DESIGN, CONSTRUCTION AND FABRICATION OF MOBILE DEEP FREEZER

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ABSTRACT

Deep freezers are considered to be an important household item that falls under the category of cooling appliances. The basic structure of the freezer consists of a thermally insulated compartment which through a proper mechanism lowers down the temperature inside it and transfers the heat from inside to the external environment. As it keeps the temperature lower so it is used to keep and store the food items which can be spoiled at ambient temperature. Deep freezers in all the sizes are available at the market but they are restricted and limited for indoor usage only as they require electricity and are large. But presently, people are more inclined towards outdoor activities and they need to have a freezer to keep the essential items saved from spoilage and wastage. Therefore this study is geared towards the designing a mobile deep freezer that is powered through the batteries and is portable which can be easily used outdoors as well carried about. Consequently, the design was fabricated using locally made materials. This is to encourage local ingenuity and to reduce cost of production comparable to already made and foreign deep freezers. It is designed to be simple, handy and readily available to be used by anyone in case of malfunctioning and for easy relocation. Though, the main limitation of the system fabricated is the long time it uses to achieve cooling and finally the machine is affordable to all, and is highly recommended for local entrepreneurs for mass production because of its cost effectiveness, simplicity and availability of spare parts.

INTRODUCTION

The most significant contribution to the development and maintenance of our modern technological society has been our ability to extract large amount of energy from natural resources. These extractions of energy allow us to control or use work, cool, power and heat to meet society needs. The science that explains and predict how much energy we may extract and how efficiently we may do it for a particular situation is called thermodynamics (IIAR, 2015). It is a science that studies energy in its various form and explains why some type of energy are easier to use than others. Because of this subject matter, the science of thermodynamics is used often by engineers and technologists in practical design problem and in problems of the operation of large or complicated system.

Deep freezers are considered to be an important household item that falls under the category of cooling appliances. The basic structure of the deep freezer consists of a thermally insulated compartment which through a proper mechanism lowers down the temperature inside it and transfers the heat from inside to the external environment. As it keeps the temperature lower so it is used to keep and store the food items which can be spoiled at ambient temperature. The refrigerators consist of different parts or components including the cabinets (inner and exterior), insulation inserted in between the two cabinets, the cooling system, fixtures, and the refrigerant. Cabinets are either made of aluminum or steel metal sheets and the exterior is usually plastic (Arora, 2020). Polyfoam or fiberglass is used as insulation which fills up space and gap between both cabinets. For refrigerant, freon is usually used which is trademarked by DuPont. It passes a nonflammable gas, which keeps the temperature low by undergoing the evaporation process repeatedly. Deep freezer in almost all the sizes are available at the market but they are restricted and limited for indoor usage only as they require electricity and are large. But presently, people are more inclined towards outdoor activities and they need to have a refrigerator to keep the essential items saved from spoilage and wastage. So, this project focuses on designing, constructing, and fabricating a mini refrigerator that would be powered through the batteries and is portable which can be easily used outdoors as well (Aich, 2020).

The concepts of preservation hence enable us to study quantitatively and qualitatively the analysis of how machines convert the chemical of nuclear energy into useful work. For decades ago the idea of preservation was very primitive but despite that, the early men had the initiatives that something could be done to preserve perishable (food) items for instance, tribes living close to the ice berg region observed that animals (fish) hunted during the winter period were preserved better than those of the summer. This was simply preserved because of the temperature variation.

In African the insulative properties of sand used in moulding clay pot for preserving water was observed to offer a cooling effect on its content. Also wet leaves were used to wrap on some fruits such as colanuts, this offers considerable preservation for a given period of time when the leaves get dried up. During these years, there was no extensive record or any constructive attempt to modernize any system that could serve the purpose (Astrain, 2015).

The boom in domestic appliance revolutionizes the refrigeration industries and its commercial outlet. The lot awareness created by refrigeration industries attracted the masses on the use and advantages of preserving with refrigeration rather than using those crude means. These demands lead to the manufacture of different types of suit particular purpose(s); thus refrigeration plant were produced to freeze fish on the traveler; freeze pre -cooked meats; poultry freezing factor, ice cream, movable refrigeration etc.

This current study focused on the design and fabrication of a mobile deep freezer. The mobility factors units the size and moreover, due to high manufacturing cost, the size is made moderate. The design objective is to produce an efficient, mobile deep freezer that could be used both for indoor and outdoor services to preserve drinks, food item, and other similar products. The limitation of change is only for smaller units of item since the size will not accommodate large quantities or units of item (Avallone, 2017).

