DESIGN AND FABRICATION OF EVAPORATIVE COOLING SYSTEM IN PASSENGER BUS.

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ABSTRACT: Evaporative cooling system has been using for many countries such as india for cooling water and providing thermal comfort in hot and dry regions. This system is based on the principle that when moist but unsaturated air comes in contact with a wetted surface whose temperature is higher than the dew point temperature of air, some water from the wetted surface evaporates into air. The latent heat of evaporation is taken from water, air or both of them. The air losses sensible heat but gains latent heat due to transfer of water vapour, thus the air gets cooled and humidified. The cooled and humidified air can be used for providing thermal comfort inside of the passengers in bus. In our project to design of cooling pads of required dimensions i.e., dimensions of mesh with pads in passenger bus and fabrication of cooling system arranged in passenger bus practically , noted thermal comfort parameters inside and outside of the bus

***IndexTerms* - coolind pads,polymer mesh,HDPE, air flow rate,valve.**

1.INTRODUCTION:

Evaporative cooling is based on a physical phenomenon in which evaporation of a liquid (usually water) into surrounding air cools an object or a liquid in contact with it. As the liquid turns to a gas, the phase change absorbs heat. Technically, this is called the “latent heat of evaporation”. Water is an excellent coolant because it is plentiful, non-toxic, and evaporates easily in most climates.

The most common example we all experience is perspiration, or sweat, which the body secretes in order to cool itself. The thin layer of water evaporates; the water vapor absorbs heat as it evaporates off our skin. The amount of heat transfer depends on the evaporation rate, which in turn depends on the humidity of the air and its temperature. When the air humidity is very high, sweat evaporates slowly. This is why you feel hotter in humid climates compared to dry climates of the same temperature: the sweat cannot evaporate as fast to cool your body in a humid climate

Evaporative cooling systems use the same laws of physics to cool machinery and buildings. Evaporative cooling is a very common form of cooling buildings because it is relatively inexpensive and requires less energy than many other forms of cooling. Unfortunately, evaporative cooling requires an abundant water source, and is most effective in climates with low humidity. In arid climates, homes and small business use direct evaporative cooling systems; often referred to as “swamp coolers” or “desert coolers”. In almost all climates, large buildings often use indirect evaporative cooling in cooling towers for the chillers in the HVAC system. Manufacturing and industry often use evaporative cooling technology to remove excess heat from machines, compressors and other equipment. In dry climates, the installation and operating cost of an evaporative cooler can be much lower than air conditioning, often by 80% or more.

In moderate humidity locations there are many cost-effective uses for evaporative cooling, in addition to their widespread use in dry climates. For example, commercial kitchens, laundries, dry cleaners, greenhouses, loading docks, warehouses, factories, construction sites, athletic events, workshops, garages, kennels and confinement farming (poultry ranches, hog, and dairy) often employ evaporative cooling.

Now a days in summer occasion temperature is increased upto45C and passengers are faced lot of problem in travelling bus due to worm air entering into the bus and feeling journey is very uncomfortable. They were feel at that time of journey some cooling air or cooling water require for comfort traveling in bus. To meet the demanding requirements for both comfort and high reliability train a/c and bus a/c applications, The a/c system must be designed considering a wide cooling capacity range and incorporating vibration resistant components.

In addition to passenger comport and system reliability, efficient use of energy is another important design factor for bus operator. As a result, light weight, compact components must be considered for use throughout the system design for transport air conditioning.

Indian road and weather conditions require highly reliable air conditioning systems and all companies to plays significant role in cost efficient solutions in people road transportation across India.

