A prototype for communitising technology: Development of a smart salt water desalination device

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Abstract. Desalination is defined as the process that removes minerals from saline water or commonly known as salt water. Seawater desalination is becoming an attractive source of drinking water in coastal states as the costs for desalination declines. The purpose of this study is to develop a small scale desalination device and able to do an analysis of the process flow by using suitable sensors. Thermal technology was used to aid the desalination process. A graphical user interface (GUI) for the interface was made to enable the real time data analysis of the desalination device. Arduino™ microcontroller was used in this device in order to develop an automatic device.

1. Introduction
Salt water desalination device is needed especially in remote and rural area. The development of this device could be a life changer as it can provide access to safe and clean water. Desalination is a process that extracts salts and minerals in saline water or a target substance. By doing so, it can help produce water resource for human needs, irrigation or others. There are many types of desalination technique, though however, there is no real time monitoring process. Hence, it is difficult to detect the actual salinity of the sea water feed and the effectiveness of the desalination process.

The objective of this research, is to develop a small scale of salt water desalination device with suitable sensor and Smart System Interface. By which the process aim of this study is to design the desalination device hardware with a built-in Graphical User Interface (GUI), that create a real time data analysis interface and can analyze the effectiveness of the desalination process. A simplest but yet can demonstrate, smart interface device is planned to be used as a monitor panel for the desalination process. This interface device is function to measure the volume of water used, as well as the effectiveness of the desalination process in real time.

This salt water desalination device is developed as a prototype for communitising technology. Communitisation technology is used to adapt the wants and needs of a community [1]. The technology had to suit a large number of people, which can be a challenge in diversity. It was stated to be an initiative for empowering and involving the community in a development [2]. There also link for sustainable development between innovation and community action [3], where it offers a possible approach in the research of the community level action for sustainability.

In general, the thermal type desalination plants had been built in large capacity facility together with a conventional power plant and in such case, the low pressure heating steam can be easily supplied from a power plant. Moreover, Middle Eastern countries traditionally preferred the thermal process to the Reverse Osmosis (RO) process from the past because the raw seawater quality obtained from Red Sea is quite bad, which causes the lifetime of the RO membrane to be short [4].
Desalination has two types which are based on thermal technologies and membrane technologies. For thermal technology it would be Multi Stage Flash distillation (MSF), Multi-Effect Distillation (MED) and Vapour Compression Flash (VCF). While for the membrane technology it would be Electrodialysis (ED), Electrodialysis Reversal (EDR), Capacitive Deionisation (CDI) and Reverse Osmosis (RO).

MSF desalination plant was to evaporate the saline water. Steam that been evaporated from saline water will be condensed on the surfaces of the cooling tube bank, in which it is place at upper section of the evaporators. Furthermore, in the MSF plant when the top brine temperature above 100°C, most of the stages will be maintained in vacuum state [5]. MED was most widely used because of its advantages of simple high thermal efficiency, pre-treatment and flexible operation mode. This system could be operated integrated or independently with other auxiliary technologies such as thermal vapour compression and mechanical vapour compression [6]. Unlike MSF, MED consists of complicated mechanism of heat transfer in which will difficult to deal with. Moreover, there has been no comprehensive study on the dynamic simulation and transient behaviour of MED alongside considering its tube- bundle. The majority of studies have instead been limited to steady-state and thermodynamic performance of the process. Therefore, from this journal a dynamic simulation of MED is been done [7].

Vapour Compression Flash (VCF) was developed to avoid the shortcoming of several existing desalination methods with technical superiority. Moreover, additional thermal energy was not necessary for VCF. During seawater desalination process, the compression system has recovery of the latent condensation heat and higher power-heat conversion efficiency. The seawater pre-treatment requirements were low, and the product water purity was high [5]. The VCF system had a greater recovery of the latent condensation heat and power heat conversion efficiency during seawater desalination. Furthermore, pre-treatment of sea water requirements of VCF are low, and the final product shows high purity of the water [5][8].

2. Methodology
Type of desalination device will be based on thermal technology, which was vapour distillation technique. This vapour distillation technique was the most suitable for making a prototype of smart salt water desalination device, because it is cost effective by comparing to others in which need more money and more complicated parts that need to build. The main objective of this study was to make a smart device in which capable of running a fully automatic desalination process and be able to demonstrate the real time analysis of the desalination process.

An illustration of the device and its flow was take place in order to create a systematic system in which can run automatically and defined in a smart device. The illustration of the device was design by using Catia™ version 5 software. The illustration and its process flow is shown in the figure 1.

