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Magnetic field potency for separation techniques

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Abstract
Pollution-free fresh water for industrial purposes is increasingly difficult to find. Groundwater availability is very limited. A very potential method to get pollution-free fresh water is done by desalination of sea water process. Numbers of seawater desalination technologies have been developed during the last several decades to augment the supply of water in arid regions of the world. However, the treatment process is quite complicated and costly. There is another potential method for converting seawater to fresh water in which continues stream of seawater dissolving ions is separated into desalted and concentration streams by using a magnetic field. Cations moving in a magnetic field from the top down will veer to the left; Anion will veer to the right, while the neutral particles will still move straight. This fundamental theory is estimated to have the potential to separate the electrolyte (salt) dissolved from the solution. To determine the possibility of applied basic theoretically, the two sources of the magnetic field, i.e. a toroidal magnet and an electromagnet (solenoidal), were composed. In the toroidal magnet, slits were made with 4 mm width. In the solenoidal magnet, distance (slits) of north and south magnetic pole was 5 mm. Through this slits, water which has small spot area and formed a sraight path (if no magnetic field)was spouted. Deflection of cations and anions will cause the water passage cross section turns into a line after going through a magnetic field. The fact observed in this experiment can conclude that the electromagnetic equipment to separate the dissolved electrolyte ions can be made. However, a further problem is increasing in the efficiency of the separation process. If the use of current electric can be economically lowered, then a device that can convert sea water into fresh water may be designed.

Keywords: electromagnetic, seawater desalination

Introduction

During dry season, the qualities and quantities of the availability of ground water is decreasing. Agricultural materials such as pesticides, insectisides, and herbicides used by farmers in the farming area are mostly dissolved into rain water and thus enter the water supply system such as ground water and surface water. Mining and other industrial activities also contribute to the ever-increasing of pollutant to the water supply system in the world.

Furthermore, the amount of water on the land had been fluctuating during a year, depends on the seasons. Higher supply in the rainy season and shorter in the dry season. The natural water which has relatively constant amount is sea water, so that the way to convert seawater into freshwater bypotent separation techniques is needed. One of the possibility of the techniques is the application of electromagnetic technique. Based on Lorentz force, when particles move away from observer and magnetic lines from top to bottom part, the kation (positive charge) will be deflected to the left and anion (negative charge) will be deflected to the right. These two particles can be separated from water molecules that relatively have straight movements [1].

The sea water to freshwater processing (Desalination process) is usually done by evaporation method. The sea water is evaporated, and then is condensed. This process will remove the salt and other impurities in the sea water, therefore, the result of the condensation is freshwater. In 2011, there were 15.988 sea water desalination units with total production of 66,5 billion m^3/day [2]. This amount would increase significantly, with estimation to reach 50.000 units in 2020 [3]. The importance of desalination process of sea water, is mostly related to the provision of drinking water for countries where which lack of water sources and supplies, such as Middle East countries.

Nowadays, developed countries such as United States, Germain, and Australia have their own installation of sea water desalination process due to higher demand of groundwater and surface water from industries that leads to the competition with civilization demands of freshwater supplies. Sea water desalination and water distillation process with evaporation and condensation, unfortunately, need complex equipments and somewhat accompanied with high

operational cost. It has been estimated that magnetization process to separate cations and anions in water will need only simple equipments and cheaper operational cost [4]. Magnetic field fulfillment is also made easierby permanent magnet technology development in this third milenia.

Desalination process available these days are: *Multistage Flash Distillation (MSF), Multiple-Effect Distillation (MED/ME), Vapor Compression (VC), Ion exchange, membrane processes (electrodialysis reversal, reverse osmosis, nano-filtration, membrane distillation), freezing desalination, geothermal desalination, and solar desalination* [2]. The use of electromagnetic waves in the sea water desalination is limited to the use of microwave to evaporate the seawater [3]. The application of the basic principle of this study is only found in an cyclotronion. The cyclotron ion itself is only used for research purposes and not for industrial purposes, aside of its use as a detector in a mass chromatograf.