This study is meant to achieve the following purposes to design and fabricate a deep freezer that will be moveable at ease, to design and construct a local deep freezer that will be efficient with less cost, to improve on the existing design taken into consideration, to detect or investigate the appropriate refrigerant that will offer the highest coefficient of performance. to design and construct a mobile deep freezer that will be durable and reliable with appropriate maintenance and to design, construct and fabricate a mobile deep freezer that will offer greater cooling effect within a short period of time and to design and construct a mini portable refrigerator that could be used to keep things cool while traveling or doing outdoor activities (Riffat, 2013).

MATERIALS AND METHOD

Specification of the Design

The importance of this design is to achieve cooling at a very low temperature without adverse effect on its content such as poisoning of food tissues. More so, it expected that this design would enable us to get acquainted with the application of thermodynamics principle to a particularly realistic state. The design intention is based on reduced cost. Long life span, fast freezing capacity to improve an existing design compactness portability ease of mobility etc. The design specification is to meet a volume capacity of about $2m^3$ but due to cost consideration of the components involved, it is desirable to limit the volume capacity to a moderate size provided its functionality is perfect or ensured

The essential design parameters for this design are; Compressor, Capillary tube, Condenser, Evaporator, Thermostat, wood, Refrigerant, Rubber seal, Rollers, copper, steel, alloys, Drier strainer, Relay, Lagging material, Aluminum foil, Lubricating oil, Plastic compartment, Fish Chamber, Over Load and Accumulator etc.

Material Selection

The first step taken in selecting materials from a variety of materials (aluminum, copper, steel, alloys, etc) was by carefully defining categorically the requirements of the desired components. This was followed by checking these requirements so as to make the selected materials readily available.

The basic schematic diagram for the refrigerator is given below

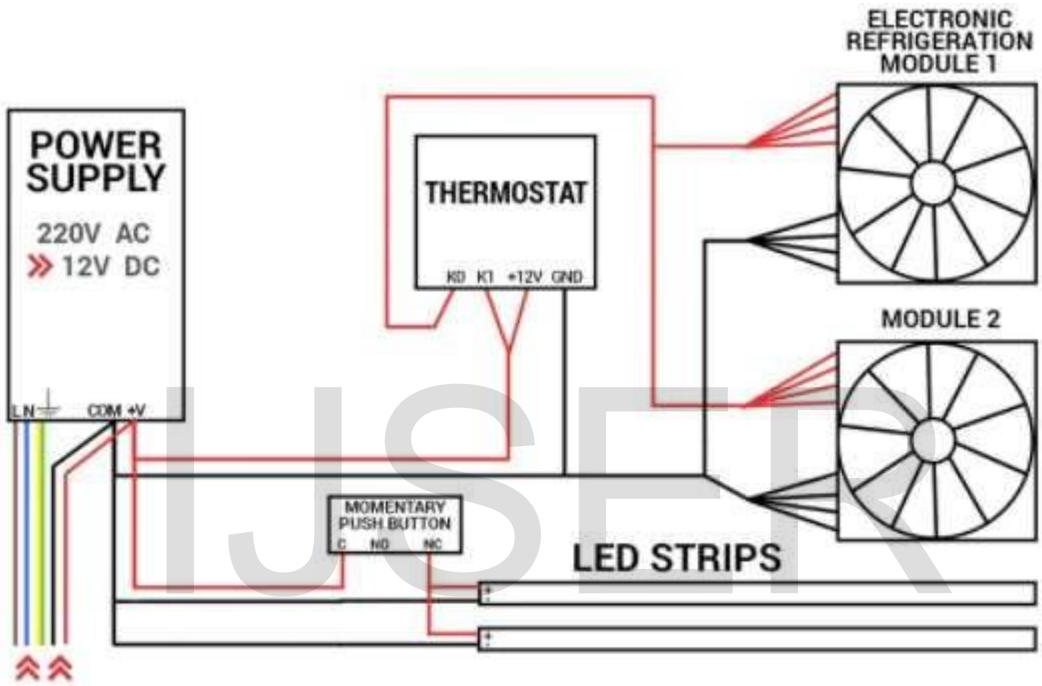
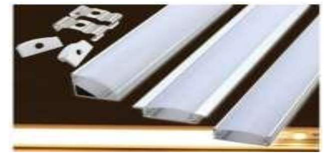


