AUTOMATIC HUMIDITY CONTROL OF HYGROSCOPIC AIR WITH AHU

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ABSTRACT: The viable solution to the high latent load that naturally occurs in tropical regions requires an alternative system that runs at relatively low energy consumption yet be able to provide indoor thermal comfort by effective handling of the excessive humidity. Although the existing outdoor air treatment system is a proven approach, it is unpopular in developing countries due to its high initial cost. In this paper, a new system termed Dual Air Handling Unit system is proposed to be the answer. The function of Humidity-control Air Handling Unit is to remove the moisture from the conditioned room up to the desired humidity level and in the process the room temperature is also fractionally reduced. The Temperature-control Air Handling Unit completes the task by removing the remaining sensible heat so that the room temperature is maintained at the required set-point. By reducing the relative humidity to 50%, a much lower value than that of the normal air-conditioning could offer, room temperature of the new system is shifted higher to 26 °C in order to reduce the energy consumption. The simulation result shows that the proposed system offers energy savings up to 13.2% compared to the conventional air-conditioning system, without compromising the thermal comfort of the occupants.

KEYWORS: Air handling unit,Heating coil,Hygroscopic,Dry bulb temperature,Wet bulb temperature.

INTRODUCTION:

Maintaining effective control of humidity is essential in industrial environments for both the health of the building and its occupants and, very often, supporting optimum performance of manufacturing processes. With the continual development of new products and manufacturing techniques in the pharmaceutical industry that require tighter and tighter environmental conditions for production, specialist environmental control systems have never been more important . It has always been known that certain processing methods require control of the environmental conditions in terms of both humidity and temperature, and conventional heating and ventilation systems have in the past been suitable. However, the development of new products, particularly biotech based, has shown that many of the systems currently installed cannot provide the close control of relative humidity necessary to ensure consistent quality and optimum productivity, especially at the fine tolerances required for hi-tech development and production needs. Conventional heating, ventilation and air conditioning (HVAC) systems are generally designed to give comfortable controlled conditions for the staff. Typically, this will be over a range of 18ºC to 23ºC with a humidity range of 40 to 60% relative humidity (RH). The human body is very comfortable in this range, feeling neither too hot nor too cold. However, sensitive research and development methods, and manufacturing of products such as pharmaceuticals or medical devices, often require control of temperature and humidity at much tighter limits, typically ±2%RH and ±1ºC.

An air handler, or air handling unit (often abbreviated to AHU), is a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handler is usually a large metal box containing a blower, heating or cooling elements, filter racks or chambers, sound attenuators, and Damper. Air handlers usually connect to a ductwork ventilation system that distributes the conditioned air through the building and returns it to the AHU. Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served without ductwork. While controlling the humidity usual way is to lower temperature to attempt a certain percentage humidity we lower the temperature according to psychrometric chart. Ones we lower the temperature the humidity falls to required level but that air becomes hygroscopic and thus more prone to absorb more moisture and again becomes humid. In order to solve this problem we can add one hitting coil which increase the temperature of air slightly and reduces its hygroscope.

LITERATURE REVIEW:

2.1 B.Venkateswara Reddy:

Air handlers may need to provide heating, cooling, or both to change the supply air temperature, and humidity level depending on the location and the application. Such conditioning is provided by heat exchanger coil(s) within the air handling unit air stream; such coils may be direct or indirect in relation to the medium providing the heating or cooling effect. Direct heat exchangers include those for gas-fired fuel-burning heaters or a refrigeration evaporator, placed directly in the air stream. Electric resistance heaters and heat pumps can be used as well. Evaporative cooling is possible in dry climates. Indirect coils use hot water or steam for heating, and chilled water for cooling.

2.2 J. Michael CARSON:

In this paper investigate the Steam Pre-Heat Coil control temperature by simply modulating a control valve, varying the flow even in extreme temperatures. Even though steam flow ismodulating, the coils rarely freeze because the condensate drops straight down the tube (by gravity) and the condensate header is outside of the cold air stream. Starting in the 1960’s and continuing through today, engineers are trained to use more modern methods of designing preheat coils; such as face and bypass, internal face and bypass, pumped hydronic, glycol, etc. Experience indicates that none of these ‘modern’ methods are as trouble free as the old fashioned vertical tube coil, which is now specified as a steam distributing type. Familiarity with the modern methods mentioned above, and a corresponding lack of familiarity with the “old fashioned” methods, makes it difficult for both the design engineer and the AHU manufacturer to understand what is meant by a “vertical tube steam distributing pre-heat coil with the headers outside of the air stream”.

