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ADVANCE COOLING AND HEATING SYSTEM FOR CABINET

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1. Abstract- **The performance analysis of modern cooling and heating system for cabinet using cellulose cooling pad is introduced in this paper. Average maximum dry bulb temperature of 41.5°C and average relative humidity of 38% is selected for the analysis. An experimental study is conducted in a room equipped with a fan and cooling pad for cooling system. Rectangular pads with rigid cellulose material is used called cellulose cooling pad. The dry bulb temperature, wet bulb temperature and humidity are estimated. Temperature difference and humidity variation with air mass flow and flow of water are plotted on the graph. Experimental measurements were carried out in comparison with desert cooler for 3 different days inside the room. The experimental results showed that advance cooling and heating system for cabinet maintaining the humidity in the specific range of 60% which is nearer to human comfort. The overall efficiency of the system is quite high and in combination with the dry and warm outside climate conditions enabled the air to enter the room with a temperature even 12ºC to 13ºC lower than that of outside air temperature. It is observed that material with higher wetted surface area gives higher saturation efficiency.**

Keywords:- **Cellulose, cooling pad, dry bulb temperature, wet bulb temperature, humidity.**

I. INTRODUCTION

This project involves making an advance cooling and heating system for cabinet, that would enable the user to control temperature and accordingly humidity of the incoming air in summer as well as in winter season. This imparts properties nearer to that of an AC, except that this device is based on the evaporative cooling principle of desert cooler in addition to that heating effect. Evaporative cooling, also known as adiabatic saturation of air is a thermodynamic process. When hot and dry air passes over a wet surface, the water evaporates and air loses its sensible heat and gains equal amount of latent heat of water vapor, thereby reducing its temperature. More the amount of evaporation, greater is the cooling effect. Thus the system is more efficient in hot and dry climates i.e. when it is most needed. The principle objective is to make the performance of this device as close as possible to that of desert cooler but with improved effectiveness.

The device employs normal components such as external body made up of GI metal sheet, submersible pump, heating coil with thermostat, water tank, a blower, regulator, manual timer kit in addition with cellulose cooling pad. This cellulose cooling pad is the most important part used in this system and it is the real replacement of conventional cooling pads called wodule. Cellulose pads have higher cooling effect, as the more amount of atmospheric air comes in contact with water in it.As per the study of one APS (Albuquerque Public Schools) engineer stated, “the average life of a cellulose pad cooler [unit] is 4 to 5 years, and with good seasonal maintenance, 5 to 7 years is not too hard to do”.[1] So it has less maintenance cost.

After increasing or decreasing the air temperature the humidity accordingly varies. Hence the temperature control and moisture control are interlinked with one another in summer season but in winter due to heating of the inside air the moisture removes.

The performance of advance cooling and heating system for cabinet is much superior to that of conventional one, as will be confirmed by the graphs and reading’s taken during the experiments. It is based on the principle of evaporative cooling effect, it gives greater rate of cooling effect nearer to human comfort.

Providing and maintaining the parameters such as dry bulb temperature, humidity, air velocity, and purity in an air is directly related with comfort of every mankind in the society

anywhere at the workplace or office, factory or industry and residential applications.The project work is completely based on experimental analysis. Suggestions made as future scope for improvements and modifications in the basic work are implemented in this project work and incorporating all those suggestions the present model is fabricated and studied the performance analysis of advance cooling and heating system for cabinet.

Different researchers have taken the efforts to improve the performance of these systems by changes in design, process and materials.

Jain [2] ,developed and tested a two stage evaporative cooler with wooden shave as packing material. Its effectiveness ranged from 1.1 to 1.2 and the cooler could achieve favorable temperature and relative humidity conditions for storage of tomatoes for 14 days.

Bashan and Housein i [3], studied important parameters affecting the saturation efficiency with durable corrugated paper as cooling media and modeled them. This media provided a wetted surface area of about 400 m2/m3.

Camargo et al' [4], developed a mathematical model of direct evaporative cooler and presented experimental results of the tests with rigid cellulose media having area density of 370 m2/m3. The saturation efficiency relation is derived in terms of heat transfer coefficient, air mass flow rate, wetted surface area of the material and humid specific heat. They concluded that the efficiency is more at higher dry bulb temperature and lower air velocity.

Dowdy and Karbash [5], tested rigid impregnated cellulose media experimentally to determine heat and mass transfer coefficients for evaporative cooling process.

This paper attempts to collectively study the performance of the cooler with cellulose cooling material as a cooling media. A cellulose cooling pad and conventional cooling material are selected for analysis.

