Experimental Study to Extract Water from the Air in the Semi-Arid Countries, Homs, Syria

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Abstract This research reviews the test dealing with the system of the extracting water from the atmosphere air as a source of the water source at the unavailable water sources areas. this would be system can operate all over the day by means of using any source of the allowable energy sources at those areas like the solar energy or the lost energy with the exhausting gases. to increase the production rate of this system, the unit in particular of absorption has been considered as a compressed tower containing porous material which holds the absorption salt of the moisture , where as a cotton cloth has been used as a holder of calcium chloride. Increasing the absorption time is executed by means of the forced bearing by using a centrifugal fan . The absorption-regeneration cycle for production of water from air have been studied, the relevant mathematical model has been deduced, to be applied in Homs climate. As through the experiment it is noticed that the rang of concentration rang is about X=0.3-0.45 %, and it can be generated about from 0.7 -1.2 m^3 of water for one ton of $CaCl_2$ at low relative humidity (40%), and about from 3-3.5m^3 of water at high relative humidity (80%), It was noticed that absorption continues for about five hours and the regeneration process continues for about 45 minutes.

1 Introduction:

The limiting condition for the need of population growth and development in many areas of the world is the fresh water supply. The problem of providing arid areas with fresh water, from our point of view, can be solved by the following methods[4]: 1-Transportation of water from other locations. 2-Desalination of saline water (ground and underground).3-Extraction of water from atmospheric air.Transportation of water through these regions is usually very expensive[4]. On the other hand, desalination of water depends on the presence of saline water resources, which are usually rare in arid regions[2]. The extraction of water from atmospheric air, however, has several advantages compared with the other methods. Where air, as a source of water is renewableand clean and the amount of water in atmospheric air is evaluated as 14000 km^3, and the amount of fresh water in the earth is only about 1200 km^3 [1]. Moreover,it is preferred to solve the water problem in these areas using the natural resources and the renewable energy sources like solar energy where the available area to collect solar radiation and volumes of air are infnite or the lost energy with the exhausting gases. Extraction of water from atmospheric air can be accomplished by two different methods [3]: The first method is by cooling moist air to a temperature lower than the air dew point. The second one is by absorbing water vapor from moist air using a solid or a liquid desiccant with subsequent recovery of the extracted water by heating the desiccant and condensing the evaporated water [3]. In this project we use the second one with $CaCl_2$ as the working desiccant for the absorption regeneration system.

2 Method and data

The absorption-regeneration cycle, which can be applied for the production of water from atmospheric air, is shown in Fig. 1. The theoretical cycle is plotted on the vapour pressure-concentration diagram for the operating absorbent and consists of four thermal processes which are: 1)Process 1-2: isothermal absorption of water vapour from air. 2) Process 2-3: constant concentration heating of the absorbent.3) Process 3-4: constant pressure regeneration of absorbent.4) Process 4-1: constant concentration cooling of absorbent.

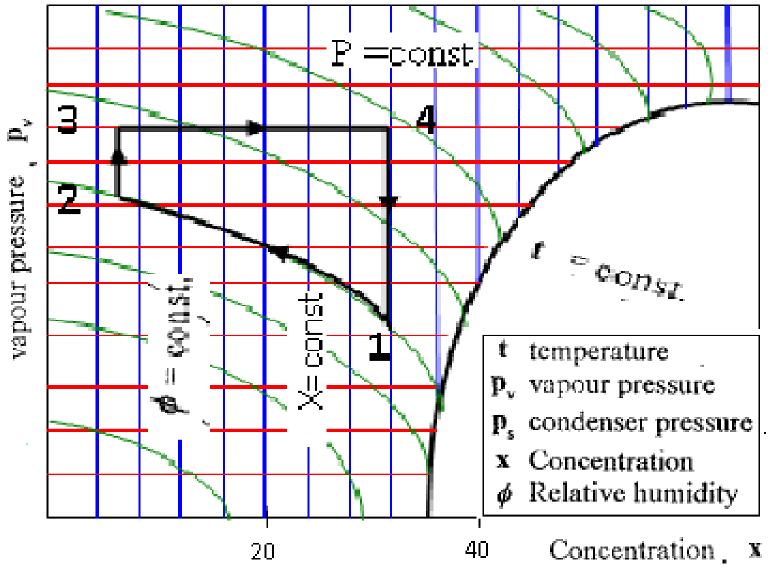


Figure .1. The absorption-regeneration cycle, for the production water from atmospheric air [1]

