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# Development of Analyzer and Rectifier for Solar Refrigeration System

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***Abstract*— Refrigeration and air conditioning have become a need in today's world. The demand for air conditioning has expanded dramatically as technology has advanced. In addition, CFC refrigerants used in vapor compression refrigeration systems endanger the ozone layer. It's past time to put solar refrigeration on the market. It does, however, necessitate a more sophisticated setup and is currently explored. If the system can be linked to a hot water supply, it could be cost-effective. The goal of this paper is to construct a reflector-assisted analyzer and rectifier. As a result, the arrangement can meet the temperature requirements even in cold weather, making it useable all year. In this paper, it is concluded that the black chrome selective coating panel, which is normally used in a water heating system, can serve the purpose of the generator and a paraboloidal dish for the analyzer should be provided with the system for making the solar refrigeration system. Using a black chrome panel and electroplating on the dish of paraboloidal concentrator with reduced diameter shows the satisfactory result.**

***Keywords*** — Flat plate collector, Parabolic collector, Paraboloidal collector, Li-Br-$H_2O$, absorption, refrigeration system.

## I. Introduction

The consumption of energy has expanded dramatically in today's advanced technology and luxury lifestyle, and the threat of traditional energy sources depletion has reached an alarming level. Non-conventional energy sources, such as tidal energy, wind energy, and solar energy, require extensive research. The use of these energies has become a necessity in recent years. Furthermore, non-conventional resources are gaining traction due to their environmental benefits and inexhaustibility as energy sources.

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In response to the crisis of conventional energy, solar energy as an alternative source of energy has gained momentum all over the world. The tapping of solar energy is a most favorable resource of energy in the belt of between latitude 40°N and 40°S in which most of the underdeveloped countries are located. India which is situated on longitude 82.5°E and longitude of local meridian 76.18°E receives nearly 5 to 7 kWh solar energy daily, per square meters of horizontal surface. In India, solar energy is available 280 days out of the year on average. Solar energy is free, unlimited, and pollution-free, which is a significant benefit in light of the current pollution crisis caused by fossil fuels. A huge number of commercial applications have already emerged in this field. Water heating [1], desalination, space heating [2], and crop drying are just a few examples. Solar refrigeration solutions that are economically viable are also being developed. CFC refrigerators also pose a threat to the ozone layer, whereas absorption refrigeration has no negative impact on the ozone layer.

Solar cooling necessitates a sophisticated setup and is highly inconvenient, which is why it is still not commercially available in the country. The principle is the same as in a refrigerator: high-grade energy is utilized to remove low-grade energy from a low-temperature environment, allowing it to chill even lower [3-4]. Solar energy has the potential to replace high-grade energy sources [5-7].

If such a solar air conditioning system can be constructed properly, the benefits will be significant [8-10]. The use of solar energy to power a traditional vapor absorption system for air conditioning has become a hot topic, and this study looks at it. Solar collectors supply energy to a thermodynamic cycle in which the working fluid for the system is a refrigerant solution with an absorbent [11-13]. Solar collector, paraboloidal concentrator, analyzer, and rectifier are the most important components for heating and cooling a building [14-15]. In this work, we are discussing mainly the Li-Br water vapor absorption refrigeration system.

### *A. Li-Br Water Vapor Absorption Refrigeration System*

Water is employed as a refrigerant, while lithium bromide salt solution is used as an absorbent in this system. An aqueous solution of lithium bromide with a high salt content has an extremely low vapor pressure. At 43.5°C, a 60 percent lithium bromide water solution has a pressure of 0.625 centimeters of mercury, which is low enough for water to boil at 6°C. Because of its low vapor pressure, lithium bromide solution has a great attraction for water vapor, therefore if water and lithium bromide solution is placed next to each other in a closed evacuated system, the water will evaporate [7].

For air conditioning, in which refrigeration temperatures below 0°C are not needed an absorption refrigeration system of this type has been successfully developed [15-17] and has achieved great commercial success, one of these types is shown in figure 1.

In the evaporator the water will evaporate, absorbing its latent heat from the remaining water and lowering its temperature to 2°C. As the pressure in the evaporator is 5.5-centimetre Hg, the cold water in the evaporator is used to cool the brine or water used for air conditioning purposes. This water vapor will be absorbed by a strong lithium bromide salt solution, which is spread in the absorber as shown in the figure, maintaining very low pressure in the evaporator [18].