![Illustration of the desalination device](image)

*Figure 1. Illustration of the desalination device.*
Designing the desalination device, a simple technique was used but yet it was an effective desalination device in order to full fill all the objectives. When dealing with fluid preventing from leakage of fluid is a crucial part or your system would not be accurate enough and lot of waste product will be produce. Never the less, the main platform was build up from steel frame and plate that would be used to place all the necessary hardware in order to develop the device.

For electrical wiring of this system it divided into two parts. Which were one for controlling the desalination process and another one to control the data transfer getting from the sensor. Thus, it had two Arduino™ microcontrollers that run independently as the programming been set specifically for each one of the Arduino™ microcontroller. Details of the circuit diagram were shown in figure 2 and figure 3.

In this device, the main electrical and electronics component were the two types of sensor and four channels relay module that being implement in this device. The specific sensor used were:

- LM35 is the type of temperature sensor that been used.
- HC-SR04 is the ultrasonic sensor used as water level sensor.

Figure 2. Circuit Diagram for controlling the smart Salt Water Desalination Process Device.

Figure 3. Circuit Diagram of the sensors for smart Salt Water Desalination Process Interface.
From text console, toolbar with buttons for common functions, test editor for writing code and series of menu were used to develop the system. The hardware is connected in order to communicate and upload programs. A GUI was made by using the Visual Studio™ C programming. This GUI provide the platform for displaying the real time data analysis of the desalination process.

![GUI of the real time data analysis interface](image)

**Figure 4.** GUI of the real time data analysis interface.

3. Results and discussions
The value of each data was taken and then analyse by using simple mathematical equation in order to interpret the data. Each data was taken according to the specific time of heating given. Therefore, six set of data have been made and analysed in order to know the initial and final state of the sample. The only manipulated variable would be the water input with starting value of 0.5 litre (L) to 1 L with interval of 0.1. While for the fixed would be the time taken to take place for the whole process.

From the figure 5, the water input for each sample were increasing with interval of 0.1 L starting from 0.5 L until 1 L. From the result after the sea water undergo desalination process, the water output from sample number one to six shows increasing of water output. Water sample for number one shows the lowest water output with 0.1078 L while water sample number 6 shows the highest water output with 0.1847 L.

![Chart of water input and output](image)

**Figure 5.** Chart of water input and output.
For a pure distilled it should be pH 7. Nevertheless, due to pure distilled water highly react to CO$_2$ from surrounding, the actual reading of distilled water would be slightly less pH 7. The targeted pH value for a successful desalination process would be range at pH 6.7 until pH 7. It shows the results that been measured and calculated which are the pH value water output and rate of the desalination process. Moreover, the results showed that the device is able to undergo desalination process although two of the result shows constant and increasing of the pH value at sample number 5 and 6 respectively as shown in figure 6. All of the sample shows the initial reading of pH value almost the same. With range of 8.4 to 8.6 pH, the reading pH of 8.4 for the lowest and 8.6 for the highest. For the water output, number of sample from number 1 to 3 shows the value below the pH 7 while for sample number 4 to 6 shows pH above pH 7.

![Figure 6. pH value of samples.](image)

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Figure 7 shows the rate of desalination process. For sample number 1 shows the lowest value with 2.57E-04 L/s and sample number 6 shows the highest value with 4.40E-04 L/s. Moreover, for sample number 1 and 3 shows the same reading with both 2.57E-04 L/s.

![Figure 7. Rate of desalination.](image)

Figure 7. Rate of desalination.
Figure 8 shows the effectiveness of the desalination process. The highest percentage achieved was 21.55% for sample number 1 following with 19.24%, 18.81%, 18.47%, 17.96% and 17.59% which were for the sample number 4, 5, 6, 2 and 3 respectively. From the percentage of effectiveness, it can be concluded that the best water intake should take in this experiment would be 0.5 L which is the sample number 1.

![Image of Figure 8: Percentage of Effectiveness of Desalination Process]

**Figure 8.** Percentage effectiveness of desalination process.

4. Conclusion
This research was accomplished with the development of the desalination device using suitable sensors and smart device interface which can be implemented on analysing real time data. Suitable sensors were incorporated which were used to get the data and to analyse the state effectiveness of the device. A smart device interface with Graphical User Interface (GUI) was developed using the Visual Studio™ as the platform. Based on the results obtained, highest water output with 0.1847 L form 1 L input, ideal pH value of 6.8, the highest rate of desalination process of 4.40E-04 L/s and the effectiveness of this device was 21.55% effective by using the water intake of 0.5 L of salt water. Finally, it can be concluded that all the objectives have been achieved and a smart salt water desalination device can be implemented as a prototype for communitising technology.

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