# EXPERIMENTAL EVALUATION OF BARIUM CHLORIDE-AMMONIA IN AN ABSORPTION SOLAR REFRIGERATION PROTOTYPE

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**Abstract**
An experimental intermittent absorption refrigeration system was built at the Energy Research Centre of the National University of Mexico to probe different absorbents. The barium chloride absorbent using ammonia as refrigerant was tested. This paper describes the equipment components and the results of the experimental work. The results showed that generation temperature was between 53°C and 75°C. The generation pressure was in the rank of 10 bar. The refrigeration capability was of 80 to 100 kJ for 100 ml of ammonia. The energy supplied to the experimental system was by means of hot water. The water was heated with an electrical resistance. Later the actual generator will be replaced by a compound parabolic concentrator (CPC) which acts as an absorber too.

**Keywords**. Solid absorbent, generation, CPC, intermittent refrigeration.

## 1. Introduction

Absorption refrigeration is based on the principle that some salts can absorb large quantities of refrigerant that can be regenerated with the application of heat. The heat energy required for the regeneration process may be supplied from any suitable heat source such as solar energy and waste heat. Absorbents used in refrigeration process can be solid such as barium chloride or liquid such as lithium nitrate.

Enibe (1997) reported than Plank was pioneer in solid absorption systems who used $CaCl_2$-$NH_3$ and hot water (100°C) as heat source, with a cooling capacity of 3768-4187 kJ/cycle, he also reported than Andrew used steam as heat source and $CaCl_2$-$NH_3$ on a food refrigerated transport van. Iloeje (1985) built an intermittent system $CaCl_2$-$NH_3$ with a double glazed collector giving a cooling capacity of 714 kJ/m$^2$ and a coefficient of performance (COP) of 0.096. Dueñas, Pilatowsky et al. (2001) reported the theoretical results of a thermodynamic analysis and dynamic behaviour of the solar heating system which operates with barium chloride-ammonia as absorbent, they reported theoretical temperatures of generation around 50-60°C and proposed the construction of the experimental unit to compare the theoretical results.

In this paper the experimental device and the results of evaluation of the $BaCl_2$ acting as absorbent in an intermittent absorption refrigeration system are presented.

## 2. System description

The experimental equipment consists basically of a reactor which acts as a generator-absorber (fig. 1), a condenser (fig.4), a storage tank (fig. 2), a spread valve and an evaporator (fig. 3).

In addition, the system has a heater-cooling subsystem that provides hot water for generation stage and cold water for absorption stage. Reactor is heated with hot water or a resistance. An acquisition data is used to read pressure and temperature values in different sections.

When the barium chloride is charged into the reactor, ammonia vapour is absorbed by the salt (fig.5), the pressure in this moment is around 3.5 bar, then the reactor is ready for the generation. The reactor is heated by of hot water between 85°C to 95°C, when the inner reactor temperature reaches values between 53°C to 80°C, the ammonia vapour is generated. In this conditions the pressure in the reactor is around 10 bar; the vapour passes to the condenser, then it passes to the storage tank; the process continues until the generation stage finishes. After, the reactor is cooled by cold water and the spread valve is opened, where the ammonia liquid is expanded, it goes to the evaporator doing the refrigerant effect, then the ammonia is absorbed by the barium chloride and the cycle is completed. A general view of the system is in fig. 6.

Fig. 1 Reactor acts as a generator-absorber. Inside there are three thermocouples

Fig.2. Storage tank

Fig. 3. Evaporator

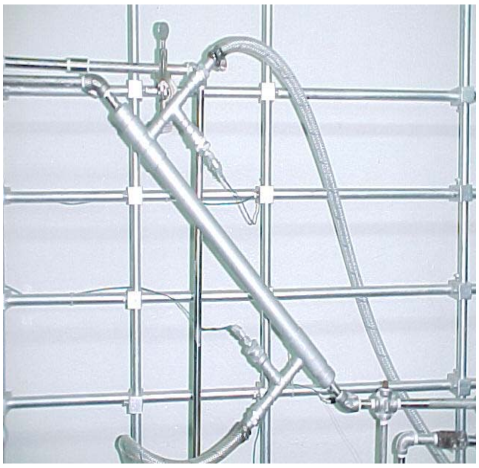

Fig.4. Condenser with water circulation

Fig. 5. Ammonia tank

Fig.6. General view of the absorption refrigeration system showing the heater-cooling subsystem

## 3. Results

The generation temperature inside reactor begins around 53°C and reaches temperature as high as 80°C, (fig.7). The temperature in the reactor inner wall is around 70°C and hot water average temperature is 85°C. The generation pressure is between 9 to 11.5 bar, depending ambient conditions. In this conditions the system generated 100 ml of ammonia liquid in the storage tank during around 2 hours. During evaporation stage the ammonia pressure descends until 1.5 to 2.5 bar with temperatures from –5°C to –15 °C during 80 minutes approximately (fig 8). The 100 ml of ammonia cools 700 ml of water from 25°C to 9°C in the evaporator.

