Design and Fabrication of Magado Air Conditioner

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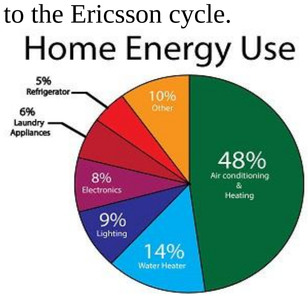
Abstract

- The main objective of this project is to design and fabricate the eco-system magnetic air conditioner through the adiabatic magnetization and demagnetization cooling effect. this is based on the principle of magneto-caloric effect.
- The combination of solid state refrigerant, water based heat transfer fluids and high efficiency leads to environmentally desirable product at minimal contribution to global warming
- The solar power is provided for energy supply for the air conditioner. room temperature magnetic refrigeration is an environment-safe refrigeration technology with many excellent features, such as compact configuration, low noise, high efficiency, high stability and longevity.

Keywords - *paramagnetic salt, magneto-caloric, magnetization and demagnetization, magnetic refrigeration.*

Objective of the Project

- Magnetic refrigeration is a cooling technology based on the magneto-caloric effect. This method can be used to attain the temperatures near 0 k, as well as the ranges used in common refrigerators, depending on the design of the system.
- In 1976, brown was the first to use MR at room temperature with a refrigerator operating according to the Ericsson cycle.

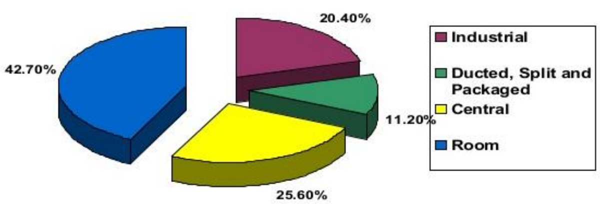


We are developing an air conditioning system that relies on magnetic fields

- The novel property of certain materials, called "paramagnetic materials", to achieve the same result as liquid refrigerants. These paramagnetic materials essentially heat up when placed within a magnetic field and cool down when removed, effectively pumping heat out from a cooler to warmer environment

Introduction

- Now a days we using the conventional refrigeration and air conditioning method like vapor compression and vapor absorption cycle. Which are based on gas compression and are not very efficient because the refrigeration accounts for 25% of residential and 15% of commercial power consumption.
- About 20-30% of the air conditioners in India still (in 2016) use HFCs. Residential and commercial buildings currently account for 72% of the nation's electricity use and 40% of our carbon dioxide (CO_2) emissions each year, 5% of which comes directly from air conditioning. The refrigerants used in AC are potent greenhouse gases (GHGs) that may contribute to global climate change.
- Refrigerants with polluting emissions could account for up to 10%-20% of global warming by year 2050. There to improvements the efficiency of air conditioning technologies and reduce the use of GHG refrigerants.

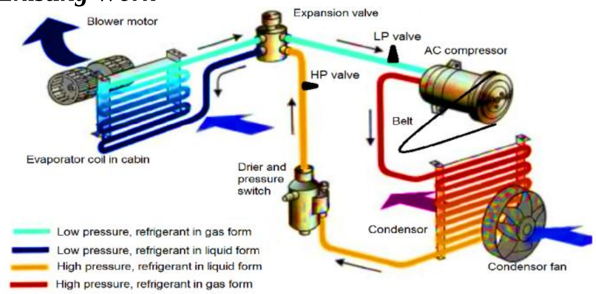


- ❖ A New designs of magnetic air conditioning components and compact devices with using of water-based heat transfer fluids. Efficiency improvements of 20-30% compared to currently available vapor compression based systems. The combination of solid-state refrigerants, water-based heat transfer fluids, and high efficiency will lead to environmentally desirable products with minimal contributions to global warming.
- ❖ In addition, magnetic refrigeration uses no ozone-depleting gases and is safer to use than conventional air conditioners, which are prone to leaks.
- ❖ This technology could reduce energy consumption for building air conditioning and providing consumers with cost savings on energy bills. The Solar Thermal Air conditioner can save you up to 60% electric bill, but as solar photovoltaic (PV) system air conditioner runs fully from solar energy, it saves you full Electric bill.

