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STUDY ON THE HEATING PERFORMANCE OF SEAWATER DESALINATION BRINE BY SOLAR ENERGY

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The solar heating process was studied with the system of evacuated tube collector. The heated media was the brine (6°Bé) , which is the same concentraion with seawater desalination brine. The automatic signal collection system was used in the brine solar energy heated system to measure ralitive parameters. The parameters measured were solar irradiance, wind temperature, humidity, wind speed and flow rate and temperature of the brine. The influence of the parameters on heat collection rate of the brine was studied. The area of the solar energy vacuum tube collector was 10 m^2. The volume flow rate of the brine was 0.12~0.14 m^3/h. The experiments were carried out in Tianjin Economic-Technological Development Area from May 2007 to May 2008. The results showed that the efficiency of heat collection is 30%~ 80%. The average heat collection rate is about 5.182 kJ /(m^2·h) based on the unit mass of the brine. An artificial neural networks model was developed basing on the principal component analysis in this work.

1. INTRODUCTION

The fresh water above the Earth which can supply direct to human use is less than 0.36 percent, and the spatial and temporal distribution of water is extremely odds, which do not match the distribution of population, infield and mineral resources. Fresh water supply is a serious shortage in some of the drought areas, brine areas, coastal and saline-alkali areas and islands. Water shortage has become one of the major problems in many countries worldwide, with a continuous increase due to population growth and higher living standards.

The seawater or brine desalination has become a pick choice for large scale pioneer of new water sources to solve the increasingly serious global problem of water shortage(Wang and Xiong,2004;Lin,2001;Ai and Wu et.al;2004). How to reduce the costs of seawater desalination is the major problem which effects the seawater desalination achieves industrialization (Zhen,2002;Glueckster m,1999). Seawater desalination is a non-spontaneous process using energy driven to separate water and salt. There are a various types of seawater or brine desalination, but the conventional methods all need consume a large amount of fuel or electricity, such as Multistage Flash (MSF), reverse osmosis (RO), Low Temperature Multiple Effect Distillation (LT-MED) and so on. Li Dengwei(2007)had an analysis of the present and future of eight desalination technology(Li and Yu etal,2007).Tong Jinzhong(2007) has introduced and compared the main methods of desalination(Tong and

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Ge,2007).Xiong Rihua(Xiong and Wang,2003)has introduced the alternative energy technology of desalination. We can learn from these research that energy consumption is the key problem which related to the cost of seawater desalination technology.

Membrane distillation (MD) is known as a process which refers to the thermally driven transport of vapor through microporous and hydrophobic membranes, it is a membrane separation technology with low cost and energy saving process. Generally, MD is carried out with lower temperature than conventional distillation and with lower operating pressures than conventional pressure-driven membrane separation process. The low-grade energy such as solar energy, industrial waste heat, ground heat can be used in MD process. MD is a novel technology for seawater desalination or the utilization of seawater desalination brine. MD has a very significant in the waste-using and energy-saving process, especially in the instance of increasing tense of energy(Ding ,Liu, et.al,2005;Chen,,Tang, et.al,2006).

Solar energy is a kind of radiation, it's not only a primary energy but also a regeneration energy. There is rich reserve of solar energy, it can be used freely, no transport, and no pollution to the environment(Xie,2000;Huang,1999;Zheng,1999).Therefore, the development and utilization of new energy, especially solar energy, for seawater or brine desalination has an important development prospect.

Some studies were investigated on the brine in membrane separation processes using solar energy. F.Banat(2002) discussed the feasibility of using simulation seawater to produce drinking water. This process was through using combination of PP tubular membrane distillation components and solar energy evaporator(Banat and Jumah etal,2002). Ma(2003) devoloped a mathematical model of membrane distillation(SPMD) basing on the heating source is solar energy.Tian (2004) developeda mathematical models of solar energy membrane system basing on the heating transfer and the relative theory. The comprehensive evaluation and prediction of the actual operational conditions and changes of the solar energy membrane system has become realization(Tian and wang,2004).

The aim of this work was studying on the heating performance of seawater desalination brine using solar energy, then developed the feasibility of utilization of seawater desalination brine by solar energy assisted low energy cost technology such as MD.

The influence of the parameters on heat collection rate of the seawater desalination brine was studied. The area of the solar energy vacuum tube collector is 10 m^2. The volume flow rate of the brine 0.12～0.14 m^3/h were carried out in the experiments. The heating performances of the brine were achieved after a whole year experiment. The experiments were carried out in Tianjin Economic-Technological Development Area(east longitude 117°70 ', north latitude 39°08') from May 2007 to May 2008.