Figure 1: Schematic Diagram of a Refrigerator

The basic electronics which would be needed for the fabrication process of the frezer along with their specifications is given below:

Table 1: Specifications of electronics used

Essentials	**Specifications**	**Diagram**
2x electronic refrigeration modules	12V 6A Semiconductor cooling equipment	
Thermostat	W1209 DC 12V -50 to +110 Temperaturesensor control switch	
Cold white LED strip	3M DC 12V, 43.2W, 180 SMD 5050	
Shrink tubes	Halogen-free heat shrink tubes	
Power plug AC	AC 250V/10A IEC320 C14	

Aluminum channel holder	50cm U/YW/V-Style	
Self-adhesive rubber seal	5M E type	

Other equipment to be used in the fabrication of the freezer are:

White sticker paper	Power plug 12v	Styrofoam
Acrylic glass and aluminum Tape	Momentary push button	Doorknobs (for setting the legs)
Medium-Density Fiberboard (MDF)	Aluminum handlebar (on lid)	Doorknobs (for setting the legs)
Styrofoam	Aluminum angles	Spray paint + clear coat
Wire terminals		

For the proper thermoelectric module, design selection for the specific application requires an evaluation of the total system in which freezer is used. As for general applications, it can be done by using standard module configurations, while in many cases, the need for special design is mandatory to meet electrical, mechanical, and many other requirements. The basic design of the freezer is based on the Vapor Compression System which is shown below in Figure:

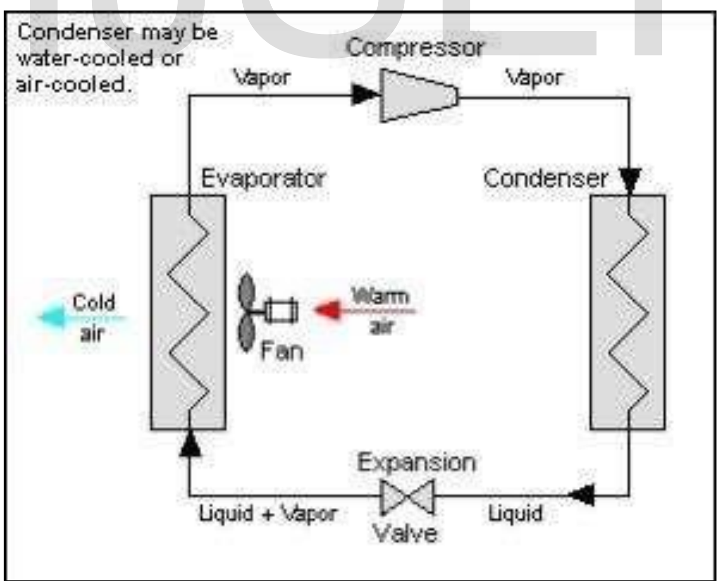


Figure 2: Typical Single-stage Vapor Compression Refrigeration

Design Standards

The design standards should be followed in each component of the system.

Table 3: Design Standard

Components	Standard
Screw	ASME
Fans	AMCA
Alternator	Delco-Remy
Battery	RESNA

Assembly of the Deep Freezer

Step 1: A freezer chamber is made for which a box for a purpose of refrigeration is made with insulation on both sides.

Step 2: An aluminum sheet of thickness 1mm is used on the outer side of the insulation. The backside of this box is created in a proper dimension to fit the fin fan assembly in it. Also, fins are attached to fans and the whole assembly is attached at the back of the refrigeration chamber. After the alignment of fans in that, some holes in a Styrofoam were made where they would enter the main compartment.