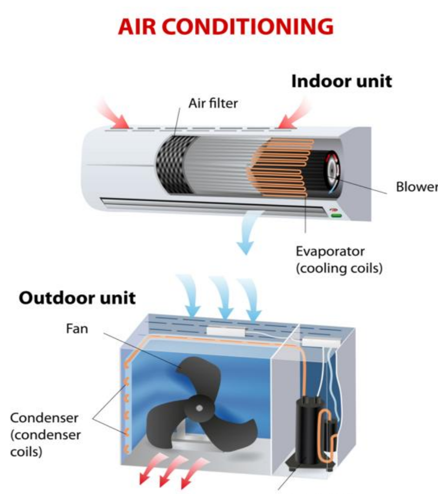
Literature Studied

- ❖ O. Ekren, et al., [1] this article described the studied performance of a near room temperature magnetic cooling system was investigated experimentally in terms of temperature span. The current setup has a permanent magnet pairs (0.7 Tesla), a magneto caloric material (Gadolinium) and a heat transfer fluid (water, ethylene glycol and 10% ethanol-water mixing) furthermore solar energy was used as a power source of liner motion of the magnetic system. The obtained results showed that ethanol-water was the best heat transfer fluid and also that optimum magnetization-demagnetization period for the system was found 10 s.
- ❖ Steven L, et al., [2] A study preliminary assessment of the permanent magnet costs and magneto caloric material costs indicates that, for suitably chosen materials and operating conditions, these costs lay well below the total manufactured costs for vapor compression based air conditioners. The combination of solid-state refrigerants, water-based heat transfer fluids, and high efficiency will lead to environmentally desirable products with minimal contributions to global warming.

Existing Work



- ❖ Your air conditioning unit uses chemicals that convert from gas to liquid and back again quickly. These chemicals transfer the heat from the air inside your property to the outside air.
- ❖ The AC unit has three key parts. These are the compressor, the condenser, and the evaporator. Your unit's compressor and condenser are typically located in the outside part of the air conditioning system. Inside the house is where you will find the evaporator.
- ❖ The cooling fluid reaches the compressor as a low-pressure gas. The compressor squeezes this gas/fluid, and the molecules in the liquid are packed closer together. The closer the compressor forces these molecules together, the higher the temperature and energy rise.



Demerits of the Existing Work

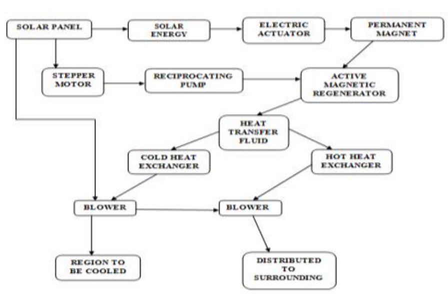
- ❖ Expensive : initial cost as well a running costs are very high
- ❖ Needs to be maintained professionally and maintenance cost is higher
- ❖ High power consumption
- ❖ The efficiency of the system.
- ❖ Leakage problems and Whether alternative refrigerants are compatible.

- ❖ Efficiency and availability of modern refrigerants.
- ❖ Higher energy costs.
- ❖ The use of air conditioning is increasing pollution in the environment by releasing poisonous gases into the environment. these gases include the chlorofluorocarbons and hydro-chlorofluorocarbons. they have a negative impact on the environment as they are part of the greenhouse gases that trap heat and lead to depletion of the ozone layer.