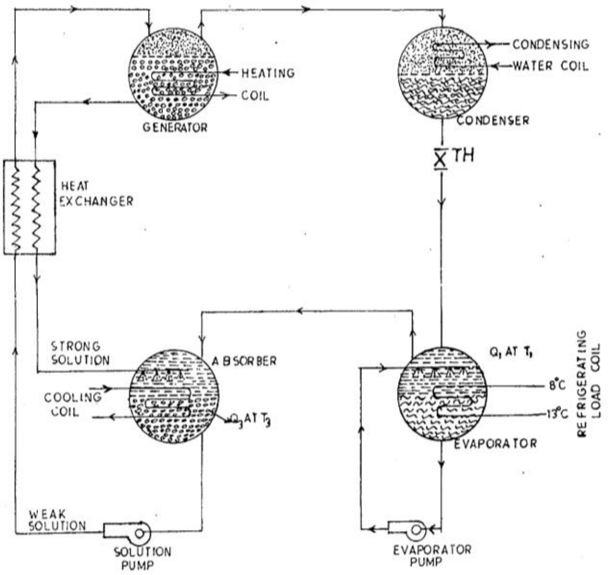


Figure 1. Li-Br-Water vapor absorption system

When water vapor is absorbed, the lithium bromide salt solution is diluted in the absorber, and it must be re-concentrated. A pump transports the weak solution to the generator, where it is heated using an external heat source. In this study, solar energy is used, and a portion of the water is extracted in the form of paper, resulting in a powerful lithium bromide salt solution. As illustrated in the diagram, this translation is sent back into the absorber via the heat exchanger [19]. The created water vapor is then transferred via the condenser, where it is condensed by cold water supplied from outside. The condensed water is returned to the evaporator to replace the water that was evaporated in the evaporator, bringing the cycle to a close.

To increase the absorptivity of lithium bromide salt solution, the heat of condensation must be dissipated from the absorber as the water vapor enters the salt solution in the absorber. This is accomplished by circulating cold water from an outside source [20].

Between the absorber and the generator, a heat exchanger cools the strong solution and heats the weak solution of lithium bromide and water. It lowers the heat load in the generator and the cooling load in the absorber, as well as the plant's overall operating costs.

The lithium bromide water refrigeration technology is mostly used to chill water and in air conditioning plants. As a result, machines with capacities ranging from 100 to 700 tons are available.

*B. Use of Solar Energy in Lithium Bromide Water Refrigeration System*

Because heat energy is necessary to make vapor, this heat energy is delivered by a solar collector in a solar refrigeration system, depending on the application. The cycle's energy requirements are fulfilled by solar energy, which lowers the cycle's operating costs dramatically. The disadvantage of using solar energy for cooling is the temperature difference between the relatively high temperature required at the generator and the comparably lower temperature than solar collectors can efficiently give [21]. The absorption refrigerator cycle's efficiency declines significantly as the operating temperature drops. To improve the efficiency of an absorption refrigerator at a fully loaded working temperature, the system would have to be rebuilt, which would increase the system's complexity and, as a result, its cost. For example, if a product is not commercially viable, there is an alternative.

On the other hand, the efficiency of solar collectors decreased significantly at the increased temperature. To maintain a reasonable efficiency at comparatively higher temperatures under mentioned, additional points have to be taken care of while designing their collectors.

- Absorber plates should be made of high-grade metals such as copper.
- The coating that has to be applied should be selective, in present work black chrome.
- Transparent cover that allows the highest possible fraction of incident radiations inside the collector and restricts the radiation to the lowest possible.
- Provided with an adjustable stand to adjust the angle according to seasons.

When analyzing the reasons that have resulted in an increase in cost in our country, where 50% of the population is below middle income, solar systems are resisted by 50% of the people owing to the high initial cost, which has no operational cost. As a result, efforts have been undertaken to generate the temperature required for Absorption cooling using a lithium bromide salt solution and a setup that can be combined with a domestic water heater so that the system can be used all year. This would be a cost-effective supplier.

## II. System Description

The proposed lithium bromide water vapor absorption cycle is shown diagrammatically in figure 2. A weak solution of lithium bromide water is pumped from the absorber to the generator which is a flat plate tubular collector. Solar energy absorbed by this flat plate tabular collector heats the weak solution to a temperature of around 80°C due to the supplied heat energy. Water vapor from the weak solution rush towards the analyzer which avails heat from the paraboloidal concentrator. Since the water vapors entering the analyzer still contain some traces of lithium bromide into it, and therefore it is further heated up into the paraboloidal connector to a temperature around 85°C. Separation of water vapor from lithium bromide takes place in the analyzer. Some traces of lithium bromide may still be with water vapors and the process, in this case, will not be isothermal. Water vapor should not contain any amount of lithium bromide. Therefore, rectifying column is introduced in the system [22].

