The Impact of Energy Recovery on Window Air-conditioner Efficiency

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Abstract: An experimental energy recovering air-conditioner can produce fresh air exchange heat with exhaust air in the heat exchanger, which has no additional moving parts. The EER of the experimental air-conditioner (EAC) is increased by 17.4~37.3 percent over that of an ordinary window type air-conditioner (OAC), which is very significant for energy efficiency. On the other hand, the fresh air proportion of the EAC is increased by ~20 percent over that of the OAC, and the indoor noise of the EAC is decreased by ~3.8 dB. Therefore, indoor environment quality can be greatly improved with the EAC.

Key words: Heat recovering, Window type air-conditioner, EER

The annual increasing range of domestic air-conditioner output reaches 48% in 1990's in China, and by 2002, the newly installed capacity reached more than one thousand kilowatt per year. Air-conditioners basically work in peak load time of electricity, and thus increasing the peak-to-valley ratio, and aggravating tension of electricity supply, so the energy efficiency of domestic air-conditioners can not be neglected increasingly. It is worthy of attention that, apart from partial window type air-conditioners, most are hardly installed any fresh air parts, so efficient and healthy air-conditioners keeping increasingly receive attentions due to the increasingly airproof characters of buildings.

1 PRINCIPLE

The experimental heat recovering air-conditioner (EAC) consists of a plate finned and countercurrent heat-exchanger and an ordinary window type air-conditioner (OAC). The heat exchanger supply and pre-cool fresh air and recover energy from exhaust air. The EAC didn't change the structure of the OAC, the heat exchanger directly linked with the crust of the OAC with an additional batholith. The EAC added no fresh air fan or exhaust air fan. Its fresh air outlet directly locates on the side of the evaporator, and fresh air is powered by return air fan. Its exhaust air outlet directly locates on side of the condensator, and exhaust air is powered by cooling air fan. The air-conditioner performance and indoor air quality (IAQ) will be improved due to the low exhaust temperature after heat exchange and increased fresh air, respectively. The air processing comparison between EAC and OAC is shown in Fig. 1. W presents the outdoor air state, W' presents the state of fresh air after precooling, N presents the indoor air state, O presents the supply air state and also the state of return air of OAC after being processed, L presents the state of return air of EAC after being processed.

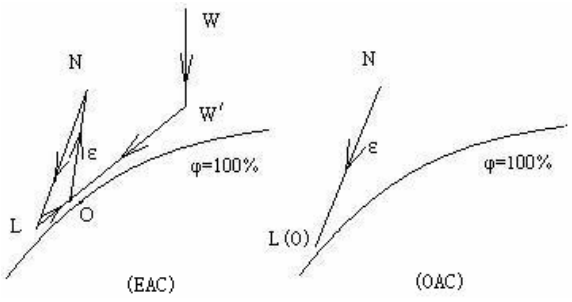

Fig.1 Air processing comparison between the EAC and the OAC

2 EXPERMENT TESTING

Two rooms with same structures and

orientations are selected for experiment testing, and their utilizations are also alike. The one is installed with the EAC, another installed with another OAC. As described in the section 1, the EAC consisted of a heat-exchanger and an OAC. For convenient comparison between the OAC and EAC, their model, and main parameters are identical as listed in Table 1

Tab. 1 The model and main parameters of window type air-conditioner

Type	KCR-30		
Rated voltage	220 V	Climate type	T1
Rated refrigerating capacity	3000 W	Whole input power	1270 W
Rated refrigerating capacity	3000 W	Whole input power	1150 W
Refrigerant	R22	Refrigerant quantity	0.61 kg
Indoor noise	55 dB(A)	Outdoor noise	62 dB(A)
Circulating air volume	700 m^3/h	Net weigh	46 kg

The experiments were processed in practical operating conditions, and the indoor or outdoor operating parameters were not controlled artificially. Although the experimental data were rather disperse, which can better reflect the essential performances of the OAC and the EAC. The enthalpy was calculated via dry and wet bulb temperature and air pressure. The types, measuring ranges and precision of main instruments are presented in Table 2.

