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DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF THE ABSORPTION TYPE REFRIGERATOR

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ABSTRACT

The absorption refrigerating mechanism is based on Dalton Law of partial pressure. The refrigerant is ammonia with hydrogen as the propellant. The unit comprises a generator, condenser, evaporator and absorber. Ammonia is driven out of the water in the boiler when heat is applied. In the condenser, it is liquefied and evaporates at low pressure in the evaporator. As the ammonia boils, it absorbs heat. The refrigerator is built entirely with locally available materials and functions on a kerosene burner. It is a viable alternative to the conventional compressor-type refrigerator and in addition avoids the hazards associated with the conventional refrigerants.

Keywords: absorption system, refrigerator, evaporator, charger.

INTRODUCTION

Refrigeration has been a major food preservation method for some time. The first generation refrigerators were the conventional mechanical compression systems. The absorption system which was originally manufactured by the Electrolux engineers in England was introduced into Nigeria in the colonial period but has become generally extinct. The present unreliability of the public power supply has made the re-introduction of the system necessary since it functions on alternative energy. The objective of this research is therefore to produce an absorption refrigerator with locally available raw materials and indigenize the technology.

THEORETICAL BACKGROUND

ABSORPTION REFRIGERATION PRINCIPLE

The absorption refrigerator comprises four main parts – the generator, the condenser, the evaporator and the absorber. Ammonia is used as the refrigerant because of its affinity for water which can dissolve enormous amounts of ammonia vapour. The energy required to activate the system is supplied by a burner. The operation of the mechanism is based on Dalton's Law of partial pressure which states that the total pressure of a confined number of gases is the sum of the pressures of each of the gases in the mixture. The absorption system is different from the compression system in that it uses heat energy instead of the mechanical compressor to change the condition of the refrigerant to provide cooling. The system has no moving parts and operates quietly. It is a sealed system with two containers – the evaporator and the absorber. The refrigerant vaporises in the evaporator. The absorbent sucks the refrigerant vapour from the evaporator and sends the dissolved refrigerant to the generator. Further heating causes a discharge of the refrigerant which passes into the condenser and the cycle is repeated. Hydrogen is also charged to propel the ammonia vapour. The hydrogen is however not absorbed in the absorber. The only energy required for the refrigerator to function is supplied by the heater.

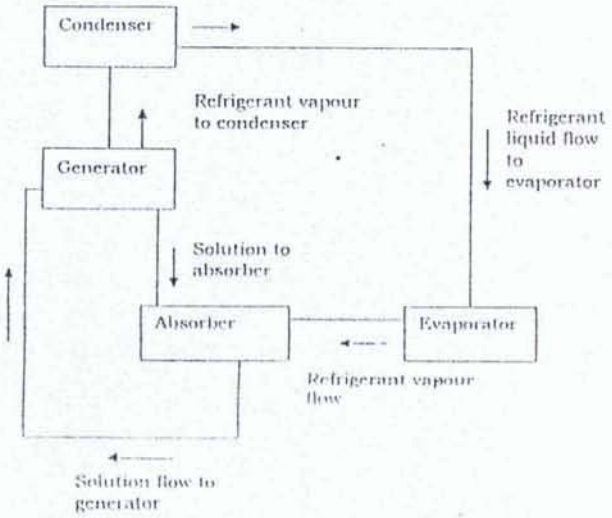

Fig 1 Schematic representation of the absorber machine

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MATERIALS AND METHODS

COMPONENT DESCRIPTION

The absorption refrigerator is shown in Plate 1. It comprises the generator, evaporator, condenser and absorber. A kerosene burner carefully adjusted to give a blue flame is used as the heat source. The fins of the evaporator are made of aluminium and are firmly attached by force fitting to the evaporator pipe. Mild steel has been selected for the evaporator because of ease of fabrication since it is not attacked by ammonia.

