

The Experimental Measurement of the LiBr Concentration of a Solar Absorption Machine

N. Hatraf, L. Merabeti, Z. Neffeh, W. Taane

Abstract—The excessive consumption of fossil energies (electrical energy) during summer caused by the technological development involves more and more climate warming.

In order to reduce the worst impact of gas emissions produced from classical air conditioning, heat driven solar absorption chiller is pretty promising; it consists on using solar as motive energy which is clean and environmentally friendly to provide cold.

Solar absorption machine is composed by four components using Lithium Bromide /water as a refrigerating couple. LiBr- water is the most promising in chiller applications due to high safety, high volatility ratio, high affinity, high stability and its high latent heat. The lithium bromide solution is constitute by the salt lithium bromide which absorbs water under certain conditions of pressure and temperature however if the concentration of the solution is high in the absorption chillers; which exceed 70%, the solution will crystallize.

The main aim of this article is to study the phenomena of the crystallization and to evaluate how the dependence between the electric conductivity and the concentration which should be controlled.

Keywords—Absorption chillers, crystallization, experimental results, Lithium Bromide solution.

I. INTRODUCTION

THE basic single-effect LiBr-water absorption cycle is illustrated in Fig. 1. The absorber/pump/solution heat exchanger/generator assembly essentially replaces the compressor in a vapor-compression refrigeration system. This assembly is sometimes referred to as a thermal compressor. A dilute (weak) solution of LiBr in water is pumped from the absorber to the generator (1-2).

A solution heat exchanger preheats the weak solution before entering the generator (2-3). A flat Plate collector heats the solution in the generator to boil the water (the refrigerant) from the solution. The water vapor then flows to the condenser (7) where it is condensed and the heat is rejected to the ambience. The condensed water flows through an expansion device (8-9), where the pressure is reduced. The heat flows into the evaporator (9) (providing the desired cooling effect) by evaporating the resulting hot vapor returns to the absorber.

The weak solution is cooled in the solution heat exchanger. When the water is boiled out of, the remaining solution becomes weak in refrigerant (high concentration of LiBr). (4-5), and then flows through a flow restriction (5-6) to lower its pressure to return to the absorber. The absorber absorbs the water vapor returning from the evaporator, diluting the weak

solution. Once the solution is reconstituted, it is pumped to the generator (2-3). The entire cycle operates below atmospheric pressure.

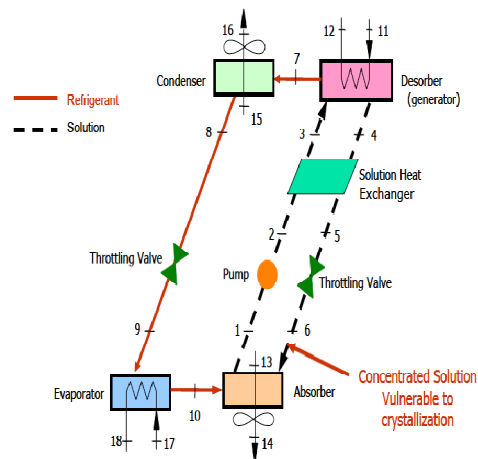


Fig. 1 Absorption chiller cycle [2]

II. CRYSTALLIZATION PHENOMENON

The crystallization in a Lithium bromide solution is a serious problem that should be taken into account, it occurs when the solution is more concentrated and cooled.

One of the methods used to measure the concentration of the solution is the method which measures the electrolyte conductivity of the binary water/lithium bromide [3].

Solid LiBr salt is structurally crystalline in nature. When LiBr is dissolved in water, it becomes an aqueous solution.

The nature of LiBr solutions is that the salt component precipitates when the mass fraction of salt exceeds the solubility limit. [6].