In the last decade, magnetic fields have been used to soften the hard water and increase the effecrivity of drinking water [5, 6]. In both of the processes, water is streamed in a pipe through magnetic fields. The softening properties of aqueous water occur because dissolved ions and water molecules experience magnetization effects and are tied together by magnetism [7]. In this bond, calcium ions do not precipitate as calcite but as aragonite which is unstable and soluble.improved drinking water quality is theorized happen because the water molecules that have passed through the magnetic field will become nano-sized magnets.

Six water molecules will form hexapolar bonds and create hexagonal structures in magnetism. This structure is two dimensional form which is different from the electrostatic hexagonal shape as a result of Van der Wals's three-dimensional bond. Flatfield-shaped hexapolar water molecules will be more easily absorbed by the body's cells and this hexapolar form also allows the water molecule to bind toxic heavy metal ions and remove them from the body. This mechanism fact, unfortunately, has not been supported by accurate and structured research data.

The purpose of this study is to provide information to construct a basic design of electromagnetic equipment with a sufficient magnetic field strength to deflect dissolved ions from the jets of water which passed through the magnetic field. To achieve this purpose, a series of activities were pursued through the manufacture of basic equipment in order to study the deflection of salt ions in the process of saltwater desalination (simulated seawater) using a magnetic field. In addition to this purpose, there is also a long-term goal that is to provide a basic structure of seawater desalination techniques primarily for industrial and residential purposes.

Material and Method

Materials

Research materials consist of magnetic field generator, adjustable dc power, water jet system, collecting result-water system, and treated water.

- The experimental magnetic field is generated using 3 (three) magnetic types i.e. permanent magnet, solenoidal magnet, and toroidal magnet. Experiment with permanent magnet does not provide observable deflection. Since the permanent magnetic field can no longer be modified, the experiment with this permanent magnet is not continued.
- The power source used consist of: auto-transformer 1000 watt (4,5 Ampere), a current rectifier (25 Ampere), and a Pb-acid battery 60 AH 12 Volts dc.
- A system for producing a water jar consist of: a peristaltic pump 100 psi, a shallow well pump, water canon for washing cars, non-rust steel sprayers, and piping system (non-rust capillaries, silicone hoses, and teflon hoses 1/8 inch).
- The system for collecting treated water consist of: small suction pump, air and water separator (air trap), and container tank. The use of suction pumps proved to be unnecessary, since the energy of the water jets is sufficient for the drainage process.
- Treated water is 1% salt water solution and sea water simulation (3,5 % crude brine solution).

Procedure

In accordance with the experimental objective of providing information to make basic equipment of seawater desalination process using magnetic field, the applied research method was 'trial and error' which was applied into 4 (four) experimental stages. The results of the 1st stage experiment shall meet the requirements for use in the 2nd stage experiment. The results of the 2nd stage experiment shall meet the requirements for use in the 3rd stage experiment. Then, next to the final stage of the desalination process of sea water, it was using a magnetic field. The experiment stages were:

1. Experiment 1 : get the jets of water with a point dot. The experiment used a pressure pump of about 100 psi and some kind of sprayer, to obtain a straight line of brine emitted with a point-shaped cross-section, at least for a distance of 30 cm.
2. Experiment 2 : build the required magnetic field strength. Equipment can be divided into power supply systems and electromagnetic systems. The power supply systems consist of variable transformer 0 up to 240 Vac (based on 220 Vac input), a step down transformer (primary coil: secondary coil = 2: 1), a silicon diode bridge (rectifier 25 ampere), a toroidal, and a solenoid.
3. Experiment 3 : determine the position of the result-water to be taken. The position is the area that produces water with the lowest concentration of solute material. It is estimated to be in the middle of the cross section of the water flow after the magnetic field is subjected, but there is a possibility of a shift. This position shift, should be anticipated with the positioning device in a micrometer scale.
4. Experiment 4 : Seawater desalination. The experiment was conducted to treat sea water into fresh water. Water quality is expressed by conductivity value. The experiment is considered successful if there is a significant decrease in the value of processed water conductivity (> 10%, water conductivity PAM Tirta Kahuripan, Bogor, about 500 µS). The efficiency of the process is expressed by the rendement of the amount of water that can be obtained compared to the amount of water processed.

