Design of Evaporative Air Cooling System for Seminar Hall

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Abstract: **Thermal environmental conditions have very good role in human occupancy and their maximum productivity. Both indoor space conditions and personal factors necessary to provide comfort.it includes the interaction of various parameters like temperature, thermal radiation, humidity, air speed, personal activity level, and clothing Due to global warming ,entire atmospheric conditions are varied very much.Major part of the building exposed to the sun the roof being heated throughout the day. The object of air cooling is to establish a stable thermal environment which satisfies the majority of occupants with respect to comfort under all the climatic conditions to which the building is subjected. For the cooling system of hall requires one cooler with water requirement is estimated as 10 lit/hr and fan rpm is 1400. The cooled air from the unit cannot be directly provided to the space to be cooled, so the duct are provided cooled air and supply proper distribution to the rooms. To implement proper distribution of cooled air to the room duct design should be precisely done; this project gives design technique of duct. The objective of centralized air cooling air is to establish a stable thermal environment which satisfies majority of occupant with respect to comfort under all climate condition to which hall is subjected.**

***Keywords*— Centralized air cooling; Cooler; Duct system; Stable thermal environment.**

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1. INTRODUCTION

Air cooling is a method of dissipating heat. It works by expanding the surface area of or increasing the flow of air over the object to be cooled, or both. It is done by using a fan blowing air into the surrounding which is to be cooled. Evaporative cooling is one of the oldest forms of cooling known and has been used by man since 2500 B.C. Building cooling load components are; direct solar radiation, transmission load, ventilation load and internal load. Calculating all these loads individually and adding them up gives the estimate of total cooling load. The load, thus calculated, constitutes total sensible load. [1]

An evaporative cooler is a device that cools air through the evaporation of water. The temperature of dry air can be dropped significantly through the phase transition of liquid water to water vapour, which can cool air using much less energy than refrigeration. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants. In all cases, the air has to be cooler than the object or surface from which it is expected to remove heat. This is due to the second law of thermodynamics, which states that heat will only move spontaneously from a hot reservoir (the heat sink) to a cold reservoir (the air).

The principle underlying evaporative cooling is the fact that water must have heat applied to it to change from a liquid to a vapour. When evaporation occurs, this heat is taken from the water that remains in the liquid state, resulting in a cooler liquid. Evaporative cooling systems use the same principle as perspiration to provide cooling for buildings. Evaporative cooling is a common form of cooling buildings for thermal comfort since it is relatively cheap and requires less energy than other forms of cooling.

1.1 Evaporative Coolers

Evaporative coolers, sometimes called swamp coolers, are less common than vapor compression (refrigerant) air conditioners, but they are a practical alternative in very dry areas, such as the Southwest. They work by pulling fresh outside air through moist pads where the air is cooled by evaporation. The cooler air is then circulated through a house. This process is very similar to the experience of feeling cold when you get out of a swimming pool in the breeze. An evaporative cooler can lower the temperature of outside air by as much as30degrees.

They can save as much as 75% on cooling costs during the summer because the only mechanical component that uses electricity is the fan. Plus, because the technology is simpler, it can also cost much less to purchase than a central air conditioner often about half.

A direct evaporative cooler adds moisture to a house, which could be considered a benefit in very dry climates. An indirect evaporative cooler is a little different in that the evaporation of water takes place on one side of a heat exchanger. House air is forced across the other side of the heat exchanger where it cools off but does not pick up moisture. Both types begin to lose their effectiveness with increasing humidity, because humid air is less able to carry additional moisture.

1.2 The principle of Evaporative cooling

As water is evaporated, energy is lost from the air, reducing the temperature. Two temperatures are important when dealing with evaporative cooling systems.

- Dry Bulb Temperature

This is the temperature that we usually think of as air temperature, measured by a regular ther mometer exposed to the air stream.