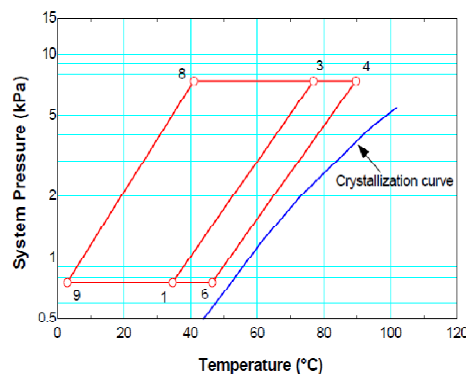


Fig. 2 Crystallization curve in (P-T) diagram

N. H., L. M., Jr., and Z. N. are with the Development Unit of Solar Equipment, road N° 11, BP 386, Tipaza, Algeria (phone: 0021-3244-10200; fax: 0021-3244-10133; e-mail: hatrafnesrine@ ahoofr, leiled@yahoo.fr, n_mass2001@yahoo.fr).

III. WHAT CAUSES THE CRYSTALLIZATION?

Many factors may cause the crystallization of the absorption machine such as the ambient temperature, the cooling mode and others.

A. The Presence of Air or Non-Condensable Gas during the Corrosion

The presence of the gas deteriorates not only the machine but also increases the pressure of the system, decreases the capacity and increases the likelihood of crystallization. The most conventional method to keep the pressure required is to evacuate vapors periodically through the vacuum pump.

B. A Very Hot Environment (High Temperature)

The ambient temperature affects mainly the operating of the absorption machine when the cooling air process is used. Increasing the ambient temperature from 25 to 35°C, the cycle approaches the crystallization line.

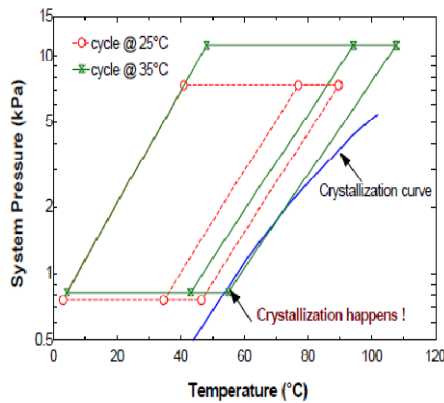


Fig. 3 The effect of the ambient temperature on the crystallization

C. The Temperature of the Cooling Water of Condensation is Low Enough

When the cooling temperature of the condenser is sufficiently low, it causes the drop of the solution in the absorber.

D. High Temperature of the Generator

The temperature of the generator is a predominant factor to improve the cop of the absorption machine up to a certain value or effect becomes constant. If the generator temperature is high, the solution becomes more concentrated and therefore crystallization takes place.

TABLE I

THE INFLUENCE OF THE GENERATOR TEMPERATURE AND THE CONDENSER TEMPERATURE ON THE CRYSTALLIZATION

T_c (°c)	T_g (°c)	Heat supplied from flat	Crystallization occurs
20	43	Yes	No
25	55	Yes	No
30	66	Yes	No
35	78	Yes	Yes
40	90	Yes	Yes
45	105	No	Yes
50	119	No	Yes
55	139	No	Yes

From Table I we noticed that as soon as the condenser temperature exceeds 40°C, the crystallization took place.

E. Failed Dilution after the Stop Working Machine

During a normal shutdown of the absorption machine, it undergoes an automatic dilution, which decreases the concentration of the solution in the absorption machine and in this case the crystallization will not occur.

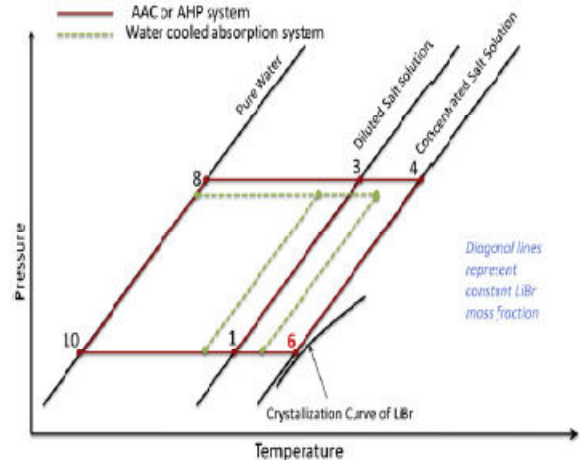


Fig. 4 The effect of the cooling mode on the crystallization phenomenon [7]

IV. EXPERIMENTAL SETUP

A. The Preparation of the Solution

As the lithium bromide is extremely hygroscopic [1], it is important to insure when preparing the sample that no moisture from the atmosphere is absorbed.

