# Study on Load Distribution of Temperature and Humidity Independent Control Air-Conditioning System

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**Abstract—Two kinds of typical temperature and humidity independent control air-conditioning system are introduced in the paper, and load distribution method is determined utilizing enthalpy-humidity chart thus laying a basis of energy saving analysis for THIC system.**

***Keywords-temperature and humidity independent control; load distribution; air-conditioning; energy-saving; enthalpy-humidity chart .***

## I. INTRODUCTION

Energy consumption of central air-conditioning systems account for about 40% to 60% of total building energy consumption, therefore it is imperative to reduce the air conditioning energy consumption according to the emphasis of the national development and reform commission on energy saving and emission reduction during the 13th five-year period. Conventional central air-conditioning systems process the indoor temperature and humidity at the same time, causing a coupling contradiction, therefore result in hidden trouble such as high energy consumption, lagging response to load change and poor indoor air quality. In 1995, academician Jiang Yi and Dr Frihaut from the United States had discussed the idea of Independent Humidity Control [1], and put forward Temperature and Humidity Independent Control (Abbreviated as THIC) air-conditioning system in 1996. THIC system can realize decoupling process of the air temperature and humidity, and can solve problems of conventional air-conditioning above mentioned. Professor Yin Ping from Hunan University introduced Dedicated Outdoor Air System(Abbreviated as DOAS) proposed by professor Mumma from American in 2001 [2], which had a same principle with THIC system. In recent years, researchers in our country have carried out a lot of researches and engineering practices [3-5] around the THIC technology, aiming at gradually solving core problems related to THIC technology and promote it, and they have made obvious progresses.

In a THIC system, the indoor terminal mainly deals with the temperature parameter, and the fresh air handling unit deals with the humidity parameter independently. How to assign fresh air load and circulating air load to the two devices will determine equipment capacity respectively, and clear up this question can only promote the energy saving analysis of the THIC system. Conclusions of other studies confined to the fresh air undertaking all indoor moisture load and part of indoor sensible heat load possibly, however, specific quantitative methods didn't be involved [6-8] up to now. In this paper, two typical application of THIC system are introduced, and load distribution method is determined utilizing enthalpy-humidity chart thus laying a basis of energy saving analysis.

## II. RESEARCH ON LOAD DISTRIBUTION FOR TWO TYPICAL SYSTEMS

Two typical THIC plans are discussed in this paper. In plan 1, fresh air is processed from state $W$ to $W_1$ by the fresh air unit, then return air is handled by indoor terminal from state $N$ to state $N'$, at last they are mixed to state $C_1$ used for undertaking indoor load. Plan 1 is an application of processing before mixed, as shown in Fig. 1. In plan 2, fresh air is processed from state $W$ to $W_2$ by the fresh air unit, then mix with returning air to state $C_2$, at last the mixed air is handled by indoor terminal from state $C_2$ to state $S$ used for undertaking indoor load, as shown in Fig. 2. In the two cases, processing of indoor terminal are both dry cooling process which is the main characteristic of the THIC system differing from other systems.

The basic situation is described as follows. Indoor cooling load is shown with $Q_N$, indoor moisture load is shown with $W_N$, fresh air cooling load is shown with $Q_W$, fresh air moisture load is shown with $W_W$, cooling capacity of fresh air handling unit is shown with $Q_1$, cooling capacity of indoor terminal is shown with $Q_2$, and meet the formula of $Q_1 + Q_2 = Q_N + Q_W$. The rest of the symbolic meaning is shown in Fig. 3, simultaneously, load distribution for fresh air unit and indoor terminal is presented clearly in the same Fig. too. Formulas of load and cooling capacity are shown in table 1 after theoretical analysis.

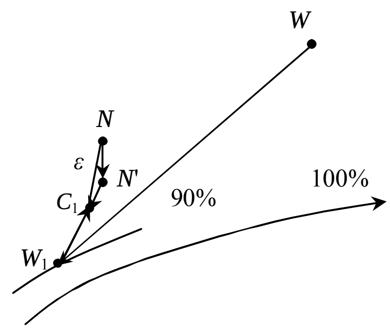


Figure 1. 1st kind of THIC Air-conditioning system.

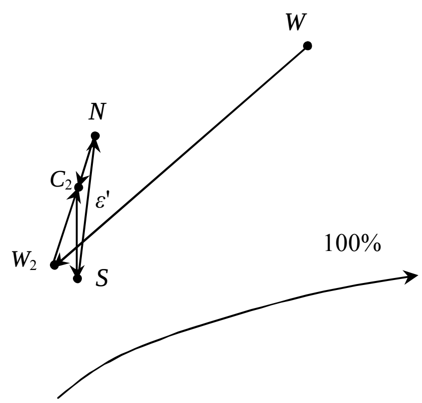


Figure 2. 2nd kind of THIC Air-conditioning system.