2.3 B.F. Yu:

The main objective of this experimental study of independent control of temperature and humidity system (ICTHS) Conventional AC systems firstly cool air below the dew-point temperature in order to condense moisture out, and then reheat it to the supply comfortable temperature before delivering it to the occupied spaces. This leads to low evaporating temperature, a poor COP value for the chillers, and higher energy consumption. Moreover, the FCU may become the hot bed of many kinds of mildew due to the existence of condensing water, which will deteriorate IAQ. The reason for all theseproblems is that the cooling process and the dehumidifying process are in the same unit and at the same time, but there is an essential difference between the two processes (Chantal., 2004). ICTHS can realize the independent control of temperature and humidity, and resolve the problems above. The ICTHS consists of a liquid desiccant system and a cooling/heating grid system. The liquid desiccant system is composed of outdoor air processors (serving as dehumidifier in summer andhumidifier in winter), a regenerator, and a desiccant storage tank. LiBr solution is used as liquid desiccant in the system,and the regeneration temperature is about 60C. The cooling/heating grid system is composed of the power driven refrigerator,the heat grid, and the FCU or radiant ceiling. Insummer operations, valves A and C are turned on and valveB is turned off, and the ICTHS performs dehumidificationand cooling of the air. Chilled water with temperature of 15–18 C flows from the refrigerator into the outdoor airprocessors and the indoor terminal devices.

2.4 MichelNoussan:

The main goal of the performance analysis is an assessment of the AHU operation over time. Multiple activities have been performed on the available data, and some of the results are presented in this paper. The main topics discussed here are the following are evolution of the energy consumption of the HVAC system over time, Main drivers of the heat consumption: outdoor temperature and classroom occupancy, Operational analysis of the heat recovery unit. Data analysis techniques can provide a significant support in the operational optimization of HVAC systems, both for fault detection and diagnosis and for reduction of energy consumption. In particularFig (1), Air Handling Units (AHU) represent a significant share of the HVAC systems of the service sector (offices, schools, commercial buildings). The operation of AHUs shows common problems and solutions, and therefore any methodology could be extended to similar applications.The HVAC system is an all air system supplying 10,000 m3/h and returning 8,000 m3/h, and 2,000 m3/h get lost for overpressure. The supply air fan has a nominal power of 5.5 kW and the return air fan has 2.2 kW of installed power. The fans are currently at fixed speed, with no inverter, and as a result the clogging of the air filters causes lower electricity consumption and air flow rate.

SIMULATION WORK

Designing of AHU involves following steps

1. Designing of blower
2. Determining the dimensions of AHU panels
3. Designing of cooling coil and heating coil

1.Designing of blower

To design blower of 0.90 m^3/s

Take O_d= 0.33m

$I_d = 0.20$m

T= 0.065m

Volume discharged per revolution

V= $(\pi/4*(O_d^2-I_d^2))*T$

$=(\pi/4*(0.33^2-0.20^2))*0.065$

$= 3.51*10^{-3}$ m^3/rev

Volume discharged at 1000rpm

$= 3.51*10^{-3} * 1000$

CFM = 3.5174m^3/min

Volume of air discharged per second

= 3.5174/60

= 0.05862 m^3/s

2. Determining the dimensions of AHU panel

Considering the cubic feed per minute

Internal dimensions are

Bottom width = 0.5m

Length = 1.4m

Height = 0.45m

After adding insulation thickness T= 0.05m

Bottom width = 0.6m

Length = 1.5m

Height = 0.55m

3.Deginging of cooling coil

Q= h A_s (T_1-T_2)

Here,

Q = heat flow rate = ?

h = heat transfer coefficient = ?