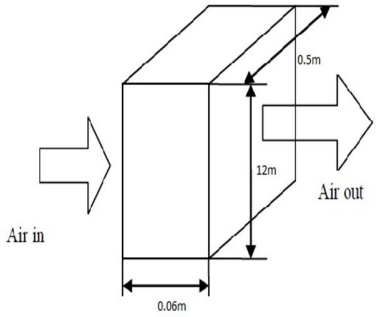
II. METHODOLOGY

A.Ambient Conditions

Weather data of Yavatmal, Maharashtra, India in the month of April for 3 consecutive days is taken to study cooling effect and month of January is taken to study heating effect. The most frequently occurring condition is of average maximum DBT of 40.5°C and average RH of 38% is selected for the analysis of cooling and DBT of 19°C and RH of 71% is selected for analysis of heating effect.

B.Geometrical Parameters Of The Pad

The cooling pad with its orientation and direction of air flow. This is the normal shape which can be used easily in the coolers. The air flows horizontally across the pad entering on one side and leaving the other. The lateral sides of the shape are assumed to be closed i.e. air is moving only in one



direction. Wetted surface areas of four pad materials are taken as 240 m^2 for rigid cellulose pad.

Fig.1 Pad dimensions and orientation

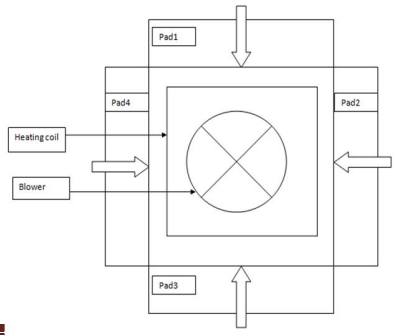
III. PRINCIPLE WORKING OF ADVANCE COOLING AND HEATING SYSTEM FOR CABINET

A. Air Circulation Process For Summer Condition

The ambient air is pulled into the system due to the suction effect created by the rotating blower. It flows through wetted water pad, known as cellulose cooling pad and undergoes evaporative cooling in the process. A portion of this evaporative-cooled air flows out of the cooler and through the diverging duct. The diverging duct causes the air to lose its kinetic energy and acquire greater static pressure The higher pressure of this air (acquired in the diverging duct) sustains the forward motion of this air and thus the cool air enters into the cabinet.

A.1.Evaporative Cooling In Water Pads

When hot and dry air passes over a wet surface of cooling pad, the water evaporates and air loses its sensible heat and gains equal amount of latent heat of water vapor, thereby reducing its temperature. More the amount of evaporation, greater is the cooling effect. Thus the system is



more efficient in hot and dry climates i.e. when it is most needed. 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 the help of a recalculating pump. Such a system is called direct evaporative cooling (DEC). If the incoming air is hot and dry, then large quantity of water can be evaporated and large reduction in air temperature is obtained.

Fig.2.Top view pads arranged on three sides

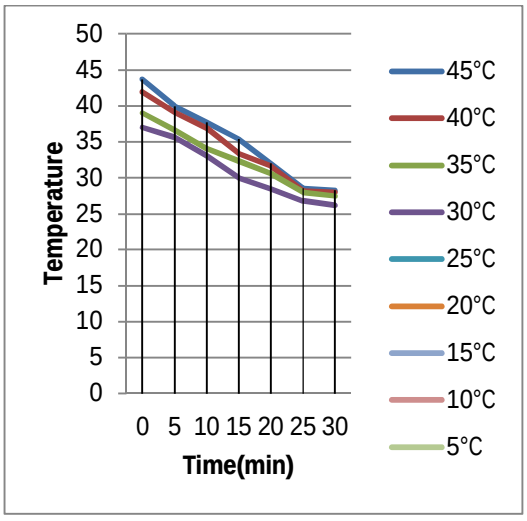
B. Air Circulation Process For Winter Condition

The ambient air is pulled into the system due to the suction effect created by the rotating blowers. The incoming air first flows through the dry water pad for filtering purpose. A portion of this cleaned air then passes over the relating coil to raise its temperature, while the blower blows the hot air through the diverging duct. The diverging duct causes the air to lose its K.E. and acquire greater static pressure. The higher pressure of this air (acquired in the diverting duct) sustains the forward motion of this air. This air stream acts as the heating stream, and enters into the cabinet.