The solution was prepared by using pure lithium bromide (99%) references as 7550-35-8, with 86.85g/mol hygroscopic and distilled water; weights of the salt were realized by a digital balance in order to vary the concentrations.

B. Instrumentation

We need from a distillatory a precise volume of water to dilute the same quantity of lithium bromide in it. The mixed solution has to be concentrated at 50%, this kind of binary solution is an exothermic reaction, so it releases heat. The solution is heated trough electrical source and an agitation to homogenize the solution, in industrial absorption chillers, absorbers are comprising of several rotating disks semi submerged in the solution for a perfect mixture[4]. Once the temperature of the solution increases, it changes the color from white to blue.

Many measurements were carried out to estimate the electrical conductivity.

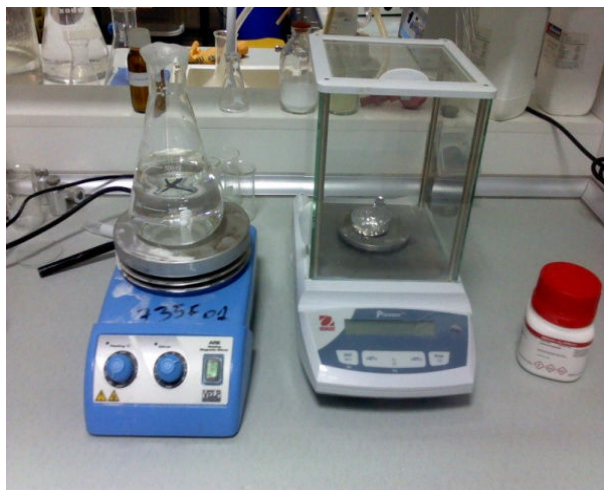


Fig. 5 The heating process of the solution

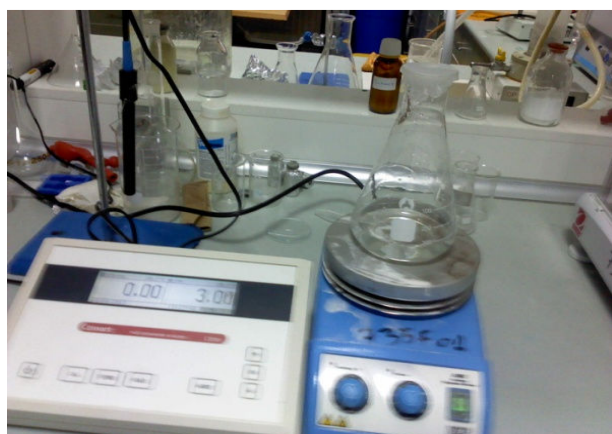


Fig. 6 The measurement undertaken

We keep the concentration of the solution constant then we vary the temperature. For each temperature we read the value of the electrical conductivity, after that we vary the concentration by adding more salt in the solution to obtain curves presented in the figure below.

C. The Crystallization Process

The boiled solution is introduced in a recipient of cooled water as shown in the Fig. 7, and then we read the temperature of the solution until the crystallization occurs.

