Development and Performance of Solar based Air Washer

Rushiprasad Watpade[1]

Student, Mechanical Engineering, MVPS's KBT College of Engineering, Nashik, Maharashtra, India

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Abstract – *This Paper presents the idea to overcome the drawbacks of existing Air Washer used in industries or anywhere. This is fully solar powered air washer which uses blower, pumps nozzle, heating & cooling coil and reservoir. Working fluids are water and air according to applications it can be used. It removes dust and all unwanted particles for cleaning and maintenance purpose also maintain required and ideal temperature in surrounding environment. Also it is cost efficient and small in size to handle and operate.*

***Key Words*: Solar Powered[1], Blower[2], Nozzle[3], Cost Efficient[4]**

1. INTRODUCTION

Water sprays are extremely used in various engineering applications, such as, firefighting, dust control, nuclear reactor core cooling, air scrubbing, evaporative and cooling spray drying. In dry and hot climates, such as the summer season in India and other locations of the world, evaporative cooling of air is a seductive energy efficient technique for producing pleasant indoor surroundings... Air washers is employed in large air-conditioning systems for dust mitigation can also be optimized for cooling with appropriate design modifications by which energy will save and utilized for further. In normal air washers, most drops fall on the floor and some drops drift with the air by the means of pressurized water. This drop motion in air which leads to mass transfer and heat due to evaporation and some sensible cooling. Evaporative cooling works by using induced processes of heat and mass transfer, where water and air are the working fluids in the solar based air washer.

1.1 PROBLEM STATEMENT

To circumvent the big size of model and cost. Improve the air cooling rate with respective temperature by using solar energy.

2. LITERATURE REVIEW

Ramzi O et al. [1] has proposed the work on a conventional solar still equipped with a self-sustainable humidification-dehumidification open air flow stream to enhance the system productivity was scrutinize. This changes maintained higher temperature difference between the saline water and the condensing surface. Correspondingly, for the evaporation-condensation processes higher driving force for the wall provided. This was attaining by continuous removal of the latent heat of condensation by the cooling water and the insulating the condensing surface from the incoming radiation.

Zouaoui Ahlem et al [2] presented desiccant cooling systems are energy efficient and allow a better indoor air quality. Desiccant dehumidification is profitable in controlling latent heat, easy to be regenerating with low-grade energy, like waste heat and solar energy, etc.

The exploitation of heat produced by solar thermal collectors is a motivating option for thermal driven J. C. Santoj et al Desiccant cooling air conditioning processes . [3] Presented an analytical solution approaches for the simultaneous heat and mass transfer problem in air washers operating as evaporating coolers is shown. A one-dimensional model using the coupled mass and energy balance equation in the air washer is shown, then initiating from a linear approach for the experimental curve of the air saturation. An analytical solution for the model was derived.

Prakash Narayan G et al. [4] said that humidification and dehumidification desalination (HDH) is a promising technology for small-scale water production applications. There are various representations of this technology which have been found by researchers around the globe. However, we have found that no study carried out a detailed thermodynamic analysis in order to improve and/or optimize the system performance. In the same paper, we find the thermodynamic performance of several HDH cycles by way of a theoretical cycle analysis. Additionally, we showed novel high-performance alterations on those cycles.

Fei Liu et al [5] proposed that the working principles and the basic features of air conditioning water heater (ACWH) system are introduced in this paper. The air conditioning water heater system can be controlled in five modes: water-heating, water-heating and space-cooling, water-heating and space-heating, space-cooling and heating. Comparatively, the system can provide much better energy performance and higher equipment utilization throughout a year, and cause less thermal pollution than heat pump water heater and common air conditioner.

S. Jothyramalingam et al. [6] proposed that this project presents the performance of air washer chilled water coil system for a yarn industry .The basic principles including (1) effectiveness, (2) saturation efficiency and energy consumption for the systems are evaluated. In addition these spray system impedes the contaminants produced in yarn industries which go into the system. Same paper presents the outputs of, energy efficiency ratio, direct evaporative cooling processes and cooling efficiency for the air washer. At different ambient conditions around India against three seasons. This result shows the dry bulb temperatures decrease up to 12°C in arid summer conditions when air washer chilled water coil system is employed. The energy efficiency ratio is high and energy consumption reduces by 22.6%for air washers in Delhi than other cities. When air washer chilled water coil system is employed the required relative humidity (RH) ranges can be easily achieved. The chilled water spray system and Air washer chilled water coil systems have been studied. The first system is found to be not suitable for the yarn industry. Hence the latter system alone has been analyzed in detail with specific reference to the geographic location (namely Delhi, Chennai, Mumbai and Calcutta) and seasonal variation in the ambient. Based on the results the following conclusions are made. At Chennai Air washer saturation efficiency is found to be 90.4%. Effectiveness of air washer chilled water coil system is found to be 64% at Chennai condition. The air washer chilled water coil system is found more efficient at Delhi where the wet bulb depression is high. Evaporative cooling is an attractive energy conservation measure to pre-cool the supply air in air-conditioned buildings where wet bulb depression is high Evaporative cooling performance differs drastically from place to place depending on the ambient conditions.