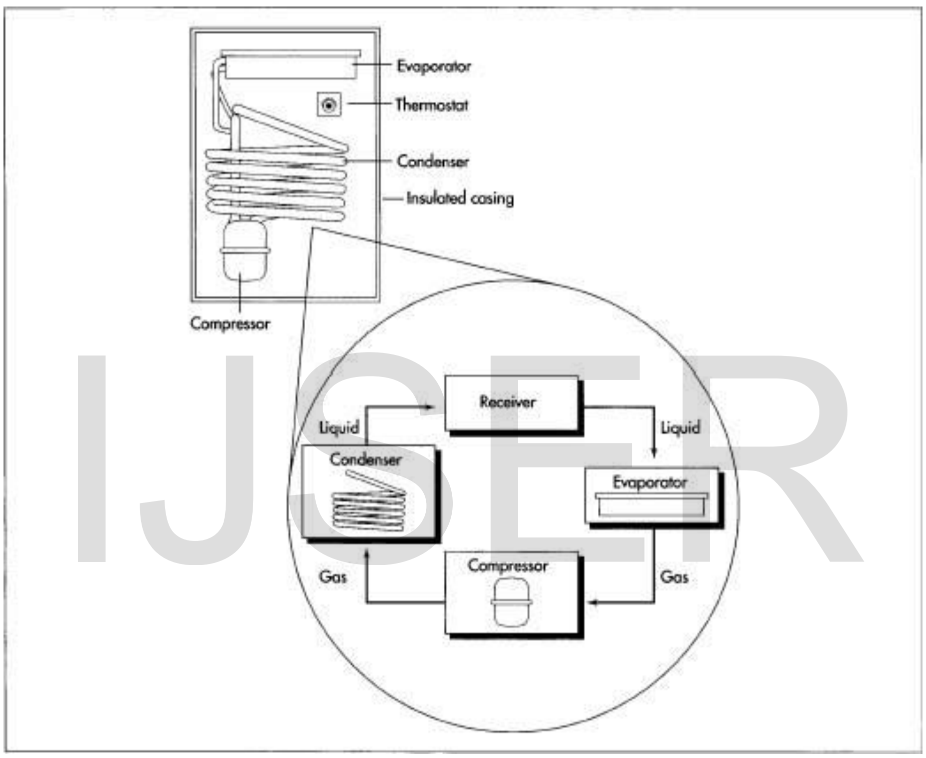
Step 3: Peltier Module is attached to the surface of the fin. Care should be taken that the module is free of dirt and oily materials using alcohol or similar materials. After that, a space for a snack shelf was made and holes were cut for the fans to properly fit in. for the lightning, LED channels were made using a tiny piece of Styrofoam to cover the top and white LED strips were used for this purpose.

Step 4: For the taping purposes, the aluminum tape was used because it looks better, and it is heat reflecting. After that cable spacing was made and the thermostat was hooked up. 12V DC power supply is used in this process, where both the fans and the module is attached to the circuit controller using wires.

Step 5: After hooking up everything to the battery, a push-button was made. After that, the exterior is made with acrylic glass and a scoring knife was used to cut that in straights. In the ned, denting painting is made. The images below describe the step by step manufacturing of a mini portable refrigerator.

Design

The contemporary freezer is based on two basic laws of physics: one, that heat flows from warmer material to cooler materials and never the reverse; two, that decreasing the pressure of a gas also decreases its temperature.



Deep frezer work by removing the warmth from the air within their interior compartments and relaying that heat to the air outside. The coolant (freon) accomplishes this transfer as it passes through a circuit, moving from the evaporator to the condenser. Beginning in the evaporator, which lies inside an insulated cabinet, the freon is heated. Because it has been made to boil, the freon draws heat from the air within the freezer. Having absorbed this heat, the freon is then routed to the condenser (Francis, 2013). In this set of copper coils (usually mounted at the back or on the bottom of the refrigerator), the freon condenses—returns to a liquid state—transferring its heat into the outside air as it does so. After cooling, the freon then returns to the evaporator, where it is once again heated and begins to absorb heat from the food stored within the freezer. Sometimes, to increase their surface area (and thus facilitate thermal transfer), the evaporator and the condenser are fitted with metal fins.

For defrosting, a coil is wrapped around the freezer unit. When the timer reaches defrost, the refrigerant is passed through this coil while it is hot to raise the temperature and melt the ice. The coil is generally positioned away from any ice makers to prevent the ice cubes from melting and freezing together.

Outer cabinet and door

- Pieces of sheet metal were welded and clinched together. Clinching is a process closely resembling stapling in that the two pieces are crimped together under pressure, though no additional pieces such as staples are added. If the part of the cabinet is to be visible, it will be welded and ground down to appear as one piece. The extent to which the welding process is automated depends on the company and the number of refrigerators being produced. A pre-coated sheet metal was used.

Inner cabinet

- The inner cabinet is made from sheet metal very similar to the outer shell. Seams were caulked to improve insulation and looks.
- The inner cabinet is inserted into the outer cabinet, and the two are snapped together before the fixtures are inserted. Some tubes and wires were run through the gap between the two before it is filled with insulation. A dispensing device was inserts in inform of foam between the walls. When heated in an oven, this foam expands to add rigidity and insulation to the cabinet. A similar process is used for the doors.

