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Design and Fabrication of Indirect Evaporative Cooler, Experimental Study on Cooling Performance

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Abstract

The domestic air coolers, which are cost effective, play a positive role in providing human comfort during atmospheric condition. However the performance is dissatisfactory where-ever high humid zones are encountered. This project paves for further evolution in areas where the performance of air cooler can be enhanced using an exchange system comprising serpentine aluminium tubes and and force convected using exhaust fan. This enables the eliminating of rise in humidity that typically encountered within the conventional air cooler. The target of this development is to supply cooled air to take care of the area where dry atmospheric temperature surge to higher value.

Keywords: Air cooler Evaporators, Exhaust fan cooling pipes, Digital Thermometer, Reciprocating pump.

1. Introduction

1.1 Introduction of indirect evaporation process

Indirect evaporative coolers are often utilized to cool down air or other fluid with wet surface heat exchangers. The surface of the cooling air passages is wetted by spray water (also named recirculation water), so water film evaporates into the cooling air and reduces the temperature of the wetted surface. The primary air or other pro- cess fluid flows within the alternative passages and is cooled by indirect contact with the spray water film through the separating wall of the warmth exchangers

1.2 Application of modern air cooler

Traditionally, air coolers are preferred to air conditioners in places with less humidity.With air coolers costing significantly but what an AC costs, while also circulating fresh air, the evaporation or desert coolers became the primary choice for purchasers, as summer approached. Traditional desert coolers, which are larger in size and need anywhere between 30-60 litres, had to be fixed near a window. Unlike modern air coolers, these desert coolers weren't portable and required either a stand or amount to for placement. Also referred to as outdoor coolers, desert coolers are suited for medium to large-sized rooms. Modern air cooling systems come with castor wheels, making it easier to manoeuvre the cooler, and use them wherever necessary.

Traditional desert coolers used cooling pads, or packing material and artificial fibres because the cooling medium. With lower water retention capability and higher maintenance, these cooling pads were inefficient and sometimes resulted in large amounts of water being consumed. Furthermore, the cooling pads made of aspen wood were also fragile, and would often get damaged during the installation.

However, the trendy air-cooling systems use cellulose cooling pads and eco-cool cooling pads, which have higher water retention capability. This ensures better evaporation, thereby increasing the cooler's cooling efficiency. The modern air coolers also include an cube tray, which could be a significant upgrade from the standard desert coolers. This feature allows customers to feature icy water to the tank, thereby enabling quick and efficient cooling.

The modern air cooler models also are sleek and trendy, a stark contrast from the standard desert coolers. Furthermore, by adding digital features, such as the digital control board, the trendy coolers offer greater convenience and fan control. Air cooling systems today also include remote, giving customers quick access to the settings. This ensures that you simply can control the speed of the fan with ease, without having to vary the settings manually.

1.3 Working Principle

Indirect evaporative cooling works on the identical principle as direct evaporative cooling lowering air temperature by water Evaporation. The major difference in an indirect system is that it uses an device to chill the air supplied to the working space. As hot air passes over these tubes, its sensible heat is removed. After passing over the tubes, the cool,dry is delivered to living space.It not only lowers down dry bulb temperature but wet bulb temperature likewise. Indirect cooling find application where low humid but 100% fresh air is required for cooling.

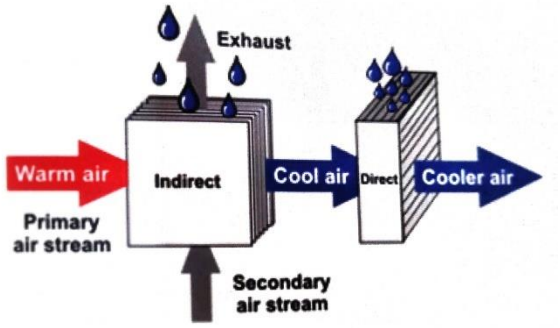


Figure 1.1: Working Principle of Indirect Evaporative Cooler

The another important point is that the recent air is cooled without gaining any extra humidity. Indirect evaporative cooling provides cool air to interior spaces with less ratio compared to direct evaporative cooling. This, cooling method is more suitable for areas where additional humidity isn't desirable. Since indirect evaporative cooling requires two pumps instead of one, it consumes little more electricity than direct evaporative cooling.