Design of Experiment

The experimental design was carried out for each experimental stage as follows:

1. Experiment 1 : try and modify the three commonly used sprayer forms to produce a water jar that is conical sprayer (conis), elongated pipe sprayer, and cyclone sprayer (resulting in a rotating jet). These three sprayer forms were attempted to produce the best emission using pressurized water from pressurized membrane pumps up

to 100 psi. The result to be achieved was a line-shaped water jet with a point-shaped cross-section.

2. Experiment 2 : using two types of magnets, i.e. solenoidal electromagnets and toroidal electromagnets.
   - Two permanent magnets were brought together in parallel to form air gap between them.
   - The magnetic field of the solenoid electromagnetwas deflected by soft iron. The ends of soft iron were brought together to form air gaps.
   - The soft iron core of the toroidal electromagnet was opened to form air gap.
   - The salt water was emitted through the air gap between the two magnetic poles.The width of the gap and the current strength of the electromagnet was set to obtain a magnetic field that could change the jets of water with a point-shaped cross-section into being spread by cross-section or field.
   - The magnetic field strength was calculated theoretically.
3. Experiment 3 : from the position of the water jet by a line of sight or plane resulting from the 2nd Experiment, a position was sought to provide water with the lowest DHL (Electrical Conductivity) value.
4. Experiment 4 : treats seawater through equipment already built from the 1st, 2nd and 3rd experiments. The experimental target was the value of DHL of the seawater treated-water to beequal or lower with the value of DHL of tap water (<400uS). The variable set to achieve this goal was the current on the electromagnet. It is possible that this goal could only be achieved when a permanent magnet was combined with an electromagnet.

Result and Discussion

Neodymium Permanent Magnet (NdFeB) Grade N48 with nickel coatedmeasuring of 50.8 mm x 50.8 mm x 25.4 mm, does not provide observable deflection. Since magnetic field strength can not be increased, that research using this permanent magnet is not continued. The experiment focused on the use of electromagnets that could provide a varying field strength.

The new water jet system is paired on the toroidal magnetic. Initial experiments show that the strength of the current flowing through the toroidal coil, is much larger than that usually occurs in the transformer system. The literature review shows that this condition occurs because what is used is direct current electricity (dc, direct currert) which does not have its own induced properties. These early experiments concluded that the number of windings should be increased, at least doubling the original coil.

Figure 1 shows the position of the jet emitted system at the top of the magnetic slot on the toroidal. This system has not been tested yet. This image points to the position of the capillary pipe on the toroidal magnetic. Attachment of equipment components using Power Glue and nut / bolt.

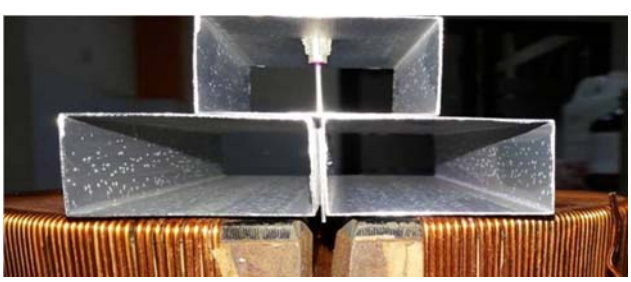

Fig 1: Position of Nozzle / Sprayer on Toroidal Magnetic Slot

Determination of Diameter and Length of Capillary Nozzle

The nozzle diameter is determined by measuring the length, dry weight of the nozzle, and the weight after the nozzle is filled with water.

Power Supply Preparation

The required power supply specifications cannot be determined with certainty. This condition causes the preparation of the power supply to be of a manageable nature to satisfy the experiment. The main power supply is a variable voltage regulator with the maximum power of 1000 watts. After the voltage regulator of this variable, a potential down-transformeris placed. The alternating current is converted to direct current using silicon smoothing system and capacitor. Figure 2 shows the power supply used in the experiment.

Fig 2: Experimental Power Supply

1st Experiment : Water Pump System

At the beginning of the experiment, a water push system was prepared using a shallow centrifugal well tub of the Panasonic brand. The water jet system used a water cannon and an agricultural sprayer.

The experiment using water canon also produced a jet of water with cross point. After careful observation, this water jet system produced a rotating current (cyclone) and extended about 5 times at a distance of about 50 cm. This condition does not match the needs of the study. What is needed in this research is a linear water jets. Figure 3 is the experimental device used in this research. Experiments with agricultural sprayer, moreover, also provide a non-linear water jets (same as the water jets from the water cannon).

