Comparison of exergy value active desalination system with and without solar collector

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Abstrak

Air merupakan sumber daya alam yang sangat penting bagi kehidupan. Air dapat diperoleh dari darat, mata air, danau, air laut dan sungai. Untuk mengolah air dan membuat air penguapan kita memiliki matahari. Dengan matahari kita memiliki energi potensial. Energi matahari Indonesia sangat banyak. Energi matahari yang melimpah di Indonesia untuk radiasi matahari dapat memberikan hasil dengan memanfaatkan energi untuk teknologi termal dan teknologi sel fotovoltaik. Air di darat dan laut harus menguap karena panas matahari. Penguapan berkumpul menjadi awan, kemudian mengembun dan pendinginan akan membentuk titik-titik air dan terjadi hujan. Proses itu membutuhkan energi. Metode eksergi adalah alternatif, teknik baru yang relatif berdasarkan konsep eksergi, yang secara longgar didefinisikan sebagai ukuran universal dari potensi kerja atau kualitas energi yang berbeda dalam kaitannya dengan lingkungan tertentu. Perbandingan eksergi desalinasi lereng ganda aktif dengan luas cekungan seluas 1.932 m^2 dengan permukaan kaca 1 m^2 dengan ketebalan kaca 3 mm. Ketinggian air dari dasar 20 mm dan dengan kolektor surya ukuran area 1m^2 lebar 500 mm^2 diuji selama 8 hari pada bulan Agustus 2018 mulai pukul 8:00 sampai 18:00. Perbandingan nilai eksergi dari perhitungan desalinasi aktif tanpa kolektor surya dan dengan kolektor surya nilai eksergi tertinggi pada pengujian hari pertama pukul 11.00 adalah 101.827 dan dengan kolektor surya 12.00 adalah 225.238 kWh, nilai eksergi tertinggi pada pengujian hari kedua pukul 16.00 adalah 7.930 dan 17.00 WIB adalah 52.332 kWh, nilai eksergi tertinggi pada pukul 12.00 adalah 67.134 dan pukul 13.00 WIB sebesar 13.680 kWh, nilai eksergi tertinggi pada hari keempat pada pukul 13.00 sebesar 172.618 dan pukul 11.00 WIB sebesar 6.734 kWh, nilai eksergi tertinggi pada pengujian hari kelima pada pukul 13.00 sebesar 182.208 dan pukul 12.00 WIB pada 22.218 kWh.

Kata kunci: air laut, desalinasi aktif, kolektor surya, eksergi.

Abstract

Water is a natural resource that is very important for life. Water can be obtained from land, springs, lakes, sea water and rivers. To cultivate the air and make the air we have the sun. With the sun we have potential energy. Indonesia's solar energy is very much. Indonesia's abundant solar energy for the sun can provide results by utilizing energy for thermal technology and photovoltaic cell technology. Water on land and sea must evaporate due to the heat of the sun. Evaporation gathers into clouds, then condenses and cooling will form air droplets and rain occurs. The process requires energy. The exergy method is a relatively new technique based on the concept of exergy, which is defined as a universal measure of different energies in a given environmental potential. Comparison of active slope desalination exergy with a basin area of 1,932 m^2 with a glass surface of 1 m^2 with a glass thickness of 3 mm. The water level from the bottom is 20 mm and with a solar collector area 1 m^2 wide 500 mm^2 tested for 8 days in August 2018 from 8.00 to 18.00. The comparison of the exergy value from the calculation of active desalination without a solar collector and with the highest solar collector on the first day of testing at 11.00 is 101,827 and with a solar collector at 12.00 is 225,238 kWh, the highest exergy value on the second day of testing at 16.00 is 7,930 and 17.00 WIB is 52,332 kWh, the highest exergy value at 12.00 was 67,134 and at 13.00 WIB was 13,680 kWh, the highest exergy value on the fourth day at 13.00 was 172,618 and at 11.00 WIB was 6,734 kWh, the highest exergy value was on the fifth day of testing at 13.00 at 182,208 and at 12.00 WIB at 22,218 kWh.