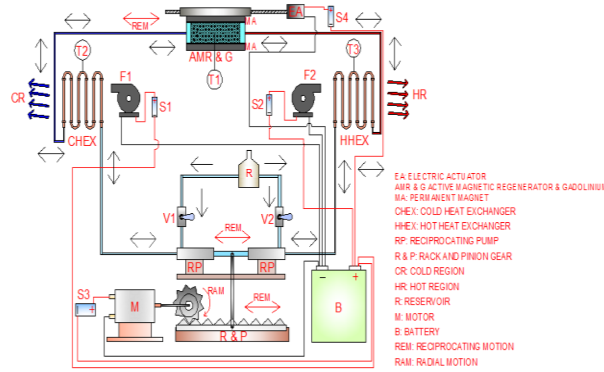
Proposed Work

- ❖ A new designs of magnetic air conditioning components and compact devices with using of water-based heat transfer fluids. Efficiency improvements of 20-30% compared to currently available vapor compression based systems.
- ❖ The combination of solid-state refrigerants, water-based heat transfer fluids, and high efficiency will lead to environmentally desirable products with minimal contributions to global warming. widespread adoption of this technology could reduce energy consumption for building air conditioning and providing consumers with cost savings on energy bills. Adiabatic demagnetization is a process of cooling. it occurs in magneto-caloric materials.
- ❖ Each atom of the material or a para-magnetic salt can be considered as a tiny magnet. when the salt is not magnetized, then then all its atoms are randomly oriented such that the net magnetic force is zero. if it is exposed to strong magnetic field, the atoms will align themselves to the direction of the magnetic field. this requires work and the temperature increases in this process.
- ❖ Now if the magnetic field is suddenly removed (demagnetization), the atoms will come back to the original random orientation. thus this requires work to be done by the atoms and consequently the material cools down.

System Model



Layout



Working Principle

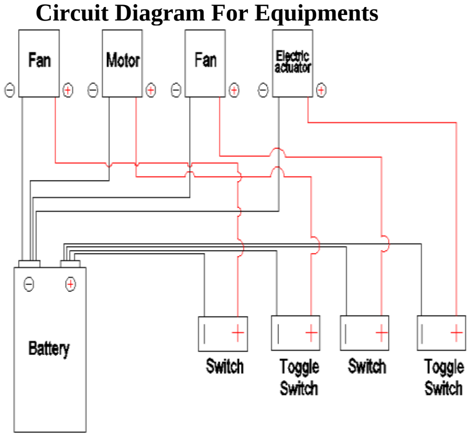
- ❖ The working principle of an AMR refrigerator and its basic components, the refrigerator consists of the following parts:
- ❖ A device responsible for creating the magnetic field, a regenerator with magnetocaloric material, CHEX and HHEX, and A device providing the flow of HTF through the active regenerator.
- ❖ The heat exchanger in this system is divided into two

  Cold heat exchanger

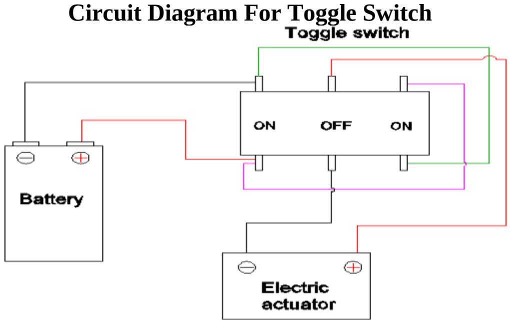
  Hot heat exchanger
- ❖ Cold region is destination path to be cooled and hot region is area which led to the surrounding.
- ❖ The AMR cycle is based on four processes: magnetization, demagnetization and two processes where the intensity of applied magnetic field remains constant.
- ❖ **Magnetization Process**: The magnetic field is applied to the magnetic material. Magnetic material temperature increases due to the MCE, while also increasing the temperature of the HTF in the AMR due to heat transfer.
- ❖ AMR cooling process to a constant applied magnetic field. This process is performed as a result of the AMRs HTF displacement with fluid from CHEX. The fluid absorbs heat from the regenerator and releases it at HHEX.
- ❖ **Demagnetization process:** The regenerator material is cooled by the MCE and absorbs heat from the HTF, achieving to lower its temperature below the initial temperature of CHEX.
- ❖ AMR heating process at constant magnetic field. At zero field the HTF, cooled in process is displaced from the regenerator towards the CHEX via fluid from the HHEX.
- ❖ The fluid in the CHEX absorbs heat from the medium to be cooled, which temperature of the fluid in motion of the HHEX is higher than that of the magnetic material; therefore, the HTF yields heat to the magnetic material while

moving towards CHEX. With this latter process, an AMR refrigerator working cycle is closed. As a result of the repetition of these processes in cycles the temperature span between the hot side and cold side of the AMR is increased. As the cycle is activated repeatedly, the temperature span becomes greater than the temperature range achieved by the MCE.

