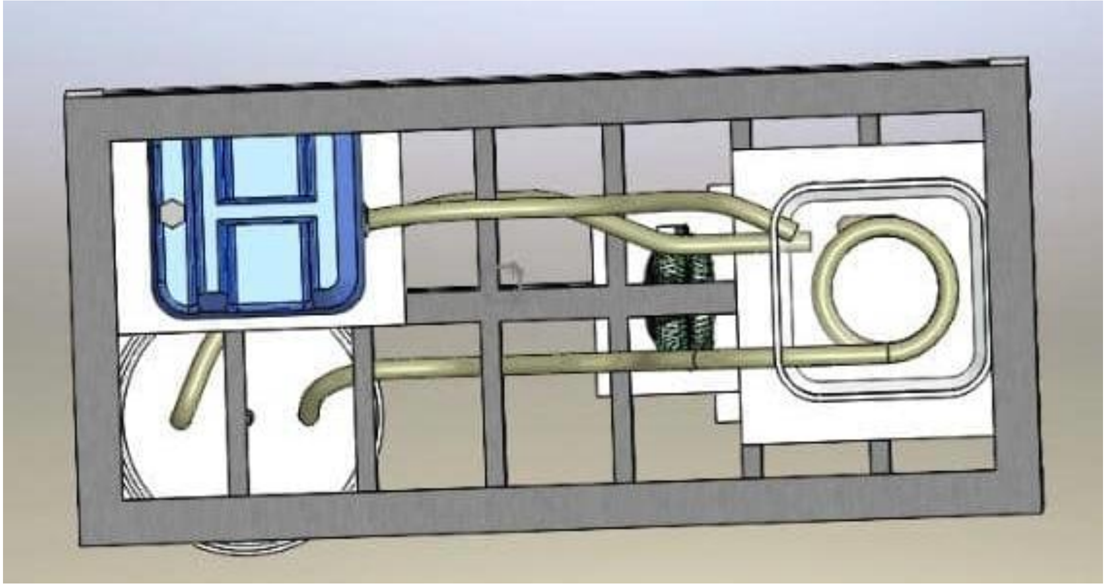


***Figure 10**: concept two top view*

***Figure 11**: concept two side view*

3.3 DECISION MATRIX

Of the 2 proposed concepts, only one can be used for the prototype. Hence a decision matrix was employed to help us make the choice. We based our decision matrix on 5 major criteria that we considered to be the most important for whatever design we choose. The criteria are:

1. Cost
2. Efficiency
3. Flexibility
4. Water purity

We then assigned each criteria weight ranging from 1 to 5 with 1 being the least important and 5 being the most important. Let discuss the criteria and how each concept was rated.

a. COST

Cost was our most important criteria when choosing a concept. Cost was assigned a weight of 5 to signify this. Concept two consist of us getting our boiler, copper pipe, water filter which makes up its major components. Thus making it the cheapest of our two concepts. Concept two was assigned a cost rating of 5 for being the cheapest. Concept two was rating one because of the high cost of purchasing the reverse osmosis membrane which was a vital component in the water filtration.

b. EFFICIENCY

Efficiency was the second most important criteria when selecting a concept. We assigned it a weight of 4. The efficiency of the concept is defined as the ability of the prototype to have a lower operational cost over the long term of usage due to the fact that distillation process is less susceptible to fouling which requires less maintenance unlike the reverse osmosis which is the prototype 1 that the reverse osmosis membrane are prone to scaling and fouling and damage from chemicals requiring frequent cleaning replacement and monitoring in contrast to distillation systems.

c. FLEXIBILITY

Flexibility was the third most important criteria when selecting our concept. We assigned it a weight of 3. We defined flexibility as our design to be able powered by different sources. This includes using waste heat from industrial proceeds on board, solar energy or our traditional fuels. This flexibility in energy sources allows for optimization based on cost, availability and sustainability factor.

d. WATER PURITY

Water purity was the fourth most important criteria when selecting our concept. We assigned it a weight of 4. Water purity in this context was based on the prototype with the least amount of impurities.

Reverse osmosis also produces high purity water by filtering out impurities but some dissolved gases may pass through, affecting the taste. When water is being purified using RO the water PH ends up being acidic due to the presence of impurities. That’s why opting for distillation prototype was our choice.