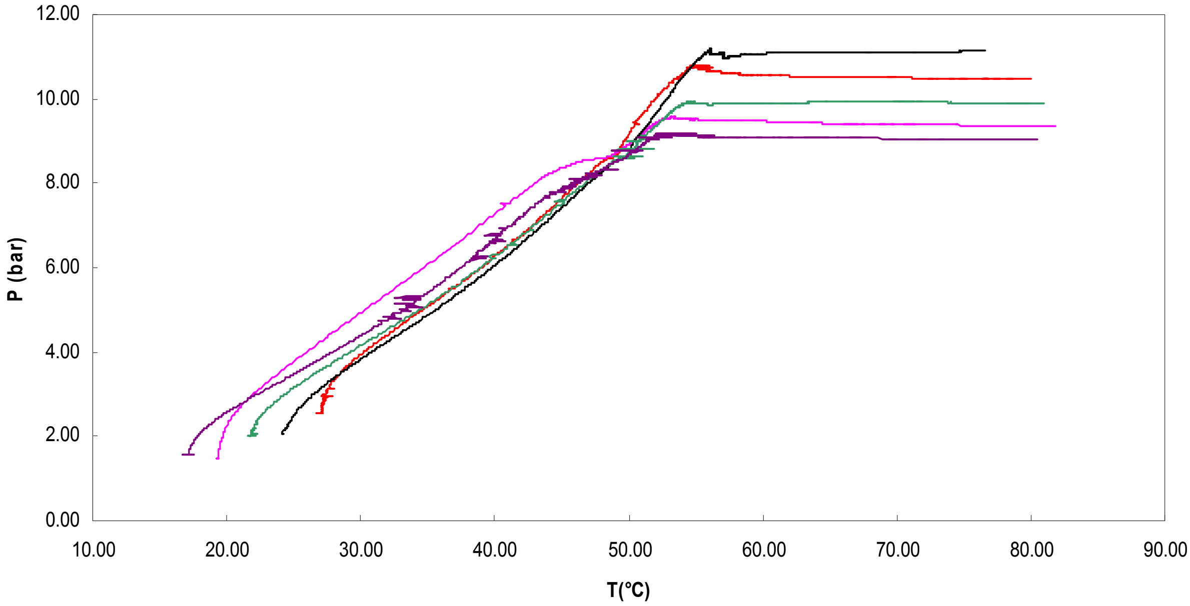


Fig. 7. Generation temperature for diferent probes

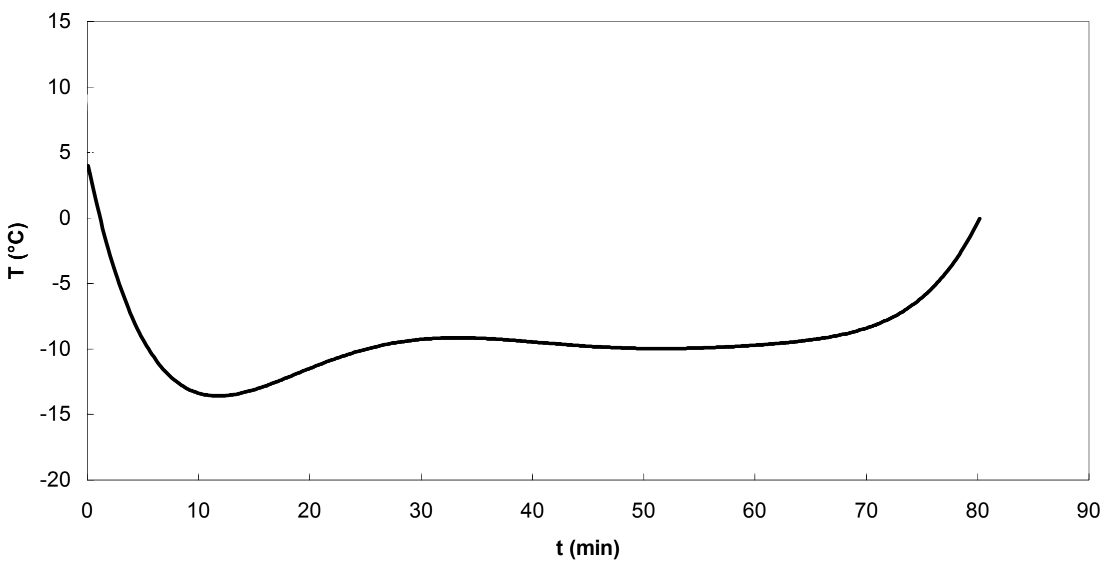


Fig. 8. Ammonia temperature during the evaporation stage

## 4. Conclusions

The generation temperatures presented in fig. 7 let think that it is possible to use flat plate solar collectors with high performance (70-75%) to heat the reactor which requires temperatures in a rank of 85 to 95°C. Other option is to use a CPC because in this kind of concentrators it is relatively easy to reach the required temperatures.
Once the generation begins, the temperature increases due to the quantity of ammonia inside the generator is only 150 ml for 0.5 kg of $BaCl_2$. With a bigger equipment the ammonia concentration could be higher and generate at temperatures between 53° to 60°C, decreasing the warm water temperatures required for the heat source. The generation rate lets think that it is possible to have the necessary quantity of ammonia to obtain refrigeration capabilities to satisfy the necessities in rural communities using only solar energy.

## 5. References

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