AN ENVIRONMENT FRIENDLY COOLING OPTION

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ABSTRACT

The impacts of air conditioning and refrigeration systems on environment are primarily linked to ozone-depleting refrigerants, energy consumption and heating the environment. Integrated assessment of ozone depletion, global warming, and atmospheric lifetime provides essential indications in the absence of ideal refrigerants, namely those free of these problems as well as safety, stability, compatibility, cost, and similar burdens.

The basic principle relies on cooling by evaporation. When water evaporates it draws energy from its surroundings which produces a considerable cooling effect. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. The efficiency of an evaporative cooler depends on the humidity of the surrounding air. Very dry air can absorb a lot of moisture so greater cooling occurs.

This paper aims at finding ways to substitute Air-conditioning with Evaporative cooling and the present efforts in this direction.

Key Words : Green energy technologies; Sustainable development; Air conditioning; Energy consumption; Environment.

INTRODUCTION

Fruits and vegetables are highly perishable and need immediate attention after harvest to prolong the shelf life. Post-harvest storage of fruits and vegetables is one of the most pressing problems in tropical countries like India. It has been estimated that about 25–30% of perishable commodities are lost annually at various levels after harvesting. There is wide gap prevailing between the production and storage capacity available in the country. Losses during storage are directly related to temperature, relative humidity and gas composition of surrounding the produce. The prevailing high temperature in tropics not only hastens all the physiological activities such as respiration, transpiration and ripening of fresh produce but also affects the physico-chemical composition eventually leading to spoilage.

The refrigeration and other commercial cold storage systems are the solution of the problem, but could not be fully exploited due to heavy initial cost and demand high input of energy. The favorable environment for storage of fruits and vegetables is low temperature and high humidity due to their high moisture contents. That is reasonably possible to achieve by evaporative cooling with comparatively low investment and less energy input. The simple evaporative cooler

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has got the limitation in drop of temperature, i.e. the maximum up to the wet bulb temperature of ambient air. It may be overcome with the modified evaporative cooling by sensible cooling of air before humidification. Evaporative cooling has been reported for achieving a favorable environment in greenhouses, animations and the storage structure for fruit and vegetables. The degree of cooling depends on the original humidity of air and the efficiency of evaporative surface. If the ambient air is having low humidity, which is modified close to 100% relative humidity, then a large reduction in temperature can be achieved.

Umbariker et al. developed the evaporatively cooled wall storage structure by using three cooling pad materials such as; fine sand, brick butt and coarse sand for orange in Maharashtra. They reported that the temperature dropped between 14 and 18.9°C and relative humidity increased in the range of 84--94.4% in brick butt pads. The minimum storage losses and quantitative changes occurred in orange during the 32 days of storage. Roy and Pal developed a zero-energy chamber using locally available material in New Delhi, India. The chamber was designed for on-farm use, operated by evaporative cooling, and was constructed from double brick with sand-filled cavity walls. The shelf life of tropical fruits kept in the chamber was increased by 2 to 14 days (15–27% increase) as compared to storage at room temperature.

Bindir has designed and developed an evaporative cooler for storage of fruits and vegetables in rural area of Papua New Guinea (PNG). The design, construction and laboratory testing of this evaporative cooler, and an assessment of their effect on the performance of rural farmers of PNG were evaluated as the low cost technology.

Jain and Das developed an evaporative theory based laboratory model of solar energy assisted desiccant cooling system for preservation of fruits and vegetables. Anyanswu studied a porous wall evaporative cooler for preservation of the fruits and vegetables. The performance of two stage evaporative cooler has been presented for room conditioning by Hisham et al.

The evaporative cooling of walls has the limitation of the portability and silting over the evaporative walls, which finally reduced the efficiency of the evaporation.

Therefore, in the present study, a portable modified evaporative cooler called two stage evaporative cooler (TSEC) has been developed to improve the efficiency of evaporative cooling for high humidity and low-temperature air conditioning.

**Advantages of Evaporative Cooling**

- Enjoy the Natural Freshness of a Cool Breeze
- Evaporative Cooling Provides 100% fresh Air.
- Evaporative Cooling Lowers the actual temperature.
- Evaporative Air Conditioners Filter The outside Air.
- Evaporative Cooling Lowers The Effective Temperature.
- Evaporative Cooling Saves Money.

**MATERIAL AND METHODS**

**Description of the evaporative systems**

The evaporative cooling systems to be designed were an indirect cooler and semiindirect solid porous cooler, consisting of two independent air flow supplies, an air flow supply used for cooling together with a return air flow in direct contact with water to favour heat and mass transfer.
In addition, the inner part of the pipes allows a two-phase flow. The presence of return air and water generates this two phase flow, whose geometry is essential for obtaining the correlations that will characterise the process in the heat exchanger. These operating conditions of the air–water flows ensure that the water film will wet the inner porous separation surface. This guarantees a heat transfer model between the different phases where the liquid is completely wetting the solid wall, thus ensuring an annular flow inside the pipes. Water is forced against the return air flow and, as it is constantly circulating, it achieves the adiabatic saturation temperature of the return air when functioning. The cooling effect of the impulse air would thus be the addition of two processes: the heat exchange between the two air flows (supply and return) plus the heat exchange process, through evaporation, between the air supply and the external wall.

In order to optimise energy efficiency, the evaporative coolers are installed in such a way that they takes advantage of the enthalpy of the return air flow from the return air in the unit, at 22 °C and 50% humidity.