Pure water vapors from the rectifier run towards the condenser and lithium bromide solution are drawn back to the generator from where the strong lithium bromide solution is again fed back to the absorber through a heat exchanger for absorbing the water vapors. Once again, the generator water vapor entering the condenser is condensed using the cold water supplied externally. The condensed water is then passed into the evaporator which is maintained at a pressure of around 5.5 cm of Hg. In the evaporator, the water evaporates absorbing the latent heat from the remaining water and lowering its temperature around 2°C. The cold water in the evaporator is then used to cool the water on brine solution used for air conditioning.

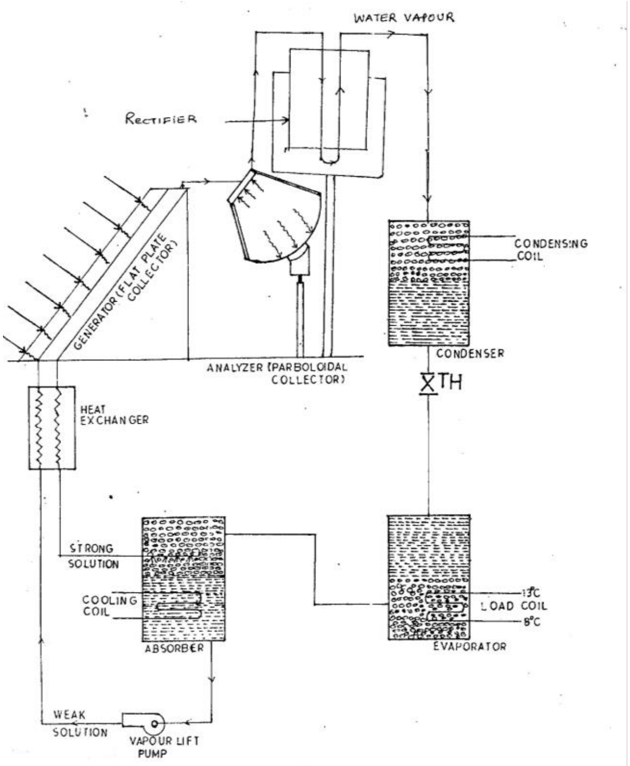


Figure 2. Proposed solar-powered Li-Br water refrigeration system

A pressure-temperature concentration equilibrium diagram for lithium bromide solution is shown in figure 3. The ideal steps in the solution cycle are indicated on the cycle shown in the diagram. The pressure in the condenser and generator is fixed largely by the condenser fluid coolant temperature and the temperature drops across heat exchanger surfaces in the generator and condenser. The pressure in the evaporator and absorber is fixed by the temperature of the cooling fluid to the absorber and by the temperature drop across the heat transfer surface in the evaporator and absorber. Thus, to keep the generator temperature within the limits, the critical design factors include the effectiveness of heat exchangers and coolant temperature. A common practice in solar experiments has been to use a water-cooled absorber and condenser, which in turn requires a cooling tower.

The absorber difference between the high and low-pressure sides of the lithium bromide water system is low enough and the system can use a vapor lift pump and gravity retain from absorber to generator.

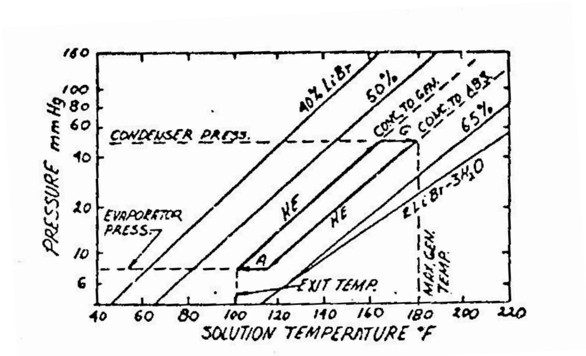


Figure 3. Pressure-temperature concentration diagram for Li-Br-H2O refrigeration system with the idealized cooling cycle

Therefore, obviating the need for mechanical pumping to move the solution from the low pressure to the high-pressure side. Hence, the major energy requirements of the system are only at the generator. Since this energy requirement is met by utilizing solar energy, the operating cost of the system turns out to be very low.

As long as the generator temperature is above the minimum, most of the machines used to date have nearly constant COP. The COP of lithium bromide water coolers is often in the range of 0.6 to 0.8. If the water is used as a coolant, the generator temperature may be in the range of 75°C to 95°C. The effect of verification in the solar energy generator is to vary the capacity of the cooler. Now, since solar-operated lithium bromide water absorption coolers generally use water as a coolant, the target maximum temperature for us should be in the range of 75 to 95 °C.

## III. EXPERIMENTAL SETUP

It was decided to use the mentioned type of solar collectors in the experimental setup for the proposed system.