In second variety of Indirect Evaporative Cooling system -primary warm air flows in enclosed channels.It gives up its heat to water films flowing down the other side of the polymeric plates. A secondary air stream flowing within the direction opposite to the water evaporates water before it's exhausted outside. Thus, in Indirect cooling system the first air is cooled without any moisture addition.

1.4 Objective of Research

Using Indirect Evaporative cooling to substitute mechanical refrigeration in dry regions, with no refrigerants and no CFCs, to avoid wasting energy significantly. Evaporative cooling is to create water directly or indirectly contact with air of low ratio, thus water evaporated to understand cooling effect.

Buildings account for nearly 1/3 of the full energy consumption, 20-30 °Cof building energy is employed for air-con and maintaining indoor thermal comfort in hotseasons.

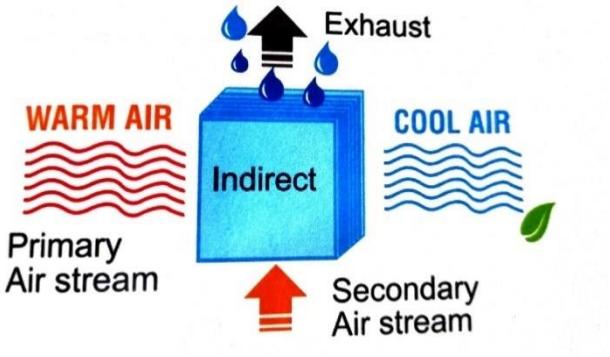


Figure 1.2: Schematic Diagram of IEC

Using IEC technology, the output temperature of water or air may be 6-10K under using DEC technology, and 3-5K not up to the inlet wet bulb temperature, reaching around 14- 18°C at ambient temperature of 35°C-38°Cand ratio of 20

Using IEC technology, electricity consumption will be reduced by 40percent to 70 percent compared with common mechanical chiller system, and no CFCs used

Huge potential to use IEC technology to substitute mechanical cooling and significantly reduce the energy use for cooling. For all year industry cooling, like data center cooling, to extend free cooling hours:

Indirect Evaporative chillers for all year free cooling, with design of high temperature cold water

Indirect Evaporative Chillers combined with mechanical chillers, with design of cold cold water

In very cold winters, using Indirect Evaporative Chillers to appreciate zero freezing.

2. Literature review

2.1 Historical development in air cooler

The primary modern cooling was invented in 1902 by Willis Haviland Carrier, a talented engineer who began experimenting with the laws of humidity control to unravel an application problem at a printing plant in Brooklyn, NY. Borrowing from the concepts of mechanical refrigeration established in earlier years, Carrier's system sent air through coils filled with cold water, cooling the air while at the identical time removing moisture to regulate room humidity.

In 1933, the Carrier air-con Company of America developed an cooling employing a belt-driven condensing unit and associated blower(Chandaket al., 2019), mechanical controls, and evaporator coil, and this device became the model within the growing U.S. marketplace for air-cooling systems

Today's air conditioners, while operating on the identical fundamental science as Carrier's 1933 system, incorporate advancements in vapor compression, diagnostics and controls, electronic sensors, materials, and energy efficiency. Carrier's new top-of-the line central air conditioning, the Infinity, is much different than the founder's early models, featuring advanced components including a two-stage scroll compressor for quieter, more energy-efficient performance (U. V.Kongrea et al., 2013).

Energy efficiency standards set by the U.S. Department of Energy are driving improvements in air-conditioning systems. "Minimum efficiency standards for AC systems have progressivelyincreased, particularly in the last five years, requiring manufacturers to optimize systems to scale back energy consumption," says Dennis Thoren, vice chairman of engineering and technology at Ingersoll Rand, Davidson, NC, which markets the popular Trane line of air conditioners. (Dr.C.R.PATIL et al., 2013)

We are using innovation to place a full new level of control within the consumer's hands, within the process reducing home energy consumption," explains Thoren, a longtime ASME member. Hesays Trane views the air conditioner united component within the automated, energy-efficient home of the longer term.