A_s = surface area = 0.225m^2

T_1 = inlet temperature of air = 40∘C

T_2 = outlet temperature of air = 20∘C

To calculate 'h' heat transfer coefficient

$Nu_x = \frac{\hbar d}{k}$

To calculate Reynolds number

$R_e = \frac{\rho v d}{\mu}$

From thermodynamic properties of material

$\rho = 1.118$ kg/m^3

C_p = 1.00752 kj/kg.k

$\mu = 190.736 * 10^{-7}$Ns/m^2

K = 27.262*10^{-3} w/mk

P_r = 0.70518

$R_e = \frac{1.1181*4.5*0.445}{190.736*10^{-7}}$

$R_e = 117.30*10^3$

Thus flow is turbulent

$N_u = 0.023 * Re^{0.8} * Pr^{0.3}$

$N_u = 0.023 * 117387^{0.8} * 0.70518^{0.3}$

N_u = 233.0037

$N_u = \frac{\hbar l}{k}$

$233.0037 = \frac{\hbar*0.445}{27.262*10^{-3}}$

h = 14.27

Q = h A (T_2-T_1)

Q = 14.27*0.25*20

Q = 70.6365 J/s

Considering no losses

$Q_{air} = Q_{water}$

For water

Q = 70.6365

h = ?

$T_{in} = 8^oC$

$T_{out} = 25^0C$

$\rho = 990.5\ kg/m^3$ … from thermodynamic property table

$\mu = 265 * 10^{-6}\ Ns/m^2$

$Cp = 4.226\ kj/kgk$

$k = 683 * 10^{-6}\ w/mk$

Q = 0.5*10^{-3} m^3/s

…. from pump

Q = A*V

$$0.5 * 10^{-3} = 0.005^2 * \frac{\pi}{4} * V$$

V = 25.51 m/s

$$Re = \frac{\rho v d}{\mu}$$

$$Re = \frac{990.5 * 25.51 * 0.005}{265 * 10^{-3}}$$

Re = 476.74*10^3

$$Nu = 0.23 * Re^{0.8} * Pr^{0.4}$$

$$Nu = 0.23 * 476740^{0.8} * 1.64^{0.4}$$

Nu = 9.77*10^3

$$Nu = \frac{\hbar d}{k}$$

$$9.77 * 10^3 = \frac{\hbar * 0.005}{683 * 10^{-6}}$$

h = 1335.59

Q = h A_s $(T_2 - T_1)$

70.6365 = 1335.59*A_s*14

A_s = 3.74*10^{-3} m

$A_s = \pi D l$

3.71*10^{-3} $= \pi * 0.005 * l$

$l = 1.26$m

CAD MODELS:

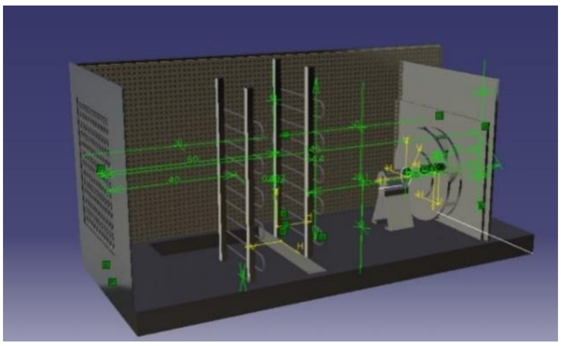

Fig.1.1 CAD Model AHU

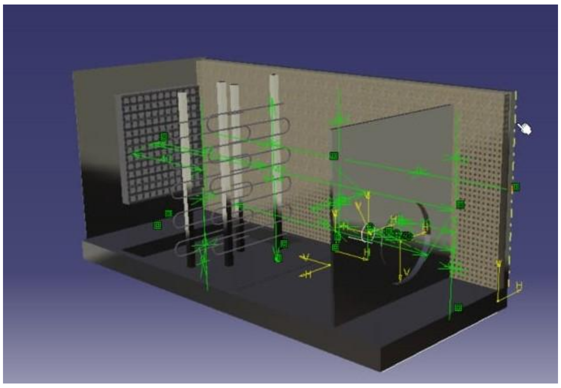

FIG.1.2 CAD Model BHU

CONCLUSION

Ensuring that such a system is installed requires, in turn, a conscientious and exceptionally careful approach from the design with more attention to detail than is given to a standard performance building. The challenge for the owner is defining expectations they wish to place on the designer. There is a need of vast improvements in this system to develop the production quality and minimize the production cost while preparing pharmaceuticals.

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