DETAILS:

COMPONENTS INVOLVED

1) **Heating coil and cooling coil**
2) **Nozzle**
3) **Pump**
4) **Blower**
5) **Reservoir**
6) **Filtering Plates**
7) **Vapour compression cycle.**

3.1 Heating coil and cooling coil:

Heating Coil and Cooling coil is mostly used for ventilation purposes. Air handling fans and air handling filters is included with Cooling & Heating Coil includes. One of the credits of Cooling & Heating Coil is that it utilized low amount of energy. We produce export and supply all sizes of Heating Coils and Cooling. For heating purpose we use solar cell of 6V capacity. And for cooling purpose we use VCC set up.

3.2 Nozzle: Nozzle controls the pressure, speed, direction, temperature, and mass's rate of flow of the fluid. The spraying nozzles are produced with the help of brass, full cone type. They are supervising for supplying water to the equipment wash system. The pressure is calculated so that the nozzles provide a perfect cone to cover 100% of the area of the reservoir. We are use sprinkle type of nozzle.

3.3. Pump:

Pump is responsible for reticulating water from the tank to the filtering area through the hydraulic network. We are use 18W capacity pump with 1.85m head. We are use electrical type of centrifugal pump

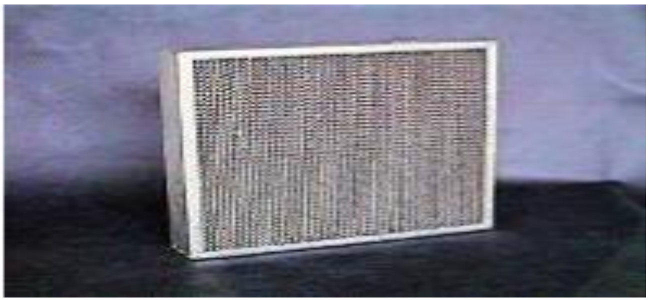
3.4 Blower: Blowers consists of rotors, that "catches" air and propel it through housing. Positive-displacement blowers offer a continuing volume of air although if the system pressure changes. Since they will turn out appropriate pressure blower's area unit especially acceptable for applications at the risk of hindering usually up to 1.25 kg/cm^2 - to blow clogged materials free. They rotate abundant slower as compare to centrifugal blowers as an example 3,600 rpm, usually belt driven to facilitate speed changes.

3.4.1 Reservoir:

Designed to produce the water flow forecasted for air wash, the recirculation tank is supplied with a biodegradable pollution drain and a level-regulating buoy. The tank is at associate degree angle in order that the powder transfers at rock bottom and it is simply dragged by the discharge drain when the recirculation water is absolutely or partly interchanged. We have a tendency to use the plastic box as a reservoir having capacity 4.2m^3.

3.5 Filtering Plates:

This area unit is beehive-type filtering metal components made from furrowed metal and equipped with an enclosed shaft to forestall deformation. Retention of particulate takes place through these components when your time the plates get fertile with dirt and need improvement. This improvement is created by water jets. We tend to area unit use a pair of 2.3μm skinny plate for filtration.



3.5.1 Vapour compression cycle:

A simple vapor compression refrigeration system consists of the following equipment's:

- Compressor
- Condenser
- Expansion valve
- Evaporator.

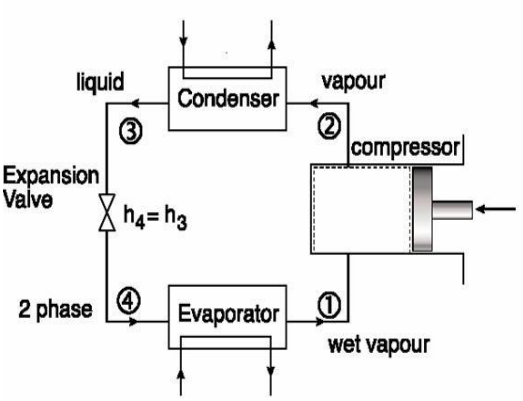


Fig.3.9. Simple vapours compression system

The coldness, air mass vapor at state 2 is compressed by a compressor to mechanical device and warm temperature and pressure vapor at state 3. This vapor is condensed into high vapor at state 4 within the condenser and then passes through the enlargement valve. Here, the vapor is throttled all the way down to a deep pressure liquid and passed on to an evaporator, wherever it absorbs heat from the encompassing from the circulated fluid and vaporizes into air mass vapor at state 2 . the cycle then repeats . a) mechanical device needs work, δ w. The work is equipped to the system from the environment. b) Throughout condensation, heat δ Q1 the equivalent of heat of condensation etc, is lost from the white goods. c) Throughout evaporation, heat δ Q2 equivalent to heat of vaporization is absorbed by the refrigerant. d) There's no exchange of warmth throughout strangulation method through the enlargement valve as this method happens at constant H.