Circuit Diagram For Equipments

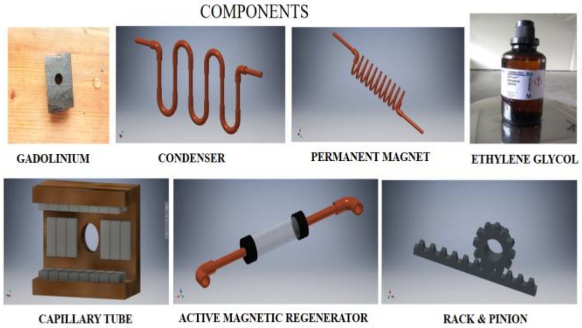


Circuit Diagram For Toggle Switch



PERFORMANCE EVALUATION

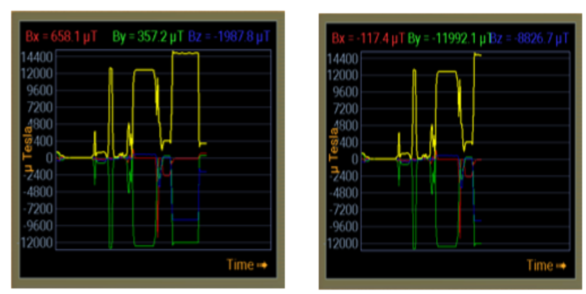
COMPONENTS



SYSTEM SETUP

Magnetic Field Graph

single permanent magnet (20mm x 10mm x 2mm) Double permanent magnet (linear direction)



Mini Prototype

- Gadolinium sample = 5.03 grams
- Sensor tip = 1.25 grams
- Sample AMR material = 0.88 grams
- Total weight of then sample material = 7.16 grams
- Single permanent magnet (20mm x 10mm x 2mm) = 2124.2 µ tesla
- Double permanent magnet (linear direction) = 14890.7 µ tesla
- AMR = 9 cm
- Gadolinium piece = 26 pieces
- Total weight = 79.47 grams
- Fabric hollow tube
- Shaft = 42.78 grams and l = 13 cm

- Reciprocating sides = 26.54 and 26.90 grams

Prototype Calculation

❖ SET 1 (after cooling kept at atmospheric condition)

Magnetization time	Cooling time	Initial temperature	Final temperature
1.11 mins	50 sec	28.9° c	25.3° c (10 mins)

Temp = time	Temp = time	Temp = time	Temp = time	Temp = time
28.8 = 30 sec	27.8 = 2.7 min	26.8 = 3.56 min	26.1 = 5.50 min	25.4 = 9.55 min
28.6 = 45 sec	27.7 = 2.12 min	26.7 = 4.5 min	26.0 = 6.20 min	25.3 = 10.40 min
28.4 = 1.10 min	27.6 = 2.28 min	26.6 = 4.18 min	25.9 = 6.35 min	TOTAL DIFFERENCE = 3.6° C TOTAL TIME SPAN = 0 – 10 MINS
28.2 = 1.22 min	27.3 = 2.45 min	26.5 = 4.30 min	25.8 = 7.5 min	
28.1 = 1.33 min	27.2 = 2.57 min	26.4 = 4.50 min	25.7 = 8.22 min	
28.0 = 1.43 min	27.1 = 3.10 min	26.3 = 5.02 min	25.6 = 8.50 min	
27.9 = 1.52 min	26.9 = 3.36 min	26.2 = 5.15 min	25.5 = 9.26 min	

❖ SET 2 (with cooling kept at room condition)

Box as room of volume = 10 x 8.5 x 3 = 255 cm3

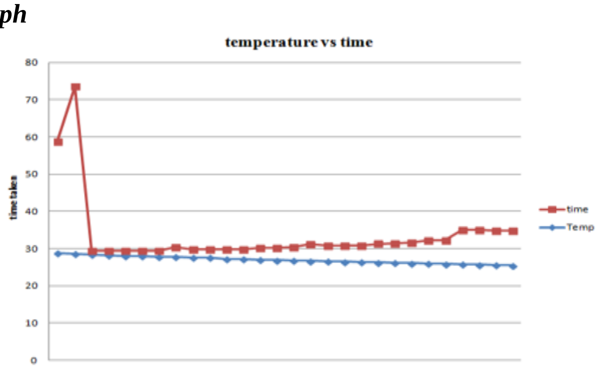
Magnetization time	gadolinium sample temperature		Room temperature (box)	
	Initial	Final	Initial	Final
1.7 mins	27.4	24.6	28.1	27.5