2. EXPERIMENT

2.1 Experimental setup

The solar heating process was studied with the system of evacuated tube collector. The heated media was the brine ($6^oBé$) which has some concentration with the brine obtained from membrane methods of seawater desalination. The brine was prepared ourselves. The area of the solar energy vacuum tube collector is 10 m^2.

Experimental setup was mainly contained the solar evacuated tube collector, automatic weather monitoring systems, automatic-collection system, and brine pump. The experimental setup was shown in Fig. 1.

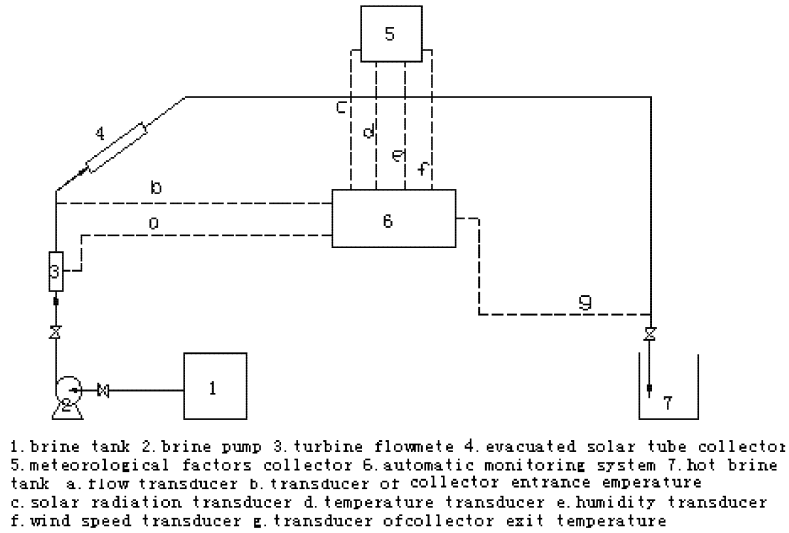

Fig.1 Experimental setup of the brine heated by solar engergy

The brine was pumped into a solar energy collector , it was heated then flowed back to the heat brine tank. The factors which effected the brine heating performace were total solar radiation intensity, temperature, humidity and wind speed. The factors of fluid flow conditions were feed volume flow rate and feed temperature. All the factors were monitored atutomaticly with a auto-monitoring systems shown in Fig.2. The data change of the factors which effected the brine solar energy heating performace were monitored and saved second by second in the systerm.

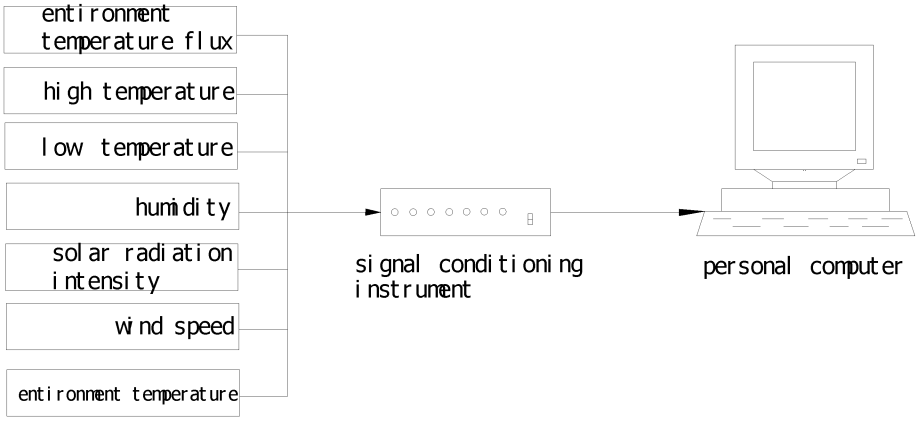

Fig.2 Automatic monitoring system of the brine heated by solar engergy

2.2 results and discussion

The effect of meteorologic factors and flouid flow factors on the brine solar energy heating performance were studied. The data was monitored and collected second by second. The brine heating performance was given by equation(1).

$$Q=\frac{C_p \times \rho \times Vs \times \Delta t}{3600 \times 10} \quad (1)$$

Where Q is the brine effective heat heated by solar energy, W/m^2; C_p is the specific heat of brine (6 °Bé), kJ / (kg·℃); ρ is density of brine, kg/m^3; Vs is flow volume rate of brine, L/h; Δt is Temperature difference, ℃; 10 is the area of vacuum tube heat collectors, m^2.

