Design and Fabrication of Evaporative Cooler with Peltier Effect (NAS3)

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Abstract— This paper presents the innovative idea about how to use peltier module in air conditioning sector. Actually in conventional evaporative cooler the water required for cooling the air is too much. To obtain the cooling effect same or more than conventional evaporative cooler we use peltier module effect to cool the air and reduce the amount of water required to cool the air in evaporative cooler. This is modification in evaporative cooler.

Key words: Honeycomb pads, Submersible pump, CPU fan, Peltier thermopile, Calorimeter, Thermal resistance, Cooling

I. Introduction

In the conventional air evaporative cooler consumes more water to evaporation cooling and consume less electrical power as compare with air conditioners. NAS3 needs less power also concentrate on reduce water requirement for evaporative cooler. The new generation evaporative cooler NAS3 is containing evaporative coils at suction side of cooler to reduce the temperature of incoming air before air enters into the coller. Coolant is use as a refrigerant in system. Peltier liquid cooler system is use to maintain the temperature of coolant which is flowing through the close cycle coolant circulation coil. To maintain the evaporation rate of water the timing pump is use which helps in pumping of water from sump to honeycomb cooling medium pad. Windows air conditioning system works on principal of vapor compression cycle and in evaporative coolers also known as swamp coolers or desert coolers hot air from outside is passed over water. The water takes up the heat from the outside air and it evaporates. Hence due to the transfer of heat from air to water, the temperature of air decreases, making it comparatively cooler. This cool air is then directed inside the room. This process when repeated constantly brings down the overall temperature of room. In this modified evaporative cooler (NAS3) we make combination of window air conditioner and swamp cooler. The air comes from outside first pass over the cooling coil then in second stage the air is pass over the water through honeycomb cooling pads. By continuing this process the temperature of room comes down.

II. Review of Literature

The following survey is taken from Elsevier Masson SAS C. R. Physique 17 (2016) 1161–1174 by Charles Grenier, Corinna Kollath, Antoine Georges France from paper topic Thermoelectric transport and Peltier cooling of cold atomic gases. This brief review presents the emerging field of mesoscopic physics with cold atoms, with an emphasis on thermal and 'thermoelectric' transport,i.e. coupled transport of particles and entropy. We review in particular the comparison between theoretically predicted and experimentally observed thermoelectric effects in such systems. We also show how combining well-designed transport properties and evaporative cooling leads to an equivalent of the Peltier effect with cold atoms, which can be used as a new cooling procedure with improved cooling power and effciency compared to the evaporative cooling currently used in atomic gases. This could lead to a new generation of experiments probing strong correlation effects of ultracold fermionic atoms at low temperatures. The last fifteen years have established ultracold atomic gases as efficient quantum simulator. Using those ex-tremely flexible systems in which geometry, interactions and disorder can be tuned at will, experiments on synthetic materials have been performed. These experiments reveal the characteristics of various phase transitions, and contribute to our understanding of strongly correlated matter.

A. Existing Basics of cold atom thermoelectricity:

1) Model:

The setup under consideration is the two-terminal setup sketched in Fig. 1. The setup is largely inspired by the ubiquitous Landauer configuration of mesoscopic physics. A large atomic cloud is divided by a suitable laser beam into two reservoirs which are connected by a narrow channel. The junction between the two reservoirs can be considered as a circuit element having a conductance G, a thermal conductance G_T and a thermopower α_{ch}. In order to get a key signature of thermoelectric effects, the reservoirs are prepared with N atoms each at a temperature T . Then, one side is heated up to a temperature $T_h = T + T_0$, the populations of the two reservoirs remaining the same.