2. REVIEW OF LITERATURE

2.1.Direct Evaporative Cooling:

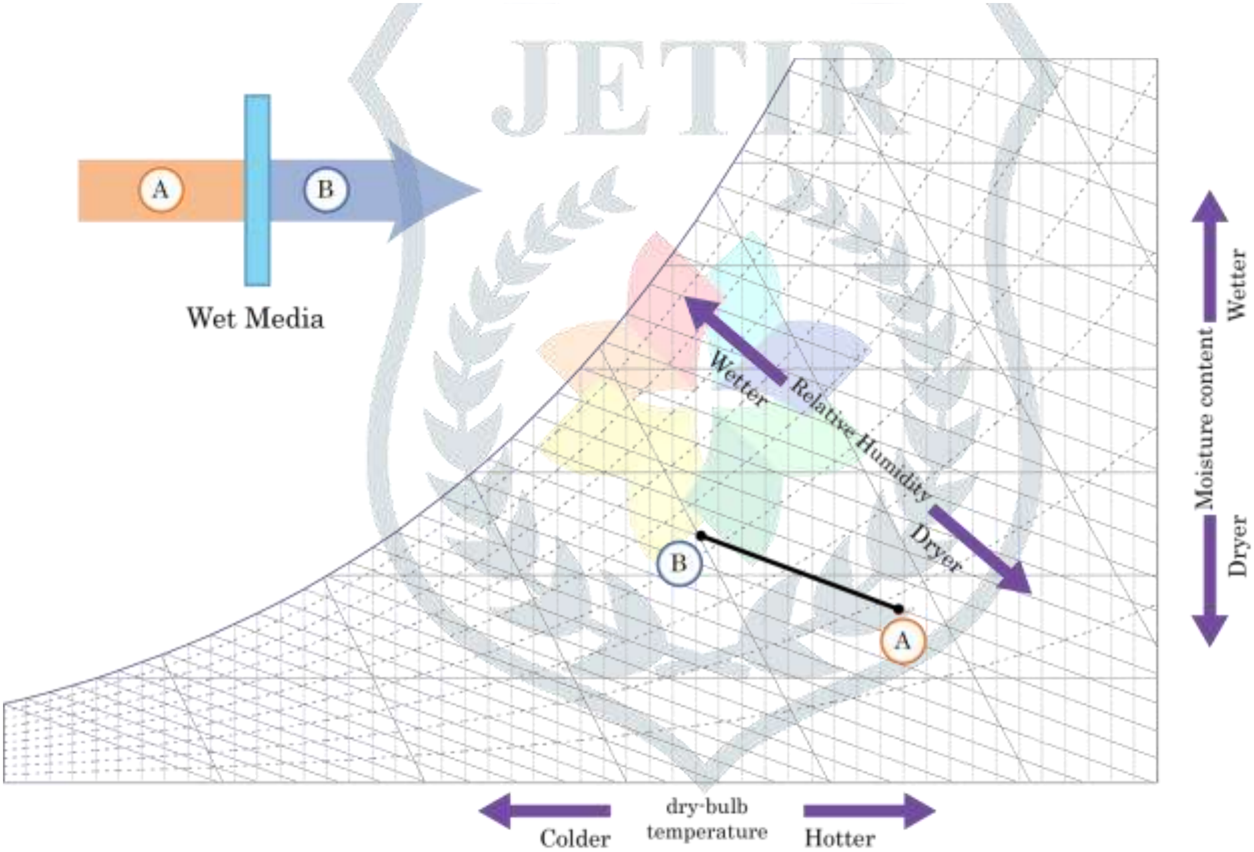


Fig.2.1. Evaporative cooling system in psychometric chart

Direct evaporative cooling (open circuit) is used to lower the temperature and increase the humidity of air by using latent heat of evaporation, changing liquid water to water vapor. In this process, the energy in the air does not change. Warm dry air is changed to cool moist air. The heat of the outside air is used to evaporate water. The RH increases to 70 to 90% which reduces the cooling effect of human perspiration. The moist air has to be continually released to outside or else the air becomes saturated and evaporation stops.

2.1.1 Mechanical Direct Evaporative Cooler:-

mechanical direct evaporative cooler unit uses a fan to draw air through a wetted membrane, or pad, which provides a large surface area for the evaporation of water into the air. Water is sprayed at the top of the pad so it can drip down into the membrane and continually keep the membrane saturated. Any excess water that drips out from the bottom of the membrane is collected in a pan and recirculated to the top. Single-stage direct evaporative coolers are typically small in size as they only consist of the membrane, water pump, and centrifugal fan. The mineral content of the municipal water supply will cause scaling on the membrane, which will lead to clogging over the life of the membrane. Depending on this mineral content and the evaporation rate, regular cleaning and maintenance is required to ensure optimal performance. Generally, supply air from the single-stage evaporative cooler will need to be exhausted directly (one-through flow) because the high humidity of the supply air. Few design solutions have been conceived to utilize the energy in the air like directing the exhaust air through two sheets of double glazed windows, thus reducing the solar energy absorbed through the glazing. Compared to energy required to achieve the equivalent cooling load with a compressor, single stage evaporative coolers consume less energy.