## III. CONCLUSION

The previous cases are typical application of THIC technology. Through analyzing load assignment for the fresh air and circulation air, its technology features as follows under summer conditions are summarized.

i) All fresh air loads which includes the fresh air of the sensible heat load and latent heat load are handled by the fresh air unit, and the latent heat is essentially moisture load which meets the formula of $Q_{WL} = (2500 - 2.3468\, t_N) W_W$;

ii) Fresh air (after processed) also should remove a part of indoor sensible heat and latent heat. Constant specific humidity line is the boundary whether or not the fresh air will undertake indoor moisture load (or latent heat load), according to comparing specific humidity difference between fresh air supplying state ($W_1$ or $W_2$) and indoor air state ($N$). Isothermal line is the boundary whether or not the fresh air will undertake indoor sensible heat load, according to comparing temperature difference between fresh air supplying state ($W_1$ or $W_2$) and indoor air state ($N$).

iii) Indoor terminal undertake the rest indoor sensible heat load, therefore the process is dry cooling. No matter mixing happened in advance or not, its load distribution will follow the laws above mentioned.

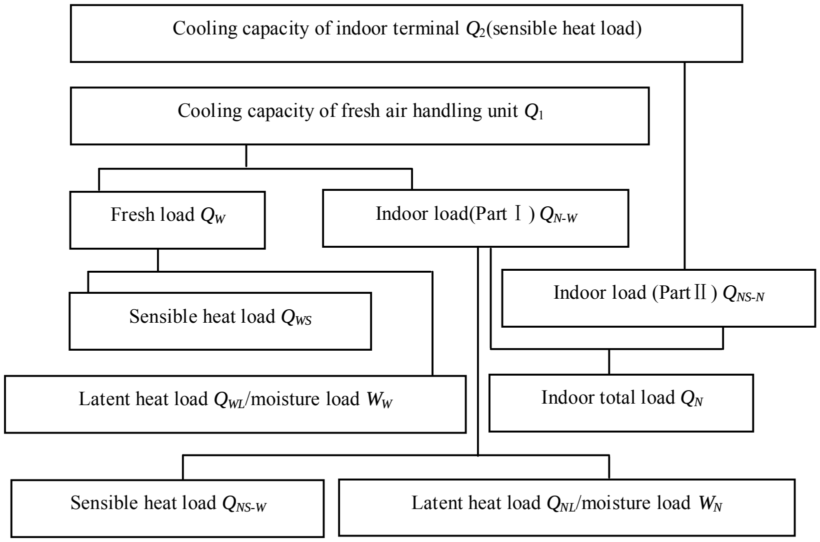


Figure 3. Load distribution.

TABLE I. FORMULA LIST FOR TWO TYPICAL THIC AIR-CONDITIONING SYSTEMS.

| | THIC Air-conditioning Plan 1 |
|---|---|
| $Q_1$ | $Q_1 = Q_W + Q_{N-W} = G_W(i_W - i_{W1})$ |
| $Q_2$ | $Q_2 = Q_{NS-N}$(Sensible Heat Load) |
| $Q_N$ | $Q_N = Q_{N-W} + Q_{NS-N} = (G_W + G_N)(i_N - i_{C1})$ |
| $Q_W$ | $Q_W = G_W(i_W - i_N)$ |
| $Q_{WS}$ | $Q_{WS} = cG_W(t_W - t_N)$ |
| $Q_{WL}$ | $Q_{WL} = G_W(2500 - 2.3468t_N)(d_W - d_N)$ |
| $Q_{N-W}$ | $Q_{N-W} = G_W(i_N - i_{W1})$ |
| $Q_{NS-N}$ | $Q_{NS-N} = cG_N(t_N - t_{N'})$ |
| $Q_{NS-W}$ | $Q_{NS-W} = cG_W(t_N - t_{W1})$ |
| $Q_{NL}$ | $Q_{NL} = G_W(2500 - 2.3468t_N)(d_N - d_{W1})$ |
| $W_N$ | $W_N = G_W(d_N - d_{W1})$ |
| $W_W$ | $W_W = G_W(d_W - d_N)$ |
| | THIC Air-conditioning Plan 2 |
| $Q_1$ | $Q_1 = Q_W + Q_{N-W} = G_W(i_W - i_{W2})$ |
| $Q_2$ | $Q_2 = Q_{NS-N}$(Sensible Heat Load) |
| $Q_N$ | $Q_N = (G_W + G_N)(i_N - i_5)$ |
| $Q_W$ | $Q_W = G_W(i_W - i_N)$ |
| $Q_{WS}$ | $Q_{WS} = cG_W(t_W - t_N)$ |
| $Q_{WL}$ | $Q_{WL} = G_W(2500 - 2.3468t_N)(d_W - d_N)$ |
| $Q_{N-W}$ | $Q_{N-W} = G_W(i_N - i_{W2})$ |
| $Q_{NS-N}$ | $Q_{NS-N} = G_N(i_N - i_5) - G_W(i_5 - i_{W2})$ |
| $Q_{NS-W}$ | $Q_{NS-W} = cG_W(t_N - t_{W2})$ |
| $Q_{NL}$ | $Q_{NL} = G_W(2500 - 2.3468t_N)(d_N - d_{W2})$ |
| $W_N$ | $W_N = G_W(d_N - d_{W2})$ |
| $W_W$ | $W_W = G_W(d_N - d_W)$ |

## ACKNOWLEDGMENTS

We acknowledge the financial supports of scientific research project of Hunan province Education Department (NO. 13c027), scientific research project of Hunan University of Technology (NO. 2013HZX10), Collaborative Innovation Centre of Building Energy Conservation & Environmental Control, and project supported by the Natural Science Foundation of Hunan Province (Grant No. 13JJ9033).

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