International Journal of Pure and Applied Mathematics
Volume 118 No. 24 2018
ISSN: 1314-3395 (on-line version)
url: http://www.acadpubl.eu/hub/
Special Issue
http://www.acadpubl.eu/hub/

A NOVEL TECHNIQUE FRIDGE POWERED BY HYBRID RENEWABLE ENERGY SOURCES FOR RURAL/ ISOLATED AREAS

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May 29, 2018

Abstract

The present paper is related to energy conservation and conversion, harvesting power from hybrid renewable energy sources, the scope of instrumentation, Electronics, and Electrical technology with the usage of battery and microcontroller. The aim of this proposed paper is to design and develop a working thermoelectric fridge that utilizes the Peltier effect. The design requirements are also to cool the volume to a temperature within a short time. This proposed fridge will be used in an isolated, rural and remote area where there is no grid electricity, or the available power supply is unreliable. Hence always there is a need for a renewable energy source. Among all other resources, solar energy is judged to be the best solution for these areas. The Peltier effect based cooler presented here is generally used in applications where both capacity and cooling demands are not too high, i,e for domestic and small business purposes.

***Key Words*:**Thermoelectric, Seebeck effect, Peltier effect, Heatsink, Fridge, Chullah, Microcontroller, and Charge controller.

1 INTRODUCTION

In India, 74% people of the total population live in villages and use the conventional resources e.g. wood, cow dung, agriculture waste and other biomass. Most of them are not literate enough to handle the instrumentation/electrical/electronics unit. Normally they use self-made chullahs for cooking purpose, in a traditional cooking furnace (chullah) 80% of the heat is wasted and only 20% is used. People living in remote areas do not get a facility for refrigeration. Pushcart vendors in most of the villages sell their goods in hot summer which often require proper refrigeration but, due to high price of refrigeration system they are not able to afford the fridge and their products get spoiled, also medical stores or clinics in the rural areas need a fridge to store the medicines and injections to keep it safe for longer time but due to high price some medical shops an invention is to design and develop a new system of working thermoelectric fridge at a lower cost that utilizes the Peltier effect and powered by hybrid renewable system. The source of the energy is waste heat from chullah and solar PV, for the people residing in hilly/remote areas/village, where there is no grid, no electricity and still the electrical power supply is unreliable. Hence a solution is renewable energy source can use. Solar energy is the best solution for this area. Our Peltier coolers fridge is generally used in applications where small size is needed and the cooling demands are not too great, such as for domestic and small business purpose. The sole aim of the invention is to design and develop a fridge to cool the volume to a temperature within a short time for rural people.

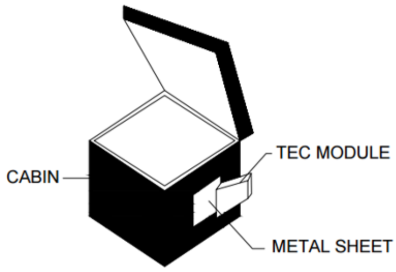

Fig.1. The proposed fridge

Product	TEC-12706
Operational voltage	12V DC
Current max	6 Amp
Voltage max	15.4 V
Power max	92.4
Power nominal	60
Couples	127
Dimensions	40 x 40 x 3.5 mm

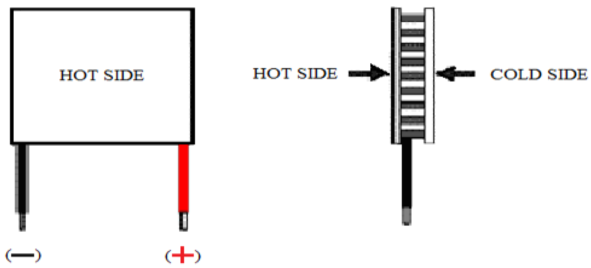

Fig.2. Schemaic view of a typical Peltier device

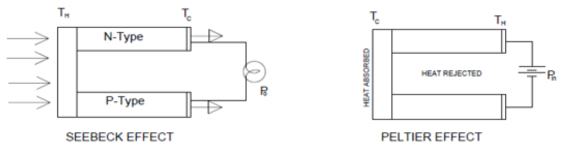

Fig.3. View of see beck and pettier effect

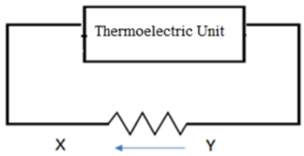

Fig.4. Single thermo electric couple with an applied temperature difference

2 DESIGN

The System design is proposed to carry out in three phases, first is the design and development of proposed fridge powered by hybrid renewable energy system, second is the self-made chullah to generate electricity and third design of solar PV.

