Centripetal Air Flow Cooler- A Review
Mohammed Ausaf Naseem1 Syed Danish Ali2 Tahoor Hassan Khan3 Syed Mohiuddin4

1,2,3 Student 4Assistant Professor
Anjuman College of Engineering and Technology, Nagpur-440001

Abstract—The centripetal air flow cooler maintains a better cooling effect and proper hygiene. The better cooling effect is obtained by using the centripetal and axial flow fan. The important components such as cylindrical cage, honey comb, and both the fans enable us to obtain higher cooling effect. Generally the normal air cooler provides a medium cooling effect by consuming more power hence in order to minimize such problem we introduced the centripetal air flow cooler. The concept behind making this cooler is to draw the air from the surrounding in the centripetal manner and then converting the air in axial manner for better and effective cooling. The use of horizontal cylindrical cage eliminates the use of excelsior (wood wool). This enables us to carry more water as compared to excelsior.

Key words: Centripetal fan, axial fan, cylindrical cage, Honeycomb

I. INTRODUCTION

Air Cooler is one of the appliances that help in keeping the atmosphere cold. The basic idea of water cooling is to find a medium that can handle and transport heat more efficiently than air. Evaporative air coolers also called swamp coolers is one of the most popular types of air coolers in India.

A. R. K. Kulkarni [1]

From this paper we have studied that evaporative cooling is also known as adiabatic saturation of air is a thermodynamic process. When a hot and humid air passes over a wet surface, the water evaporates and air loses its sensible heat and gains equal amount of load heat of water vapour thereby reducing its temperature. The most common evaporative cooling system uses a wetted pad through which air is passed at uniform rate to make it saturated. Pads can be wetted by dripping water on upper side with help of a recirculating pump. Such a system is called direct evaporative cooling. If the incoming air is having low humidity, large quantity of water can be evaporated and large reduction in temperature can be obtained.

More amount of evaporation, greater is the cooling effect. Thus the system is more efficient in hot and dry climate therefore when it is most needed.

II. OVERVIEW

The overview can be seen as the performance of rectangular, cylindrical and hexagonal shapes of evaporative cooler pads of material corrugated paper, high density polythene and cellulose type were theoretically analysed.

Performance in terms of saturation efficiency and cooling capacity is calculated for different mass flow rates of air. The saturation efficiency has highest value of 91% for hexagonal pad of aspen material and corresponding outlet temperature of air is 26.9°C. Lowest value of 72.4% is obtained for rectangular pad of cellulose material and corresponding outlet temperature is 29.6°C.

Higher wetted surface area per unit volume gives higher efficiency as regards the material are concerned. Higher thickness increases wetted surface area to give higher efficiency for the same shape. Cooling capacities increase with mass flow rate of air indicating large mass of air being cooled but decreasing efficiency.

A. Poonia M.P. [2]

From this journal paper we have studied that how a cooler can be used to cool drinking water and foods and vegetables economically. The parameters that we have learned from this journal are:

1) The developed cooler can be used for the purpose of storage of vegetables, bakery products, chocolates, medicines etc. including drinking water. The main medicines which can be stored in the temperature range of 22 - 27 °C: Prophecies is the medicine used to treat male pattern hair loss in men only 7.

2) Average effectiveness is found to be 65.42 % which is comparable with unloaded condition.

3) In unloaded condition, WBT (21.2 deg. C) has been obtained only in 25 minutes contrary to 52 minutes when it is connected to the G.I. box having cooling water as well as drinking water in it.

4) Developed cooler performs better over its nearest rival i.e. clay pot which is most popular in desert areas for cooling the drinking water.

5) Vegetables can be stored up to five days without any decay in their properties.

6) Around 30W energy can be saved by using the developed attachment with the conventional desert cooler without affecting the performance of the cooler.