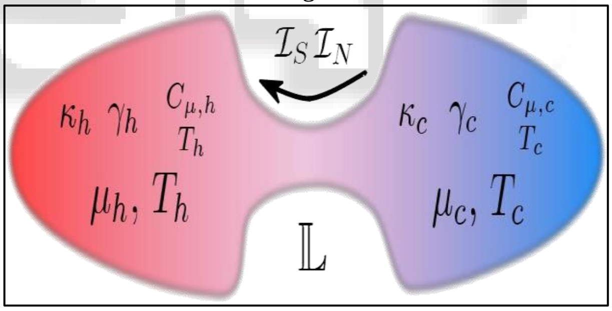

Fig. 1: Mathematical Model

Cold atom systems are well isolated. This means in particular that the total particle number is conserved, implying that current between the reservoirs is only a transient effect and no stationary regime will be reached. It is useful to view the above setup as the analogue of a capacitor (each plate being a reservoir) connected to a resistor (representing the junction), and the actual experiment as the transient discharge of this capacitor. We assume that the temperature and chemical potential biases $T = T_h - T_c$ and $\boldsymbol{\mu} = \boldsymbol{\mu}_h - \boldsymbol{\mu}_c$ are small with respect to the Fermi temperature T_F and energy E_F (with $T_F = E_F/k_B$) of the entire cloud. Therefore, particles and heat flow can be described using linear response and the transport properties of the junction by a constant matrix L of transport coeffcients. Thermoelectric effects originate from a reversible coupling between heat and particle flow. Within linear re-sponse, the expressions of the particle and entropy currents I_N and I_S in terms of the chemical potential and temperature biases $\boldsymbol{\mu}$ and T are obtained following Onsager's picture of coupled transport processes.

III. NEW PROPOSED SYSTEM DESIGN

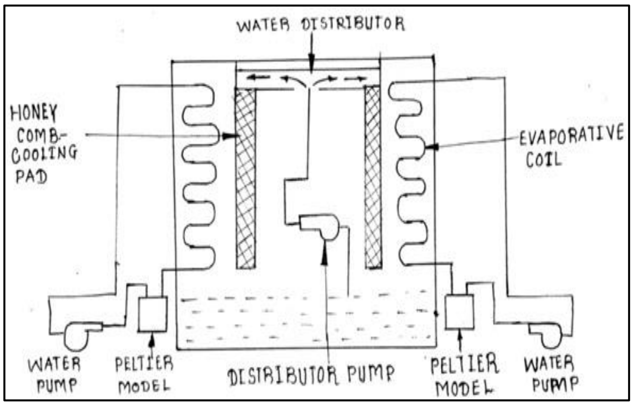

Fig. 2: proposed design diagram of overall project

As shown in fig. the conceptual model of air cooler is containing different equipments. Air suck from atmosphere first stick on evaporative cooper coils. Then cool air further cooled in honeycomb cooling medium pads. The water supplied to honeycomb cooling pad is from timing distributor pump. Water is circulating through copper evaporative coils and the cooling of water obtained by using peltier water cooler model. The close water circuit coils are design to circulate the cooled water refrigerant. Two different small water pumps are use to circulate the cooled air comes through peltier water cooler model. A water distributer are use to give a supply for evaporative cooling to honeycomb cooing pads.

A. *Major components:*

1) Honeycomb cooling medium pad.
2) Galvanized steel body.
3) Evaporative coils.
4) Peltier water cooler model
5) Water distributer pump.
6) Fan.

Sr. No.	Parameters	R.M.S.	Material	Qty
	Length of Copper Coil	4572 mm	Copper	2
	Submersible Pump	-	-	2
	Peltier Water Cooler Model	-	-	2
	Evaporative Cooler Motor	-	-	1
	Plastic Blade	2743.2 mm	Plastic	1
	Water Distribution Pipe	□□□□□□6096 mm	Plastic	1
	Honey Comb Pads	4876.8 □ 5486.4 mm	Wooden	2

Table 1: Components Details

1) *Honeycomb cooling medium pads:*

In conventional evaporative cooler grass pads are use to make a contact between hot air which comes from outside and water. But the main disadvantage observed with use of grass pad is, it consumes more water for cooling. As our main target is to reduce the water requirement for cooling we replaced grass pads with honeycomb pads.NAS3 is the cooler of 2.5ft high so as we design we take a two honeycomb pads of 17inch length and 19inch height and 2inch thickness.