The absorption is assumed to be isothermal becuseThe rate of absorption of vapour from atmospheric air is usually small so that the heating efect for the absorbent is small [1]. The thermal processes of this cycle are carried out between two concentration limits; X_1 and X_2 and the cycle has other operation limits which are maximum regeneration temperature, t4 (C^{0}) ; condensation pressure, p_s and maximum absorption pressure, p_v $(mmHg)$ [1].Evaluation of these operation limits is important from the point of view of system design and construction. Therefore, a description of the efect of weather conditions on the cycle operation is presented here[2]. Mass of water vapor absorbed or generated by salt is calculated by[5]:

$$m = \left(\frac{X_{\max} - X_{\min}}{X_{\min}} \right) M_d \qquad \text{.......................................(1)}$$

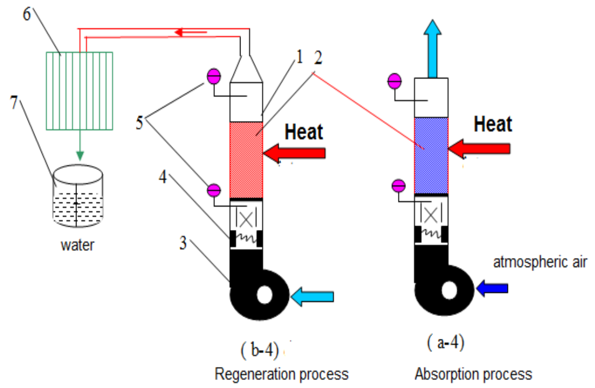
where X_{max} and $X_{min}$$\left(\frac{Kg_{CaCl2}}{Kg_{water}}\right)$ are the concentrations of strong and weak solution, respectively. M_d (Kg) mass of strong solution it is taken at the beginning of absorption.With the help of CaCl2 data which used as a dryer [1], the following correlation is obtained as a result of treatment of the available data[5]:

$$X_{\min} = \left[\ln p_v - \left[a_0 - \frac{b_0}{t + 111.9} \right] \right] / \left[a_1 + \frac{-b_1}{t + 111.9} \right] \qquad \text{....(2)}$$

Wher : X_{min} the minimum concentration (concentrations of weak solution), a_0, a_1, b_0 and b_1 are the regression constants and their values are given in Table [1] with the corresponding ranges of P_v, t, X, t : ambient temperature , P_v vapour pressure .

3 Experimental Study and discussion

The aim of the experimental work is to evaluate the performance of the system in Syrian climate with application of $CaCl_2$, which is the most available and cheap absorbent as the working desiccant, also, to increase the production rate of this system, the unit in particular of absorption has been considered as a compressed tower containing porous material which holds the absorption salt of the moisture , where as a cotton cloth has been used as a holder of calcium chloride. Increasing the absorption time is executed by means of the forced bearing by using a centrifugal fan . The absorption-regeneration cycle for production of water from air have been studied, Experiment took place in the city of Homs - Syria which has a semi-arid climate In the summer and winter of 2006 the first period from 01.10 to 20.01.2006. and the second from 10.08 to 20.08 .2006 in the same time, system operation problems must be highlighted. Figure 2 shows a schematic diagram of the experimental apparatus. The followed figures show the experimental results: It has been proved by the results measured, and the figure (3) that the time required to reach the complete the process of absorption proportional inversely with relative humidity,and for relative humidity 70% is 290 minutes, while for relative humidity 50% is 315. From figure (4) that the operational concentration of the system is X = 0.3 - 0.45 % and the minimum values of the concentration of X_{min} suit inversely with relative humidity at constant temperature during the experiment, we note that at low values of temperature will be absorbed more effectively and this agreed with theoretical values calculated from equation (2) the effect of temperature diminishes at higher values of relative humidity ($\varphi > 75\%$).From Figure 5 and 6 we note that the amount of water produced from this device increases with increasing relative humidity and decreased air temperature.