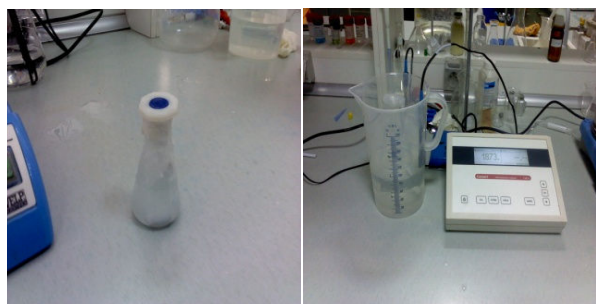


Fig. 7 The crystallization of the solution

V. RESULTS AND DISCUSSIONS

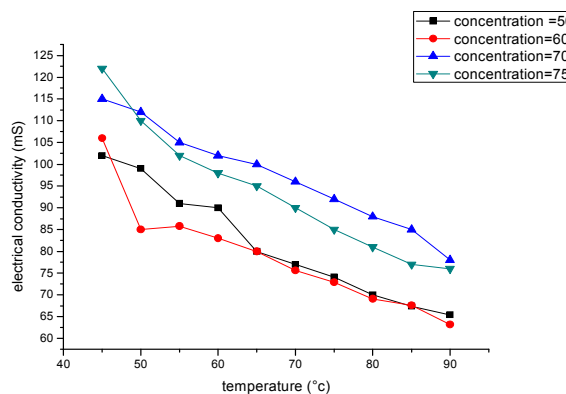


Fig. 8 The relation between the electrical conductivity and the concentrations

The Fig. 8 presents how the temperature affects on the variation of the electrical conductivity and the concentration of the Lithium bromide /water solution in one hand, and the relationship between the concentration and the electrical conductivity in the other hand. These experiments agree with the trends presented by Hamann [5].

For a constant concentration, the electrical conductivity decreased with the increase of the temperature. It is due to the fact that diluted solution (containing more water) has a high electrical conductivity because it conducts the electricity, more the solution becomes concentrated, (less water), and the conductivity becomes less.

After many experimental investigations, we have noticed that cooling a lithium bromide/water solution concentrated at 75% and heated to 90°C, the solution crystallized.

VI. CONCLUSION

The aim of this paper is to find and explicit a relationship between the concentration of the lithium bromide water solution and the electrical conductivity in order to prevent the crystallization of this solution. In the case of the crystallization, the salt crystals block the absorption machine and as a consequence the machine stops working.

Those experimental investigations allow us to know at which value of the electrical conductivity (which is easy to estimate), the solution will crystallize, so we can either add water to the absorber of the absorption machine to dilute the concentrated solution or to stop heating the solution.

ACKNOWLEDGMENT

Authors and with gratitude thanks the members of the laboratory of water treatment for their help and assistance.

REFERENCES

- [1] R. Lide, R. Kehiaian, CRC Handbook of Thermo physical and Thermo chemical Data, CRC Press, Boca Raton, Florida, USA, 1994. W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont CA: Wadsworth, 1993, pp. 123–135.

- [2] K. Herold, R. Radmacher, A. Klein, and A. Sanford, Absorption Chillers and Heat Pumps. CRC Press; New York, (1996). B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.
- [3] R. Horn, Determination of Concentration in Lithium-Bromide Refrigeration Cycles by Measurement of the Electrolytic Conductivity or Density", Progress in Refrigeration Sci. Tech. Pro. Int. Congr. Refrig. ; 2(317-328). 1969
- [4] F. Swallow, I. Smith, "Vapor absorption into liquid films on rotating discs", International Journal of Refrigeration, Vol. 12, 1989J. Wang, "Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication)," *IEEE J. Quantum Electron.*, submitted for publication.
- [5] H. Hamann, A. Hamnett, Vielstich, "Electrochemistry" Wiley-Vch. Weinheim. Germany. 1998, pp. 13-65..
- [6] J. Labus. «Modelling of small capacity absorption chillers driven by solar thermal energy or waste heat". Thesis,Rovira I Virgili university,Tarragone,2011.
- [7] K. Wang, O. Abdelaziz, P. Kisari, E. A. Vineyard,"State-of-the-art review on crystallization control technologies for water/LiBr absorption heat pumps".