III. OVERVIEW

After attaching the G.I. box with desert cooler investigations were made as in the case of desert cooler. Average effectiveness is found to be 65.42 %. There is no significant difference is obtained with unloaded condition. Drinking water was the main objective behind designing the present cooling system. Performance of the cooler was taken with drinking water in the G.I. box as well as without attaching the G.I. box with the existing cooler. The outside conditions during experiments were observed to be hot and dry (40 deg. C DBT and 17% R.H.). At these conditions, temperature, almost WBT (21.2 0C) has been obtained only in 25 minutes without attachment in contrary to 52 minutes when it is connected to the G.I. box having cooling water as well as drinking water in it. For circulating the cooling water in desert cooler without attachment conventional pump was kept in position whereas in the case of attachment another pump mounted in the G.I. box was in operation. The lag of 27 minutes was due to the load of additional cooling water as well as drinking water. It can be concluded that performance of the desert cooler is affected in terms of time lag but not in terms of minimum temperature obtained by it.
The temperature of cooling water in desert cooler as well as in G.I. container reaches to its WBT almost at the same time i.e. 52 minutes after the start of cooler.

**A. Seth I. Manuwa [3]**

From this journal paper we studied that different cooling pads that can be used in an evaporative air cooler and the level of cooling the material can provide. The different types of materials that can be used are jute, latex foam, charcoal and wood shavings. Shapes of cooling systems considered were of hexagonal and square cross-sections. Some physical properties of pad materials that could affect the effectiveness of the evaporative coolers were also determined.

From the results of this study, the following over view can be drawn:

1) Hexagonal cross section cooler are more efficient than square cross section cooler in terms of the saturation efficiency, maximum temperature drop and increased RH values.
2) The maximum mean temperature drops obtained during this study were 6.4 and 6.2oC for hexagonal and square cooler, respectively. Similarly the maximum mean saturation efficiencies were 93.5 and 84.1% for hexagonal and square cooler, respectively.
3) Some local pad materials (jute, latex foam, charcoal and wood shavings) and shapes (hexagonal XS and square XS) were studied for the purpose of constructing evaporative cooling systems.
4) The effectiveness of the pads in decreasing order of magnitude is: jute > latex foam > charcoal > wood shavings.
5) The performance of these pads compare favorably with those reported by other researchers elsewhere.
6) More tests are required especially ‘load tests’ to ascertain the effectiveness of the coolers.

**B. Krishna Shrivastava [4]**

From this journal paper we have studied the analysis of coconut coir pad of evaporative cooler. This paper investigates the performance analysis for a new sustainable application to reuse a Coconut Coir fiber, in evaporative cooling pads. Coconut coir pads are fabricated and tested on low cost desert coolers used in this region.

The coconut coir fiber pad was analyzed and compared with those of a commercial Aspen wood (wood wool) pad. Results show that the coconut coir fiber pad had similar saturation (cooling) effectiveness of near about 60% while the Relative humidity drop was observed from 80-85% of Aspen wood pad to 50-60% of Coconut coir pad. Also the water consumption rate for coconut coir fiber pad is less than Aspen wood pad. In addition, the cooling potential of the coconut coir pads was analyzed using the average climatic conditions of Jalgaon (Maharashtra) in India as the temperature in Jalgaon during summer season is near about 40°C to 45°C. The analysis shows that the air temperature leaving the coconut coir pad varied from 27 to 32°C. Commercial development appears feasible given the coconut coir pad’s good performance, lower cost and its availability throughout the country. Also the life of Coconut Coir Pad as compared to Aspen Wood pad is more.

The evaporative cooling is done in various stages is mentioned as follows:

1) Single stage / Direct system
2) Two-Stage System

The graph below shows the performance of the coconut coir

![Fig. 1: Performance of coconut coir](image)

