# Performance of Indirect Evaporative Cooling System using Peltier effect and Desiccant wheel

**Dr. N Kapilan[1] Monish NP[2] Pradeepa G[3] Sanjeev LD[4] Shamanth Hadimani[5]**
[1]Head of Department [2,3,4,5]Student
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]NCET, Bangalore, India

*Abstract*— To improve the performance of indirect evaporative cooling system using Peltier effect and Desiccant wheel. Peltier effect is an effect through which heat is either liberated or absorbed when electric current passes across a junction between two conductors. Desiccant wheel is mainly used here for dehumidification process there by maintaining the moisture content. The unit consisting of hot chamber and cold chamber. Passing air through desiccant wheel for dehumidification and then feeding it to heat exchanger for making air chilled and implementation of seasonal efficiency by varying the speed of desiccant wheel. The speed of the desiccant wheel would be 10-20 RPH.

***Keywords:*** Alternative Cooling, Adsorption, Hybrid, Solar, Performance

## I. Introduction

Indirect evaporative cooling system lowers the temperature of air through some type of heat exchanger arrangement.

The thermo electric cooling fan is used to suck the heat from the air this results in the Peltier effect and the cool air is sent towards the desiccant wheel

As the Desiccant wheel rotates, the desiccant passes alternately through the incoming air where the moisture is absorbed, and through regenerating zone where the desiccant is dried and the moisture is removed.

As the Desiccant wheel continue to rotate the process will be repeated. The Regeneration process is done by the use of electric heating coil. The silica gel is not a “Gel” as it is mentioned in its name, but it is of porous granular structure form of silica which is made from sodium silicate.

The silica gel has the ability to absorb the moisture content and hold the moisture in it from the atmospheric air.

Most commonly there are two types of silica gel available in the market which are indicating and non-indicating type.

## II. Literature review

Mazzei. using the computer simulation tool, compared the operational cost of desiccant cooling system and the traditional systems and predicted a reduction of Thermal power up to 52% and saving in operational cost of about 35%. The authors projected if the regeneration of the desiccant would be done by waste heat. They have also found, when the indirect evaporative cooling in conjunction with desiccant humidification i.e. the reduction in cooling power and increase in cost saving. The operating cost will vary with the variation in the cost of electricity units, as it may vary from place to place.

Alizadeh. experimented with a prototype of solar LDAC absorber unit over a commercial site of about 200m² area located on the Persian Gulf region, the performance of the solar LDAC unit in controlling the temperature and humidity was satisfactory. The experiment shows that the conditioner unit can have effectiveness of 82% when used with liquid desiccant. The maximum electrical utilization for experimental units determined is 3KW with an electrical COP of about 7.

Kadoma investigated the impact of the desiccant wheel speed, air velocity and regeneration temperature on the COP. The authors showed the existence of an optimal speed and established that the COP decreased when the air flow rate increased and, on the contrary, the temperature of regeneration and the capacity of cooling had the same evolution tendency.

Desiccant cooling systems can not only be used for comfort air conditioning but also for products in markets, warehouses as well as for the preservation of stored cereals. Thorpe et al developed and tested a desiccant cooling device, regenerated by solar energy employed to preserve stored grains. The device produced the cooling energy almost the 50 times of the electrical energy input.

Aly (1988) analysed an integrated vapour compression and a waste heat dehumidifier air conditioning system. The waste heat of the vapour compression unit by the heat pump in a heat recovery system is entirely used to regenerate the drying matrix. The condition which was designed in Jedhah, Saudi Arabia, the overall cooling COP achieved by the combined system reaches 1.73, which is 25 % more than that of the vapor compression alone. When the ARI conditions are applied, the combined systems show an overall COP of 1.76 with 27 % energy saving compared to vapor compression alone.

Ismail (1991) analysed the performance of a solar regenerated open cycle desiccant bed grain cooling system. The experiments were performed to build a solar cycle grain cooling system. The device consisted of two beds of silica coupled with 95.85m2collector. Results from an experimental series suggest that the device may be used to cool up to 200 tons of grain. Consumption of electrical power of the device is in order of 0.3 watt per ton of grain cooled and the amount of total electrical energy consumption is of the order of 0.7 KWH per ton of grain stored for a 6 months' period.

The various researchers have applied different methodologies to get evaporative cooling effect. The literatures are classified on basis of the methodology applied for the specific applications.

## III. Principle of Indirect Evaporative Cooling System

The Indirect evaporative cooling works on the same principle as the direct evaporative cooling lowering air temperature by causing water to evaporate. Main difference in the indirect evaporative cooling system is that a heat exchanger is used to cool the air supplied to the living space. In the heat exchanger the evaporative cooling cycle occurs.

