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Feasibility Study of using Nozzles for Air Cooling in Air Cooling System

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ABSTRACT: Evaporative cooling systems are the cheaper and more environmentally friendly alternatives to cooling as it consumes less energy. The performance of evaporative cooler is directly related to the ability of the padding materials to evaporate water (cool) at given humidity. This makes the air, cool and the fan throws this air in the rooms. However evaporating water system fails to deliver cool air in the monsoon season as humidity level in the atmospheric air is already high and further adding moisture to the room air, increases the level of discomfort. This major drawback can be eliminated if we place many, small converging nozzles in the pad and replace it with the conventional cooling pads. As the air passes through the nozzles it will undergo temperature drops. Thus there is no need for spraying water to the pads to cool air. This paper aims at finding the theoretical feasibility of using converging nozzles for cooling air in a cooling system.

KEYWORDS: Alternate to evaporative cooling, Cooling using Nozzle, No increase in Humidity .

I. INTRODUCTION

Evaporative cooling systems have been used widely in developing world's where cost of using air conditioning can be very high due to costly electricity. India being one such country uses very large amount of desert coolers. In India since majority of people are poor or have moderate living standards so it becomes very important that these evaporative cooling systems uses electricity efficiently. The evaporative cooler performance is directly related to the ability of the padding materials to evaporate water (cool) at given humidity. The cost of acquisition and operation of a cooling system is a fraction of conventional air conditioning and mechanical refrigeration systems. In evaporative cooling process hot air is passed through the wetted pads as a result part of the water will be evaporated and is carried with air by increasing the specific humidity of air. The major disadvantage of using evaporative cooling system is that this system add humidity to air which becomes very troublesome in monsoon season. As in rainy season there is already so much humidity in air, adding more water to air make cooling ineffective. The only remedy for this is to add dehumidifier to the cooling system but this raises the cost of the cooling system and makes it equivalent to air conditioning units cost.

The factors that determine the performance of cooler is the material used for pads. Many researchers have tried to find the padding materials which can successfully be replaced with the traditional material for effective cooling. Vivek, W.K (2011) [1] used four different pads of Stainless Steel wire mesh, coconut coir, Khus and Wood wool for evaluating the cooler performance. Faleh Al-Suleiman, (2002)[2] evaluated the performance of three natural fibers (date palm fiber, jute and luffa) used as wetted pads in evaporative cooling and found the average cooling efficiency is highest for jute at 62.1%, compared to 55.1% for luffa fiber, 49.9%. R.K. Kulkarni and S. P. S. Rajput, (2010), [3] theoretically analysed the performance of jute fiber rope bank as media in evaporative systems, determined the relationship among air velocity, cooling efficiency and temperature decrease at cellulose based evaporative cooling pads. Many researchers have almost investigated the cooling pad material highlighting important role of cooling pad in cooling. Present work, focuses on the non-conventional pad material by providing many converging nozzles in place of the cooling pad. This is one way to make cooling systems electricity efficient. This will also make the cooling system

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effective in monsoon season as cooling air through a nozzle system does not require to add water to air. So humidity of air will not increase further which happens in the case of evaporative cooling system. As the fan sucks the air this air will enter the cooling system through nozzle and will expand due to which the temperature of air will fall automatically.

II. RELATED WORK

A nozzle is a device which increases the velocity of a fluid by decreasing its pressure. In doing so temperature of fluid also decreases. In this cooler the modification is done by introducing nozzle in place of cooling pad material in the pad. Pad of the system is made cuboid in shape with width being comparatively small to length and breadth. The pad is made from wood. Since wood is natural product and has very less life cycle assessment in terms of carbon footprint. So using wood as a material for pad would also be beneficial for environment. Cooling is done without any cooling fluid being circulated. So long life of wooden pads can be easily expected. The cooler is so designed that the main fan can only suck air from surrounding through nozzles. These nozzles are fitted in the wooden board. The boards with nozzles are placed in three sides of the cooler body. The pressure behind fan is low and pressure in front of fan is high. Nozzle works when air enters at high pressure. Low pressure in cooling system due fan creates the pressure difference. As the air enters the nozzle initially it will be compressed than it will undergo sudden expansion thereby temperature of air decreases. This principle is used to lower the air temperature.