2.1.2 Passive Direct Evaporative Cooler:-

Passive direct evaporative cooler can occur anywhere that the evaporatively cooled water can cool a space without the assist of a fan. This can be achieved through use of fountains or more architectural designs such as the evaporative downdraft cooling tower, also called a “passive cooling tower”. The passive cooling tower design allows outside air to flow in through the top of a tower that is constructed within or next to the building. The outside air comes in contact with water inside the tower either through a wetted membrane or a mister. As water evaporates in the outside air, the air becomes cooler and less buoyant and creates a downward flow in the tower. At the bottom of the tower, an outlet allows the cooler air into the interior. Similar to mechanical evaporative coolers, towers can be an attractive low-energy solution for hot and dry climate as they only require a water pump to raise water to the top of the tower. Energy savings from using a passive direct evaporating cooling strategy depends on the climate and heat load.

2.2.InDirect Evaporative Cooling:-

Indirect evaporative cooling (closed circuit) is a cooling process that uses direct evaporative cooling in addition to some type of heat exchanger to transfer the cool energy to the supply air. The cooled moist air from the direct evaporative cooling process never comes in direct contact with the conditioned supply air

2.3.Recommendation for Water Efficiency:

The water efficiency of direct evaporative coolers varies greatly by make, model, and installation. A perfectly efficient EC would use only 6.1 L of water per ton-hour of cooling. (Most single family homes require 3.5 tons of cooling per hour). Current makes and models range in water efficiency from 12 L to 60 L per ton-hour. It is reasonable to set 18.9 L per ton-hour” as a minimum water efficiency standard for this equipment. But Unfortunately, there is not yet standardized testing protocol for water efficiency of direct evaporative coolers.

3.DESCRIPTION

3.1.Air Cooler Cooling Pad Types:

The cooling pad material play significant role in the cooling. The hot air is first passed through the cooling pads. The cooling pads which already absorbed the cool water are ready to transfer the cooling to the air. The cool air came out of the cooling pads immediately circulated outside with the help of fan
The cooling pads are of two types.

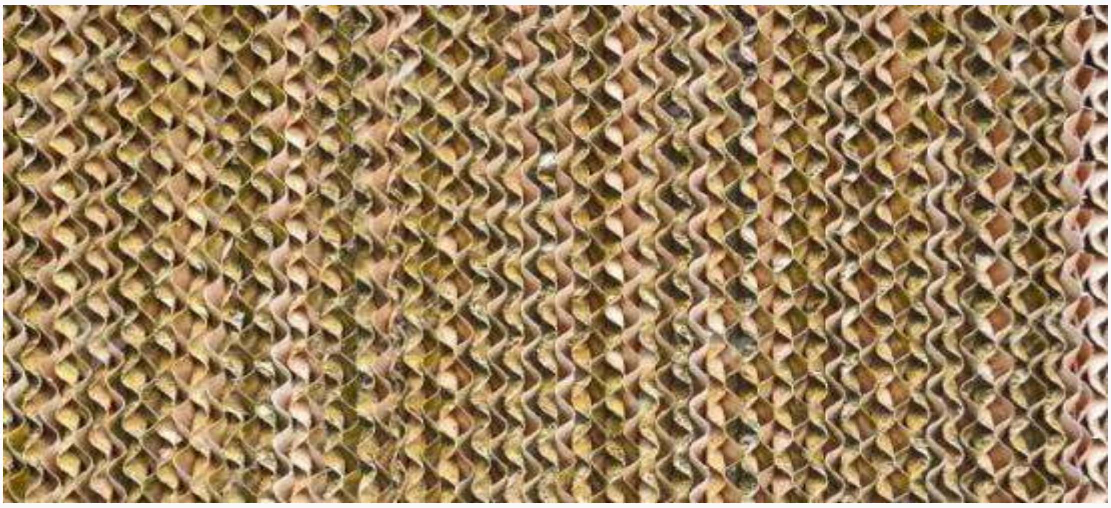
- Aspen wood wool cooling pads
- honeycomb cooling pads