The experimental result of solar radiation intensity, the heating collector of brine and the change of efficiency which is the rate of the heating of brine and solar radiation intensity was shown in Fig. 3.A conclusion can be drawn from Fig.3 that the larger of the solar radiation intensity, the larger of the heat of brine obtained from solar energy. There is a direct ratio between the heat of brine obtained from solar energy and solar radiation intensity.The efficiency of the solar collector is different with the solar radiation difference under the normal working conditions. The efficient is range from 30% to 80%. After 5:00pm, as the apparent decline of solar radiation intensity while the heating of brine is not, therefore, the efficiency appear to more than 100 percent, especially in winter. The emergence of the efficiency of a month is more than 100% because of the analysis erroe based on the average data of months,t.

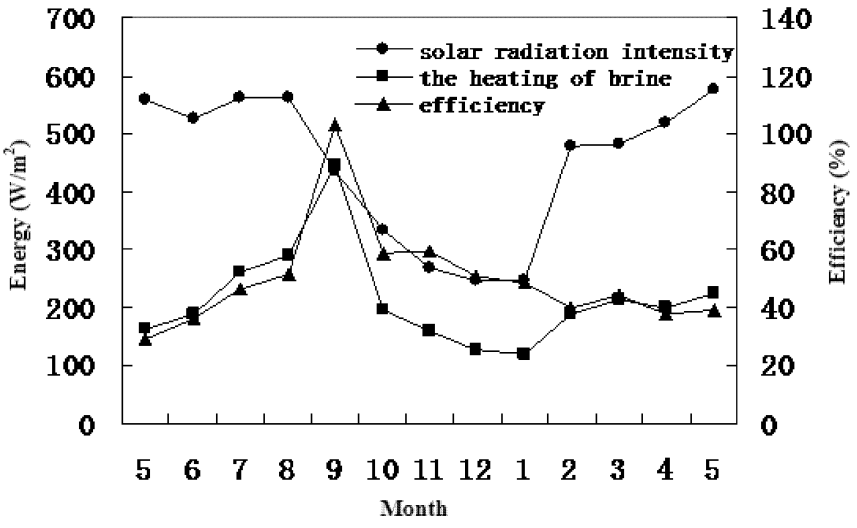

Fig.3 The heating performance and efficiency of brine vs. Solar radiation intensity from May 2007 to May 2008

3 ARTIFICIAL NEURAL NETWORKS MODEL

Artificial neural network(ANN) is a foreland field which has a rapid development in recent years. Because of its function characteristic, such as large-scale parallel processing, fault-tolerant, self-organizing, self-adaptive capacity and strong associate function, ANN has become a powerful tool for many problems. It has played a major role in breaking through the bottlenecks of science and technology, and it is useful to explore complexity phenomenon in more depth exploration such as non-linear and so on. ANN has been widely used in many projects field (Xia,2003). There are many types of ANN and the widely used network is a feed-forward BP network (Hu and Yu,1993;Li and Peng,1999). BP network is a typical multi-layer neural network, usually includes input layer, hidden layer and output layer. The hidden layer can be one or more layer.

In this work, four-BP network includes input layer, middle layer (hidden layer) and output layer was constructed. First of all ,weight W_{ji} and threshold θ_j, θ_k of the connection between adjacent two node have given for the random number between -1 and 1.There are six factors include solar radiation intensity, environment temperature, humidity, wind speed as well as flow and entrance temperature of the brine need to check, and four stat analysis include exit temperature of brine ,the heating of brine, efficiency and the heating saving percentage of heating calories which is in the process of the application in MD, based on the temperature of MD from 20ºC to 70ºC. Therefore ,a BP network models of six input node and four output node was set up. Node of the hidden layer was selected by training through structure of different nodes of hidden layer. In accordance with the convergence rate of error of the various network and the size of MSE of degree of fitting characterization, 15 nodes is the best for the network. After a number of training and generalized by the experimental data, use a better value weight for the initial value of Wji, to determine the network. The network is training for 2000 times and the study efficiency for 0.001.Take the hour average data of one year's for the training sample, while taking the month average data(May,2007 to May,2008) for the test sample. The forecast chart of the model was shown from Fig.4 to Fig.7.