1. Duct of galvanized steel 20x20 cm^2. 2. Absorbent material 3. Fan 4. Electric heater 5.Measured temperature and humidity of the air (testo) 6. Vapor condenser 7. Bottle collecting water condensate

Fig. 2. Schematic diagram of the experimental apparatus

4 Conclusion

An integrated desiccant for production of water from ambient air has been designed, constructed and experimentally tested. Calcium chloride is applied as the working desiccant in this investigation work. The system operation involves absorption of water from ambient air then the desiccant regeneration as well as water vapor condensation, to be applied in Homs climate. As through the experiment it is noticed that the range of concentration range is about X=0.3-0.45 %, and it can be generated about from 0.7 -1.2 m3 of water for one ton of CaCl2 at low relative humidity (40%), and about from 3-3.5m3 of water at high relative humidity (80%), It was noticed that absorption continues for about five hours and the regeneration process continues for about 45 minutes. The design of a tightly closed system seems to be extremely important to minimize vapor leak during regeneration. This system, which has been studied here is applicable in the city of Homs, Syria. Air can be a source of fresh water in arid and semi-arid and even desert area.

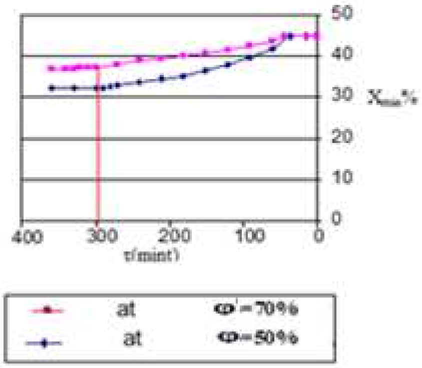


Figure 3
Determine the time requred for the process of absorption

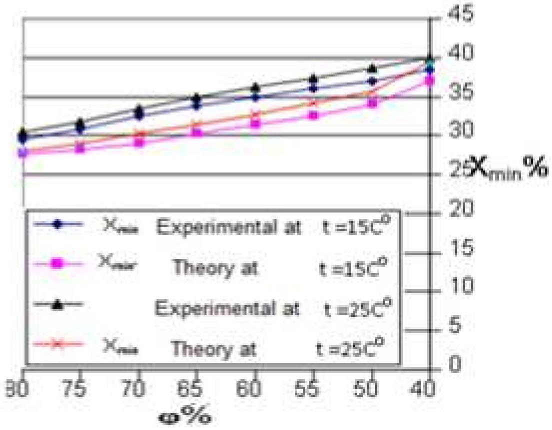
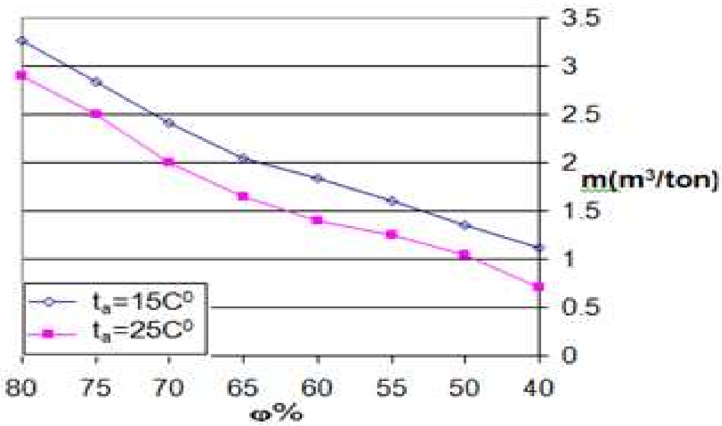


Figure 4
The effect of temperature and relative humidity on the minimal concentration of the solution



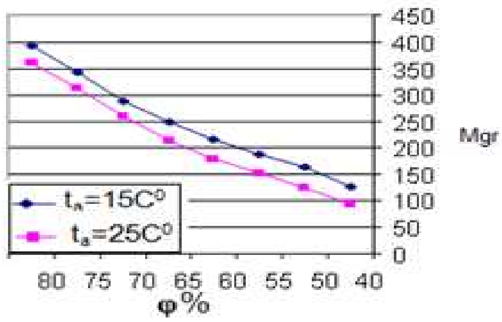


Figure 5
The effect of temperature and relative humidity on the amount of produced water in one day per 1000 Kg of $CaCl_2$ where m m^3/ton$CaCl_2$ amount of produced water

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