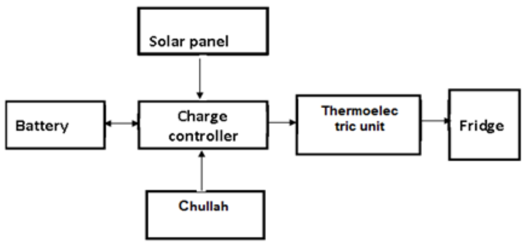

Fig.5. The overall structure of the utility model using 2-D view

The proposed TEC fridge will utilize the power from the hybrid renewable energy resources like solar panels, and the heat source of domestic chullah. By applying a low voltage DC power source to a thermoelectric module, heat will be moved through the module from one side to the other. One side will be cooled while the opposite side is simultaneously heated. In this thermoelectric cooling system, a doped semiconductor material takes the place of the liquid refrigerant, the condenser is replaced by a heat sink, and the compressor is replaced by a DC power source. The application of DC power to the thermoelectric module causes electrons to move through the semiconductor material. At the cold end of the semiconductor material, heat is absorbed by the electron movement moved through the material, and removed at the hot end. Since the hot end of the material is physically attached to a heat sink, the heat is passed from the material to the heat sink and then it transferred to the environment.

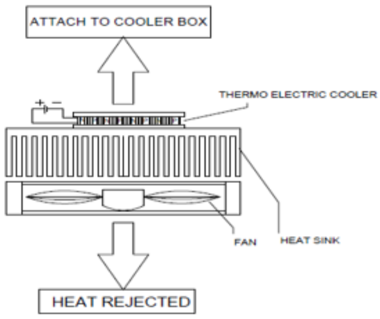

Fig.6. The typical diagram of thermoelectric unit on fridge model

Renewable source of heat and solar are charging the battery through a charge controller and that stored power is used for refrigeration. Different types of chullah are used by different people hence it is very difficult to accommodate the thermoelectric units with respect to shape/size. The proposed chullah unit will have a definite number of thermoelectric units (at least two thermoelectric (TEG)) connected in series to generate Electricity from the waste heat.