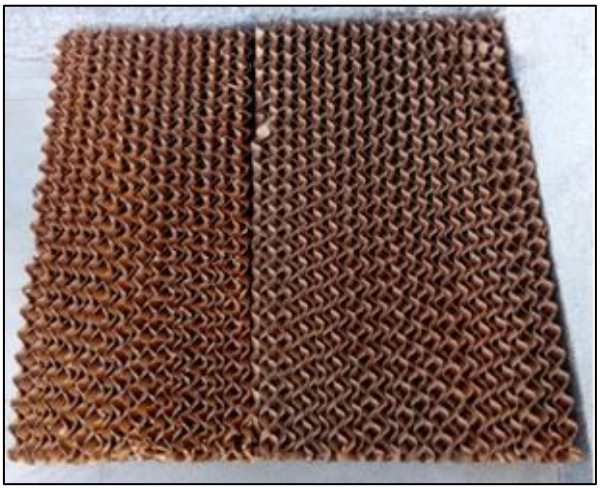

Fig. 3: working of honeycomb cooling pad

2) *Galvanized Steel Bode:*

The material use to make the body of air conditioner is galvanized steel. We can also use plastic and fiber for the same purpose. Plastic and fiber available in less cost but fiber coolers have lesser cooling efficiency as compared to steel body coolers. The galvanized steel has great thermal properties and suitable for air conditioning purpose. Galvanized steel have great corrosive resistance properties and long life.

Fig. 4: galvanized steel sheet

3) *Evaporative Coil:*

A heat exchanger is a device designed to efficiently transfer or "exchange" heat from one matter to another. When a fluid is used to transfer heat, the fluid could be a liquid, such as water or oil, or could be moving air. The most well known type of heat exchanger is a car radiator. Evaporator is an important component together with other major components in a refrigeration system such as compressor, condenser and expansion device. The reason for refrigeration is to remove heat from air, water or other substance. It is here that the liquid refrigerant is expanded and evaporated. But in NAS3 we use water as refrigerant and no vapour compression cycle use. Hence we don't use compressor and condenser in it. And cooling is done with help of thermo electric cooling device also called as peltier cooing model. Heat exchangers are devices that transfer heat in order to achieve desired heating or cooling.

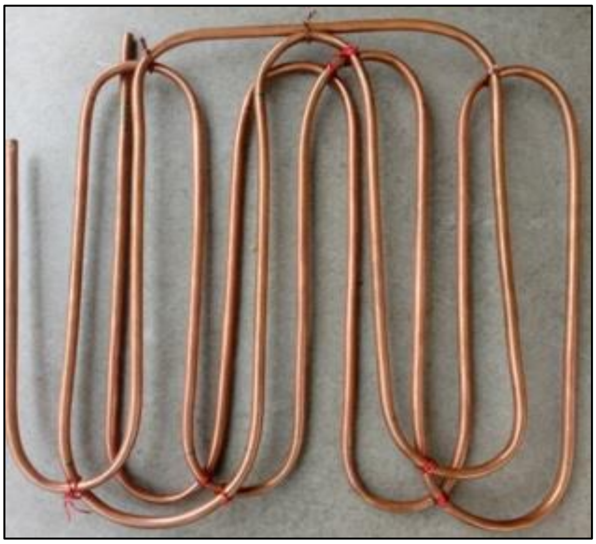

Fig. 5: Evaporative coil

4) Peltier liquid cooler model:

As our design says we need to cool the air by some degree before it enters in honeycomb pads to obtain our desire goals we place cooper coils before the honeycomb pads and the cold coolant is use to cool the coil. For continuous cooing of coolant we make a peltier liquid cooling model to maintain the temperature of coolant. As shown in fig. we make a model like sandwich. We fixed CPU fan at hot side of peltier module and one cooling block of same size of peltier module at cool side of module. We maintain the temperature of coils by cool the returned coolant from coils. The peltier assembly having a separate sump and it works in close cycle.

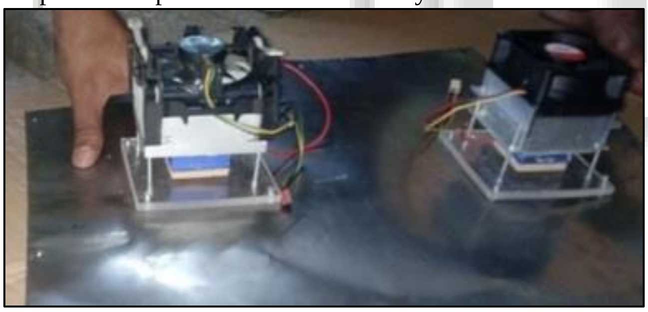

Fig. 6: Components Of Peltier Model

***5)** Water Distributor Pump (Two water submersible pump with separate sump):*

We supply water at top of honeycomb pads with help of main submersible pump. We use another small size submersible pump to supply the coolant to cooling coils. In close circuit of small submersible pump, coolant first flow through the peltier liquid cooling model then flow through cooper coils. The hot coolant comes out from cooper coils come back in separate small sump. There is a two separate sump with two separate submersible pumps. The detailed sump design and line diagram as shown in fig. 7.

