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Analysis on Heating Load Calculation of Duct

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Abstract: The energy consumed by heating, ventilating, and air conditioning (HVAC) systems has been Increasing over the last decades. Thus, improving efficiency of HVAC systems has gained attention of industry and academia. This concern has posed challenges for modeling and optimizing HVAC systems. The traditional methods, such as analytical and statistical approaches, usually involve assumptions that may not hold in practice since HVAC systems are complex, nonlinear, and dynamic. Data-mining is a novel science aiming at extracting system characteristics, identifying models and recognizing patterns from large-size data sets. It has proved its power in modeling complex and nonlinear systems through various effective and successful applications in industrial, business, and medical areas. Applications of classical data-mining approaches, such as neural networks and boosting tree have been reported in the HVAC literature. Evolutionary computation, including swarm intelligence, have rapidly developed in the past decades and then applied to improving the performance of HVAC systems. This analysis focuses on modeling, optimizing, and controlling HVAC systems. Data-mining algorithms are utilized to extract predictive models from experimental data sets provided by the Energy Resource Station located in Ankeny,. In the optimization process, two set points of the HVAC system, supply air duct static pressure set point and supply air temperature set point, are controlled aiming at improving energy efficiency and maintaining thermal comfort. However, for some special projects, due to the specific design and control of the HVAC system, conventional settings may not be necessarily energy-efficient in daily operation. The HVAC system design and equipment selection for a commercial building (376 TR) is included as a case study in this paper. The outcomes of this paper are efficient design of HVAC system with minimum energy consumption and equipment selection based on operating

I. INTRODUCTION

In this, a time-series-based model is extracted by a data-driven approach to predict energy consumption and indoor temperature of an HVAC system. A simulation is also built based on the same data-driven approach to simulate energy consumption and indoor temperature of the HVAC system.

The effectiveness of the data driven approach has been demonstrated in the literature. Poisson and uniform distributions are applied to simulate the behavior of the occupants impacting the internal heat balance. An optimization model is developed from the predictive model to minimize energy consumption while maintaining the indoor air temperature within a desirable range. The supply air static pressure and the supply air temperature set points are generated by this optimization model by applying a nonlinear interior-point algorithm to it.

The interior-point method was originally developed for linear programming optimization and then extended to non-convex nonlinear programming. A case study is presented to validate the effectiveness of the proposed approach

II. OBJECTIVE

The goal of the analysis reported in this is to minimize the total energy consumption, while maintaining the indoor temperature (thermal comfort) at a desirable level by adjusting two controlling set points: the supply air static pressure and the supply air temperature set point. In this analysis , the indoor humidity is not considered since the relevant data in the experimental building cannot be obtained. Another reason is due to the average humidity in our experimental location that falls in the desirable range most of the time. Therefore, humidity is not necessary to be considered in the model proposed in this analysis. Thus, in constructing the energy consumption predictive model and the indoor temperature predictive model, it is necessary to include the two set points as parameters

The internal heat gain has a significant impact on the HVAC energy consumption. In commercial buildings, the number of occupants is a random variable. Thus, it is necessary to model activities of the occupants. In this analysis, considering its successful application in simulating discrete occurrences, a Poisson process is applied to model arrival of the occupants, and a uniform distribution is used to model their departure.

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III. HEAT LOAD CALCULATION OF DUCT

A. *Ventilization*

Area of west wall = h x width
12x10.42
= 125.04 sq. ft.
Transfer coefficient factor (μ) = .48
W= 43

1) weight ΔT
20 48
60 40
Mean = (48+40) / 2
= 44
ΔT = 44

Daily range for Lucknow = 30
ΔT= 44+15
= 59
= 125.04 x 59 x .48
= 4132.4544 Btu/hr.

2) *Area of roof* = *l x b*
= 12.16 x 10.42
= 126.7072 sq.ft

Trans Gain Except Wall And Roof

a) *Area of all glass*
Area = 12sq.ft
ΔT(DBT) = 35
= area xΔT xμ
= 12x 35x 1.13
= 474.6 Btu/hr.

b) *Partition area*
Area = 126.7072 – (7x3) door area
= 104.44
ΔT = 30
Thickness = 4
Weight = 20
μ = .31
= area x μ x ΔT
= 971.292 Btu/hr.

Area of bathroom / eastside
= 42 sq.ft.
= 42 x .31 x 30
= 390.6 Btu/hr.

Perimeter of door and window
= 34
1ft. = 1 cfm
= cfm x 35 x 1.08
Infiltration = 1285.2
Outside air (by pass factor)
= cfm x ΔT x BF x 1.08

= 151.2 Btu/hr.

3) *Internal Heat*

a) *For Peoples*

= no.of people x sensible heat
= 2 x 245 (75 degree DBT) table no.48
= 490

b) *Power in HP/area*

Light = watt x 3.41
= 1.2 x 3.41 x 127.26
= 520.74729

Appliances = 400 x 3.41
= 1364 Btu/hr.

Addition of total Btu/hr. , we get total heat
i.e. = 13396.1433 Btu/hr.

4) *Room Sensible Heat*

= (13396.1433 x 10) /100 (F.O.S = 10%)
= 1339.61433 Btu/hr.

Effective room sensible heat
= total heat + room sensible heat
i.e.= 14735.1576 Btu/hr.