The explanation of what happens in an indirect evaporative cooling system:

The atmospheric air is blown through a heat exchanger that is supplied with water. One of the design for this type of heat exchanger features a series of cooling pads that are kept wet on their outside surfaces. As the hot air passes over these cooling pads, the water evaporates and the tubes are cooled. After passing over the cooling pads, the cool, moist air is exhausted to the outside.

As cooling happens on the heat exchanger's exterior surfaces, atmospheric air is drawn through the tube interiors. This air is cooled, but without gaining any extra humidity, before it is blown through ductwork to the building interior.

Indirect evaporative cooling method provides cool air to interior spaces with less humidity compared to direct evaporative cooling.

## IV. EXPERIMENT PROCEDURE

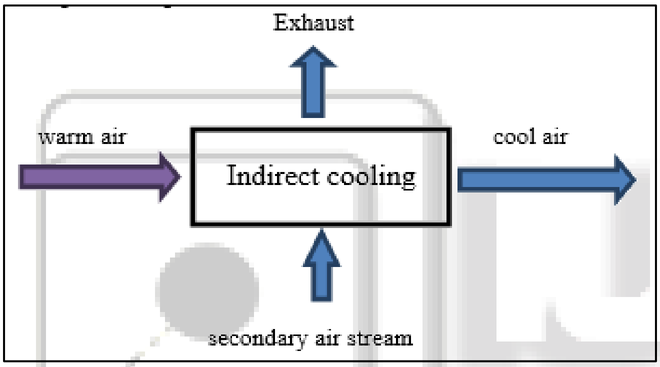


Fig 1.0: The schematic representation of Indirect Evaporative Cooling System.

IDECS mainly consists of two zone which are dehumidifying in cooling zone and regeneration zone.

Atmospheric air is drawn by the blower which is thermoelectric cooling fan used for Peltier effect which consists of the Peltier device in which the water is allowed to flow through it which results in decrease in the temperature of the water, so the water which is allowed to flow on the cooling pads will be lower in temperature and the air is fed to desiccant wheel where all the moisture present in that air is absorbed by desiccant material present in wheel. This dry air is fed into evaporative cooler.

The moisture locked into desiccant material is passed into regeneration zone whose temperature is maintained with the help of small electric heater.

Due to the removal of moisture, a part of desiccant wheel will get regenerated, this moisture is eliminated out from the room through the duct and cycle is repeated.

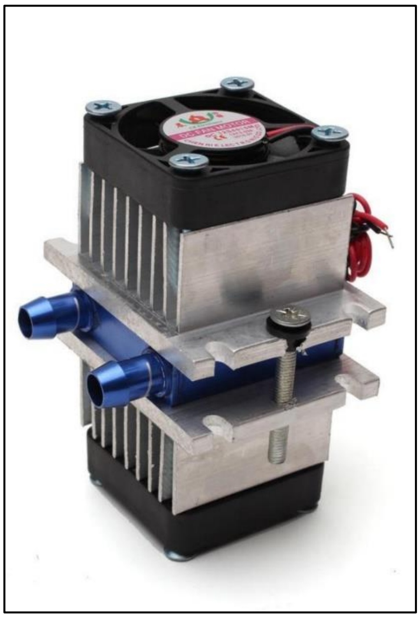

Fig. 1.1: Thermoelectric Peltier Device

Thermoelectric cooling is achieved through Peltier effect. A heat flux is created between a junctions of two different types of materials. Due to this heat flux between the junction, heat will be liberated or absorbed and effect is called Peltier. Therefore, Peltier devices can be used for both cooling and heating. The Heat can be transferred from one side to another side of the active heat pump (Peltier device) by consuming electricity. Heat will be liberated or absorbed depending the direction of electric current. These devices are called Peltier devices. These Peltier devices are most used for cooling rather than heating.

TEC consists of alternate P and n type semiconductor interconnected. This device can also be a thermoelectric generator. There will be temperature difference built up when voltage is supplied across the device resulting in cooling. Difference in voltage will be build up when one side of the device heated to a greater temperature than other side, which will result in working as a generator.