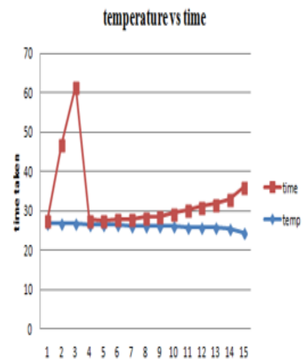
TEMP DIFF = 2.8° c

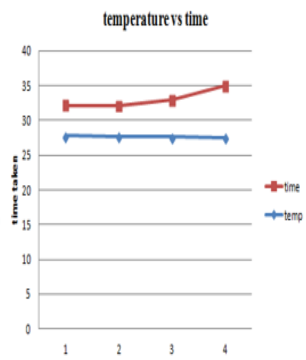
TEMP DIFF = 0.6° c

gadolinium sample temperature			Room temperature (box)
Temp = time	Temp = time	Temp = time	Temp = time
27.0 = 0.5 sec	26.4 = 1.40 min	25.9 = 4.30 min	27.8 = 4.39 min
26.9 = 20 sec	26.3 = 1.52 min	25.8 = 5.30 min	27.7 = 4.44 min
26.7 = 35 sec	26.2 = 2.22 min	25.7 = 6.10 min	27.6 = 5.30 min
26.6 = 1.1 min	26.1 = 2.58 min	25.6 = 7.30 min	27.5 = 7.55 min
26.5 = 1.12 min	26.0 = 3.40 min	24.6 = 11.50 min	

Graph







Observation And Tabulation

Magnetization period	Time	Temperature	Demagnetization period	Time		Temperature	
0 – 2.30 min	25 sec	30.1° c	2.03 – 11.00 min	2.59min	6.49 min	30.5° c	29.7° c
	35 sec	30.2° c		3.30 min	7.19 min	30.4° c	29.6° c
	42 sec	30.3° c		3.58min	8.02 min	30.3° c	29.5° c
	1.40 min	30.4° c		4.30 min	8.53 min	30.2° c	29.4° c
	1.59 min	30.5° c		5.01 min	9.40 min	30.1° c	29.3° c
	2.22 min	30.6° c		5.35 min	10.2min	29.8° c	29.1° c

Cost

MATERIAL	QUANTITY	COST
GADOLINIUM	1 (80 grams)	3000
PERMANENT MAGNET	42(40mm x 20mm x 2mm)	1500
ELECTRIC ACTUATOR	1	200
DC MOTOR	1	650
RACK AND PINION	1	250
HEAT TRANSFER FLUID	1(LT) (ethylene glycol)	1000
BLOWER FAN	2	100
HOT AND COLD HEAT EXCHANGER	2	500
TEMPERATER SENSORS	2	500
RECIPROCATING PUMP	1	100
WOOD	1.5 meter	400
TOTAL	54	8200

Conclusion and Future Work

❖ In our project phase II we have Endeavour our idea, designed and fabricated magado air conditioner supported by additional energy of solar. The objective of this project is to reduce global warming, reduction liquid refrigerant and at minimum cost of air conditioner.

❖ The reading is taken based on the temperature reduction in the AMR and time required for the temperature different and graph are plotted.

❖ A New designs of magado air conditioning components and compact devices with using of water-based heat transfer fluids. Efficiency improvements of 20-30% compared to currently available vapor compression based systems.

- Reduction in global warming and less consumption in electricity and replacement of harmful refrigerant and overcome of compressor ,which is major reason for current consumption.

Future Scope

- Gadolinium, a typical magneto-caloric material, has a maximum ∂Ta of 2.5 °C (4.5 °F) at the Curie temperature in a 1 T field. The Curie temperature, and thus the temperature of the peak ∂Ta, may be moved by adjusting the magneto-caloric material composition. The effect is considerably stronger for the gadolinium alloy Gd_5 (Si_2Ge_2)and Gd-Er.
- Increase in magnet source will increase the cold temperature span, we have used 6 (40mm x 20mm x 2mm) for 5 grams of gadolinium. Then for 80 grams it required least of 60 magnets to increase the magnetic field.

- Leakage is the major factor that we have faced; prevention of the leakage in the fluid transferring pump will increase the efficiency of the air conditioner. By changing the material (such as stainless steel, metal etc…) and fixture position the system will be more efficient.

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