Study on Energy Saving of the Interlayer Ventilation Wall Used in Clean Operation Rooms

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Abstract: Recovery energy of the exhaust in air conditioning is very important to clean operating rooms. In disinfected operating rooms, we often use completely fresh air conditioning system in order to maintain cleanliness. All the return air of the air conditioning must be discharged. For recovering the exhaust energy, whole heat exchangers are used, and they may bring cross-infection in clean operating rooms. Cross-infection would negatively affect cleanness. This paper puts forward an air layer inside of a building's external wall that acts as a passageway for air conditioning exhaust, and also providing a place for the thermal exchange of the air conditioning exhaust. This kind of envelope is named an interlayer ventilation wall. There are two advantages. First, it will recover and reutilize the energy that the air conditioning exhaust takes, avoid cross-infection between the fresh air and the exhaust. Second, it will lower the energy loss of the heat exchange through the envelope. The energy saving effect will be very significant in clean operating rooms.

Key words: clean operating room; interlayer ventilation wall; energy saving

1. INTRODUCTION

The clean operation room should always be controlled in any case so as to lower any potential risk of infection. Airflow pattern of air conditioning system play an important role in controlling the temperature and humidity stability and preventing secondary contamination in the operation area, but it also must maintain a high indoor sterility level. The clean air conditioning system can achieve the requirements.

The completely fresh air supply system should be widespread used in infection operation room and ward for preventing cross-infection. The exhaust energy is great in the completely fresh air system, so it have been the people's one of the focuses about how to makes use of this part of energies that the airs take. It will be perfect that connect the recovery of the energy that the air exhaust takes with the reduction of the energy consumption that is influenced by the outside wall from the angle of the compound energy saving. At the meantime, the operation room contamination can efficiently be controlled.

2. TECHNIQUE OF RECLAIM ENERGY FROM THE EXHUAST OF AIR CONDITIONING

Heat exchanger is a good technique to reclaim energy of the exhaust and decrease the fresh air energy consume. The whole heat recover include with film and rotary. There is a thin film between two current in the whole film heat recover. The whole heats recover required better materials for the mechanics of heat and mass transfer. Rotary heats recover is limited for its complex construction. The two kinds of whole heat recover will produce cross-infection between fresh air and the exhaust[1].

For satisfy the cleanness of fresh and extend

service life of filter, heat tube heat exchanger and the whole heat recovery with solution circuit is often used[2]. These ways of reclaim energy improve from the equipments of air conditioning, which are not combined with building constructions themselves, so they are limited in some practical applications.

3. A NOVEL EXHAUSTS HEAT RECOVERY SYSTEM OF AIR CONDITIONING

3.1 Diagrammatic Sketch of Interlayer Ventilation Wall

This paper puts forward a novel interlayer ventilation wall to realize energy saving and cleaning stopping cross-infection between return air and fresh air. The interlayer ventilation wall combined with structure of building and center air conditioning system. The layout of the wall is shown as fig.1.

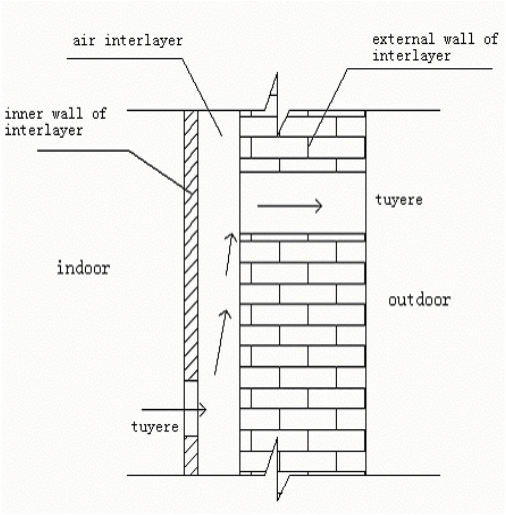

Fig. 1 A Kind of New Wall of Central Air Conditioning System

We can see from Fig.1, the air exhaust, instead of returning to the air conditioning equipment room through the return air pipe, is discharged to the interlayer of the building envelope structure directly. In the interlayer, the air exhaust of the air conditioning can fully exchange the thermal energy with the building envelope construction, to recover the energy that the air exhaust takes as much as possible. The wall of flowing air layer absorbs heat in summer while releasing heat in winter. Besides, the energy is reserved near the envelope and the fluctuation of temperature lags considerably[3]. Furthermore, the wall makes the inside-surface temperature of the building envelope structure closer to the indoor temperature, reduces the heat radiation between humans and the building envelope structure, and increases the thermal comfort of the human body. Therefore, when the indoor designed temperature is increased (or reduced) appropriately to lower the energy consumption, occupants can still feel the same thermal comfort as usual. The exhaust volumes are controlled by bacterial concentration, the air cleanliness, and the air change rate.

3.2 Experimental Verification

This mode of exhaust energy recovery of air conditioning stops cross-infection possibility between fresh air and return air. Indoor air quality and cleanness standard are assurance. In the mean time, the heat transmission load of envelope decreased greatly for the exhaust of air conditioning passing through the air interlayer. The energy of air conditioning system would be saved considerably.

The experiments have been done for verifying the energy saving characteristic of interlayer ventilation wall. The experiments results are shown as Fig.2. When the air change rate of the experimental room is 30-40 per hour through the interlayer, we can see from the figure, the average temperature difference between inlet and outlet is 4.38℃, the maximum temperature difference is 4.88℃ under the stabilization work condition. Because the air conditioner is not conversion, start periodically, the temperature of indoor air is turbulence, the temperature difference between inlet and outlet is fluctuant correspondingly too. The fluctuant range do not exceed 1℃.