**IV. OVERVIEW**

The better performance for the 7 cm pad thickness as the comfort zone in summer season lies between the relative humidity 30-65% and DBT between 23-27 °C. The water consumption for coconut coir is significantly lesser than Aspen wood. The saturation effectiveness range from 36.84 to 57.89 % for coconut coir pad (7cm). The outside DBT for both the Aspen wood as well as coconut coir pad is near about same i.e. 36-38 °C. The inside DBT varies from 26 to 31°C and from 27 to 30°C respectively. This shows that the inside temperature for aspen wood pad is lower than that of coconut coir pad. Thus the cooling efficiency is more for aspen wood pad than coconut coir pad. The inside WBT for Aspen wood and Coconut coir varies from 19.5 to 25°C and from 18 to 21.5°C respectively. This shows that WBT achieved for coconut coir pad is less than that for aspen wood pad. The inside relative humidity for Aspen wood and Coconut coir varies from 45.76 to 85.18% and from 30.16 to 61.84% respectively. The condition of coconut coir pad gives the result in the comfort zone suitable to human body and decreases the suffocation in the room when the evaporative cooler is fitted outside the room.

The result shows that water consumption rate of coconut coir pad is too much less than the aspen wood pad due to less humidity and contain less moisture. And the result shows that water consumption rate of aspen wood pad is too much high than the coconut coir pad due to high humidity. As the water consumption rate for coconut coir pad is less, thus the moisture content in the pad will also be very less. This gives the low relative humidity. In aspen wood pad, the water in the pad soaked which creates more moisture content in the pad, which gives more relative humidity.

**A. V. S. Shammy [5]**

From this journal we have studied the various specifications of the blower fan and blower motor.

**Blower Motor:**

Forced air is passed through heating or cooling elements and circulated to the desired locations. Blower motors provide that air movement. A blower motor is a term that actually describes a combined unit--an electrical motor and a fan.
Most often, a centrifugal fan, which looks like a 6- to 10-inch hamster cage, is used.

These fans--mounted in "housings"--are used to force hot or cold air through ducting and vents. These blower motors are compact in structure and elegant in design, and highly demanded due to their minimum energy consumption and requirement of low maintenance. These Cooler Motors are commonly installed in a variety of coolers.

1) **Blower Fan:**

Air cooling systems in Cooler most commonly rely on forced air. Forced air is passed through cooling elements and circulated to the desired locations. Blower provides this air movement.

Fan efficiency is the ratio between the power transferred to the air stream and the power delivered by the motor to the fan. The power of the airflow is the product of the pressure and the flow, corrected for unit consistency. Another term for efficiency that is often used with fans is static efficiency, which uses static pressure instead of total pressure in estimating the efficiency. When evaluating fan performance, it is important to know which efficiency term is being used.

The fan efficiency depends on the type of fan and impeller. As the flow rate increases, the efficiency increases to certain height.

V. **OVERVIEW**

From this journal paper we have come to a conclusion that the generally used blower motor is of 1300rpm and the motor with this rpm can throw air at a distance of 10 feet. By using such kind of motor would be suitable for cooling area of 150(sq.ft.).

A. **Vivek W. Khond [6]**

From this paper we have studied the experimental investigation of desert cooler performance using four different cooling pad materials. Evaporative cooling is a very common form of cooling buildings for thermal comfort since it is relatively cheap and requires less energy than many other forms of cooling. However evaporative cooling requires an abundant water source as an evaporator, and is only efficient when the relative humidity is low, restricting its effective use to dry climates.

The different parameters that we have studied from this paper are:

Experimentation was conducted under varying speed of fan, and parameters like water consumptions, cooling efficiency, and air velocity were measured. Graph also revealed that water consumption rate for stainless steel wire mesh pad is very low as compared to other Pads. Maximum water consumption was observed in wood wool pad. Coconut coir and Khus pad also shown less water consumption rate as compared to conventional wood wool pad. At high fan speed, water consumption was lower for all pad materials. Maximum cooling efficiency was found in wood wool and Khus pad materials. Stainless steel wire materials pad shows poor cooling efficiency as compared to other pad materials but can be used where relative humidity was higher. As fan speed decreases, cooling efficiency of all pad materials increases.