Fig 3: Panasonic GL-75JXK and Water Canon Experiments (left) and Water Pump Trial Results (right)

From the experimental experience of this water jets, it can be concluded that the jets of water are straight and not spinning, and will be generated from laminar loose flow. Based on this assumption, the emission system is tested using a capillary pipe. This experiment gives a pretty good result. The resulting water beam is still a straight line at a distance of more than one meter. Furthermore, the water jet system to be used is a capillary pipe system. In fact, the Panasonic pumps which is used cannot provide pressure up to 100 psi. Therefore, a peristaltic pump is prepared which can provide pressure up to 100 psi.

2nd Experiment: The Effect of The Magnetic Field to Ions in The WaterJets

Two Permanent Magnets

Experiments using two permanent magnets did not yield observable results. The jets of water jets still look straight. The condition that may occur is the effect of ion deviations that are relatively smaller than the effect of ion dispersion in the water. Since the magnetic field strength cannot be modified, this experiment is not continued.

Solenoidal Electromagnets and Toroidal Electromagnets

The experiment used the solenoidal magnetic field and the toroidal magnetic field are as the arrangement of equipment as shown in Figure 4.

Fig 4: Complete Trial Equipment (left: Toroidal Magnetic Field; Middle: Resource; Right: Solenoidal Magnetic Field; Rear: Pump of Water Jet System)

Experiments using solenoidal magnetic field provide relatively similar deviation with experiments using a solenoidal magnetic field. This deviation is relatively small to be accurately measured. However, it can still be observed (qualitatively) that the widening of the water course is influenced by the strength of the current used. Usable current strengths are limited to 4 amperes for toroidal magnetic fields and 2.5 amperes for solenoidal magnetic fields. Strong current cannot be set exceeding 4 amperes. In addition to resource problems, there is also significant rise in coil temperature. It is assumed that the problem lies in the overly coiled winding coil structure, and the resources connected indirectly to the PLN power grid. Improvements are made by raising the silicon of the ac power converter to dc into 25 amperes; increasing the capacitor capacity to 20,000 uF; and preparing battery 12 V 60 AH. The experiment, however, is still in progress. It is planned that the observations will be done in a short time by photographed.

Conclusion

Experiments in Research 'Magnetic Field Potential for Separation Techniques' give the following conclusions:

1. The toroidal magnetic field and the solenoidal magnetic field may be used to separate dissolved ions from the aqueous solution. The efficiency of the separation cannot yet be determined, but it is expected that this process can be far more efficient than desalination techniques of seawater by distillation.
2. The stronger the current is channelled to the toroidal coil and/or to the solenoidal coil, the separation occurs will be stronger. This condition occurs because the increase in current will increase the strength of the generated magnetic field. Unfortunately, there is a limited factor from the ability of the core material to accommodate the strong magnetic field.
3. Separation efficiency using a toroidal and solenoidal magnetic field with standard dimensions, as is commonly encountered in applied technologies, is relatively very low. Efforts to increase the efficiency of separation can be done by designing toroid and solenoid specifically for the purposes of this separation.
4. The potential of permanent magnets for this separation technique is relatively very low.

Suggestion

To improve separation efficiency in subsequent trials, it is recommended to:

1. Create a toroid and / or solenoid with a porch shape corresponding to the solution flow line that is being processed. The general shape required is a triangular shape with a pointed shape on the top and extends to the bottom. This design can increase separation efficiency up to tens of times.
2. Looking for patio materials that can accommodate a relatively high magnetic field strength. This material should be better than soft iron (iron with low carbon content).
3. There must be a correlation between the speeds of the water jet with the strong magnetic field. Theoretically, a low velocity will provide a circle of trajectories with smaller radii. In fact, there will be an obstacle from the attraction between the opposite charges. An experiment to determine the relationship between the velocity of the water jet and the strength of the magnetic field must be carried out using equipment that can be arranged precisely and accurately.
4. The experiment uses a permanent magnetic field, can be combined with a solenoidal magnetic field. It is done by placing a permanent magnet as a solenoidal or toroidal electromagnetic porch.

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