Keywords: seawater, desalination active, solar collector, exergy.

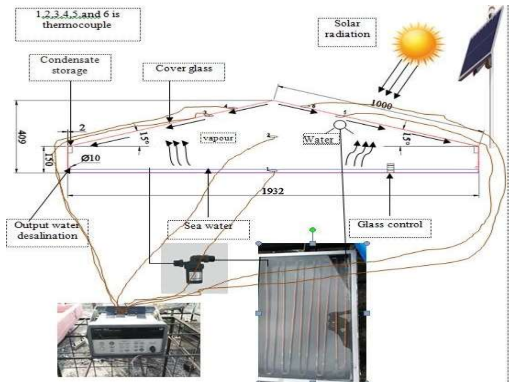
1. Introduction

Water is a natural resource that is very important for life. Water can be obtained from land, spring, lakes, sea water and river. To process water and to make evaporation water, we have sun. With sun we have potential energy. Indonesian solar energy is very much. The abundant solar energy in Indonesia for solar radiation can provide results by utilizing energy for thermal technology and photovoltaic cell technology. Water on land and sea must evaporate due to the sun's heat. Evaporation gathered into clouds, and then condensed and cooling will form water points and rain occurs. The process of that need a energy. The exergy method is an alternative, relative new technique based on the concept of exergy, loosely defined as a universal measure of the work potential or quality of different forms of energy in relation to a given environment. An exergy balance applied to a process desalination active with solar collector and without solar collector tells us how much of useable work potential, or exergy supplied as the input to system under consideration has been consumed (irretrievably lost) by the process. The lost of exergy or irreversibility, provides a generally applicable quantitative measure of process inefficiency. Analyzing a multi-component plant indicates the total plant irreversibly distribution among the plant components, pin pointing those contributing most overall plant inefficiency. An experimental and numerical study on the solar water heater is carried out in Blida area, Algeria during winter in this work. Numerical results are confirmed by experimental results, where the numerical results are presented in two forms: Numerical solution based on estimated equations of climatic data and numerical solution based on actual values of weather data. Finite difference method was used to analyze and simplify energy balance equations. [1]. Cogeneration of electricity and freshwater by integrating photovoltaic/thermal collectors and desalination systems is one of the most promising methods to tackle the challenges of water and energy shortages in remote areas. This study investigates a decentralized water/electricity cogeneration system combining concentrated photovoltaic/thermal collectors and a vacuum multi-effect membrane distillation system. The merits of such a configuration include high compactness and improved thermodynamic efficiency [2]. In this study, a comprehensive exergetic performance investigation of a single slope a passive solar still system is theoretically presented. Energy and exergy methodologies have been applied for all components of the solar still comprising glass cover, brackish water and basin-liner. Also, exergy irreversibility analysis was conducted to identify and localize the sources responsible for the exergy destruction and losses in the system for further analysis and improvement. The theoretical model was solved numerically by using fourth-order Runge-Kutta method and the program was written by MATLAB [3]. The shortage of potable water, especially in developing countries has attracted researchers to try and overcome this problem. Desalination is one of the most effective methods used to solve this problem. Among desalination techniques, Reverse Osmosis (RO) has higher priority than thermal desalination methods, on account of its comparatively limited energy consumption [4]. Simplicity of solar distillation system makes it very attractive, but the yield as well as the overall efficiency is very low. Different types of absorng materials e.g. black ink, black dye solution in brackish water and black toner on water surface were used to evaluate their effect on the yield. As the absorng material absorbs more insolation to increase brackish water temperature, increases yield as well as overall energy efficiency [5]. The tendency to renewables is one of the consequences of changing attitudes towards energy issues. As a result, solar energy, which is the leader among renewable energies based on availability and potential, plays a crucial role in full filing global needs. Significant problems with the solar thermal power plants (STPP) are the operation time, which is limited by daylight and is approximately half of the power plants with fossil fuels and the capital cost. Exergy analysis survey of STPP hybrid with PCM storage carried out using Engineering Equation Solver (EES) program with genetic algorithm (GA) for three different scenarios, based on eight decision variables, which led us to decrease final product cost (electricity) in optimized scenario up to 30% compare to base case scenario from 28.99 $/kWh to 20.27 $/kWh for the case study [6]. Improving the efficiency and sustainability of water treatment technologies is crucial to reduce energy consumption and environmental pollution. Solar-driven devices have the potential to supply off-grid areas with freshwater through a sustainable approach. Passive desalination driven by solar thermal energy has the additional advantage to require only inexpensive materials and easily maintainable components. The bottleneck to the widespread diffusion of such solar passive desalination technologies is their lower productivity with respect to active ones [7]. Exergy analysis of solar thermal systems includes both various types of solar collectors and various applications of solar thermal systems. As solar collectors are an important technology when sustainability is considered, exergy analysis, which gives a more representative performance evaluation, is a valuable method to evaluate and compare possible configurations of these systems. It should be noted that this review is based on literature published in the last two years [8]. The technology of distilling seawater into fresh water has been carried out with various models and methods. The distillation process is one of the effective methods to get clean water by utilizing solar energy as the main energy source [9]. The difference between this study and the nine literatures are to see the exergy value of active desalination with a solar collector and without solar collector. The literature study only knows the exergy value their own tool. In this study, comparing two desalination basins and measurements were made on the same day and in the same place.