VI. **OVERVIEW**

A special test setup is designed to evaluate the performance of four materials to be used as wetted pads in evaporative cooling. The chosen materials are Wood wool, Coconut coir, Khus and Stainless steel wire mesh. The performance criteria include cooling efficiency, air velocity and water consumption rate. The results show that the average cooling efficiency is highest for wood wool (87.5%), compared to 75% for Khus pad, 71.42% for Coconut coir pad and 50% for Stainless steel wire mesh pad at same fan speed. But water consumption rate is higher for wood wool pad, as compared to Coconut coir, Khus and Stainless steel pad. Highest velocity of air was found in Coconut coir pad at same fan speed. Minimum water consumption was found in stainless steel wire mesh pad.

A. **D.A. Hindoliya [7]**

From this paper we had studied the preliminary assessments if indoor conditions and the thermal comfort in a room coupled with direct evaporative cooler in four different climatic zones of India. A room in building was simulated to obtain hourly values of room air dry bulb temperature and relative humidity for the summer months of march, April, May, and June in selected locations in hot and dry, composite, warm and humid, and moderate climatic zones. In June perfect comfort is not achieved in any of the four climatic zones. Whereas in Indore rooms conditions were close to watts comfort zone whereas in Bangalore cooling in not required in this month.

VII. **OVERVIEW**

In March, evaporative cooling is required in only two of the locations under considerations: Akola (hot and dry) and possibly Mumbai (warm and humid). In April, room temperatures are well within the watts comfort zone in hot and dry, composite and moderate climatic zones whereas in warm and humid zones room conditions in guwahati are close to watts comfort zone, but in Mumbai comfort zones are not achieved.
In may thermal comfort was achieved in zones hot and dry and composite zone whereas in Indore are within the comfort zones whereas in Delhi they are close to comfort to the comfort zone.

In June proper thermal comfort is not achieved with evaporative cooling in any four climatic zones under considerations except in Indore zone, where room conditions are close to comfort zone.

It was also noted that two different locations in a climatic zone differ from each other considerably therefore a single location may not represent the whole climatic zone from the view point of evaporative cooling.

A. M. S. Sodha [8]

From this paper we have studied the model for the evaluation of the variation of the water temperature along the direction of flow in an evaporating pad. The model had been used to evaluate the mean air exit temperature and the transient temperature of the water in the tank.

The analytical results are in agreement with the observations in our experiments.

The time variation of the temperature of water in the tank had been investigated and the new concept of using the tank water for cooling had been investigated theoretically and experimentally; the theory was in good agreement with experiment.

It was seen that the penalty on the mean exit air temperature was negligible for thermal loads \( Q \) (for cooling) of the order of 1 kW; it was seen that it is 0.6 °C for \( Q = 2 \) kW.

Further it was concluded that for typical coolers the steady state temperature of water in the tank was reached in a time of the order of one hour or less.

To have a controlled experiment, the cooler was fitted with an exit air duct going out of the room. The inlet air for the cooler was drawn from air in a \((6\times6\times3.6)\) m³ room with an open window. The temperature and humidity of the air in the room (i.e. the inlet air of the cooler) and that of washed air were determined by temperature and humidity sensors, the mean values were used for comparison of the data with theory.

The velocity of the air incident on the pad was measured at four points by an anemometer and the average value used for computing \( h_c \).

The single evaporating pad with dimensions \((0.76\times0.60\times0.10)\) m³ had the \((0.76\times0.60)\) m² faces bare for inlet and exit air, the \((0.76\times0.60)\) m² faces were covered by the plywood and the top \((0.60\times0.10)\) m² face was covered by the perforated bottom of a tray with an inlet for pumped water. The water from the bottom \((0.60\times0.10)\) m² face was allowed to fall on a perforated tray (with sensors) placed over the tank.

The pad was made of GLASdek with evaporating surface of 440m²m⁻³ and convective heat transfer coefficient. The water falling down the pad is collected in a tank and pumped back to the top of the pad through an insulated pipe and rotameter (to measure the flow rate) outside the cooler assembly. One could use the circulation of water in the tank for medium cooling of extraneous objects. To simulate the heat transfer, electric heating coils \((500 \text{ W}, 750 \text{ W}, \text{ and } 1000 \text{ W})\) were placed in the tank (one at a time). The water inlet and outlet temperature for the pad were also recorded.