3**.1.1.aspen wood wool cooling pads**:-

3.1.1 Aspen Wood Wool Cooling Pads

Aspen cooling pads are often referred as Aspen cooling pads as well. Aspen cooling pads are made up of wood shavings and synthetic fibre. They look like almost grass. The most important aspect of Aspen cooling pads is they are much cheaper, very economical. Because of this price difference, the air coolers with Aspen cooling pads are much cheaper. The only problem with the Aspen cooling pad is they need high maintenance. You need to clean the Aspen cooling pads very frequently. Apart from that they are very less durable and you need to replace it frequently. It has observed that Aspen cooling pads are moderately effective in cooling. In other words, Aspen cooling pads are less effective compared to the home comb cooling pads.

3.1.2.HoneyComb Cooling Pads:-



Honeycomb cooling pads are made of cellulose material. They look like honeycomb so usually it is referred as honeycomb cooling pads. Honeycomb cooling pads are very effective in cooling and requires less maintenance or cleaning. Apart from that they are very durable compared to Aspen cooling pads. Because of this reason most of the high end air coolers uses Honeycomb cooling pads. In general, desert air coolers uses Honeycomb cooling pads for their efficiency of cooling the air at larger scale efficiently. The only con of the honeycomb cooling pads is they are much expensive, this is the reason Honeycomb cooling pads usually used only in high end desert coolers and not in the low end personal air coolers. Aspen and honeycombs cooling pads are available in all types of air coolers like personal,desert air coolers

Best handpicked Air coolers with Aspen cooling pad material

- Personal Air Cooler
- Symphony (5.1 to45lts)Air Cooler

Best handpicked Air coolers with Honeycomb cooling pad material

- Crompton Evaporative Air Personal Cooler
- Bajaj Room Cooler
- Bajaj Icon (30 to 43lts) Room Cooler
- Symphony Air Cooler with Remote

3.1.3.Difference between Aspen and Honeycomb cooling Pads:

Feature	**Honeycomb cooling pads**	**Aspen cooling pads**
Material type	Cellulose material, look like honeycomb	Made of wood shavings synthetic fibre, look like grass maintenance
Maintenance	Less	High
Durability	High	Less
Efficiency	High	Less
Price	Expensive	Economical

3.2.Water tank :

Air coolers make use of an evaporative cooling method. In this method, water is converted into water vapour, which reduces the temperature of the air blown by the fan or blower. It's important to have air coolers that have large water tanks. Larger the water tank, the longer the air cooler will run. You need to select an air cooler that has a water tank that's the right size for your h personal air coolers come with a wide range of water tanks sizes. Personal air coolers have tanks of 20 to 30 litre capacities while desert air coolers capacities range from 31 to 500 litres plastic tanks availavable in market.

3.3.DC ELECTRICAL MOTOR(24V):-

A **DC motor** is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

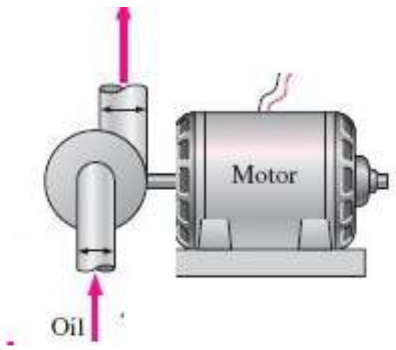


Fig.3.3.1.dc electrical motor,24v

3.4..Polymer mesh:

- Contents 100% nylon
- Description: The possibilities are endless with nylon netting fabric! This versatile netting fabric is ideal for costumes, bridal accessories, petticoats, tutus, party dresses and more!
- Fabric Weight Very Lightweight help
- Washing Instructions: Hand Wash/Drip Dry