4. ACTUAL MODEL:

5. CALCULATIONS:

From the standard atmospheric condition

For the summer

3.5.1 cooling coil design

T_1=35°C

ϕ1=70%

Required condition

T_2=25°C

ϕ2=50%

Volume of air supply V_a

$=\upsilon_1/\upsilon_{s1}$

=19.49/0.909

$=21.44 m^3/h$…………….. (3.7)

Mass flow rate M_a

$=V_a \times \rho$

=21.44×1.225

=26.264kg/h…………(3.8)

Cooling coil capacity

$=m_a \times (h_2 - h_1)$

=28.56×(50-30.5)………..(from psychrometric chart)

=556.92 KJ/h

=9.282 kW …….(3.13)

Therefore in VCC set up adjust as 10kW.

Efficiency of VCC set up=$T_1/(T_2-T_1)$

=25/(35-25)

=2.5 …….(3.14)

For the winter

3.5.2 heating coil design

T_1=20°C

ϕ1=30%

Required condition

T_2=27°C

ϕ2=50%

Volume of air supply V_a

=$^{\upsilon}{}_1/^{\upsilon}{}_{s1}$

=19.49/0.8358

=23.318 m³/h……………..(3.11)

Mass of air supply M_a

=V_a×ρ

=23.318×1.225

=28.56kg/h ………(3.12)

Heating coil capacity

=m_a×(h_2-h_1)

=26.26×(100.5-50.5)………..(from psychrometric chart)

=1313KJ/h

=21.88kW ………(3.9)

Therefore 25kW solar panel is use.

Efficiency of solar panel=η=(T_2-T_1)/T_2

=(27-18)/27

=0.39………………..(3.10)

η=39%

3.5.3 Blower design:

Volume flow rate (ὺ) =21.442m³/hr

=21.442/3600

=5.956×10^{-3} …(3.15)

Mass flow rate m = (ṁ)

=1.225×5.95×10^{-3}

=7.2962×10^{-3} kg/s

=26.26kg/hr …..(3.16)

Sensible heating

Q=ṁC_p(t_2-t_1)

=26.26×1.005×(29-20)

=237.52kJ/hr ….(3.17)

3.5.4 Pump design

Volume flow rate (ὺ) =A×h

=5×4.5×0.073

=1.6425m³/h ….(3.18)

Mass flow rate = (ṁ)

=1.6425×1000

=1642.5 kg/s

=27.375kg/hr ….(3.19)

Sensible heating

Q=ṁC_p(t_2-t_1)

=26.26×1.005×(29-20)

=237.52kJ/hr ….(3.20)

3.5.5Nozzle design

M_w=1642.5kg/sec

=0.4561kg/h

M_w=n×Area of nozzle

0.4561=n×π×d²/4

Consider d=3.5cm ……..(from standard datasheet)

n =6 …..(3.21)

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CONCLUSION:

The final scope of Lot 6 products that should fall under EU policy requirements has been adapted from Task 1 and the whole preparatory study, distinctions being made between the types of requirements proposed for the different product categories. The five main generic product categories are air conditioning chillers, air conditioners, air conditioning condensing units, heat rejection units and fan coil units. For the 3 first categories, distinctions in cooling principle and sink type have been made. Standardization needs have been detailed. For part of the different product categories, as classified by cooling principle and sink type, and concerning seasonal energy performance, it is only necessary to adapt and update the current prEN 14825 standards to take into account the new sets of reference hours evaluated in Task 6 for an average EU climate. Gas engine air conditioning chillers, air conditioners as well as all air conditioning condensing units, whatever their cooling principle, require a new energy performance standard. For the remaining product categories, the existing energy performance standards shall be updated as described in this report. The main subcategories for which one or more base-cases have been defined in Task 4, for which an improvement potential has been estimated in Task 6 and for which different sets of energy efficiency and refrigerant fluids political measures have been proposed are electric air-cooled air conditioning chillers < 400 kW, electric air-cooled air conditioning chillers >400kW,electric water-cooled air conditioning chillers<400kW,electric water-cooled air conditioning chillers>400 kW and electric air to-air air conditioners. In terms of energy efficiency MEPS and refrigerant fluid policy options, split systems, VRF systems and package air-to-air air conditioners have been therefore grouped together into this air conditioners single category, because of low differences in energy performance levels for current products as well as future improved products, due to very similar improvement potentials.