Fig. 1.2: Desiccant Wheel

Figure 1.2 shows the most common basic layout of a desiccant wheel consisting of an adsorbent-glazed wheel rotating between the two air streams, with a sensible cooling coil (evaporator) to eliminate the sensible load. The wheel will rotate at very low speed of almost one revolution per minute Due to this the sensible energy is transferred from the regeneration air stream to process air stream is small. However, the water vapor adsorbed onto the desiccant surface in the process stream undergoes a phase change from vapor to an adsorbed quasi-liquid (an adsorbed substance generally has internal energy so between its solid and liquid form at the temperature given). The release of that latent heat raises the process air temperature, in general the sensible gain of heat and the latent energy removed from the process stream are almost equal. Which means the desiccant wheel is a constant enthalpy device exchanging latent energy for sensible energy, along with it dehumidifying and heating the process air stream.

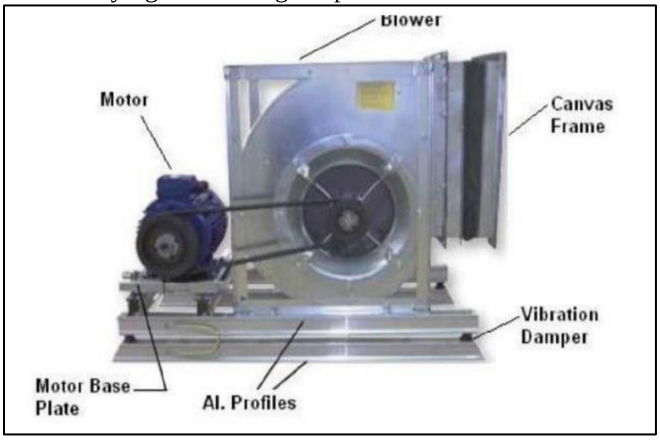


Fig. 1.3: Main Blower and Motor

Figure 1.3 the Blower-Motor is assembled on aluminum blower rails which are assembled in perpendicular directions. The blower is fixed on one set of rails and the motor on second set which is fixed perpendicular to it.

## V. Results and Discussion

The experiment has been carried out on different steps, first is indirect method, second is direct method, third is combination of direct and indirect method, fourth is indirect using desiccant wheel, fifth is indirect using Peltier effect and desiccant wheel.

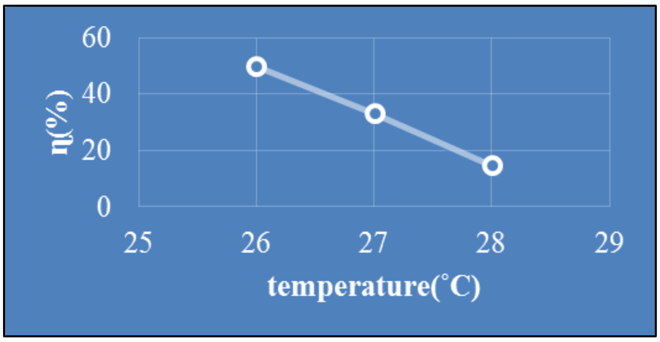


Fig. 2.0: Shows the graph of the direct method on the basis of temperature vs efficiency

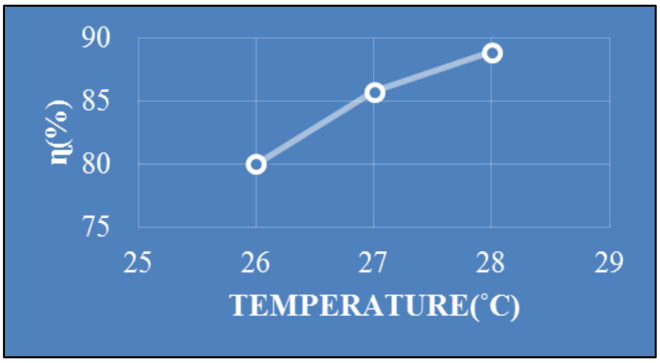


Fig. 2.1: Shows the graph of the combination of direct and indirect method on the basis of temperature vs efficiency.

## VI. Conclusions

The indirect evaporative cooling system is the one in which we use the indirect method of cooling by using the additional devices one is the Peltier device which is used to create he Peltier effect in which the water is allowed to flow through it which results in decrease in the temperature of the water, so the water which is allowed to flow on the cooling pads will be lower in temperature and the other instrument is desiccant wheel which consists of the desiccant (silica gel) on the outer surface of the desiccant wheel which reduces the humidity of the air by absorbing the moisture content in the atmospheric air which converts the air into dry air and this dry air is more suitable for the evaporative cooling method, by using square desiccant we found that temperature was reduced by 3℃. By using Peltier effect and desiccant wheel indirect evaporating cooling system can be improved.

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1) MONISH N P 1NC16ME066
2) PRADEEPA G 1NC16ME078

3) SANJEEV L D 1NC16ME089
4) SHAMANTH HADIMANI 1NC16ME091

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