3. Design of indirect evaporation based air cooler

3.1 Introduction to design process

The desert cooler is a simple tool that creates moisture in the air and blows out the cool air towards the surrounding area. Typical layout of a desert cooler includes a motor fan or bower and a hydraulic pump. For this project, a cool evaporated desert air will be is designed in detail with the performance analysis of each of its components. The design and construction purposes of the desert cooler are given below:

1. Provide Cooling Room and provide air permeability.

2. Keep the building extremely economical and efficient.

3. Enhance efficiency by setting an accurate desert cooler.

4. Learn about the complete Desert Cooler design.

5. The social impact of the desert cooler is very beneficial for desert people, such as the desert families also use it at higher temperatures, especially at relative gatherings in tents times The social impact of the desert cooler is very beneficial for desert people, such as the desert families also use it at higher temperatures, especially at relative gatherings in tents.

3.2 Methodology of design

Design procedure consists of following stages

1. Air cooling is a system of dissipating heat. It works by expanding the face area or adding the inflow of air over the object to be cooled, or both. In the case of the ultimate, it's done by using a addict blowing air into or onto the object one wants to cool. The addition of fins to a heat Gomorrah increases its total face area, performing in lesser cooling effectiveness. There are two types of cooling pads that can used for air cooling one is the honeycomb design and another bone is excelsior. In all cases, the air has to be

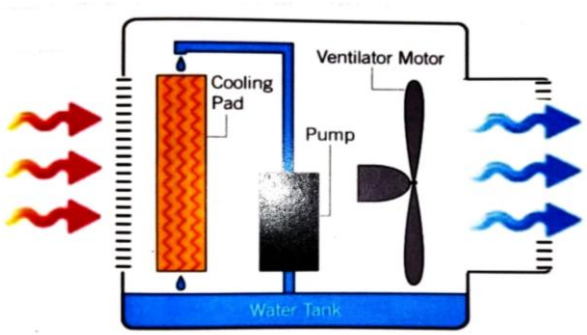


Figure 3.1 Methodology of design

cooler than the object or face from which it's anticipated to remove heat. This is due to the alternate law of thermodynamics, which states that heat will only move spontaneously from a hot force to a cold force the air.

3.3 Material selection for air cooler

1. Khus / synthetic grass may be a native Indian grass which has traditionally been used as a coolant in Indian households. largely used as evaporative mats and screens, the dry air cools because it passes through layers of wetkhus. Cultivated in Madhya Pradesh and Rajasthan, the grass is transported largely across North India during summers. The best place to position your air cooler is correct ahead of the window. Hotter the air, faster the evaporation and cooler the air blown out by the fan. It's also important to form good ventilation within the room to push the humidity out. so as to try to to this, you wish to open windows within the room. However, if your air cooler placed indoor or under a roof within four walls, then you can opt Honeycomb cooling pads. Though they are expensive as compared to the former one, its other advantages make it cost efficient in the long term. Moreover, they provide better cooling than wood wool pads.

3.4 Main exhaust fan

1. Exhaust fan is used as to suck the air and threw within the room. Exhaust fans are accustomed to create low

pressure inside cooler chamber to pull excess moisture and unwanted odors out of a selected room or area.

2. They will be controlled by a wall switch, or certain models are equipped with a thermostat that signals the unit to return on when certain temperatures are reached within the area.

3.5 External fan

This fan is used for cooling water those flowing under aluminium pipes for the heat dissipation or tube cooling. This type of fan, is used in rear side,left side and rightside of the body of cooler. Each fan rotation is similar to each other.

3.6 Cooling pipes

The pipe we use in cooler named aluminium pipe, its specification are 20mm diameter of aluminium we cut the pipe according to the measurement and fix it by Assembly in all three side panel. It is use for flow the water under the pipe section for extra cooling by help of evaporation method we can change the temperature of water and air we cool the suck air by threw throwing air by exhaust fan.

3.7 Rubber hose

It use for flow liquid from one aluminium pipe to another in serpentine path.Rubber tubing, also known as rubber hose or rubber piping, is made of natural and synthetic rubber and is used to circulate and transport liquids and gases for household and industrial uses.

3.8 Primary cooler regulator

Primary regulator main use to control the main exhaust fan.voltage regulator, any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage.

3.9 Secondary cooler regulator

It is use to control external exhaust fan.voltage regulator, any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage.