3.4 DESIGN CALCULATIONS

Our prototype was constructed on a frame for easy arrangement of the various components in its compartment. . The height of the frame is 5ft. The length of the frame from left to right is 4ft and the width is 1 ½ . The motors used are 50Watts, 12V motors. They have a mechanical horsepower of 6hp. The copper pipes used is 15 yards in length. The structure consists of three stacks of which the distance between each stack is 18inch.

The water intercooling had a total of 7 coils and the air intercooling had a total of 4 coils. With this arrangement we had very little loss in steam. As most of the steam produced were condensed into liquid.

3.5 THE PROTOTYPE

Concept two was chosen with the aid of the decision matrix. The materials needed were identified and purchased. Then fabrication began.

The frame was the first to be fabricated. Lengths of metals were brought. The metal was cut to the desired measurements and then welded together to the desired shape

Figure 12 *The frame.*

Once the frame was standing, the rest of the materials were being placed in their various compartments. The boiler, the storage tank and the conductor pipe were fixed in the boiler and the cooling storage tank. Next the both major compartment were fixed into their various compartment on the frame.

The copper wire were coiled and Placed into the pressure pots which served as our boiler and our cooking gas as the source of heat. This is used to efficiently transfer heat to the liquid being distilled. We decided to coat the copper making it resistance to corrosion making it beneficial in the maintaining of the purity if the distilled products

Figure 13 *The boiler and the copper wire.*

The DC motors were used in cooling the pipes when hot steam passes through it.

ENGINEERING BILL OF MATERIALS

S/N	PARTS	PARAMETERS	MATERIALS	PRICE (₦)
1	Frame	`5ft x 4ft x 1½ft	Mild steel	45,000
2	Copper pipes	15 yards	Copper	35,000
3	Filters	1 piece	Plastic	2,000
4	D.C motors	50W, 3.7V 3 pieces	-	18,000
5	Rubber	3 pieces	Plastic	10,500
6	Pressure cooker	1 piece	Stainless steel	45,000
7	Gas cylinder	1 piece	Steel	15,000
9	Impeller blades	2 pieces	Rubber	2,000
10	Valves and fittings	2 packs	plastic	6,000
11	Wires	2 yards	Copper	1,000
		Total		179,500

S/N	Service	Price (₦)
1	Transportation	7,000
2	Sea water transportation and test result	15,000
3	Workmanship (Fabrication)	30,000
4	Workmanship (3D design)	35,000
	Total	87,000

3.8 SAFETY AND PRECAUTIONS

- Eye protections was worn when welding
- All welded joint were smoothed out with a grinding machine to avoid injury
- The copper wire were coated to minimize corrosion.
- The bearing and nuts which held the other major components to the compartment were tightened to prevent accidental loosening.
- Turn off the boiler when not in use.

3.9 MAINTENANCE

- Water quality monitoring: continuously monitor the quality of the feed water and the distilled water produced checking for the PH levels and contaminants.
- Cleaning the distillation apparatus regularly to remove impurities and build up scale that affect the efficiency of the process most especially in the boiler.
- Filter maintenance: regularly replace or clean filters setup to prevent clogging and ensure optimal water flow and purity.

3.10 LIMITATIONS

- Water loss: this process results in some water loss due to evaporation during heating and cooling. This loss can reduce the overall efficiency of the process and increase water usage.
- Energy intensive: this process requires large amount of energy to heat the salt water to its boiling point and then cools and condenses the vapor back into liquid.

CHAPTER 4

RESULTS AND DISCUSSIONS

4. 1 Experimental Setup:

Overall Design:

The desalinator is designed to be portable, allowing for easy transportation and operation in various locations. It consists of a compact unit that can be easily assembled and disassembled for maintenance and storage.

Dimensions:

- Height: Approximately 5 feet
- Width: Approximately 1½ feet
- length: Approximately 4 feet

Flow Rate:

The flow rate of seawater through the distillation setup was measured at regular intervals during the experiment to assess its consistency and any variations. The initial flow rate was recorded as 4Cl per minute (CLPM). For the first 30 minutes, the system was relatively slow and we could only produce about 120Cl for the initial stage. After the first 30minutes the boiler has gotten to its maximum temperature and the flow rate remained relatively stable with a flow rate of 6cl per minute, with minor fluctuations observed due to factors such as changes in temperature and pressure.