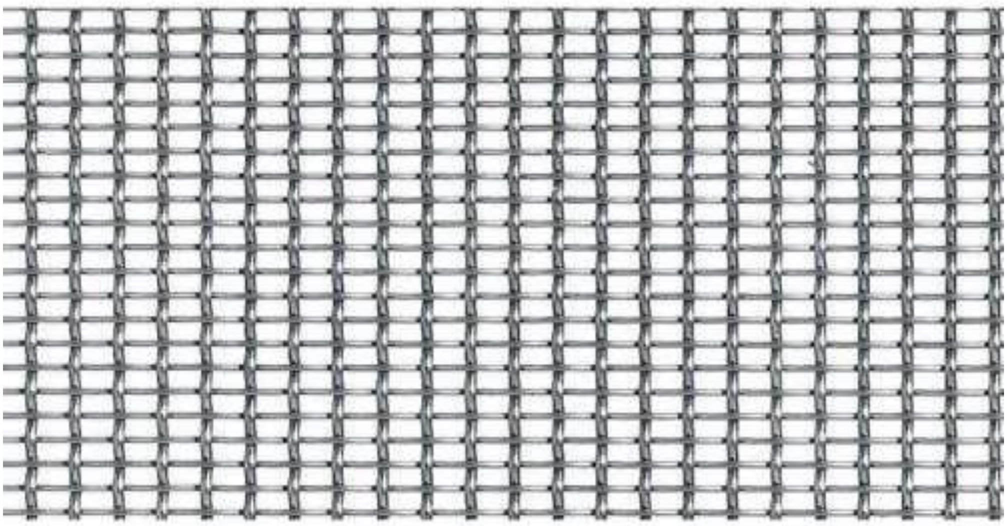


FIG.3.4. SQUARE PLASTIC MESH

3.4.1.mesh Product Details:

Brand	Isolon
Mesh Shape	Square Mesh
Size	As per our requirement
Usage	Industrial

In order to retain remarkable position in this industry, we are providing a wide array of Square Meshes. A general purpose mesh in square pattern.can be used in office homes as partitions,fencing,desert cooler mesh,etc.

3.5.High-density polyethylene pipes:-

High-density poly ethylene is a produced from the monomer called alkathenem or polythene when used for pipes , With a high strength-to-density ratio, HDPE is used in the production of corrosion-resistant piping, HDPE is commonly recycled. HDPE a higher It is also harder and more opaque and can withstand somewhat higher up to120 °C

Fig.3.5.high density polyethyne pipes

3.6.CUT OF VALVE:

Cut of valve is a devive to resist the flow of in a system .A simple shower cut-off valve can save you money and save water.A valve is made of brass,steel,polythyne or plastic availavable in market.In our projectE2 brass Valves used.one valve used right side of the bus body pannel and second valve used left side of the bus body panel

Fig:3.6.cut of valve

3.7.T-type pipe connectore:-

8mm plastic pipes are used in our requirement.

To connect two out let pipes and one in let pipe.

- Part Manufacturer: TEFEN
- Brand: TEFEN

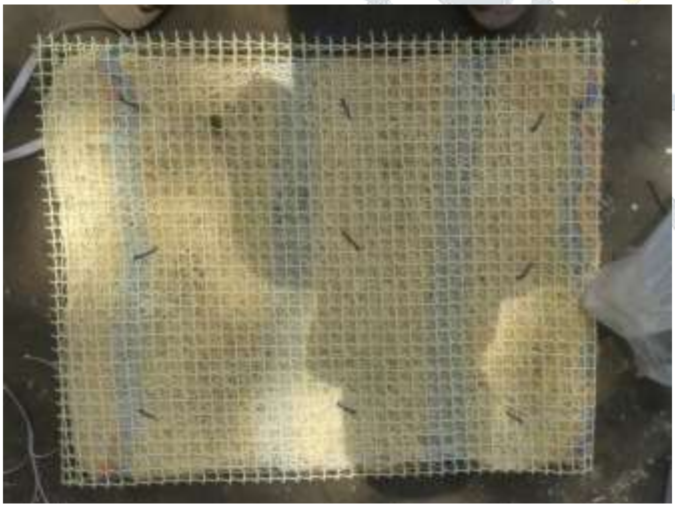
- Intended Use:
- Replacement Part, Type: Air & Fuel Delivery