IV. OBESERVATIONAL GRAPH

5.1.Temperature Vs Time Graph

5.1.1.For Advance Cooling And Heating System For Cabinet



Graph no.1

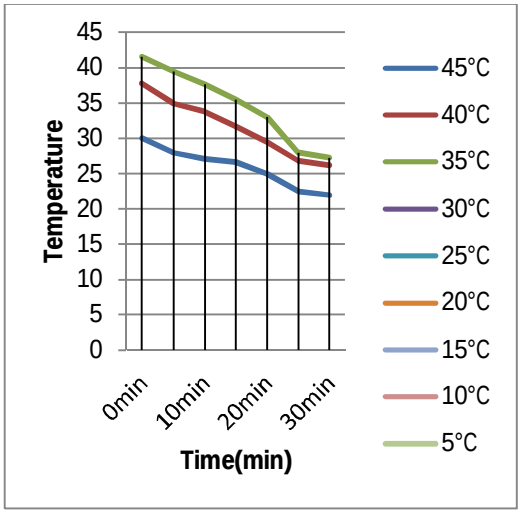
Violet Line => Temp. drop from 43.7°C to 28.3°C at 100% water flow

Red Line=> Temp. drop from 42°C to 28°C at 75% water flow

Green Line=> Temp. drop from 39°C to 27.5°C at 50% water flow

Blue Line=> Temp. drop from 37°C to 26.2°C at 25% water flow

5.1.2.For Conventional Desert Cooler



Graph no.2

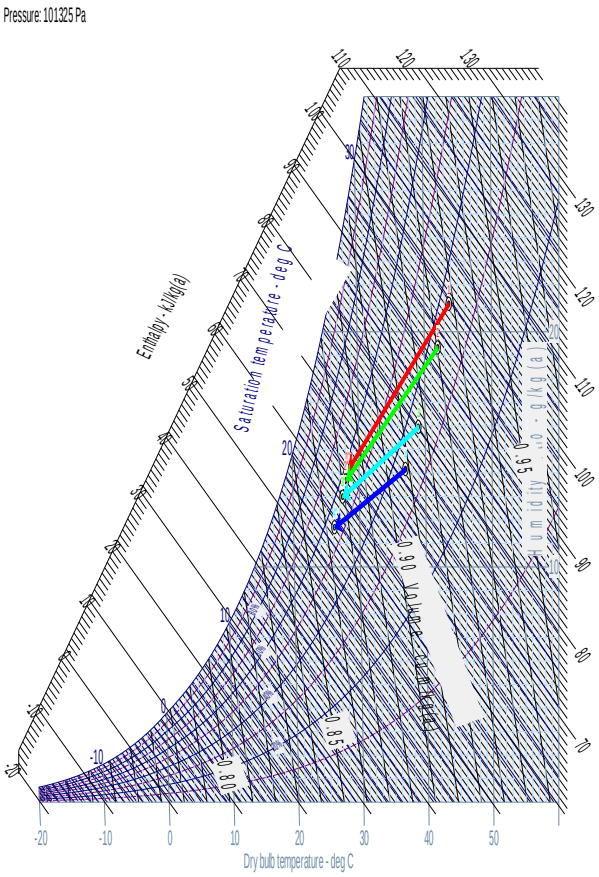
Blue Line => Temp. drop from 30°C to 22°C at time duration 9am to 9.30am

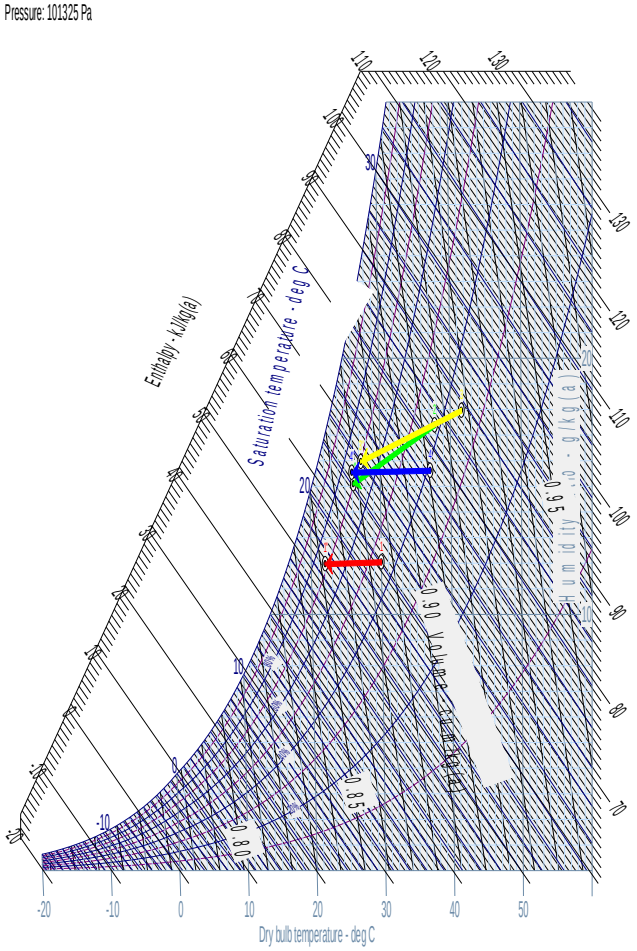
Red Line=> Temp. drop from 37.8°C to 26.2°C at time duration 12pm to 12.30pm