1. Flat plate tubular collector.
2. Paraboloidal concentrator for the analyzer.

Since the system is not complete as absorber and evaporator is not available in the refrigeration laboratory therefore water alone is used for taking the reading of temperature instead of Lithium bromide water solutions.

*A. Proposed Absorption Type Generator*

The view of this work is to utilize the same setup of flat plate collectors which are been commonly used commercially for water heating purposes in winter, for achieving the required temperature for air conditioning in winter with the minimum changes wherever required. Black Chrome coated fin and tubes absorber is the very latest type of flat plate collector which is now very popular in the use for heating purposes. The coating of black chrome is applied on 0.2mm thickness, the fin of 122 mm width and length 1710 mm whereas polychrome is its brand name which is of company M/s Solchrome Systems India Limited, an Indo-Canadian joint venture at Parwanoo (HP). These fins are tig welded on the copper tube of 12.7 mm outer diameter, 0.7 mm thickness, and 1716 mm in length. 7 pieces of this were used in the experiment. Whereas built-up panels of 10 tubes are commercially available from the marketing division of the company. The advantage of this coating is that more energy is generated per square meter installed and having high operating efficiency. Thermal conductivity through the tig welding interface is 100%, which is for optimum heat transfer. These fins and tubes are joined by soldering the U bend of the tube of the diameter 12.7 mm OD, by flaring the end of bends. Tubes are overlapped at the joint for the joint to be leak-proof. Then these joined fin tubes are placed in a wooden box and insulated by thermocol and glass wool from the bottom and sides. The panel is covered with a glass sheet to reduce re-radiation losses. During the experiment, however, it was observed that at the ambient temperature of 29°C. The temperature recorded was 67.4°C at the flow rate of 12 l/hr and however, the temperature of 80°C can be obtained at the negligible flow. Since the study was carried out considering the dual purpose of heating water and air conditioning, therefore flow should be sufficient, which ultimately means the total collection of heat energy. Therefore, the tube light generator earlier used in the experiment was used in series. Then the temperature of 83°C was recorded which is within the range of 75 to 90°C of Lithium Bromide water solution. The temperature can be still increased by using a complete panel of 10 tubes. But the corresponding losses will be increased at high temperatures. Therefore, it is the prime importance that the area should be decreased at a higher temperature. Therefore, for complete vaporization, the requirement of the analyzer and rectifier is a must.

*B. Paraboloidal Collector, Analyzer*

In an earlier experiment, a disc plate of diameter 1.2 m was used for the paraboloidal collector. It was provided with 2 axis tracking system using 2 brackets and bolts. The reflecting surface used was looking glass. But looking Glass has almost no workability which results in fabrication problem. To give proper paraboloidal shape to concentrator mirror had to be broken into small pieces which were then glued individually on the dish surface which does not produce proper center of the concentrator and result in low concentration.

Studies have already been conducted using silver paper as reflector material for this paraboloidal surface. The paper was pasted on the surface with the help of glue. Reflecting properties of the paper, however, does not match with that of a mirror. The further paper has poor workability and gets damaged in moisture. It is also possible to use a metal reflector of aluminum and silver.

In the experiment brass sheet of thickness 0.7 mm was electroplated with nickel chrome. Since the brass has good fabrication properties. However, due to the problem of electroplating, the 4 pieces were fabricated to give proper shape. The disc diameter was reduced to 0.7 m instead of 1.2 mused earlier.

The dish provided with 2 axis tracking using two brackets and bolts. The first bracket is welded with the dish surface on one side and disconnected with the help of a bolt with the second bracket on the other side. The other side of the second bracket is connected to the stand with the help of another bolt. The dish surface can be turned towards the sun by turning the second bracket. It can also be treated in a way to collect maximum solar radiation from a particular direction by turning the first bracket. Thus, a manual two-axis tracking has been provided to the dish surface.

For the analyzer, a copper cylinder of 0.2 mm diameter and length 0.5 mm was used. Through this cylinder, the copper tube coil of size 5/7 inch has been passed. Heated water leaving the generator was made to pass through this cylinder through this copper tube coil for further heating. The separation of water vapor from the strong solution of lithium bromide in water will occur. This copper cylinder, therefore, acts as an analyzer for the system as actual separation of water vapor takes place. The copper cylinder was sealed so that the temperature of the air may be maintained and that may be transferred to the copper tube and further to the solution. This cylinder was supported over the paraboloidal concentrator at its focal point with the help of the mild steel rods with adjustable height. Since the analyzer gets heated by the reflection from the paraboloidal concentrator, it has been named a reflective analyzer.

### *C. Rectifying Column*

In the system, vapor distilled from the generator contains a considerable amount of absorbent paper, even after the analyzer which subsequently reaches the evaporator after condensation. As a result, the evaporator would not be isothermal, and a required low temperature would not be obtained. Rectifying column is to be used in addition to the analyzer.