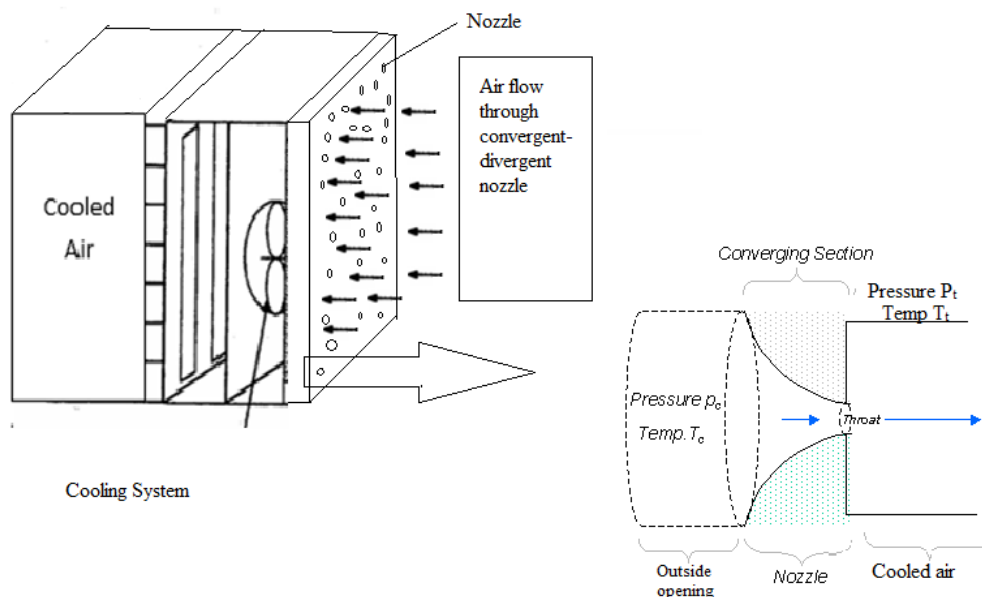


Figure 1 Cooling system with converging nozzle for cooling air.

Suppose area at entry level is A_1 , velocity is C_1 , Temperature is T_1 , Pressure is P_1 , specific enthalpy is h_1 and at exit conditions be A_2, C_2, T_2, P_2, h_2 . Since no work is done in nozzle, heat exchange is also very little comparable to 0, so from steady state equation we get

$$(C_2^2 - C_1^2)/2 = h_1 - h_2 \text{ if entry velocity is very small than } C_1 = 0.$$

For the case of gas (air)

$$h_1 - h_2 = C_p(T_1 - T_2)$$

$$T_2 = (h_1 - h_2)/C_p + T_1$$

Let the pressure and temperature at throat be P_t and T_t .

$$\text{So } P_t/P_1 = (2/\gamma + 1)^{\frac{\gamma}{\gamma-1}}$$

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And $T_t/T_1 = 2/\gamma + 1$

Where γ is heat capacity ratio which for air is 1.4

Hence temperature at throat = 0.83 times temperature at entry

In summer the temperature of air is suppose 35° Celsius. So after passing through nozzle the temperature of air will be reduced to 29° Celsius according to theory. Hence theoretically the use of nozzle for cooling could work very well.

III. DESIGN OF NOZZLE

Ejectors used in ejector refrigeration system Mary L. Mason at. El. (4) conducted an experiment at static conditions to determine the effect of increasing the circular-arc throat radius on nozzle internal-performance. They found that throat contouring results in improved values of discharge coefficient but has no significant advantage in internal thrust ratio except at nozzle operating conditions where internal flow separation occurs.