3.10 Digital thermometer

Digital thermometer use to measure the temperature of room and we can easily see the exactly temperature of the room.Digital thermometers work by using heat sensors that determine body temperature. They can be used to take temperature readings in the mouth, rectum, or armpit. When assessing digital thermometer readings, keep in mind that armpit (auxiliary) temperature runs about 1/2 to 1 °F (0.6°C) cooler than oral readings.

3.11 Wires

Wire is most important part for cooler wireing. In this cooler we use two type of wire the specification different from each other. Both wire fully manufactured in a secured brand link poly-cab. That's why we use this type of wire under water and it works great in it. we use 1mm wire under body and 1.5 mm wire in outer body in cooler.

3.12 Distributor

According to use distributor is the plastic made product that we use for the distribution

3.13 Primary pump

The function of a recirculating pump is to ensure that hot water is always available as close to the consumption point as possible, in order to reduce water waste and to increase comfort. Normally uncontrolled pumps are used as the flow variation is relatively small.A circulatory pump or circulating pump is a specific type of pump used to circulate gases, (N. et al., 2008) liquids, or slurries in a closed circuit. They are commonly found circulating water in a hydronic heating or cooling system. Because they only circulate liquid within a closed circuit, they only need to overcome the friction of a piping system (as opposed to lifting a fluid from a point of lower potential energy to a point of higher potential energy) (C. and S, 2002).

3.14 Secondary pump

The function of a recirculating pump is to ensure that it (G. and R., 2006) circulate the water from reservoir to aluminium tube and the serpentine path circulate the water coming from reservoir to the path and when the water exit the aluminium pipe,water recycle in reservoir.

4. Fabrication of indirect evaporation based air cooler

4.1 Introduction

Mechanical Engineering apart from manufacturing and manufacturing is irrational and inseparable. The manufacturing and production process is responsible for the con- version of immature materials into finished products according to the required size, specification and the effective use of the latest technology.

New developments and requirements have encouraged us to consider new developments in the air conditioning Engineering field.first planning We need a sheet metal

the structure of the cooler and cut-out body is in a circular shape according to the details of the exhaust fan. and the cooling length and width range is equal to 3.5 x 2.5in.

Then on the front side of the cool area, we attached an exhaust. The Ex- haust fan has 4 wings connected by nuts and bolts to cooler body in exhaust fan using 800rpm engine (revolution per minute), 400watt and copper winding.It has 220volt ower consumption, 15Hz, single phase.

Outside the cool body, the front side is electric board attached and 2 con- ollers to control speed finish fan.and if we adjust the fan speed a different speed rameter as well data will be calculated continuously. Minimum data speed and high eed data calculates medium and third effective data.adopted.

4.2 Methodology adopted for fabrication

In our project, we create a cooler with advanced structures. Only standard cooler only has one exhaust fan. Our coolers further required addition of 3 extra external exhaust fans in initial cooler body. On the front side of the cooler, we also attached a digital thermometer to record instantaneous temperature of the outlet air. The process of forced convection is utilized at 3 sides of air cooler by using separate attachment of the aluminum pipes in a serpentine manner using pipe joints. Then all four cooler panels are connected to the water tank, and then we use the metal turn the sheet into a metal body or box. Main engine and secondary motor, The main engine is used to transmit water the other three sides (on cool grass) The second engine is used for running water from the water tank to the snake's moving pipes and through recycled over and over again.

4.3 Assembly of Components

Figure 4.1: Assembly of cooler

4.4 Working process of air cooler

1. An air cooler works on the principle of evaporation of water to cool the air

2. Air cooler has three main parts; a water tank with water, ab absorbent seat.

3. We fill the tank and let the absorbent sheet soak it up.

4. As water evaporates from the sheet,it cools the air around it.

5. In our project, we developed a cooler with enhanced properties.

6. Here, In this water cooler, we used 3 external exhaust, 2 Pumps and one mainexhaust to enhance it's cooling capacity.

7. We used aluminium pipes instead of normal rubber pipes, and arrange all aluminium tube in serpentine path.

8. Aluminium pipes improves the galvanic balance of the materials, giving better corrosion resistance and less heat transfer performance degradation during its service.

9. To control the internal and external speed (RPM) we use controller or regulator it control the all fan speed we attached

10. Primary regulator control the main exhaust fan speed and the secondary regu- lator control the external exhaust fan we attached.

11. And use two water pump for the circulate the water.primary pump flow the water in the absorption pads and the secondary pump circulate the water in aluminium pipe we arrange threw distributor.