A cylinder of 0.25 m diameter and length 0.45 m is used through which 2 tubes of 20 mm diameter are passed parallelly. Tubes are joined from the bottom, forming U-tube. Since the system is still not complete and the solution is not available in the lab, the performance of the rectifier could not be determined. The cylinder is coated black from the outer surface so that the temperature may not fall.

## IV. OVERALL SYSTEM

In the experimental setup, the tubular generator is coupled with the black chrome fin and tube panel to form a generator which will be an absorption-type generator. The paraboloidal concentrator is used for analyzer which forms reflective type analyzer, keeping in mind the objective of achieving maximum heat gain at minimum cost and with full utilization of the available space. In the absence of the lithium bromide water absorption refrigeration system in the lab, tests were made using water as the working fluid and an overhead tank was used for supplying water to the generator to create the required pressure difference for the flow of water through the generator and analyzer. The overhead tank was placed at a height of 12 feet from the floor, on which both the collectors were placed. The generator fixed in a wooden box is placed on an adjustable metal stand. One analyzer was placed on the paraglider collector using a suitable mounting arrangement. The interconnection was coupled with flexible tubes for regulating the flow. Globe valve was connected in line at the entrance of the generators. Then the water flows from the overhead tank and is allowed to pass through the absorption type generator. The corrugated sheet of the flat plate collector collects heat from the sun and transfer to the tubular generator. The heated water then passes through the black chrome-plated fins and tubes panel where the fins absorb the heat of the sun and transfer it to the tube. The heat absorbed by the absorption generator is transferred to the water flowing through this generator. The water, therefore, gets heated up sufficiently at the flow of 12 liters per hour, and then this heated water is passed to the analyzer. During the experiment at an early stage, when the analyzer was not covered with glass cover, the temperature got reduced which forced to cover the cylinder to reduce the heat losses. A rectangular box of glass was put on the analyzer and we get than a positive result. The paraboloidal concentrator of the analyzer collects solar energy from the Sun, concentrates it onto the copper cylinder as it is located at the focal point of the paraboloidal concentrator. The energy absorbed by the copper cylinder, which is blackened to increase its absorptance, is transferred to the water passing through the coil cylinder is airtight so that the temperature of the inside coil may be increased by absorbing the focal energy. The water, therefore, gets further heated up as it enters the analyzer and comes out of it at a still higher temperature. Then this heated water was allowed to pass through the rectifier and then to the water-cooled condenser where discharge was collected. The temperature was recorded by a thermometer in the inlet of the tubular generator. Inlet of black chrome fins and tube panel. The outlet of black chrome panels, the outlet of the analyzer, and the outlet of the rectifier as details of that record are shown in observation results and discussions.

## V. Observations

Different tests were conducted to find out the effectiveness of the components individually as well as collectively. The following tests were undertaken:

### A. Black Chrome Panel

Water was allowed to flow through the Black Chrome anel at the rate of 12 l/hr and temperatures at inlet and outlet were recorded with clear sky and without any significant wind. Observations of temperature are presented in Table 1 and Figure 4.

Where,

T1 = Inlet temperature of black chrome panel

T2 = Outlet temperature of black chrome panel

TABLE 1.

RECORD OF TEMPERATURES

| S.No. | Time (Hrs) | T1 | T2 |
|---|---|---|---|
| 1. | 10:00 | 27.0 | 34.0 |
| 2. | 11:00 | 28.0 | 59.0 |
| 3. | 12:00 | 28.5 | 64.6 |
| 4. | 13:00 | 29.0 | 67.0 |
| 5. | 14:00 | 29.2 | 67.4 |
| 6. | 15:00 | 28.6 | 63.0 |

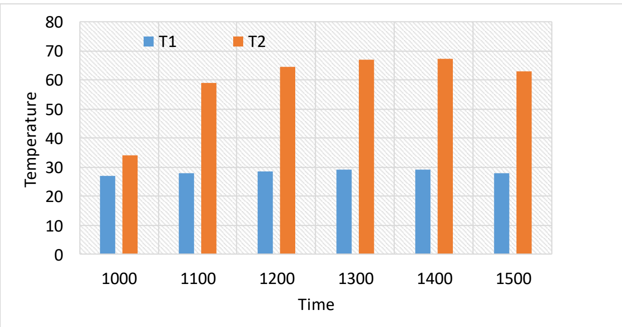


Figure 4. Graphical representation of variation in outlet and inlet temperatures for black chrome panel

### B. Black Chrome Panel coupled with Tubular Generator

Thereafter, the tubular generator was put in series, and water was allowed to flow at the rate of 12 liters per hour, and the temperature was recorded with a clear sky without any significant wind. The readings of the temperature are presented in Table 2 and Table 3 and in Figure 5 and Figure 6.

where,

T1 = Inlet temperature of tubular generator.