There are many set of parameters required for nozzles that will affect the exit temperature. Few of them are

- 1) Nozzle size, given by the exit area, A_e .
- 2) Type of gas, usually defined by thermal capacity ratio $\gamma \equiv cp/cv$,
- 3) Chamber (or entry) conditions: *pressure at entry* and *Temperature at entry* are considered.
- 4) Discharge conditions: p_0 , i.e. the environmental pressure (or back pressure), is the only variable of importance. discharge pressure, p_0 , is different than with exit pressure, p_e ,

Suppose we assume pressure ratio (ration between pressure at exit and pressure at entry) to be 0.99. In actual the pressure ratio will be less than this. From calculations we find optimum Area ratio comes out to be 4.86 which is similar to as proposed by yan and cai (5). If we built a nozzle with throat Area of $.01 \text{ m}^2$ than mass flow rate of each nozzle comes out to be 23.38. The mass flow rate of fan used in cooler is 233.8 than 10 number of nozzles are required to be built in pad of the cooler.

IV. DISCUSSION

Isentropic nozzle flow cooling system will be more Energy efficient as this arrangement of replacing cooling pads of evaporative cooling system with small nozzles built in the pads will result in more energy efficient cooling system. Since nozzle arrangement will not require cooling fluid for cooling so the energy required by pump to throw the cooling fluid towards the pads will be reduced as there will be no requirement of the pump. This will also remove the requirement to fill the cooling system with cooling fluid. This will also help in preventing humidity from increasing in monsoon season as no water is added here.

Another advantage of nozzle build pad is that the size of cooling system will be hugely reduced and the cooling system will become compact as it does not require water spraying unit as well as water storage unit. Another support of using such type of cooling pad is that it could be used both ways that in front of fan or at back of fan to give cool air. Also in summer this cooling unit will give cool air but if we use the cooling pad backward that is exit point of nozzle where temperature is T_2 is placed outside to open and entry point of nozzle where temperature is T_1 is kept towards fan. Than from formulae we know T_1 is higher than T_2 therefore the temperature of air from fan will be higher so the cooling unit could be used as blower in winter.

V. CONCLUSION

The study theoretically evaluates the potential of cooling air using an isentropic nozzle flow in a cooling system. Here we tried to replace conventional cooling pads of evaporative cooling systems with cooling pads having many small converging nozzles built in the cooling pads. From theory we know that when fluid passes through nozzle its temperature at exit decreases. Thus using nozzles can provide cooling of air without addition of water. Also from theory we find that exit velocity is higher than entry velocity. This will aid the fan in easy throwing of air.

Isentropic nozzle flow coolers can therefore be used to improve the human thermal comfort in residences, schools, commercial centres, hospitals, and industries provided the main parameters for cooling fall within the recommended range. Hence we conclude that cooling systems with nozzle built in pads could be a great alternate to cooling air by evaporative cooling and it has many advantages over evaporative cooling systems. Further experiments needs to be

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performed to prove that nozzle based cooling system will be beneficial than evaporative cooling system and also to find that placing pads with nozzle in front of fan will give better results or placing pads at back of fan will give better results.

VI. FUTURE SCOPE

Using more than one layer of nozzle pads will result in further drop in temperature but appropriate amount of pressure difference would also be required. So this study could further be extended by studying the effect of using more than one layers of pads with built in nozzle.

REFERENCES

- [1] Vivek, W.K. 2011. "Experimental Investigation of Desert Cooler Performance Using Four Different Cooling Pad Materials". American journal of Scientific and Industrial Research 2 {3}: 418-421. 2011
- [2] Faleh Al-Suleiman, (2002). Evaluation of the performance of local fibres in evaporative cooling. Energy conversion and Management, volume 43. Issue 16: pp. 2267-2273.
- [3] R.K. Kulkarni and S. P. S. Rajput, (2010), Theoretical Performance analysis of jute fibre rope bank as media in evaporative coolers. Indian journal of Science and Technology, Vol. 3 No. 10: pp.1075-10805.
- [4] Mary L. Mason, Lawrence E. Putnam, and Richard J. Re, The Effect of Throat Contouring on Two-Dimensional Converging-Diverging Nozzles at Static Conditions.
- [5] Yan jia, Cai Wenjian, (2012), Area ratio effects to the performance of air-cooled ejector refrigeration cycle with R134a refrigerant.