Overall, the average flow rate of seawater through the distillation setup was 6 CLPM, with variations within ±0.5 CLPM throughout the experiment. These variations were considered acceptable and did not significantly impact the overall efficiency of the desalination process

4.2 RESULTS OF DISTILLATION:

The results of the distillation process indicate a successful removal of salt from seawater, resulting in the production of potable water.

Initial Salt Concentration: The seawater used in the experiment was obtained from the Escravos river in Delta state Nigeria. The lab result from the water show is shown below

Below is the test result from the lab for our salt water from Martlet Environmental Research Laboratory Limited (A division of Macgill Engineering & Technical Services Limited) for the Escravos River Water

4.3 RESULT OF CHEMICAL ANALYSIS

Code	pH	EC	Sal.	Cl	Na	Ca	NO_3	SO_4	TOTAL HARDNESS
		µS/cm	g/l	mg/l					
Escravos Water	7.6	41,000	18.52	2528	88.7	155.6	22.0	35.8	820.1

Final Salt Concentration: After the distillation process, the salts and minerals present in the initial stage were no longer present in the distilled water as the lab test showed that the distilled water contained only oxygen and hydrogen H_2O.

Consistency of Results: Multiple trials were conducted to ensure the consistency and reliability of the distillation process. The results were found to be consistent across different runs, demonstrating the repeatability of the experiment. .

Overall, the distillation process proved to be effective in removing salt from seawater, producing high-quality potable water suitable for various applications.

4.4 DISCUSSIONS

Energy Consumption: The energy consumption of the distillation process was measured and recorded throughout the experiment. The primary source of energy consumption was a cooking gas used to boil the seawater and initiate the distillation process.

Energy Input: The cooking gas that uses LPG to operate. The total energy input for the distillation process can be calculated by scaling the gas cylinder before and after the distillation process to determine the amount of LPG consumed by the system for a particular volume of sea water distilled. Our finding showed that it required 100grams of LPG to distill 5 litres of brim water.

Efficiency of Energy Utilization: The efficiency of energy utilization in the distillation process can be determined by comparing the amount of energy input to the amount of fresh water produced. This provides insights into the energy efficiency of the distillation setup and any potential areas for improvement.

Comparison to Industry Standards: The energy consumption of the distillation process can be compared to industry standards or benchmarks for similar desalination technologies. This helps evaluate the efficiency and cost-effectiveness of the setup in relation to existing solutions.

Overall, monitoring and analyzing the energy consumption of the distillation process provides valuable insights into the operational costs and sustainability of the desalination setup.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

In conclusion, the development and implementation of the desalination system, incorporating both distillation and intercooling methods, represent a significant step forward in addressing the pressing global challenge of water scarcity. Through meticulous design, construction, and testing, our team has successfully demonstrated the effectiveness and efficiency of our system in producing fresh water from saline sources.

The utilization of the distillation method has proven to be a reliable and robust approach for removing salts and impurities from water, ensuring the production of high-quality freshwater suitable for various applications. Furthermore, the incorporation of both water and air intercoolers in the system has enhanced its overall performance by optimizing the temperature conditions during the desalination process.

Our project underscores the importance of interdisciplinary collaboration, innovation, and sustainability in tackling complex engineering challenges. By leveraging principles from mechanical, chemical, and environmental engineering fields, we have developed a scalable and adaptable desalination system capable of meeting the diverse water needs of communities worldwide.

Looking ahead, further research and development efforts are warranted to enhance the efficiency, affordability, and accessibility of desalination technologies. Through continued innovation and investment, we can pave the way towards a more water-secure future for generations to come.

5.2 RECOMMENDATIONS

- The system can be improved by automating the system. This would make the system to perform task on its own without any human operation
- Since the electrical system do not require much power to operate, it can be replaced with solar energy
- We recommend a clean renewable source of heat such as biogas which can be gotten from disintegrations of organic waste on the ship
- The water intercooling can be improved by channeling the pipes carrying steam to pass through the keel of the ship. As this will help to provide sufficient cooling water required by the system
- The hot air from output of the air intercooling system can be used for various purposes such as heating cabins, providing warmth in cold conditions, drying wet gear or clothing, or even for regeneration purposes on the ship’s engine

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