3.8.Air flow:

As a model of an air conditioner, it's important to buy an air cooling pads that fits the size of bus. Airflow of an air cooling pad is also measured in terms of CFM (cubic feet per minute). The CFM denotes the amount of air cycled indide of bus each minute. You can choose the right size for the cooling pads by calculating the CFM required for bus. You can calculate the required CFM by dividing the cubic feet of seloon of bus by two. For example, if bus seloon is 200 sq feet in size, with the ceiling at a height of 10 feet. Then the CFM required would be 1,000 (200 sq ft x 10 ft/2).but air flow depend on vehicle speed.i,e.,0 to 80 kilometer per hour.In our experiment air flow of inside of the bus taking approximate 60% reduction of out side air flow velocity.

4..EXPERIMENTAL SET UP.

In our project experimental set up as shown in given figures:



4.1.cooling pads arreged in mesh

fig.4.2.210L.plastic drum in fitted inbus .

Fig4.3.T-connector and pipes fitted on inside top of the bus

fig.4.4. 24v.dc motor fitted in bus behind driver seat

4.5.cooling pads arranged on bus right side as shown figure

4.6. cooling pads arranged on bus left side as shown figure

5.OBSERVATIONS AND CALCULATIONS.

5.1.Cooling pad dimensions:-

Lenth L =60cm

Width b =50cm

Cooilng pad area =60*50=3000cm^2

Required cooling pads = 16 no's

6.2.Water tank capacity = 210 lts or 180 lts

6.3.Dc electrical motor =24volts,1500 to2500rpm

6.4.Hdpe pipe =8mm dia.and 80mts lenth

6.5.T-connector =8mm dia.,20mm lenth plastic

6.6.Cut of valve =8mm dia.,brass material

6.7.temperature calculations:

T_1 = Temperature at outside of the bus.ie.environment ^{0}C

T_2 =Temperature at inside of the bus ^{0}C

T_3 = Temperature at inlet of the water ^{0}C

T_3' =Temperature at at out let of the water ^{0}C

The following performance characteristics are to be founding for various evaporator temperatures.

$$LMTD = (\Delta T1 - \Delta T2) / \ln(\Delta T1/\Delta T2)$$

$\Delta T1$ = T_Hot_In - T_Cold_Out

= 41-26

=15

$\Delta T2$ = T_Hot_Out - T_Cold_I

= 34-25

= 09

LMTD = (15-09)/ln(15/09)

= 11.7^{0}

6.RESULTS AND DISCUSSIONS

Experiments was conducted on practically in passenger bus and to maintain comfort temperature.i.e.,to decrease temperature upto 5to 7^{0}C compare to outside temperature and inside temperature of the bus.passengers are feeling happy and comfort travelling in bus .

7.1 Performance of the air cooling system in bus:-

S.NO	Parameters	Out side of the bus	Inside of the bus
1	Temperature(0c)	38 to45	30 to35
2	Relarive humidity	50to60	75to90
3	Latent heat	low	high

Air flow velocity inside and out side of the bus calculated given bellow:-

S.NO	Vehicle speed kph	Air velocity Out side of the bus m/s	Air velocity Inside of the bus (approximate)m/s
1	20	5.5	1.2
2	30	8.3	1.8
3	40	11.1	2.4
4	50	13.8	3.0

5	60	16.6	3.6
6	70	19.4	4.2

7.CONCLUSION

In this project we have designed of cooling pads of required dimensions taking from passenger ordinary bus ,cooling pads are arranged in side of the mesh and aluminum sheet fitted one side of the mesh .this on bus body panel as shown in fig.5.5 .DC motor ,210lts.water tank,pipes arranged as shown fig.5.3,5.4.This set of experiment arranged in ordinary bus practically. cooling system parameters are observed in passenger bus and noted thermal comfort parameters. We have calculated pareameters Inside and outside of the bus successfully.i.e.,Temperature decrease inside of the bus 5 to 8^{-0}C.passengers were feel like a air conditioning bus ,travelled with low bus charge amount compare to A/C bus.

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