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A Technical Review on Atmospheric Water Extraction

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Abstract- In the present work, an investigation on the review of extraction of atmospheric water with the application of solar energy to heat a bed of desiccant for recovery of water from atmospheric air is presented. The study also aimed at evaluating the effects of different parameters on the productivity of the system during operation period. These parameters include system design characteristics and the climatic conditions. An experimental unit has been designed and installed for this purpose in climatic conditions of different areas. The desiccant is subjected to ambient atmosphere to absorb water vapour in the night. During the sunshine period, the layer is covered with glass layer where desiccant is regenerated and water vapour is condensed on the glass surface. Ambient temperature and bed temperature are recorded. Also, the productivity of the system has been evaluated. Desiccant concentration at start of regeneration is selected on the basis of the climatic data of the particular region. Experimental measurements show that about 1.0 liter per m2 of pure water can be regenerated from the desiccant bed at the climatic conditions of the region. Liquid desiccant with initial concentration of 30% can be regenerated to a final concentration of about 44%. Desiccant concentration at start of regeneration is selected on the basis of the climatic data of region. This method for extracting water from atmospheric air is more suitable for desert areas.

1. INTRODUCTION

Water is basically necessary for life. The amount of fresh water on the earth is only 2.53 percent (35 million km³) of the total amount (1.384 billion km³). A large fraction of fresh water (24 million km³) is ice and permanent snow in the Antarctic and Arctic regions. The main source of water for human consumption (fresh water lakes and rivers) contains about 0.26 percent of the total global fresh water reserves (90,000 km³).

Atmospheric air contains about 14,000 km³ of water in vapor form, and hence it can be used as a new and renewable water resource. Extraction of water form atmospheric air can be accomplished by two different methods. 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 liquid desiccant, with subsequent recovery of the extracted water by heating the desiccant and condensing the evaporated water.

Moreover, solar energy can be used as a renewable source of heat in extraction processes of water from atmospheric air. In present work an analytical study is done for calculation of mass of absorbed water from atmospheric air. Calcium chloride and silica gel are used as desiccant for absorbing the moisture and tilted surface wooden box with glass covering is used for evaporating and condensing absorbed water vapors. The study which is carried out theoretically, aims to evaluate the effect of different parameters on the system performance. These parameters include driving parameters which are radiation intensity and ambient temperature and other auxiliary parameters such as climate, region, day, time and surface area.

Naturally, water scarcity is not a new problem. Contaminated drinking water is dangerous to health. A recent study by Lorna of WHO indicates that every eight second a child dies from a water related disease and that each year more than 5 million people die from illnesses linked to unsafe drinking water or inadequate sanitation. Household water filters cannot remove all the parasites, viruses, bacteria and heavy metals. These factors indicate the need of developing or identifying appropriate techniques suitable for an arid place especially situated at remote villages in developing countries in order to produce good clean potable drinking water, and to conserve water and energy.

2. LITERATURE REVIEW

The first project was proposed by V. V. Tygarinov named as "An Equipment for Collecting Water from Air," in Russia, 1947 [2]. An apparatus consisting of a system of vertical and inclined channels in the earth to collect water from atmospheric air by cooling moist air to a temperature lower than its dew point has been proposed.

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A. M. Hamed, "Absorption-Regeneration Cycle for Production of Water from Air-theoretical Approach"[1]. Description and analysis of the theoretical cycle for absorption of water vapour from air with subsequent regeneration, by heating is presented in first model. A theoretical limit for the maximum possible amount of water which can be collected from air using the desiccant through the absorption regeneration cycle at certain operating conditions of ambient parameters, heat to be added to the desiccant during regeneration and maximum available heating temperature could be evaluated through the analysis of this cycle. The absorption regeneration cycle, which can be applied for the production of water from atmospheric air, is shown in Figure 2.1. The theoretical cycle is plotted on the vapour pressure-concentration diagram for the operating absorbent and consists of four thermal processes which are:

- Process 1-2: isothermal absorption of water vapour from air.
- Process 2-3: constant concentration heating of the absorbent.
- Process 3-4: constant pressure regeneration of absorbent.
- Process 4-1: constant concentration cooling of absorbent.



Fig. 1 Absorption regeneration cycle

This cycle can be applied in desiccant systems with different configurations and different heat sources. As the purpose of this cycle is to produce water from air and the input energy to the system is the heat added during the regeneration process, then the efficiency of the cycle can be defined as the ratio of heat added to regenerated vapour to the total heat added. Theoretical analysis showed that, strong and weak solution concentration limits play a decisive role in the value of cycle efficiency. However, a modified cycle is described and analyzed by Sultan. In this modified cycle, the practical considerations were taken into account.