**Fig. 1 :** Indirect evaporative cooler.

![Indirect evaporative cooler](image1)

**Fig. 2 :** Semi-indirect evaporative cooler.

![Semi-indirect evaporative cooler](image2)
The design of our coolers for evaporative recovery has been carried out taking both economic and technical factors into account, thus making them both feasible and efficient. By feasible we mean a design that can be installed, and by efficient one which recovers the maximum amount of energy available from the air coming from the airconditioned premises. It should be mentioned that these coolers also give greater interior air quality. The indirect evaporative cooler works with the following mechanisms:

- Heat and mass transfer in the return air flow.
- Heat transfer in the primary air flow.

The exchanger, made of flat plates, is in crossflow, allowing us to recover sensible heat in the primary airflow. There is no mix between the two flows intervening in the exchange process, consequently there is no possible risk of contamination from Legionella.

The indirect evaporative cooler uses the reduction of the dry air bulb temperature and the water temperature to the wet bulb temperature in order to transfer energy from the primary flow to the secondary flow, using the exchanger, which obtains an effectiveness of between 60 and 70%. The specific humidity is constant during the process. With all of the conditions outlined, the indirect evaporative cooler consists of 25 flat plates.

**Theory of two stage evaporative cooling**

The principle of two-stage evaporative cooling is to reduce the wet bulb temperature of outdoor air before it passes through the evaporative pad. A heat exchanger before the humidifier can provide this condition. Thus the more temperature drop is possible with evaporation cooling. The advantage of this type of system is that dry bulb temperature of outdoor air can be reduced below its wet bulb temperature. The maximum possible dry bulb temperature drop with number of spray chambers in series could be difference in $T_a$ and $T_g$, but due to precooling of air in heat exchanger, the maximum possible drop in the dry bulb temperature could be difference in $T_a$ and $T_h$. 

**Fig. 3** : Evaporative cooler with a recovery configuration.
Development of two-stage evaporative cooler

The two-stage evaporative cooling consisted of a plate heat exchanger, two humidifying chambers, two fans for forced airflow, water pump, water tank and an air filter. These components were mounted together on an aluminum angle frame. The aluminum material was selected for construction of frame, body and water tank in prototype to prevent from corrosion. However, these components can be made out of galvanized iron to reduce the cost of cooler at the time of commercial production. The most important component of the TSEC was plate type heat exchanger. The material of plate should have good thermal conductivity for effective heat transfer from primary airflow to secondary stream. Therefore, the aluminum plates of 0.5mm thickness were used to make the heat exchanger. The 60 numbers of aluminum plates used in heat exchanger were of 750_750 mm. The heat exchanging plates (aluminum) were arranged vertically and parallel to each other at the spacing of 12 mm. The alternative passes were used for horizontal flow of hot air (primary stream) and vertical flow of cold air (secondary stream) to provide non-mixing cross flow. The humidifier was made of aluminum sheet, framed in 50mm thickness and stuffed with wooden shave for absorption and providing thin layer of water for evaporation. The developed two-stage evaporative cooler is shown in Fig. 4. The outdoor air was passed through the coir pad for getting filtered before entering into the heat exchanger. The
humidifying pad was kept vertically across the airflow. The sensibly cooled fresh air from heat exchanger was humidified through first humidifier (cooling pad).

The conditioned air was allowed to enter into the storeroom, where it was mixed with room air and temperature was likely to be increased by respiration of product and the available room condition. The air of the storeroom should be allowed to exit, which is the requirement of evaporative cooling for continuous circulation. This was accomplished by taking out the room air, which was humidified through the second humidifier and passed vertically upwards through the heat exchangers as coolant-air (second stream). The second stream provided cooling to the air in first stream and exhaust to the storeroom.

**Fig. 5 :** Input temperature (ºC) vs. output temperature (ºC) in the semi-indirect evaporative cooler.

**Fig. 6 :** Input temperature (ºC) vs. output temperature (ºC) in the indirect evaporative cooler.
The water was supplied in humidifier by pump through nozzles provided on the 12 mm PVC tubes. The 60 l of water tank was provided at the bottom of cooler for 12 h of continuous operation. The fans of 450mm swept diameter were used of the commercially available cooler.

RESULTS AND DISCUSSION

A two-stage evaporative cooler was designed, developed and evaluated for suitability of short-term storage of fruits and vegetables. The cooler was portable and the dimensions were 1500 mm_1000 mm_2000 mm as length, breadth and height, respectively. The temperature drop by the two-stage evaporative cooler depends upon the relative humidity of the ambient condition. The developed two-stage evaporative cooler could be able to drop the temperature up to the wet bulb depression and to 90% relative humidity. The effectiveness of the two stage evaporative cooler ranged from 1.1 to 1.2 over the single evaporation. Cooler was tested with tomatoes and could achieve the favorable temperature and relative humidity for safe storage for 14 days.

In an Evaporative Air Cooler the latent heat that is absorbed by the water as it changes from liquid to vapor is taken from both the air passing through the media and the water left in the media - so both the air and water are cooled and their temperature falls. The water does not concern us, but the cooled air is what we want.

CONCLUSION

The above illustrates that when water passes over the media and air is blown through it, water evaporates and the air is cooled so that the dry bulb temperature of the cooled air approaches the original air wet bulb temperature. Note that the total amount of heat has not changed, but its nature has changed. The small amount of latent heat in the original water vapor in the air has become larger because of an increase in the amount of water vapor, due to evaporation.

REFERENCES


SAVE THE ENVIRONMENT

Good environment is good health

Air pollution causes health hazards

Recycle every drop of water