2. Method

On this occasion of research was carried out experimentally, by using direct observe what happens when the testing process is carried out in order to obtain the necessary data according to comparison exergy desalination active with solar collector and without solar collector. In terms of this research has been determined within the constraints of the problem that method use in active desalination using a double slope. That utilities energy the sun to raise temperature water to be evaporation process and solar collector for additional heating.

Figure 1. The scheme desalination active with solar collector.



Temperature and External Coefficient of The Basin

The heat energy emitted by the sun is directly received by the Basin cover glass which will then enter the Basin and be absorbed by water by convection and radiation.

$$H_{cg} = [5.7 + 3.8\,V] \leq \frac{5m}{s} \quad (1)$$

$$[6.15xV0.8] > 5\;m/s$$

Heat transfer coefficient (h_{rg}) can be calculated using Equation 2.

$$H_{rg} = \frac{\epsilon_g\,\sigma\,(T_g^4 - T_{sky}^4)}{(T_g - T_a)} \quad (2)$$

Temperature and Internal Coefficient of Basin

Principle of radiation heat transfer will take place if between two things object different temperatures. Radiation heat transfer coefficient from water to the glass side surface with Equation 3 (h_{rw}).

$$\epsilon_{eff}\,\sigma[(T_w + 273)^2 + (T_g + 273)^2 \text{ x } (T_w + T_g + 546)] \quad (3)$$

The convection heat transfer coefficient (h_{cw}) and the Equation 4 are used as follows.

$$0.034 \text{ x } 5.67 \text{ x } 10^{-8}\,[(T_{giE} + 273)^2 + (T_{giW} + 273^2)] \text{ x } [T_{giE} + T_{giW} + 5546] \quad (4)$$

Energy Eficiency to Water

Energy of solar received water by distillation every hour can be calculate with Equation 5.

$$En_{hours} = [\,h_{ef,E}\,(T_{bf} - T_{giW})]\,Ab \quad (5)$$

Energy efficiency the overall can be calculated with this Equation 6.

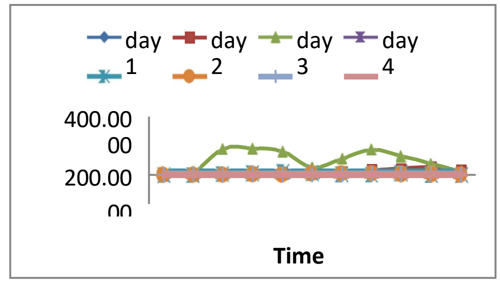
$$H_{En} = \frac{(m_{ewE} + m_{ewW})\,L}{\left(A_{gE} - I_{SE}(t)\right) + \left(A_{gW} - I_{SW}(t)\right)\,3600}\,x100 \quad (6)$$

Energy analysis does not show internal irreversibility.