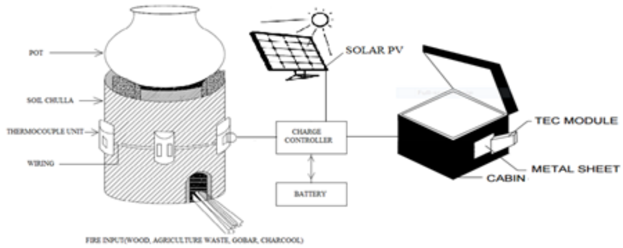

Fig.7. The overall structure of the utility model in 2-D view

3 DETAILED DESCRIPTION

The proposed system is made of an aluminum metal sheet with a thermal conductivity of 210W/mk is used as an inner wall of the fridge which works against heat, cold, sound and humidity. The dimensions of the inner portion of the fridge are 18cm x 18cm. A layer of graphene is coated to the metal sheet (inside the fridge), to increase the efficiency of refrigeration in the proposed system. Graphene has a property of superconductivity which means electricity can flow through it with zero resistance. The outer wall of the metal sheet is covered with a cardboard sheet with a thermal conductivity of 0.21W/mK for giving strength and insulation and it is coated with a paste of Plaster of Paris for good effect of cooling. Cardboard sheet is then bounded by Styrofoam with a thermal conductivity of 0.033W/mK for thermal insulation. A Peltier setup is then fixed on the two sides of the fridge for the cooling process. The Peltier effect converts electric voltage into a change in temperature because there are two dissimilar conductors into the circuit one junction of the unit will be cooled and the other will be heated. The cold end of the thermoelectric module is used in the system to cool the fridge and hot end is attached to a heat sink for heat rejection. In proposed system, LED is present inside the box which will automatically glow when the door of the fridge will be opened. A microcontroller has been used for controlling the voltage manually by using switch and temperature that is displaying on the LCD. The proposed fridge will utilize the power from the renewable energy resources like solar panels and the waste heat source of domestic chullah. A 5-watt solar panel is used. A double input charge controller is designed for charging the 12V battery. The Chullah is of 18cm and 23 cm in height, the indoor part is of dimension 11cmX15cm and the projection base of 10cm. It is made up of mud from local clay normally portable in nature provides a better combustion. During the operation of the Chullah, a part of the waste heat will be converted back into dc power by the thermocouple units and through the concept of waste heat recovery. By applying a low voltage DC power source to a thermoelectric module, heat will be moved through the module from one side to the other. One side will be cooled while the opposite side is simultaneously heated. In a thermoelectric cooling system, a doped semiconductor material takes the place of the liquid refrigerant, the condenser is replaced by a heat sink, and the compressor is replaced by a DC power source removed at the hot end. Since the hot end of the materials is physically attached to a heat sink, the heat is passed from the material to the heat sink and then it transferred to the environment. In general, Peltier cooling technology uses no motors or compressors, so it operates noiselessly. It does not contain refrigerants which are harmful to the ozone layer or contribute to the greenhouse. The component can be easily replaced when it is not working properly.

4 ANALYSIS

A prototype was designed and tested with the following discussions: The thermoelectric device is connected to the Chullah with hot side temperature of 70 C and cold side temperature of 26 C. The thermoelectric device with a heat sink and fan assembled mounted on the wall, the hot side touching the wall surface of the chullah, while the cold side was left at room temperature. As the temperature of the chullah wall surface increased, the voltage and current from the thermoelectric unit started increasing as well. The temperature of the wall surface and the outer side of the thermoelectric device is measured by a digital thermometer. The measurement of voltage and current is accomplished by using a multimeter, with the probes placed at the positive and negative terminals of the thermoelectric device. A single thermoelectric device has a voltage and current rating as mentioned below.A temperature difference of thermoelectric device, T = 52oC (Hot side temperature Th= 70oC & cold side temperature Tc = 26o C Output voltage: 6.41 V; Output current: 700 mA; Output Power: 4.487 W. Two Thermoelectric devices are connected in series and the output voltage is to be 12.5V with a current of approximately 1A and in order to obtain a higher rating of current, the thermoelectric devices will be connected in parallel. The energy thus generated is stored in a battery and used later for giving power to the fridge.

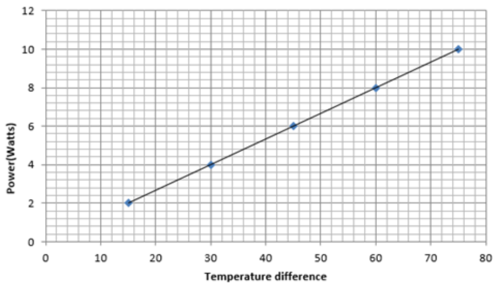

Fig.8. Variation of power Vs temperature difference for challah

The open circuit voltage of a thermoelectric device with temperature difference is determined by the expression $V = SxT$
Where: V is the output voltage from the thermoelectric device in volts.
S is the average See Beck coefficient of the thermoelectric device in Volts/.
T is the temperature difference across the thermoelectric device in degree Kelvin, where $= T_h - T_c$

When a load is connected to the thermoelectric device the output voltage (V) drops as a result of internal device resistance.