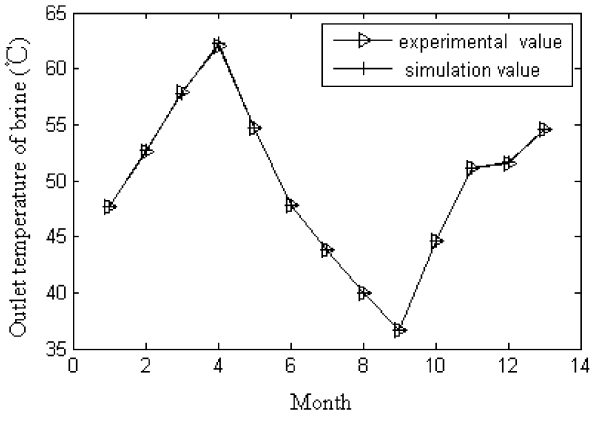

Fig.4 Outlet temperature of brine vs. time

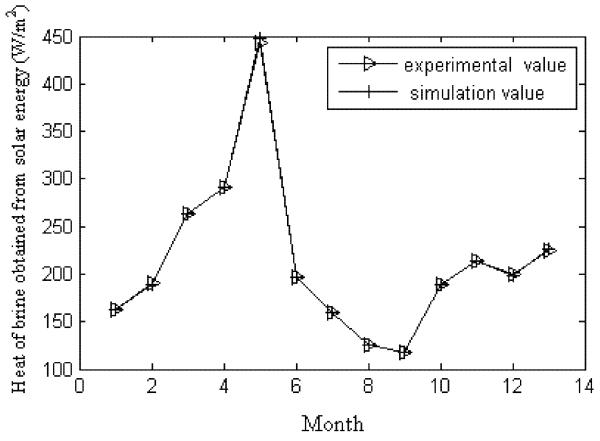

Fig.5 Heat of brine obtained from solar energy vs. time

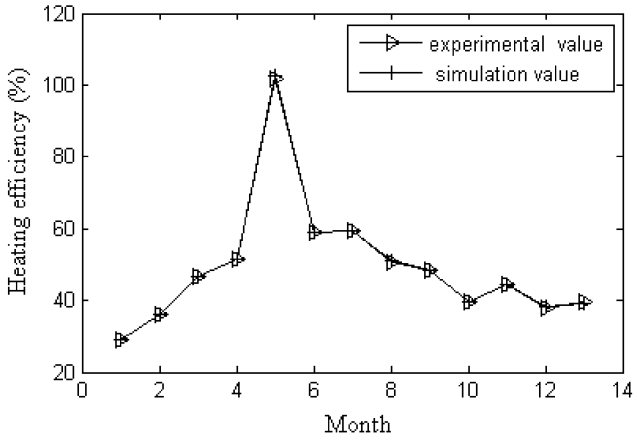

Fig.6 Heating efficiency vs. time

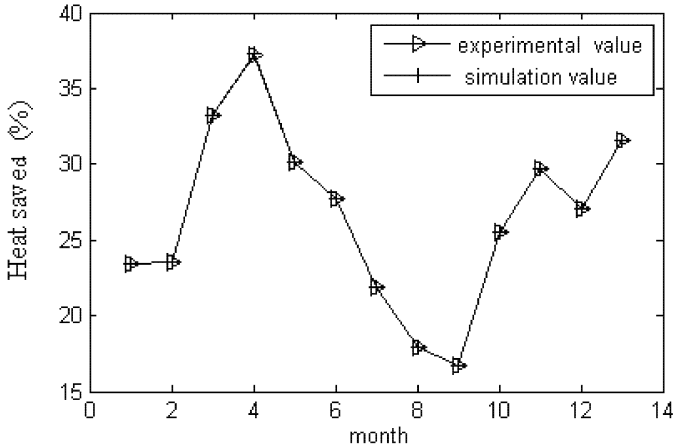

Fig.7 Heat saved vs. time

4.CONCLUSION

A conclusion can be drawn that among the meteorologic factors, solar radiation effected the heat of the brine during solar energy heated process most, then was the temperature. When solar radiation less than 200w/m^2 and temperature lower than 20 ℃, the heating effect is not obvious. Environment humidity and wind speed had less influence to the heating effect. At the same climatic conditions, the heat collection rate of the brine increases with decreasing the temperature of the brine at the same feed flow rate. The temperature of the brine increased with decreasing the feed flow rate at the same feed temperature and the same environment factors condition.
In this work, An artificial neural networks model was developed basing on the principal component analysis, which showed a good prospect for brine heated by solar energy in the application of MD process and relatived membrane sepeariong process.

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