T2 = Outlet temperature of tubular generator/ Inlet temperature of black chrome panel.

T3 = Outlet temperature of black chrome plated panel.

TABLE 2.

RECORD OF TEMPERATURES

| S.No. | Time(Hrs) | T1 | T2 | T3 |
|---|---|---|---|---|
| 1. | 10:00 | 26.8 | 30.0 | 35.2 |
| 2. | 11:00 | 27.6 | 43.0 | 68.0 |
| 3. | 12:00 | 28.0 | 49.0 | 75.0 |
| 4. | 13:00 | 28.2 | 50.2 | 81.0 |
| 5. | 14:00 | 28.2 | 49.8 | 82.2 |
| 6. | 15:00 | 27.8 | 44.2 | 74.8 |

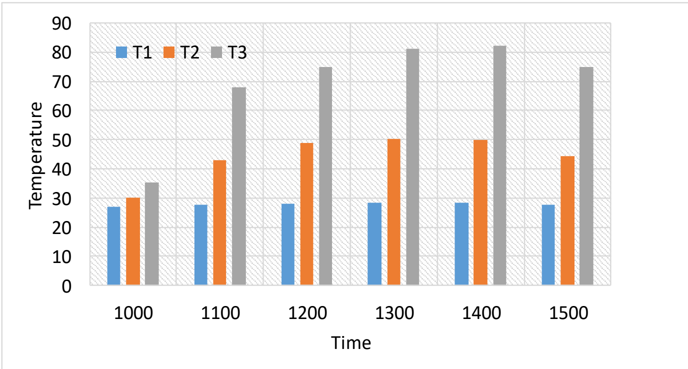


Figure 5. Graphical representation of variation in outlet and inlet temperatures for black chrome panel coupled with tubular generator.

TABLE 3.

RECORD OF TEMPERATURES

| S.No. | Time (Hrs) | T1 | T2 | T3 |
|---|---|---|---|---|
| 1. | 10:00 | 27.0 | 30.4 | 35.8 |
| 2. | 11:00 | 27.6 | 42.8 | 73.4 |
| 3. | 12:00 | 28.0 | 47.0 | 80.0 |
| 4. | 13:00 | 28.2 | 48.0 | 80.6 |
| 5. | 14:00 | 28.0 | 47.8 | 80.4 |
| 6. | 15:00 | 27.8 | 44.6 | 75.0 |

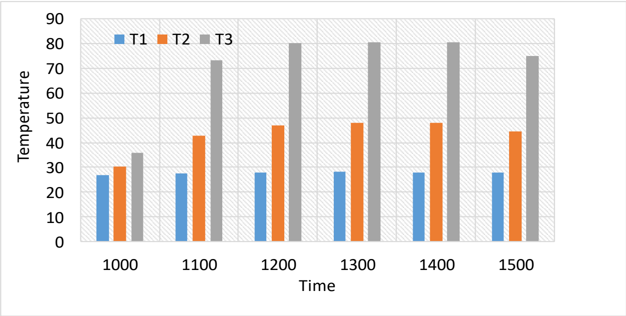


Figure 6. Graphical representation of the variation of inlet and outlet temperatures for black chrome panel coupled with the tubular generator.

### C. *Absorption Generator with Analyzer and without Glass Cover*

The heated water was allowed to pass through the analyzer without a glass cover, which proves to be fruitless and the temperature decreases even further. The readings of temperature are recorded and tabulated in Table 4 and Figure 7.

Where,

T1 = Inlet temperature of the tubular generator.

T2 = Outlet temperature of tubular generator/ Inlet temperature of black chrome panel.

T3 = Outlet temperature of black chrome-plated panel/ Inlet temperature of the analyzer.

T4 = Outlet temperature of the analyzer.

TABLE 4

RECORD OF TEMPERATURES

| S.No. | Time (Hrs) | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| 1. | 10:00 | 26.8 | 30.2 | 36.0 | 33.0 |
| 2. | 11:00 | 27.6 | 42.8 | 76.0 | 72.0 |
| 3. | 12:00 | 28.0 | 47.4 | 79.8 | 75.4 |
| 4. | 13:00 | 28.0 | 47.8 | 80.8 | 76.0 |
| 5. | 14:00 | 28.2 | 47.6 | 80.6 | 76.0 |
| 6. | 15:00 | 27.1 | 44.0 | 75.2 | 67.4 |