- Wet Bulb Temperature

This is the lowest temperature that can be reached by the evaporation of water only.
When considering water evaporating into air, the wet-bulb temperature, as compared to the air's dry-bulb temperature is a measure of the potential for evaporative cooling. The dry and wet bulb temperature can be used to calculate the relative humidity. Evaporation will take place when the humidity is below 100% and the air begins to absorb water. Any given volume of air can hold a certain amount of water vapour and the degree of absorption will depend on the amount it is already holding. The term humidity describes how much water is already in the air; relative to the amount it is capable of holding. Air is saturated when it cannot hold any more water. Energy is required to change water from liquid to vapour. This energy is obtained in an adiabatic process from the air itself. Air entering an evaporative air cooler gives up heat energy to evaporate water. During this process, the dry bulb temperature of the air passing through the cooler is lower.

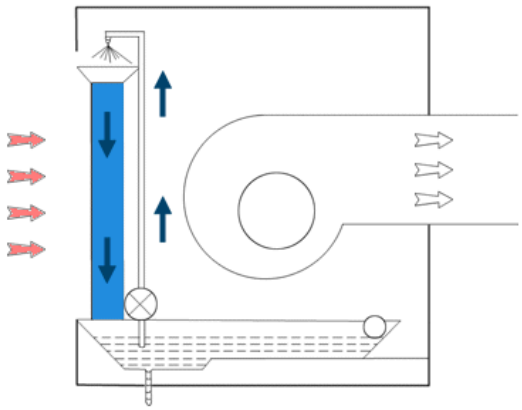

Fig1: Evaporative Cooling System

2.LITRATURE REVIEW

1 JOURNAL OF ENVIRONMENTAL RESEARCH AND DEVELOPMENT "Design of Air Cooling System for College Auditorium",S.S. Wane and M.B. Nagadeve, Dr. Punjabrao Deshmukh Krushi Vidhyapeeth, Akola Maharashtra: In this paper we are going to explain the design of centralised air cooling system for college auditorium. The present building of college auditorium posed the problem of ill-ventilated atmosphere and suffocation in most of its part during the programs. Major part of the building exposed to the sun the roof being heated throughout the day. The object of air cooling is to establish a stable thermal environment which satisfies the majority of occupants with respect to comfort under all the climatic conditions to which the building is subjected. Hence it was decided to provide the false ceiling and design air cooling system for college Auditorium for better comforts to the occupants during longer program. For the cooling system of auditorium requires two coolers with water requirement is estimated as 8 lit/sec and power requirement is 120 Watts. Solar and transmission heat gain through walls and roofs etc. Solar and transmission heat gain through doors, windows or wall glasses. Transmission gain through partition wall ceiling floor etc. Infiltration of direct air from some inlets like doors or windows. Internal heat gain from occupants, light appliances etc. Additional heat gain not accounted above, safety factors etc. Return duct heat gains, supply duct leakage, heat gain from door, fan and pump.

2 INTERNATIONAL JOURNAL OF EMERGING TECHNOLOGY AND ADVANCED ENGINEERING "Design Optimization and Installation of the Evaporative Cooler.", Md. Almostasim Mahmud, Dr. Md. Alamgir Hossain, M.A.Muktadir : This Evaporative cooling is an environmentally friendly air cooling system that operates using induced processes of heat and mass transfer, where water and air are the working fluids. It consists, specifically, in water evaporation, induced by the passage of an air flow, thus decreasing the air temperature. In Bangladesh, Evaporative cooler is already being used in different industries that is imported from varies countries. But most of the cases these are not efficient due to installation error & lack of adjustment with climate change over the year. Initially this paper presents the construction of an evaporative cooler using a test bench of cooling tower for the air flow and water supply facility where local materials were used as evaporative pad. Afterwards; it presents installation in different situation & adjustment of the cooling units with the climate. It concludes that under proper installation, evaporative cooling system is very cost effective & has a very large potential to propitiate thermal comfort and can still be used as an alternative to conventional systems in regions where the design wet bulb temperature is low.