Cooling system

- The freezer components are attached to the cabinet using screws and clips. The tubing is soldered together, and a protective coating is sprayed on the joints. The order of this assembly varies between manufacturers and models. The copper tubing from which the coils (condensers and evaporators) have separately been cut, bent, and soldered is then attached to the refrigerator as a unit.

- The seal on the freezer door is created by means of magnet laden gaskets that are attached to the doors with screws. Handles and hinges are also screwed onto the door before its hinges are screwed onto the cabinet. Some adjustment is allowed for proper operation of the door.

Testing and adding accessories

- Most manufacturers mix testing with manufacturing from this point on. The unit is leak tested with nitrogen (a safe gas that makes up about 79 percent of the air); if it passes, it is charged with refrigerant and subjected to further testing. Next, the accessories (shelves, crispers, ice trays, etc.) are added and taped down for shipping. The unit is given a final look and then packaged for shipping.

Results, Analysis and Discussion

Experimental Setup:

The freezer is coupled with the heat pipe. Hot side of the Peltier is coupled with that of heat pipe. Cold side of the Peltier is equipped with a compact heat sink. There was an air duct that was responsible for drainage of air from cold side. Multipoint recorder is used in this used experiment. Infrared thermal imager is used to monitor running state of experiment.

Figure 3. Experimental Setup

Results and Analysis:

Relationship of the cooling produced and voltage is show in the figure below:

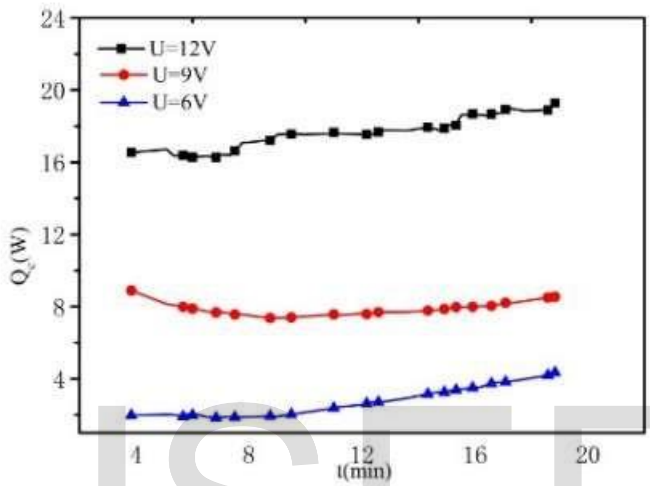


Figure 4. Cooling load Vs Time

It can be seen from the graph that cooling production increases with the increase in the working time and then tends to stabilize. It can be seen that when the working voltage is 12V, then cooling production is largest. When the cooling production was below 9V then working condition show the red line and the cooling production is lower than that of 12V. And when the voltage is below the cooling production is the lowest.

Graph below shows the relationship between temperature difference and time.

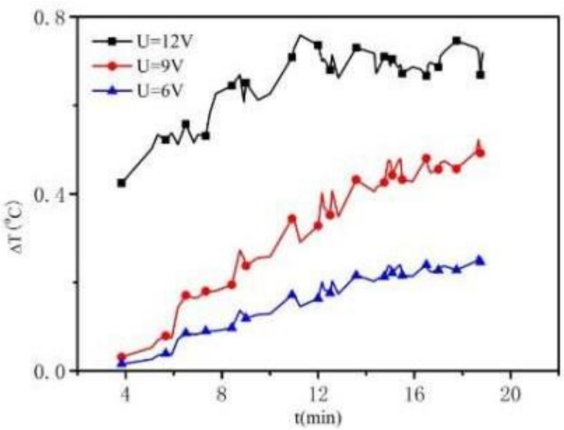


Figure 5. Temperature difference Vs time

The graphs show that the temperature difference is also the function of the voltage with respect to the time. For higher voltage the value of temperature difference is also high and with the passage of time, temperature difference also increases.

Conclusion and Recommendations

Conclusion

This study on manufacturing a mobile deep freezer was very interesting to perform. The whole process involved in the design and construction was so amazing. The freezer worked very well but it has a limitation that it took much time to cool and besides that, it remained cool for a longer time.

Recommendations

The developed freezer is functional as per the batteries and electricity or power availability which makes it restricted in use so new research and project can be made while considering other options like heat, solar system, etc. The project can be made in a better manner if it is made through a thick and high aluminum pipe material as it would speed up the heating process of the freezer so that it may become cool earlier than now. It is also recommended to see the alternates for compressors as this would reduce the cost of the system and would increase its capacity.

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