In the proposed system of the fridge. For analyzing the performance of the system, water load is considered as the active heat load to the system. Water at 28 C was filled in the container and kept in the fridge before switching ON the system. The temperatures at every 5 minutes interval were tabulated. The readings were recorded for 25 minutes. The cabin temperature drop was at an average rate of 50oC. The greatest temperature difference between the thermal load and the ambient environment that can occur. So in the worst-case, difference between the ambient and load temperatures will be the temperature difference, T in the equations which follow. Including both the conductive and convective heat transfer components of the load, denotes this equation:
$Q = (\Delta TA)/(1/h + L/k)$,Temperature to be maintained inside the cabin $= 8^0$ C
Outside temperature or ambient temperature $= 28^0$ C
Temperature difference between the cabin walls $= (28 - 8)^0$ C $=$

20^0 C
Thermal conductivity of metal sheet(Kms) = 52 W/mK
Thermal conductivity of expanded polystyrene(Keps) = 0.033 W/mK
Thermal conductivity of cardboard sheet(K_{cs}) = 0.21 W/mK, h_{air} = 10 W/m^2K
Area=0.18X0.18=0.0324m2
$Q = (\Delta TA)/(21/h_{air}$+l1/$K_{eps}$+l2/$K_{ms}$+l3/$K_{cs}$)) = (0.032420)/(21/10+0.025/0.033+0.002/52+0.0046/0.21) =0.668W Q1=Q2=Q3=0.668W
Passive load through the walls Q_P= (Q_1+Q_2+Q_3) 2 = (0.668+0.668+0.668) 2=3.924$W \approx 4W$ Q_P+Q_C = 4 + 10 = 14 W For safety, QTP$\approx 20W$

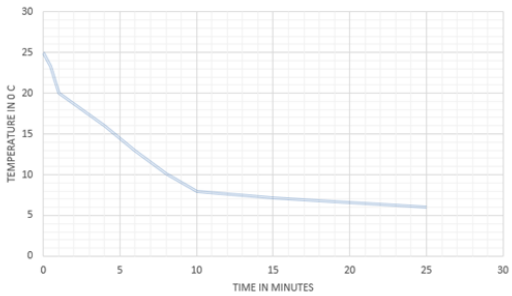

Fig.9. Variation of power Vs temperature difference for challah

5 SYSTEM DESIGN

Proposed invention design values are:
Power, Q = 20 Watt heat load
Maximum outside air temperature, T_A= 28C
Temperature for the inner box, TC = 8C
The temperature at the hot side(T_H) will be equal to the sum of ambient temperature (T_A), and the rise in temperature across the heat sink from rejecting the heat load (Q) and the T_E module power (V x I).
$T_H = T_A + (VxI + Q)R_Q$
Where, R_Q is the thermal resistance of heat sink in ^0C.
In this design, we will keep the rise of temperature of the heat sink to not more than about 15^0C above ambient. This would give us a thermoelectric module hot side temperature of about 43^0 C.
$T_H = 28^0C + 15^0C = 43^0C$ The temperature differential across the thermoelectric module can be calculated as follows:

$\Delta T = T_H T_C = 43^0 C - 8^0 C = 35^0 C.$

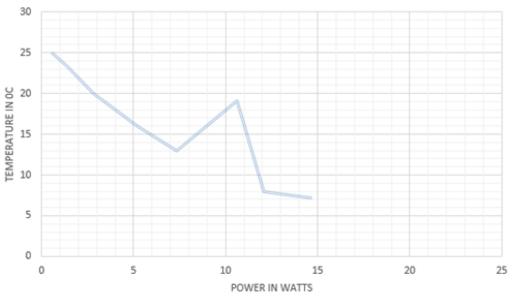

Fig. 10. Variation of power Vs temperature difference for fridge

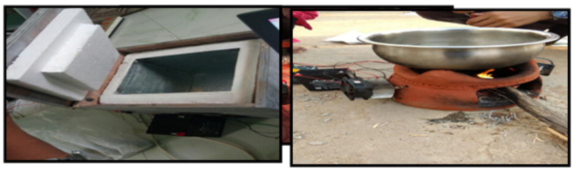

Fig. 11. Snapshot of the working model

6 CONCLUSION

We are successful in designing a system that fulfils the proposed goals. The prototype model designed is used only for light heat load to lower its temperature to a particular temperature. But if we proceed for commercial application tailor made systems can be designed .The prominent merit of the system that, such system requires low power to drive fridge. This work has provided us an exposure and experience to use our limited knowledge material assure an excellent future for TEC. Integration of renewable energy as power source this proposed fridge is very useful for remote rural places where there is no electric supply.

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