3 DESIGN OF AN AIR DISTRIBUTION SYSTEM FOR A MULTI-STORY OFFICE BUILDINGBy- Dave janquart: Earlier the use of air conditioning for comfort purpose was considered to be expensive, but now-a-day, it has been a necessity for all human beings. Window air conditioners, split air conditioners are used in small buildings, offices etc. But, when the cooling load required is very high such as big buildings, multiplex, multi-story buildings, hospitals etc. centralized unit (central air conditioners) used. The central AC's systems are installed away from building called central plant where water or air is to be cooled. This cooled air not directly supplied to the building rooms. When the cooled air cannot be supplied directly from the air conditioning equipment to the space to be cooled, then the ducts are provided. The duct systems carry the cooled air from the air conditioning equipment for the proper distribution to rooms and also carry the return air from the room back to the air conditioning equipment for recirculation. When ducts are not properly designed, then it will lead to problem such as frictional loss, higher installation cost, increased noise and power consumption, uneven cooling in the cooling space. For minimizing this

problem, a proper design of duct is needed. Equal friction method is used to design the duct, which is simple method as compared with the other design methods.
The duct design for TIIR building is done, by using equal friction method. All values are comparable with duct software called ductulator. The calculated value of frictional is less or near as calculated by software. Due to less value of friction drop, duct diameter is increased but loss in total pressure (i.e. static pressure, velocity pressure) can be avoided. Due to increased duct diameter the use of damper may be decreased. Also the circular duct can carry more air in less space, because of that, less duct material, less duct surface friction and less insulation is required. Pressure loss in duct fitting can be minimized by proper design the elbow shape. Ansys 13.0 software is used to analyze the pressure loss in circular and rectangular duct. After analysis we conclude that the circular duct has minimum friction loss, so it is better shape for ducting.

4 DESIGN OF AIR COOLING DUCT "Version 1 ME, IIT Kharagpur "

Static Regain Method:

This method is commonly used for high velocity systems with long duct runs, especially in large systems. In this method the static pressure is maintained same before each terminal or branch. The procedure followed is as given below:

i. Velocity in the main duct leaving the fan is selected first.

ii. Velocities in each successive runs are reduced such that the gain in static pressure due to reduction in velocity pressure equals the frictional pressure drop in the next duct section. Thus the static pressure before each terminal or branch is maintained constant.

ii. If section 1 is the outlet of the fan, then its dimensions are known from the flow rate and velocity (initially selected), however, since both the dimensions and velocity at section 2 are not known, a trial-and-error method has to be followed to solve the above equation, which gives required dimensions of the section at 2.

iv. The procedure is followed in the direction of airflow, and the dimensions of the downstream ducts are obtained.

v. As before, the total pressure drop is obtained from the pressure drop in the longest run and a fan is accordingly selected.

Static Regain method yields a more balanced system and does not call for unnecessary dampering. However, as velocity reduces in the direction of airflow, the duct size may increase in the airflow direction. Also the velocity at the exit of the longer duct runs may become too small for proper air distribution in the conditioned space.

5 NEW EVAPORATIVE COOLING SYSTEMS: "An Emerging Solution for Homes in Hot Dry Climates with Modest Cooling Loads", By- Midwest Research Institute National Renewable Energy Laboratory Division: This report on new emerging evaporative cooling options is one a series of technical briefs being prepared by the Southwest Energy Efficiency Project (SWEEP) in support of the U.S. Department of Energy's Building America Program. Its intended audience is builders and design professionals interested in employing technologies that will reduce energy costs in both new and existing housing stock. Feedback from all readers on the form and content of this report are welcome. A companion report, "Evaporative Cooling Policy Options: Promising Peak Shaving in a Growing Southwest," is aimed at energy program policy makers, planners, and analysts. It includes information on energy and economic analyses associated with various levels of the penetration of evaporative cooling technology and associated policy options.

Concerning the evaporative cooler systems themselves, there's a need to think of them as systems thoroughly integrated into energy-efficient structures. Techniques for sealing them carefully and simply during shoulder and winter seasons coupled with ensuring that there's no risk of freezing need to be developed. Up-ducts need to be redesigned to be thoroughly insulated and positively sealed during times when cooling isn't needed. And controls need to be developed which not only vary fan speeds and control water cleaning cycles, but also monitor efficiency performance to signal the need for maintenance.