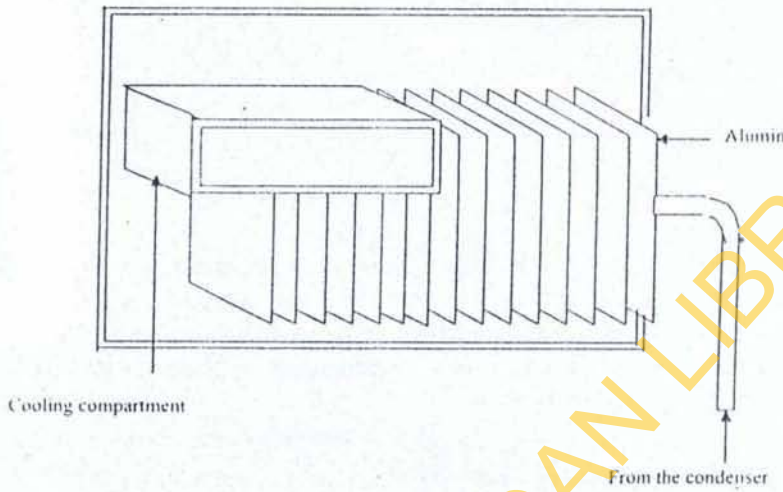

Fig. 3 The Evaporator

CONDENSER: The condenser in the refrigeration cycle removes the condensation heat from the refrigerant vapour. As a heat exchanger the heat from the hot refrigerant is rejected to the condensing medium – air. There are three types of condensers, viz; air cooled, water cooled and evaporative condenser. In this project, the air cooled condenser is used. The diameter of the condenser tubing is 10mm. The cooling fins are 1mm thick and are spaced at 10mm for heat dissipation.

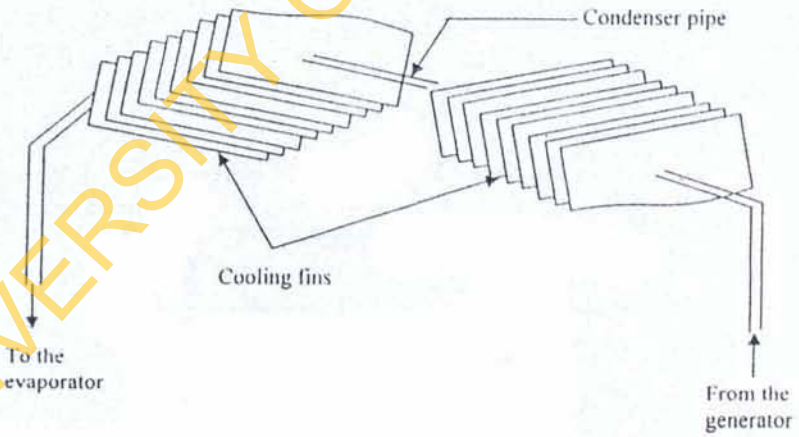

Fig. 4 The Condenser

THE ABSORBER

The absorber is a storage tank for the liquid refrigerant and water. It provides enough reserve liquid refrigerant to ensure that the liquid line refrigerant is sub-cooled and free of fresh gas.

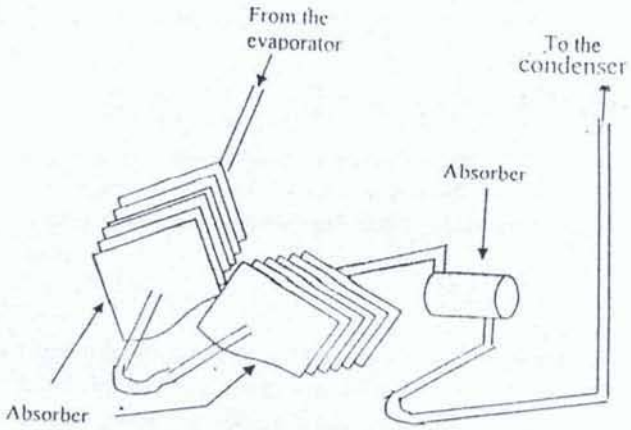

Fig. 5 The absorber

GENERATOR

The generator is a cylinder 10 mm diameter and 400 mm long. It is made of cast iron. It is positioned so that when heated, the refrigerant vapour can move upward to the condenser at high temperature and pressure. It is designed with an exhaust pipe to allow for the escape of exhaust gas from the burner. Mild steel is chosen because it is not attacked by ammonia and can withstand the heat from the burner.

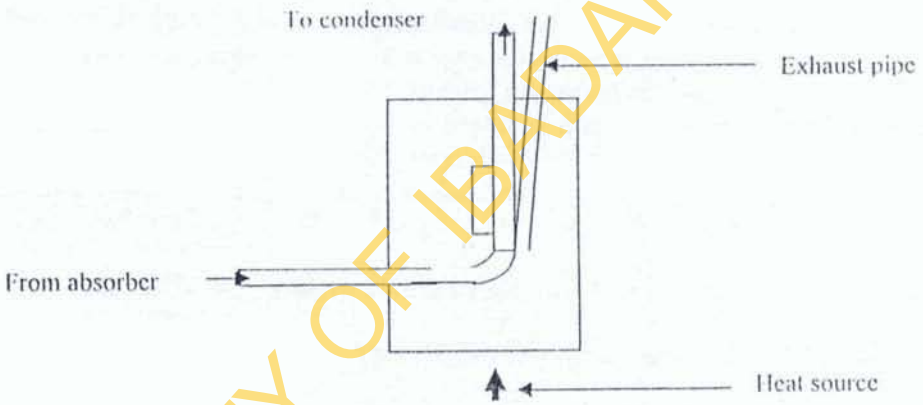

Fig. 5 The generator

CABINET

Galvanized sheet was used for the casing. It was lagged by 30mm glass wool blanket all round to reduce heat exchange with the environment.