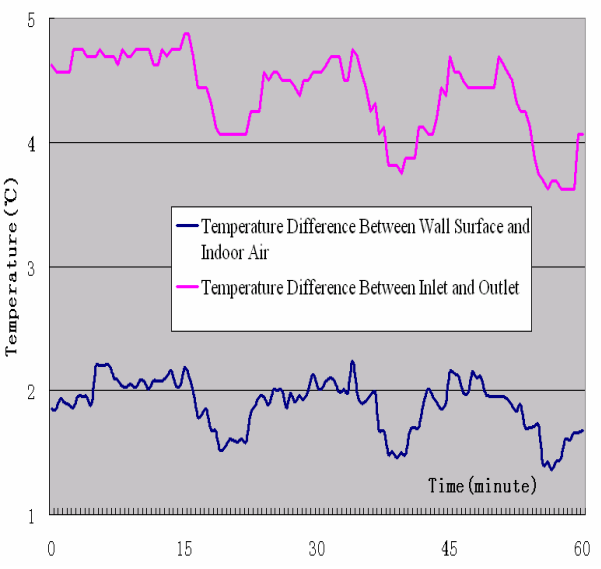

Fig.2 The Temperature Difference Between Inlet and Outlet, The Temperature Difference Between Wall Surface and Indoor Air

When the air change rate decreases, the temperature difference between inlet and outlet will increase. The maximum temperature difference has exceeded 10℃. Because exclaim energy increases with the increment of exhaust volume and the temperature difference between inlet and outlet, so the reclaim energy of exhaust is very great.

It will be weaken that the temperature of outdoor influent the indoor thermal (cool) load because of the envelope interlayer. Most of thermal loads from envelope to indoor are discharged by the exhaust currents. The temperature difference between wall surface and indoor air is nearly uniform. The average temperature difference between wall surface and indoor air is 1.88℃ when the air change rate is 30-40 per hour according to our experiment, see as fig.2. So the indoor thermal comfort is satisfaction.

3.3 Placement of Interlayer Ventilation Wall

For operation cleanness air conditioning system, the exhaust and the fresh air has no chance to approach so that it is impossible to produce cross-contamination used interlayer ventilation wall. Especially to the whole fresh air conditioning system, the exhaust volume is as much as supply air nearly, it is very obviously to energy saving.

The bacterial and virus from the patients will stay a long time in normal air currents, and it is easy to diffusion. Proper currents will be disturbed by frequent ambulation of doctors and nurses. So separate current circuit should be arranged in infectious ward and clean operation room to guarantee the current cleanness of doctor working areas. It is importance to adopt a simple and effective system to control the clean operation room areas. The interlayer ventilation wall can make as individual returning circuit either fused with envelope perfectly. Fig.3 illustrates the construction. Because most of return air were already removed by the interlayer ventilation wall, the supply air were not contained any return air, the terminal high-efficiency particular air (HEPA) filter will not receive much particulate loading. The filter dust-hold and the recirculating airflow rate can be changed slowly, and they could not affect the positive pressure control. The filter life will elongate.

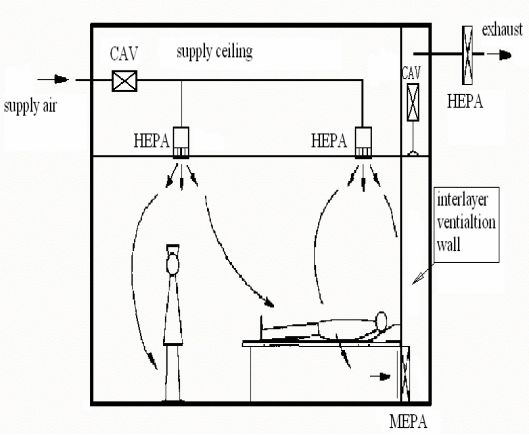

Fig.3 Current Type of Clean Operation Room with Interlayer Ventilation Wall

Considering the clean operation department as a fail-safe system, the control of positive pressure was a more important consideration. Only with the assurance of the orderly graded pressure distribution in the clean operation department, which can be maintained in any condition, can the risks of infection in an operation area be reduced effectively, and the highly sterile environment of a clean operation room area can be safeguarded[4]. The interlayer ventilation wall system that achieves the requirements of the Standard can be used economically and effectively with easy adjustment and operation.

The interlayer ventilation wall can be used in both new building and old building renovation. The

requirement of construction technique is low and construction difficulty is small. The internal wall is not bearing partition, can be built as individual wall. The internal wall material can use the gypsum plank. The controllable tuyere valves are installed in the lower of gypsum board and the higher of external wall. The terminal medium-efficiency particular air (MEPA) filter is installed the inlet. The supply air and exhaust system used constant air volume (CAV) system to assurance proper positive pressure. The thickness of the interlayer can be from 4cm to 10cm. The thickness is too small, construction difficulty increase, the thickness is over 10cm, the effect of energy saving is not obvious and the occupied area will increase. Renovation of the interlayer ventilation wall is very convenience. It is little that the initial investment increase. The payback period is only about 4 years (based on the buildings in Shanghai area and standard air conditioning system) according to our calculation.

4. CONCLUSION

Energy saving of clean operation room was a more important consideration in assurance of indoor air quality and absolute safety. Interlayer ventilation wall not only reclaim adequate energy of air conditioning exhaust but also put an end to cross-contamination between fresh air and the exhaust for the completely fresh air system. The construction difficulty and increased initial investment is lower than separate exhaust system.

The applications of interlayer ventilation wall will extensive use in clean air conditioning system as a novel energy saving wall.

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