The temperature of water in the tank was also periodically monitored, it was seen that the temperature variation at different points in the tank was not more than 0.1 °C; this may be due to the shallow depth and turbulent mixing due to pumping and falling water.

VIII. OVERVIEW

A model for the evaluation of the performance of an evaporating pad, taking into account the variation of the temperature of water and the direction of flow in an evaporating pad had been developed and validated experimentally.

The model had also been extended to evaluate the temperature of the tank as a function of the rate of heat addition (to cool extraneous objects), it had been also validated experimentally. It was seen that for typical coolers the steady state was reached in a time of the order of one hour or less.

A. S. Kachhwaha [9]

In this paper we have studied that a new type of direct evaporative cooler, a thin plastic plate was utilized as surface for evaporating cooler, a thin plastic plate was utilized as surface for evaporative cooling. A theory was proposed to correlate heat and mass transfer coefficients of wet and dry surfaces. Characteristics and performance of a cross flow evaporative cooler using honeycomb paper as packing material has been studied. Due to maintenance problems and a lower adiabatic efficiency of conventional pads, rigid media cellulose pads are preferred today.

This study presents development of a single procedure to Dowdy & Karabash and validated with experimental results.

1) Experimental procedure

Variable parameters during experiments were air velocity, inlet water temperature and inlet air conditions. No attempts were made to control inlet air and water conditions respectively, which are totally governed by ambient air. At the start of experiment, water temperature is normally within the range of DBT and WBT of inlet air.

During observations, water temperature approaches towards WBT of air. Sump water temperature at pad entry. Therefore real controllable parameter was air velocity, which was measured at five locations of cooler exit cross section and consequently, average velocity over evaporative pad, range for variation was calculated.

At particular instant of time, inlet and outlet air conditions were measured simultaneously by digital hygrometers. Total time for measurement of various readings for one observations was ≤2 min, during which change in ambient condition were found to be insignificant, after an interval of 15 min, measurements were repeated for next observation. In each set 5-7 observation were taken accordingly.

IX. OVERVIEW

Experiments indicate that DBT decreased is attainable by employing evaporative cooling during dry months. Using present methodology, variations in temperature and
humidity predictions are within the range of 15% and 10% respectively.

Therefore, present methodology could be used for design and analysis of direct type evaporative coolers.

A. Ashok Kumar Sharma [10]

From this paper we have studied that in the recent decades the demand for air cooling has increased due to high dry bulb temperature and low humidity of air in Rajasthan; especially in Jaisalmer districts where during summer dry bulb temperature of air is reached up to 50°C while relative humidity is below 48%. This climate is suitable for evaporative cooling. In a conventional air cooler a motor is used to drive the fan and pump water for cooling and humidification of air.

In this paper a modified cooler is presented with low electric energy consumption using natural draft system for air flow through the cooler. The major advantage of this equipment the fan used for air flow through cooler and thus reducing the electricity requirement.

A modified cooler has been manufactured which has cooler grills on four sides of the cooler. The grills are provided with the arrangement to receive maximum naturally blowing air. The outlet of air from the cooler is facilitated at the bottom along with the water tank. This tank will convey air to test chamber where cooling is required. The cooler grills are provided with cellulose pads. Inside the cooler the pads are facilitated with baffles which allow naturally blowing air inside the cooler through conical receiver.

Since this cooler uses only naturally blowing air for cooling purpose therefore, no blower is required electric power will be used only for circulating water from tank to grills with help of the electric pump.

X. Overview

Naturally draught cooler is also effective equipment in providing cooling effect without using blower.

The device is comparatively more effective with black colored exhaust ducts.

Since there is no blower In the modified desert cooler therefore, no electricity in operation and environment friendly use.

The cooler is suitable for most of the building types.

REFERENCES