Green Line=> Temp. drop from 41.6°C to 27.3°C at time duration 3pm to 3.30pm

5.2.Psychometric Graph

5.2.1.For advance cooling and heating and system for cabinet





5.2.2.For conventional desert cooler

Psychometric Graph no. 1

Point1=43.7°c DBT & 37% humidity Point1''=28.3°c DBT & 58% humidity

Point2=42°c DBT & 37% humidity Point2''=28°c DBT & 57.3% humidity

Point3=39°c DBT & 36% humidity Point3''=27.5°c DBT & 56.1% humidity

Point4=37°c DBT & 35.7% humidity Point4''=26.2°c DBT & 54.6% humidity

Psychometric Graph No. 2

Point1=30°c DBT & 45.1 % humidity Point1''=22°c DBT & 72% humidity

Point2=37.8°c DBT & 41.8% humidity Point2''=26.2°c DBT & 70.2% humidity

Point3=41.6°c DBT & 35.2% humidity Point3''=27.3°c DBT & 69.5% humidity

Point4= 37.1°c DBT & 39.1% humidity Point4''=26°c DBT & 73.1% humidity

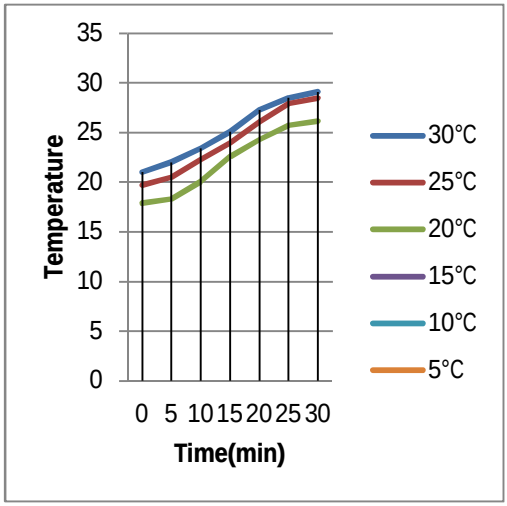
5.3.Temperature Vs Time Graph For Heating Coil

Graph no.3

Blue Line=> Temp. increase from 21°C to 29.1°C at time duration 7pm to 7.30pm

Red Line=> Temp. increase from 19.7°C to 28.5°C at time duration 9pm to 9.30pm

Green Line=> Temp. increase from 17.9°C to 26.2°C at time duration 11pm to 11.30pm



V. RESULT'S AND CONCLUSION'S

[1]The temperature Vs time graph shows that(Temperature vs Time Graph no.1 and 2), temperature drop occurs due to the application of advance cooling and heating system for cabinet up to 12°C to 13°C, whereas only up to 10°C drop occurs at conventional desert cooler.

[2]The decrease in temperature in advance cooling and heating system for cabinet maintains the humidity in the specific range of 56-58% which is nearer to human comfort, whereas humidity increases up to 70-71% in conventional desert cooler.(psychometric graph no.1and 2).

[3]It is observed that in winter season(Temperature vs Time Graph no.3) by the application of heating coil, increases the temperature up to 8-10°C at night by decreasing the humidity to human comfort.

VI. REFRENCES

[1] Study report of David Robertson, Facilities and Planning Engineer with Albuquerque Public Schools, August 30, 2007

[2]D. Jain, "Development and testing of two stage evaporative cooler," Building and Environment, vol. 42, pp. 2549-2554, July 2007.

[3] A.Beshkani, R.Hosseni, "Numerical modeling of rigid media evaporative cooler," Applied Thermal Engineering, vol. 26, pp.636-643, April 2006.

[4]J.R.Camrago, C.D.Ebinuma, J.L.Siveria, "Experimental performance of a direct evaporative cooler operating during summer in Brazilian city," International Journal of Refrigeration, vol.28, pp.1124-1132, November 2005.

[5]J.A.Dowdy, N.S.Karbash, "Experimental determination of heat and mass transfer coefficients in rigid impregnated cellulose evaporative media," ASHRAE Transactions, vol.93 (2), pp. 382-395. 1987.

[6]H.El-Dessouky, H.Ettouney, and A.Al-Zeefari,"Performance analysis of two stage evaporative coolers," Chemical Engineering Journal, vol. 102, pp.255-266, September 2004.

[7]Cooler Indirect/Direct Evaporative Monitoring Report 6, Davis Energy Group,2002.

[8]Evaporative Air-Conditioning 7, World Bank Technical Paper No. 421.

[9]Desert cooler specifications retrieved from " www.symphony.com"

[10]Psychrometric properties calculator retrieved from, "www.sugartech.co.za"

[11]Advanced Evaporative Cooling White Paper 8, Davis Energy Group,2006