The trends toward using more compressor-based air conditioning in new homes in the Southwest are disturbing given the energy-efficiency opportunity offered by modern evaporative cooling systems. The greatest barriers to acceptance of this newly-improved technology are misperceptions based on the performance of old evaporative cooling technology and the lack of awareness on the part of the buying public and the builders who serve them. For the vast majority of the public and the building profession evaporative cooling means unsightly, low- tech and often poorly-performing swamp coolers. This does not need to be the case. However, a major education and awareness-building effort is needed to convince homeowners and builders that evaporative cooling can be high-performance alternative to conventional air conditioning systems it's potentially much less costly over its lifetime, and can be designed to be as comfortable as the alternative.

3.Design of Hall

Before going further for the designing of the duct, we study the plan of seminar hall.
In which we measured the height, breadth, length of the seminar hall and calculated area.
As the seminar hall is of irregular shape as shown in fig. we firstly calculated the area of rectangular part and then the area of curved part. The exact area of seminar hall is 133 sq. m. we consider the contact of roof and the walls to sunlight at various time i.e at morning, evening, and afternoon.

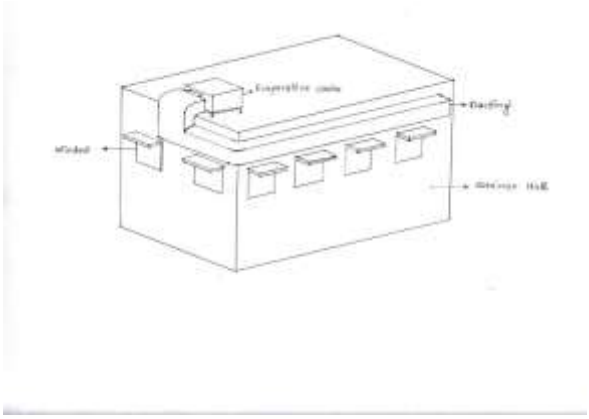

Fig 2 : Concept designing of centralized air cooling system

We considered following factors for the designing of air cooling system
Area = 133 SQ. M
Q = Volume * Air changes/ hr.
Dias size = 16' * 7' * 7" (LBH respectively).
Cabin door size = 0.85m * 2.34m (LH respectively).
There are 6 windows in seminar hall, one entry door.
Chairs (90 no's) with folding writing pads.
Ceiling with plaster of Paris.

2.2Specifications

1. **Duct Sizes**
   - 1st duct with canvas = 42" * 42"
   - 2nd duct = 36" * 36"
   - 3rd duct = 30" * 34"
   - 4th duct = 30" * 30"
   - 5th duct = 30" * 25"
   - 6th duct = 25" * 25"
   - 7th duct = 25" * 20"
2. **Grill Size** = 36" * 10"
3. **Cooler size** = 72" * 48" * 60" (LBH respectively)
4. **Blower**
   - Power = 1200watt
   - Current = 2.3 amp
   - Speed = 700 rpm
5. **Water Tank** = 150 lit.
6. **Pump**
   - No. of pumps = 2
   - Voltage = 220v – 240v ~ 50Hz
   - Flow Rate = 2300 lit/hr.
   - Power = 35watt

3.Result

As the roof being in contact with the sun, summer heat can cause indoor conditions to become much hotter than desired. Evaporative cooling is one way to reduce temperatures inside seminar hall. As water evaporates, it absorbs energy from the surrounding environment. A well-maintained ventilation system with evaporative cooling can reduce incoming air temperature by 8 to 12°C. Cooler indoor temperatures can improve the environment for the occupants. Evaporative cooling systems lower air temperature using mists, sprays, or wetted pads. Introducing water into ventilation air increases relative humidity while lowering the air temperature. For evaporative direct cooling systems a technology is presented which involves humidification and thus the cooling of air. In some cases efficiency is not efficient due to installation error & lack of adjustment with climate change over the year [2].

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