12. When both pump is on the circulation of water is going on and both absorption pads and aluminium tube waist water discharge in water tank for re-circulation

13. All is set to use the cooler, when we gives the electricity in cooler all pumps and exhaust fan are on and cooler working is on.

14. Our enhance work working the circulation pump circulate the water in aluminium pipe then water temperature is going below, and process is start.

15. Aluminium tubes chilled the air of surrou

nding, then our external exhaust fan on and throw this chilled air to the absorbing pad.

16. Chilled air passes threw the absorption pads and the air become more chilled.

5. Experimental Study

After the process of complete assembly and setting the process of working proce- dure, we proceed to evaluate

the performance of indirect evaporative cooler under atmospheric temperature 35 - 45°C. It is used to relieve extreme heat in the air with extra help external fans used for providing chilled humid air. Its function as a suction agent in the flowing fluid of the tube cool with the help of outside fans. When the fan wind passes pipes and a panel of grass and the inner cooler atmosphere cools in itcompared to the standard cooler.

5.1 Process parameter of air cooler system

Its process parameters are atmospheric temperature, humidity, temperature of outletof cooler, temperature of tank.

5.1.1 Experimental data

Initially the air cooler is operated at normal working condition with only one pump operating and one exhaust fan (front one) running. Under these situations, the experi- mental data(see Table 5.1) is collected for getting outer outlet temperature at different atmospheric temperatures. Table 5.2 refers to experimental data collection while the air cooler is running with 3 fans running simultaneously.

However, the process of cooling also comprises the performance of air cooler under main exhaust fan operation (see Table 5.3)

S.No	Atmoshpheric temp℃	Humidity %	Outlet temp℃	Tank Temp℃
1	30℃	66	24℃	21.6℃
2	35℃	35	25℃	21℃
3	40℃	21	25℃	19.7℃
4	43℃	17	27℃	19.3℃
5	45℃	15	30℃	19.2℃

Table 5.1: Experimental data:- 1

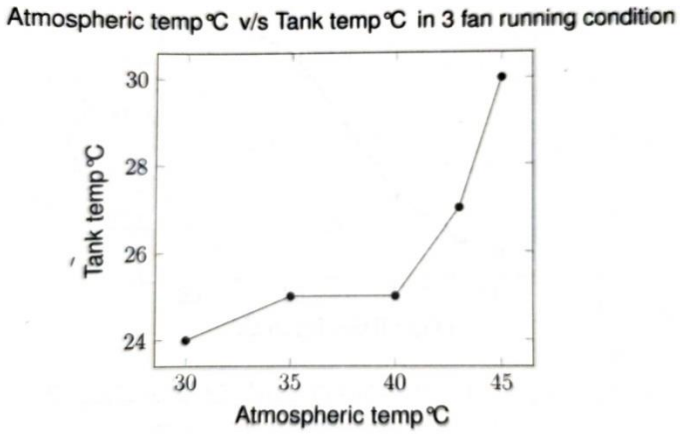
S.No	duration (min)	Atmospheric temperature	humidity %	Temperature of outlet of cooler
1	0 min	40℃	21	40℃
2	5 min	40℃	21	32℃
3	10min	40℃	21	29.6℃
4	15min	40℃	21	24℃
5	20min	41℃	21	21.6℃