5) *Room Latent Heat*

a) Infiltration = cfmx Δgr/lb x 0.68
= 34 x 10 x 0.68
= 231.2 Btu/hr.

b) Outside air
= cfmx Δgr/lb x BF x 0.68
= 40 x 10 x 0.1 x 0.68
= 27.2 cfm

c) People = people x lh
= 2x205

6) *= 410room Latent Heat*

= infiltration + outside air + people
= 668.2 Btu/hr.

(F.O.S = 10%) = 66.82 Btu/hr.
Effective room latent heat = 668.2 + 66.82
= 735.02 Btu/hr.

7) *Outside Air Heat Sensible*

= cfm x ΔT (DBT) x (1 – BF) x 1.08
= 42 x 35 x (1-0.1) x1.08
= 1571.724 Btu/hr.

Latent heat = cfm x Δgr/lb x (1- BF) x 0.68
= 282.744 Btu/hr.

8) *Grand Total Heat*

= RSH + ERLH + OAH
= 15656.21 Btu/hr.

Converting Btu/hr. into ton of refrigerant
= 15656.21Btu/hr.
= 1.3 tr

9) Effective Room Sensible Heat

$$= \frac{\text{eff. Room sensible heat}}{\text{Eff. Room total heat}}$$

(RSH + RLH)

$$= \frac{14735.7576}{14735.756 + 735.01}$$

ESH = 0.9524

ADP = 54.45 (table no. 65)

10) Dehumidified Rise

= (1- BF) x (room temp. – ADP)

= (1- 0.1) x (75 – 54.45)

DH.Rise = 20.344

Dehumidified cfm $= \frac{\text{eff. Room sensible heat}}{1.08 \times \text{dh. Rise}}$

$$= \frac{14735.7576}{1.08 \times 20.344}$$

= 670.69 cfm

Analysis Of Internal Heating Load Of The Hvac System

Time and date		Avg. no. of occupants	Occupants heating (wh)	Lightning (wh)	Total internal heat load (wh)
0:00-8:00	16/07/2017	0	0	0	0
8:00-9:00	16/07/2017	4.68	524.55	1000	1524.55
09:00-10:00	16/07/2017	8.97	1004.25	1000	2004.25
10:00-11:00	16/07/2017	5.95	666.	1000	1666.9
11:00-12:00	16/07/2017	9.35	1047.15	1000	2047.15
12:00-13:00	16/07/2017	9.09	1017.9	1000	2017.9
13:00-14:00	16/07/2017	7.47	836.55	1000	1836.55
14:00-15:00	16/07/2017	10.49	1209	1000	2209
15:00-16:00	16/07/2017	6.27	702	1000	1702
16:00-17:00	16/07/2017	10.36	1160.8	1000	2160.25
17:00-18:00	16/07/2017	10.01	1121.25	1000	2121.25
18:00-19:00	16/07/2017	9.21	1031.55	1000	2031.55
19:00-20:00	16/07/2017	6.42	719.55	1000	1719.55
20:00-21:00	16/07/2017	5.75	643.5	1000	1643.5
21:00-22:00	16/07/2017	10.38	1162.2	1000	2162.2
22:00-23:00	16/07/2017	9.47	1060.8	1000	2060.8

23:00-00:00	16/07/2017	6.86	768.3	1000	1768.3
00:00-08:00	17/07/2017	0.00	0	0	0
08:00-09:00	17/07/2017	3.05	341.25	1000	1342.25
09:00-10:00	17/07/2017	7.61	852.15	1000	1852.15
10:00-11:00	17/07/2017	14.56	1630.2	1000	2630.2
11:00-12:00	17/07/2017	11.40	1277.25	1000	2277.25
12:00-13:00	17/07/2017	6.06	678.6	1000	1678.6
13:00-14:00	17/07/2017	7.23	809.25	1000	1809.25
14:00-15:00	17/07/2017	6.51	729.3	1000	1729.3
15:00-16:00	17/07/2017	8.67	971.1	1000	1971.1
16:00-17:00	17/07/2017	11.93	1335.75	1000	2335.75
17:00-18:00	17/07/2017	7.56	846.3	1000	1846.3
18:00-19:00	17/07/2017	7.82	875.55	1000	1875.55
19:00-20:00	17/07/2017	10.06	1127.1	1000	2127.1
20:00-21:00	17/07/2017	7.70	861.9	1000	1861.9
21:00-22:00	17/07/2017	7.66	858	1000	1858
22:00-23:00	17/07/2017	8.62	965.25	1000	1965.25
23:00-24:00	17/07/2017	9.96	1115.4	1000	2115.4

IV. RESULT

1) The occupied schedule is from 8:00 am to 12:00 am;
2) The mean inter-arrival time of the occupants is 15 per hour;
3) Occupants' stay in the conditioned space follow uniform distribution (0h, 1h);
4) The arrival and leaving processes are independent;
5) Each occupant produces 400 BTU (421,740 Joules) heating load per hour, including sensible and latent heating load. The occupants' arrival and staying is simulated by using MATLAB and the internal heating load results for 07/16/2017 – 07/17/2017 are shown in Using the simulated internal heating load together with the observed supply air duct static pressure set point and supply air temperature set point as inputs for simulation models, the energy consumption and indoor temperature from 07/16/2017 – 07/17/2017.

V. CONCLUSION

A. HVAC is one of, if not, the most important utility in health product manufacturing operations. HVAC systems are critical and represents increased risk as the complexity and cleanliness of the operation increases. Validation of HVAC systems is necessary.

B. HVAC systems must be properly designed for the intended application, qualified, and their operation monitored continuously to complete the validation.

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