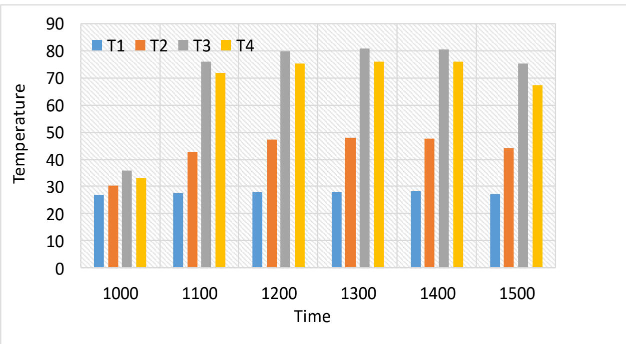


Figure 7. Graphical representation of variation in inlet and outlet temperatures of absorption generator with analyzer without glass cover.

### D. *Absorption Generator with Analyzer and with Glass Cover*

The glass cover was put to cover the analyzer. Then it showed a good result. The readings of the temperature were recorded and are tabulated in Table 5 and Figure 8.

Where,

T1 = Inlet temperature of the generator.

T2 = Outlet temperature of tubular generator/ Inlet temperature of black chrome panel.

T3 = Outlet temperature of black chrome panel/ Inlet temperature of analyzer.

T4 = Outlet temperature of the analyzer.

TABLE 5.

RECORD OF TEMPERATURES

| S.No. | Time(Hrs) | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| 1. | 10:00 | 26.8 | 30.0 | 35.8 | 35.6 |
| 2. | 11:00 | 27.0 | 47.6 | 73.8 | 75.2 |
| 3. | 12:00 | 27.1 | 47.2 | 79.8 | 82.0 |
| 4. | 13:00 | 27.6 | 47.4 | 80.8 | 84.0 |
| 5. | 14:00 | 27.4 | 47.2 | 81.0 | 84.2 |
| 6. | 15:00 | 27.0 | 43.8 | 76.2 | 78.1 |

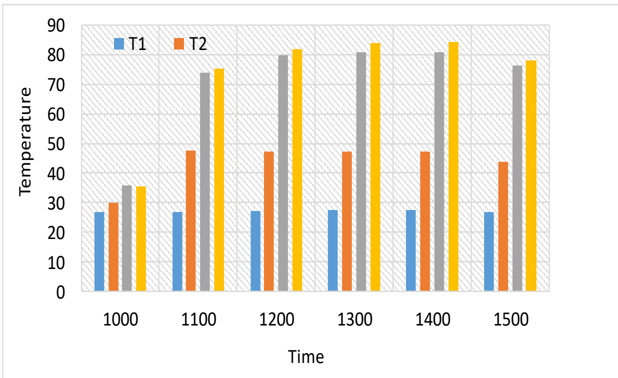


Figure 8. Graphical representation of variation in temperatures of absorption generator with analyzer and glass cover.

### E. *Absorption Generator, Analyzer with Rectifier*

The rectifier was coupled with the analyzer and the temperatures are recorded in Table 6 and Figure 9.

Where,

T1 = Inlet temperature of the tubular generator.

T2 = Outlet temperature of tubular generator/ Inlet temperature of black chrome panel.

T3 = Outlet temperature of black chrome panel/ Inlet temperature of the analyzer.

T4 = Outlet temperature of the analyzer.

T5 = Outlet temperature of the rectifier.

TABLE 6

RECORD OF TEMPERATURES

| S.No. | Time(Hrs) | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|---|
| 1. | 10:00 | 26.6 | 30.6 | 35.0 | 35.6 | 35.4 |
| 2. | 11:00 | 27.0 | 42.4 | 74.0 | 75.4 | 73.0 |
| 3. | 12:00 | 27.2 | 47.0 | 79.6 | 82.2 | 79.0 |
| 4. | 13:00 | 27.4 | 47.4 | 81.0 | 84.2 | 80.6 |
| 5. | 14:00 | 27.4 | 47.2 | 81.0 | 84.0 | 80.2 |
| 6. | 15:00 | 27.0 | 43.6 | 76.0 | 80.4 | 77.0 |

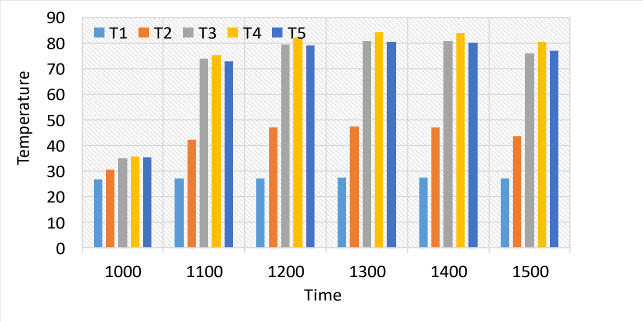


Figure 9. Graphical representation of variation in inlet and outlet temperatures of absorption generator and analyzer with rectifier.