Fig. 7: submersible pumps

6) Motor & Blades:

In evaporative cooler fan is major component it sucks air from atmosphere and delivered to the room. Many types of fan available in market but in our air conditioning project the cost, size, suction pressure, air delivered rate are considered as major parameters to be desided.12V fan are desirable for this project but it still has to be tested. The general requirements of fan are fulfill by using simple 12V air circulation fan in small size evaporative coolers.The fan was used to throw the air in specified room area but in evaporative cooler it will face resistance in suction side because of honeycomb cooling pads and our inventive evaporative coils. So, before we decide the fan resistance to air and suction pressure of fan it has to be calculated.

Fig. 8: Fan

B. Requirement Specification:

Here briefly description of human comfort parameter with their range and other specification considered for calculation,

Sr No.	Parameter	Inside	Outside
1	Dry bulb temperature in degree faranhite	*76*	*106*
2	Wet bulb temperature in degree faranhite	*78*	*64*
3	Percent relative humidity	*78*	*50*
4	DP – differential pressure	*67*	*56*
5	GR/lb	*100*	*70*

Table 2: Considered Parameters for Structure Design

Even if all these factors may vary with time, standards usually refer to a steady state to study thermal comfort, just allowing limited temperature variations. Also some comfort parameters is taking in account while designing the air condition system for specific area. Some of them listed below

1) Metabolic rate.
2) Clothing insulation.
3) Air temperature.
4) Mean radiant temperature.
5) Air speed.
6) Relative humidity.
7) Natural ventilation.

IV. Working Process

Now we are going to discuss the working process of NAS3 from beginning. We divide the whole air cooling process in two sections. In first stage the coolant is supply to small

40mm side cube water block which is attached with cooling side of peltier module. With help of small size submersible pump we pick the coolant from coolant sump and supply to peltier model. The coolant get cooled in peltier model after that low temperature coolant flowing through cooper coil. The coolant absorbs heat from air which comes from surrounding. The single submersible pump is use to supply the coolant to both peltier models. At last the returned hot coolant liquid again comes back in single coolant sump. Hence this close circuit gives primary cooling to system.

Second stage of air cooling is similar as swamp cooler. The water is picking by main submersible pump from water sump. The water is supply to both honeycomb pads at top side. The air and water getting contact with each other in honeycomb pads and water get evaporated by getting an heat from hot air comes from outside. This is simple water evaporation process which conducted in honeycomb pads. To maintain the humidity and water flow we can cut the supply of water to honeycomb pads. The micro controller is use to on/off the switch of water circulating submersible pump.

We use small exhaust fan with 9inch blade. The fan is use to suck the air from outside and delivered cooled air to room. After air passed through cooper coils and honeycomb pads air get cooled and delivered to room.

V. Influenceing Factor

Since there are large variations from person to person in terms of physiological and psychological satisfaction, it is hard to find an optimal temperature for everyone in a given space. Laboratory and field data have been collected to define conditions that will be found comfortable for a specified percentage of occupants [1]. There are six primary factors that directly affect thermal comfort that can be grouped in two categories: personal factors - because they are characteristics of the occupants - and environmental factors - which are conditions of the thermal environment. The former are metabolic rate and clothing level, the latter are air temperature, mean radiant temperature, air speed and humidity. Even if all these factors may vary with time, standards usually refer to a steady state to study thermal comfort, just allowing limited temperature variations. Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55) [1]. Maintaining this standard of thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC (heating, ventilation, and air conditioning) design engineers. Thermal neutrality is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. The main factors that influence thermal comfort are those that determine heat gain and loss, namely metabolic rate, clothing insulation, air temperature, mean radiant temperature, air speed and relative humidity. Psychological parameters such as individual expectations also affect thermal comfort [2].

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