A. M. Hamed "Application of Solar Energy for Recovery of Water from Atmospheric Air in Climatic Zones of Saudi Arabia."[3] In this paper the application of solar energy to heat a sandy

bed impregnated with calcium chloride for recovery of water from atmospheric air is presented. The study also aimed at evaluating the effects of different parameters on the productivity of the system during regeneration. These parameters include system design char- acteristics and the climatic conditions. An experimental unit has been designed and installed for this purpose in climatic conditions of Taif area, Saudi Arabia. The experimental unit which has a surface area of 0.5 m^2 , comprises a solar/desiccant collector unit containing sandy bed impregnated with calcium chloride. The sandy layer impregnated with desiccant is subjected to ambient atmosphere to absorb water vapor in the night. During the sunshine period, the layer is covered with glass layer where desiccant is regenerated and water vapor is condensed on the glass surface. Ambient temperature, bed temperature and temperature of glass surface are recorded. Also, the productivity of the system has been evaluated. Desiccant concentration at start of regeneration is selected on the basis of the climatic data of Al-Hada region, which is located at Taif area, Saudi Arabia. Experimental measurements show that about 1.0 liter per m2 of pure water can be regenerated from the desiccant bed at the climatic conditions of Taif. Liquid desiccant with initial concentration of 30% can be regenerated to a final concentration of about 44%. Desiccant concentration at start of regeneration is selected on the basis of the climatic data of Al-Hada region. The climate of Taif city is dry compared with that for Al-Hada region. This method for extracting water from atmospheric air is more suitable for Al-Hada region especially in the fall and winter.



Fig. 2: Working model by A. M. Hamed





Fig 3 Temperature v/s Time graph by A. M. Hamed

Alexander Bolonkin "Extraction of Freshwater and Energy from Atmosphere"[4]. Author offers and researches a new, cheap method for the extraction of freshwater from the Earth's atmosphere. The suggected method is fundamentally dictinct from all existing methods that extract freshwater from air. All other industrial methods extract water from a saline water source (in most cases from seawater). This new method may be used at any point in the Earth except Polar Zones. It does not require long-distance freshwater transportation. If seawater is not utilized for increasing its productivity, this inexpensive new method is very environment-friendly. The author's method has two working versions: (1) the first variant the warm (hot) atmospheric air is lifted by the inflatable tube in a high altitude and atmospheric steam is condenced into freswater: (2) in the second version, the warm air is pumped 20-30 meters under the sea-surface. In the first version, wind and solar heating of air are used for causing air flow. In version (2) wind and propeller are used for causing air movment. The first method does not need energy, the second needs a small amount. Moreover, in variant (1) the freshwater has a high pressure (>30 or more atm.) and can be used for production of energy such as electricity and in that way the freshwater cost is lower. For increasing the productivity the seawater is injected into air and solar air heater may be used. The solar air heater produces a huge amount of electricity as a very powerful electricity generation plant. The offered electricity installation in 100-200 times cheaper than any common electric plant of equivalent output.



Fig 4 Working model by Alexander Bolonkin

"Experimental Elsarrag Esam investigations on water recovery from the atmosphere in arid humid regions".[5] In this paper author propose the project in Gulf region which is one of the most arid regions in the world. The lack of water is considered as the most important problem. Annual rainfall is slight and erratic, with an annual average of 81 millimetres in Doha. As a result, renewable ground water resources are extremely limited and, in addition, there are problems with groundwater salinity. The atmosphere, endless source of water, contains a large quantity of water in the form of vapour in varying amounts especially in Gulf coastal region. In this paper two methods of collecting water from the atmosphere are presented. First by collecting condensate water, which is usually discarded, from existing air conditioning systems. Experimental measurements of water recovered from the atmosphere by existing air conditioning systems have been carried out. The average rate of condensed water collected during the experiments is found to be about 7.21/day per kW cooling. The experiments demonstrate a cost efficient means of water recovery which can be implemented in air conditioned buildings. The second method is a novel tilted solar absorption/desorption system, modified from conventional solar still, which used to collect water from the atmosphere. Air is entered to the system at night where water is absorbed by the desiccant. In the daytime the desiccant is heated by solar energy to evaporate the absorbed water. Calcium chloride is used as the desiccant and a corrugated blackened surface is used to heat the desiccant in daytime. It is found that the factors have the greatest effect on the evaporation of water from the desiccant are the temperature difference between the desiccant and the glass and the desiccant flow rate. The higher evaporation rate from the solar tilted unit is found to be about 0.181/min per m2 of solar collector area.

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Fig 5 Working Model by Esam Elsarrag

A. E. Kabeel "Application of sandy bed solar collector system for extraction of water from air".[6] In the present study the effect of using sandy bed solar collector system for extraction of water from air has been demonstrated. The sandy bed used to simulation of the Arab country desert condition. The system is studied experientially at three different tilt angle 15, 20 and 25 degree. The theoretical model was constructed to study the effect of various parameters such as solution concentration and solar radiation intensity. The results show that the system can provide an amount of 1.2 liter of fresh water per square meter of glass cover per day. The agreement between theoretical results and experimental measurements is found to be reasonable. Results show also that the tilt angle of 25 degree give a higher productivity during the experimental period.



Fig 6 Model by A. E. Kabeel

3. CONCLUSION

From the above papers we conclude that the water extracted is pure and with varing area and tilt angle we found that the regeneration rate is get increased. In the first paper we found that how the water is extracted from air from second-one we learn the absorption-regeneration cycle. And from third, fourth and fifth we found that in arid as well as in gulf region the water will be extracted. From sixth paper we found that how angle of tilt affects the extraction rate.

4. REFERANCES

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