Energy efficiency of a system have different behaviors depending on climate and operating conditions.

3. Result and Discussion

Based on the test results, calculations can be made to obtain exergy data, where the highest exergy value at the first day of testing at 12.00 p.m. is 225,238 kWh, the highest exergy value at the test of the second day



at 17.00 p.m. is 52,332 kWh, the highest exergy value is at 13.00 p.m. amounting to 13,680 kWh, the highest exergy value on the fourth day of testing at 11.00 a.m. amounting to 6,734 kWh. Based on the test results, calculations can be made to obtain exergy data, where the highest exergy value on the fifth day test at 12.00 p.m. is 22,218 kWh, the highest exergy value on the sixth day test at 15.00 p.m. is 8,728 kWh, the highest exergy value is at 17.00 p.m. amounting to 8,33 kWh, and the highest exergy value at the test of the eighth day at 15.00 p.m. amounting to 6,712 kWh.

Figure 2. Exergy loss for the first to eight day.

Results of Exergy Active Desalination without Solar Collector

Based on the test results, calculations can be made to obtain exergy efficiency data, where the highest exergy efficiency value at the first day testing at 11.00 a.m. is 0.1018 kWh, the highest exergy efficiency test at the second day at 4.00 p.m. is 0.0079 kWh, the highest exergy efficiency value is on day testing third at 12.00 p.m. at 0.0671 kWh, the highest exergy efficiency value at the testing of the fourth day at 13.00 p.m. is 0.1726 kWh. Based on the results of testing, calculations can be made to obtain exergy efficiency data, where the highest exergy efficiency value at the fifth day test at 13.00 p.m. is 0.1822 kWh, the highest exergy efficiency test at the sixth day at 13.00 p.m. is 0.1365 kWh, the highest exergy efficiency is on day testing seventh at 12.00 p.m. at 0.2319 kWh and the highest exergy efficiency value at the test of the eighth day at 14.00 p.m. amounting to 0.1735 kWh.

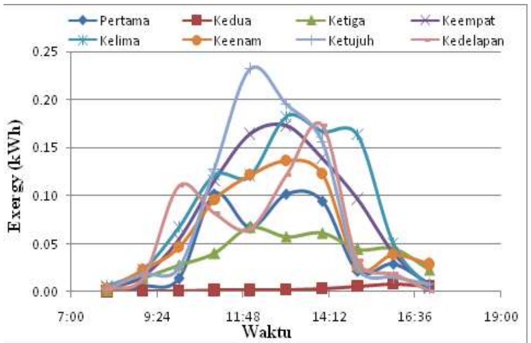


Figure 3. Exergy the first day to eight desalination active without solar collector.

4. Conclusion

The comparison of the exergy value from the calculation of active desalination without a solar collector and with the highest solar collector on the first day of testing at 11.00 a.m. is 101,827 kWh and with a solar collector at 12.00 p.m. is 225,238 kWh, the highest exergy value on the second day of testing at 16.00 p.m. is 7,930 kWh and 17.00 p.m. is 52,332 kWh, the highest exergy value at 12.00 p.m. was 67,134 kWh and at 13.00 p.m. was 13,680 kWh, the highest exergy value on the fourth day at 13.00 p.m. was 172,618 kWh and at 11.00 a.m. was 6,734 kWh, the highest exergy value was on the fifth day of testing at 13.00 p.m. at 182,208 kWh and at 12.00 p.m. at 22,218 kWh. Suggestions for further researchers can vary the thickness of the glass and pay attention to the cooling rate in the basin due to heating due to the addition of solar collectors.

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