Tab. 2 The type, measuring range, precision of main instruments

Name	Type	Measuring range	Precision
Dry and wet thermometer	DHM2	-26~51 ℃, 10~100%	0.1 ℃
Thermometer	Glass mercury	0~50 ℃	0.1 ℃
Barometer	2BY215-84	8~106 hp	
Anemoscope	QDF-2A	0.05~10 m/s	0.01 m/s
Power meter	JB2170-77	0~6000 W	1 W
Noise meter	HS6288B	35~130 dB	0.1 dB

In the period of testing, the range of indoor and outdoor air parameters were as follows: outdoor temperature -30.3~35.4 , relative humidity

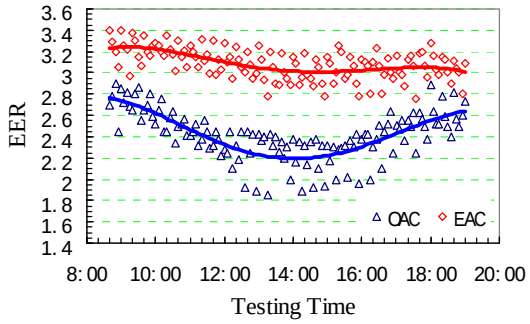

Fig.2 EER comparison between the OAC and the EAC

59.2~72.3%, indoor temperature 23.8~25.6 ℃, testing time 8: 40~19: 40. The change of EER of both OAC and EAC is shown in Fig. 2.

Figure 2 shows: (1) the EER of the EAC ranges in 3.02~3.24, and is 17.4~37.3% higher than that of OAC ranging between 2.20 and 2.76; (2) in the condition of changing outdoor parameters, the performance of the EAC is more steady than the OAC, and the changing range of EER is smaller; (3) the change of outdoor parameters is a key factor affecting air-conditioner performances, the EER is at peak at morning and night and is at valley during 12:00~16:00. Because of the heat exchanger, the actual temperature difference between the evaporator and condensator is smaller in the EAC than in the OAC, the EAC presented more steady operating performance than the OAC, and the EER of the EAC is greatly improved due to energy recovering.

Additionally, testing results showed that the fresh air proportion of the EAC increased 20% or so than that of OAC, and the IAQ was greatly improved. The indoor noise range of room with the OAC and the EAC was 69.6~71.3 dB and 65.9~67.5 dB, respectively, while the indoor background noise value was 51.7 dB. The reason for the noise decrease may be probably the cooling air reduction of the condensator.

3 DISCUSSIONS

The improvement of living standard must lead to an increasing proportion of domestic air-conditioner. Figure 3 shows the increasing

utilization of domestic air-conditioner in Shanghai

within last several years [1]. There are more than 24 and 40 cities which have inadequate electricity supply in 2004 and 2005' respectively, and electric power often broke off in large areas. It is far more impossible to obtain two-fold GDP by 2020 based on current energy increase rate. In many developed countries, energy consumption of buildings accounts for 40% of the total, and some .developed areas also reached this level in China. With the advent of 21st century, the average index reaches 27.8% in China. Up till now, the buildings areas are more than 430 million m^2, among these only 5% come up to the energy efficiency standard. More than 90% new buildings rank in ones with inefficient energy consumption. Though energy consumption per square meter building for heating is about 3 times that of developed countries with similar climate conditions, the thermal comfort is inferior in China.

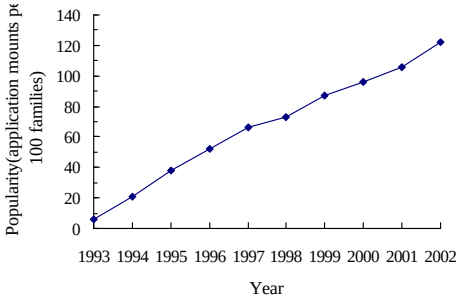

Fig.3 the increasing utilization of domestic air-conditioner in Shanghai

The time of residents staying indoors is increasingly longer, According to a survey, residents stay indoors in more than 88% time[2], so IAQ is significantly important for health. The IAQ is becoming deteriorative due to increasing airtight capacity of buildings and diversified indoor ornamentation. However, it can not effectively improve IAQ by means of only increasing fresh air but result in excessive energy consumption, so it is greatly important to develop healthy and efficient air-conditioners.

4 CONCLUSIONS

Energy recovering air-conditioners possesses the advantages as follows: (1) alleviating the contradiction of fresh air and energy consumption, improving IAQ and energy efficiency, (2) alleviating peak load impact of city electric power network.

The EAC has added no moving parts, the indoor noise is lower than that of the OAC, and thus indoor environment becomes quieter.

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