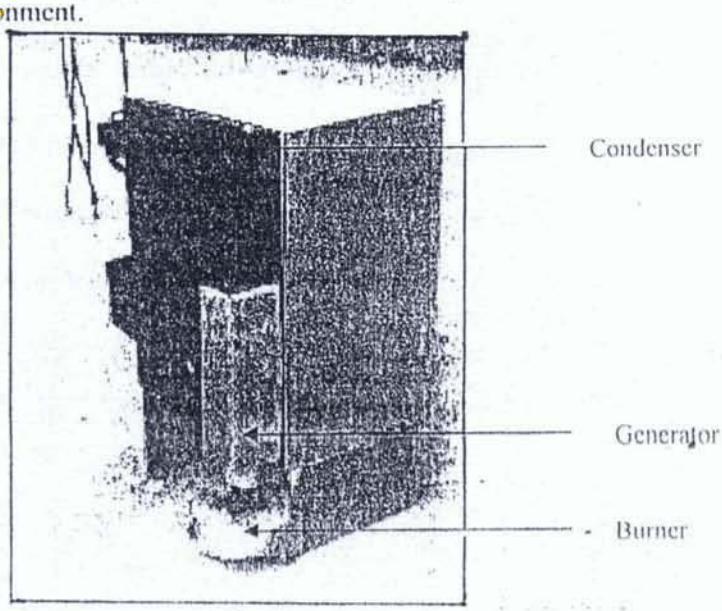

Plate 1 Rear view of the refrigerator showing the generator, condenser, absorber and burner.

THE REFRIGERANT

The refrigerant is a cooling agent which absorbs heat from another body. There are various types of refrigerants. These include ammonia; carbon dioxide, ethyl chloride, ether, methyl chloride, sulphur dioxide and some fluorocarbons. Ammonia is selected for this project because of its ability to boil at low temperature and its ability to be absorbed and discharged from water with ease. It permits automatic operation and minimum maintenance.

RESULTS

The kerosene burner was ignited and adjusted. It was placed in the designated platform. As the heat was applied, the condenser started to get warm indicating immediate and effective compression within three minutes of application. Within two hours a temperature drop of 12°C was achieved in the empty compartment. When the compartment was filled with assorted bottles containing liquid, it took approximately ten hours for the temperature to drop to 6°C (Popoola, 2004). The refrigerator may be used at any location. The refrigerator was found to be a very good alternative to the conventional system. Kerosene was consumed at the rate of 25cl per hour of operation when the compartment was properly stocked. Once properly adjusted to give a blue flame, the burner was very effective and needed little attention. The exhaust pipe extracted unburned fumes.

CONCLUSION

This absorption refrigerator designed, fabricated from locally available raw materials and tested costs about fourteen thousand naira (see appendix 1) and is very effective in preserving food and providing chilled water and beverages using kerosene. It is generally maintenance free. The only maintenance required is the decarburizing of the charger. It is very useful at this time of erratic and unpredictable power supply. Kerosene was chosen as the energy source because of its availability in all parts of the country. It may be replaced by a solar heater or liquid propane gas.

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APPENDIX 1: PRODUCTION COST OF PROTOTYPE

S/No	Component	Material	Quantity	Unit cost (₦)	Total Cost (₦)
1	Body	Mild steel	1	4000	4,000
2	Door	Mild steel	1	1500	1500
3	Stand	Mild steel	1	600	600
4	Pipes 10mm dia x 2000mm	Mild steel	1	1500	1500
5	Fins 290 x 120 x 1	Aluminium	30	20	600
6	Fins 90 x 68 x 1	Mild steel	60	10	600
7	Absorber tank	Mild steel	1	250	250
8	Lagging	Fibres		300	300
9	Kerosene burner		1	700	700
10	Screws M-6	Steel	10	20	200
17	Labour				2500
18	Transportation				1500
19	Miscellaneous (10% of total cost)				1230
		Total Cost			13530