Although the Eu®P methodology designates the Task 6 LLCC improved products as the reference to be taken for energy performance MEPS, discussions have been proposed to define more soundly, when necessary, realistic SEER MEPS. This applies especially for air-to-air air conditioners.

Three policy scenarios of energy performance MEPS have been proposed in terms of SEER (final energy = electricity) and EER (final energy = electricity) for the five main categories of electric products, on a three Tiers basis, which comes down to 2015, 2017 and 2019. EER MEPS have been introduced to forbid products with a sufficiently high seasonal performance but a low full-load performance that could have an impact on the electricity grid at the time of summer electricity peaking demand in warm countries. Although a seasonal energy performance index in cooling mode lacks for gas engine products, equivalent SEER MEPS expressed in primary energy have been discussed for gas engine air-cooled air conditioning coolers and the gas engines which are air-to-air air conditioners.

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REFERENCES:

[1] K. A. Joudi and Mehdi.S.M., "usage of indirect evaporative cooling to variable domestic cooling load", Energy Convers and Manage, 41.vol(17), pp.1931-1951, 2000.

[2] Y.M. Xuan, F. Xiao, X.F. Niu, X. Huang and S.W. Wang, "Research and application of evaporative cooling in China: A review (I) – Research Review Article", Renew and Sustainable Energy Reviews, vol.16(5), pp.3535-3546, 2012.

[3] Camargo R .Ebinuma D C and Silveira,J "Thermoeconomic findingd of an evaporative desiccant air conditioning system" , Appl. Therm. Eng., vol.23(12), pp.1537–1549, 2003.

[4] M. El Hourani, K. Ghali and Ghaddar .N, "Effective desiccant dehumidification system with two-stage evaporative cooling for warmth and hot surrounding", Energy and Buildings, 68.vol, Part A, pp.329 - 338, 2014.

[5] F.P. Incropera, D. P. DeWitt, T.L. Bergman , Lavine A.S., Fundamentals of mass and heat Transfer, 6th ed, 1.vol,Publisher : chapter11 Willey:Heat exchanger, pp.686-700, 2006.

[6] Whitaker, S., Simultaneous Heat Mass and Momentum Transfer in Porous Media: A theory of drying, Academic press vol.13, pp.119-203, 1977.

[7] Mhimid, A. and Nasrallah Ben, S, Theoretical study of mass and heat transfers during drying of granular components, In: Turner, I. and Mujumder, S.; eds, Mathematical modelling and numerical techniques in drying technology, Marcel Dekker Inc., New York,vol.27, pp.381-413, 1993.

[8] L. Zili and S.Ben Nasrallah, Heat and mass transfer during drying in cylindrical packed beds, Numerical Heat Transfer, part A, vol. 36, 201-228, 1999.

[10] M. L. Hunt and C. V. Tien Le, "Non-Darcian assembly in cylindrical packed beds", J. ASME. Heat Transfer, 110.vol(2), pp.378-384, 1988.

[12] M.H. Ahmed, N.M. Kattab, and Fouad.M, "Changes and optimization of solar desiccant wheel performance" , Ren. Energy 30.vol, p.305-325, 2005.

[13] A. Sakoda, and Suziki.M, "contemporaneous transport of mass and heat in unopened type adsorption cooling system use solar heat", J. Solar Energy Engineering., ASME 108.vol, pp.239-290, 1986.

[14] A. Kodama, T. Hirayama, M. Goto, T. Hirose, and R. Critoph.E, "The usage of psychrometric charts for the sweeling of a thermal swing desiccant wheel" , Appl. Thermal Eng., vol.21(16), pp.1657-1674, 2001.

[15] H.T. Chu, K.C. Ng, A. Malek, , T. Kashiwagi, A. Akisawa, and B.B. Saha, "Changes and the performance of two bed, silica gel-water adsorption coolar", Int. J. Refrigeration 22.vol(3), pp. 194-204, 1999.

[16] L.Z. Zhang, Niu J.L."A pre-cooling Munters surrounding control desiccant cooling cycle in amalgamation with chilled-ceiling panels", Energy, 28.vol (3), pp. 275–292, 2003.

BIOGRAPHY:

Mr. Rushiprasad R. Watpade
BE Mechanical Engineering
MVPS's KBT College of Engineering