F. *Absorption Generator, Analyzer, Rectifier, and Condenser*

The water-cooled condenser was connected and the readings of the temperature were recorded and are tabulated in Table 7 and Figure 10. Where,

T1 = Inlet temperature of the tubular generator.

T2 = Outlet temperature of tubular generator/ Inlet temperature of black chrome panel.

T3 = Outlet temperature of black chrome panel/ Inlet temperature of the analyzer.

T4 = Outlet temperature of the analyzer.

T5 = Outlet temperature of the rectifier.

T6 = Outlet temperature of condenser.

TABLE 7

RECORD OF TEMPERATURES

| S.No. | Time(Hrs) | T1 | T2 | T3 | T4 | T5 | T6 |
|---|---|---|---|---|---|---|---|
| 1. | 10:00 | 26.7 | 30.5 | 35.0 | 35.7 | 35.4 | 29.0 |
| 2. | 11:00 | 27.0 | 42.4 | 74.1 | 75.6 | 73.1 | 33.3 |
| 3. | 12:00 | 27.2 | 47.1 | 79.5 | 82.1 | 79.2 | 33.4 |
| 4. | 13:00 | 27.4 | 47.4 | 81.2 | 84.3 | 80.6 | 34.6 |
| 5. | 14:00 | 27.3 | 47.2 | 81.1 | 84.1 | 80.3 | 34.5 |
| 6. | 15:00 | 27.1 | 43.5 | 75.8 | 80.3 | 77.1 | 32.7 |

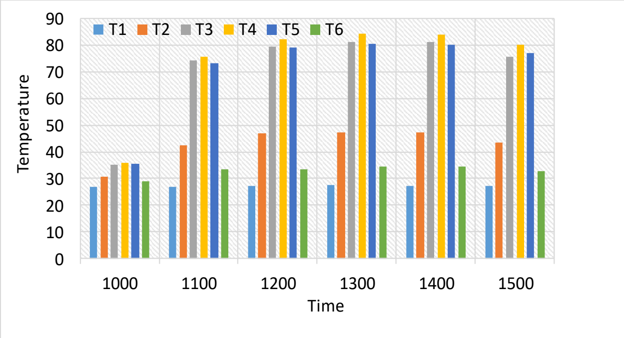


Figure 10. Graphical representation of variation in inlet and outlet temperatures of absorption generator, analyzer, rectifier, and condenser.

## VI. CONCLUSION

- A vapor absorption refrigeration system using lithium bromide water solution having a water cooler condenser requires a generator, analyzer temperature of from 75 to 95°C. A combination of absorption generators having black chrome, selective coating, and paraboloidal concentrator for analyzer will be disc having nickel-chrome plating.
- In the mid part of the day when the solar flux will be maximum, the temperature available will also be maximum. This temperature is sufficient for the full capacity operation of a lithium bromide refrigeration system having a highly effective heat exchanger between absorber and generator and a water-cooled condenser.
- The system performs satisfactorily even in the condition of the crude components. The performance will improve with the improved components.
- The system takes about an hour to achieve the temperature required of the refrigeration system. Moreover, this adverse effect may not produce a hindrance since the cooling load will be lesser. Moreover, the system may start early by supplying auxiliary energy in the hour when solar energy is not available.
- The systems component should be thermally insulated and the length of the tube in between components should be as minimum as possible.

- The storage facility must be provided with capacity depending upon heating and cooling load.
- The tracking system must be automatic and should be synchronized with the position of the sun since in commercial use manual tracking will not be possible in any way.
- The capacity of the lithium bromide water vapor absorption refrigeration system using solar power generated and analyzer as described varies directly with outside atmospheric temperature and hence the cooling load. A solar-powered lithium bromide water refrigeration system is therefore feasible and logical.
- The maximum temperature achieved from the absorption generator was up to 87°C at the flow rate of 12 liters per hour. When the system may not be of refrigeration use, the system may be used for water heating, and at required temperature consequently flow will be increased correspondingly.
- As observed during the experiment, without a glass cover analyzer does not serve the purpose and after providing the glass cover it serves the purpose. Therefore, if the analyzer will be completely enclosed, it will give a better result.
- This study further reveals that the latest water heating panel of selective coating may serve the purpose of the generator and in addition to that paraboloidal analyzer and rectifier are required on the heating side and condenser which will also heat the water. It will be able to supply hot water also.
- Although the electroplating of nickel-chrome is not as reflective as that of glass, due to its better workability, which gives it proper paraboloidal to be possible, makes it favorable than glass which was earlier used in the experiment.

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