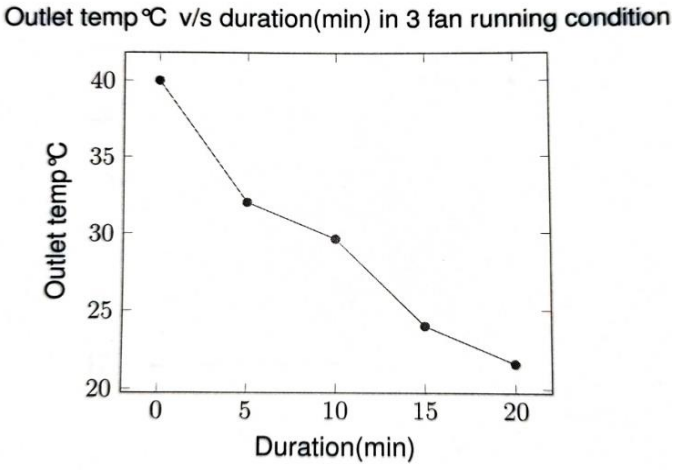
Table 5.2: Experimental data:- 2

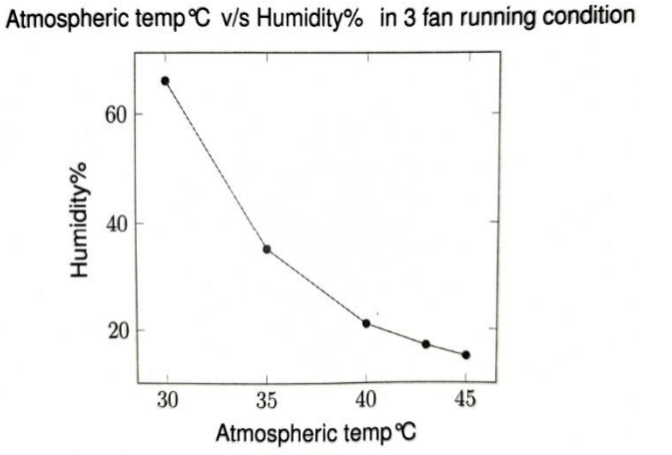
S.No	Atmospheric temp℃	Humidity	Temp℃of outlet	Temp℃of tank
1	30℃	66	30℃	21℃
2	35℃	21	26℃	20℃
3	40℃	17	27℃	19℃
4	43℃	17.2	27.5℃	19.2℃
5	45℃	15	28℃	18℃

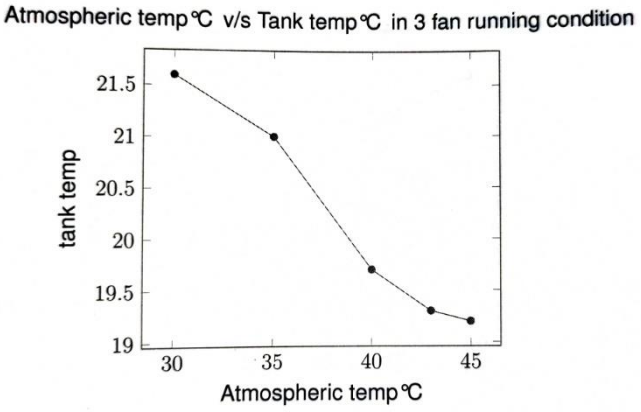
Table 5.3: Experimental data:- 3

5.1.2 Variation of process parameter based on ambient temperature









6. Result and discussion

6.1 Cooling Capacity & Consumption of Water:

The cooling capacity (c)of a direct evaporative cooler and the water consumption of the evaporative cooler, (Qco) are determined from equations below:-

$$Q_c = m_a x\ C_p x\ (T_1 - T_2)$$

$$Q_{co} = m_a x (w_1 - w_2)$$

6.1.1 It can be written as equation follows:

COP=QC/[P consumed blower(air) +P Consumed pump(water)]

6.2Performance evaluation of indirect evaporation cooler

We have performed several operations of modified indirect evaporative cooler. The reduction in outlet temperature of a normal desert cooler is observe to be less. The region behind lower drop outlet air temperature can be attributed to less generation of moist air inside the cooler due to approximately natural evaporation taking place over the grass pad of cooler,the single exhaust fan assembly create the sufficient negative air pressure inside cooler as a result the cooled grass pads over around 28 to 35°C.

6.2.1 Observation on modified indirect evaporative air cooler

In our modified air cooler force convection of serpentine tubes heat exchanger as well as and grass pads, the rate of evaporation is significantly higher. Further more the drop in temperature of flowing water through heat exchanger creates the sudden drop in the water temperature to nearly 18 to 22 °C. This is sufficient to create a low outlettemperature of indirect evaporative cooler.

6.3 Future outlook

Basically our modification and generalization of indirect evaporation cooler is much cheaper than the desert cooler price self.Further more the power consumption of indirect evaporation cooler is nearly higher than a normal desert cooler.

This enables the project as an attractive alternative of one ton air conditioners in households application therefore our project should be adopted by proposing a variety of startup in local and organised air cooler market we hope that our develop- ment work may pave a long standing path of cooler manufacturing and development which can compete with air conditioners systems at lower price at lower price con sumption.

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