Application of the VRV Air-Conditioning System Heat Recovery Series in Interior Zone and Analysis of its Energy Saving

Qiang Zhang Deying Li Jiandong Zhang
Master Student Professor Engineer
Key Laboratory of Heating, Gas Supply, Ventilating & Conditioning Engineering
Beijing Institute of Civil Engineering and Architecture, 100044
Beijing & China
E-mail: zhangqiang1980@126.com

Abstract: To reduce the energy consumption of air conditioning systems, we can use the VRV air conditioning system to supply cold loads in the winter for rooms in the construction inner zone where cold loads need to be supplied. The VRV air-conditioning system of variable frequency technology can achieve the effect of energy conservation. In this article, we analyze the application of the VRV air conditioning system heat recovery series in the construction inner zone and its energy saving characteristics via a project example.

Key words: VRV air-conditioning system; heat recovery series; construction inner zone; energy saving

1. INTRODUCTION

With the continuous development of national economy, the size and volume of modern architectures are constantly growing in many large and medium-sized cities emerged lots of office buildings and shopping centers and other buildings, which have a common feature of a larger presence within the district. In such buildings, it was possible that some rooms need to be heated up at the same time; some other rooms need to be cooled down. But the traditional air conditioning and traditional forms can only heat up or cool down at a time .Thus the indoor heat and cold sinks haven't been fully utilized. Not only can this substantially increase the capacity of air conditioners, but also enormous waste of energy would be caused.

Theoretical analysis and practical tests[1~3] show us that failing to set air conditioning system in light of the differences between the building inner and outer zone in a building with inner zone would not meet the requirements of environmental comfort, but would cause the serious mixed loss of heat and cold energy as well as the great difficulties to the reconstruction. For the design of air conditioning in a building with inner zone, the new added No.5.2.3 regulation of *Code for design of heating ventilation and air conditioning* 2001 edition requests that in the inner zone and the surrounding areas of the buildings with large discrepancy of load characteristics, in the rooms which must be heated and cooled respectively at the same time, the air conditioning system should be installed respectively.

Engineers have put forward some different modes of air conditioning system, some of which have been applied for buildings with inner zone[4]. Such as setting the heating system alone in outer zone, and CAV air conditioning system with a variable fresh air volume in the inner zone; setting heating system in outer zone and VAV air conditioning system in inner zone; closed-loop water source heat pump system; VRV air conditioning system heat recovery series; multi-zone air conditioning system, and so on. The different air conditioning systems have their own advantages and disadvantages. In this paper, we will only introduce the application of VRV air conditioning system heat recovery series in interior zone, and analyzes its energy saving efficiency.

2. SYSTEM STRUCTURE AND RUNNING PATTERN

VRV air conditioning system heat recovery series is composed of several indoor units and several

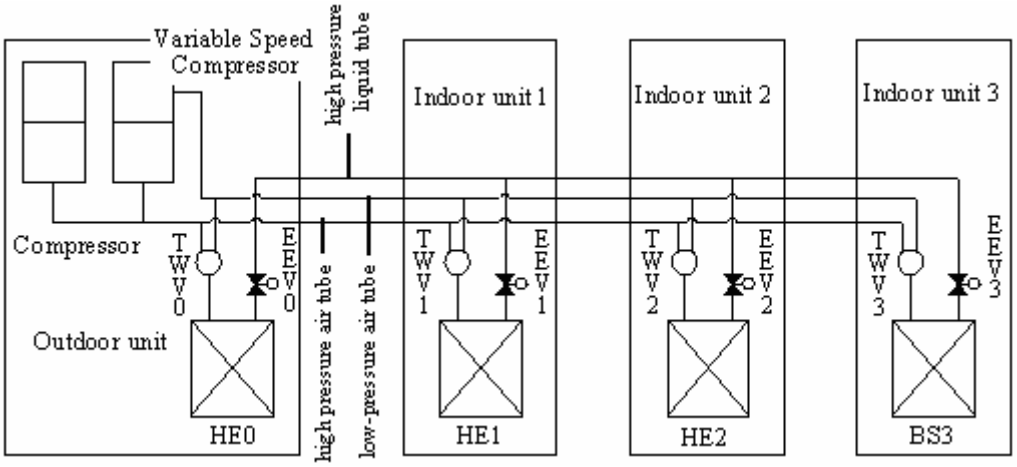

Fig. 1 The principle diagram of VRV air conditioning system heat recovery series

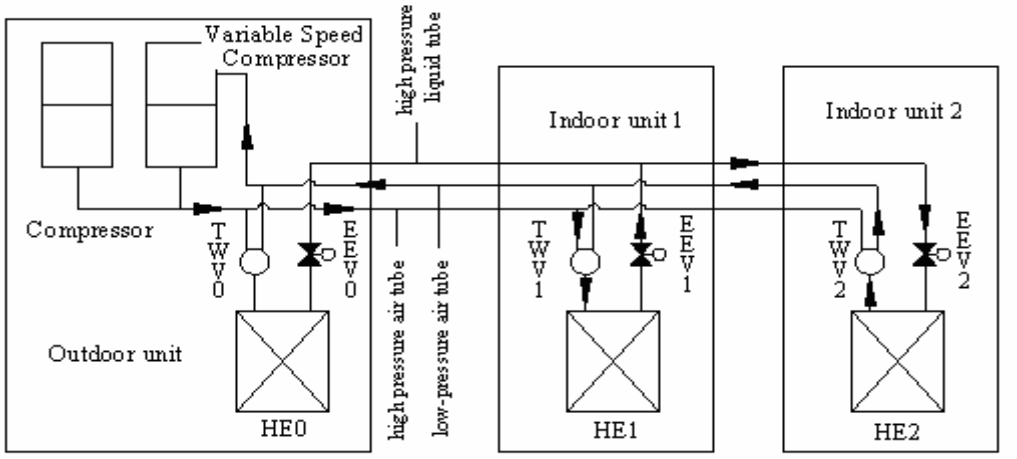

Fig. 2 The principle diagram of refrigerant's current direction in the system

outdoor units. This paper will analyze the most typical system of one outdoor unit. Fig.1 shows the system's structure and the principle diagram.

The outdoor unit is composed of variable frequency compressor, heat exchanger module and etc. The indoor unit is just a heat exchanger module. The heat exchanger module is composed of electronic expansion valve, heat exchanger, two position three way electromagnetic valve and three tubes (the high pressure air tube, the high pressure liquid tube and low pressure air tube). The outdoor unit module's structure is the same as the indoor unit module, the indoor unit connects the heat exchanger module with the system through the switches between the two position three way electromagnetic valve and the electronic expansion valve. [5]

The controllers were fixed between the indoor and outdoor units, and they would switch the tubes automatically according to the signals (to heat or to cool) from each room. When the rooms need to be cooled, the three tubes would be switched to the sucking tube and the liquid tube, then the high pressure refrigerant would evaporate and return vapor after throttle. Then the coils of indoor unit would function/work as evaporator and make the room cool. When the rooms need to be heated, the tubes would be switched to the air exhaust tube and the liquid tube, then the high pressure refrigerant vapor would emit heat in heat exchanger (condenser) inside room and would be congealed to liquid. The outdoor units can run the refrigerating circulation up to snuff for -5~40℃ scope of the outdoor temperature (the indoor wet-bulb temperature 15~25℃); running the heating circulation up to snuff for -10~15℃ scope of the outdoor temperature (the indoor dry-bulb temperature 16~27℃).

Fig. 3 The distribution of the De Bao hotel

Through the above analysis, we can tell that the structure of modules of the indoor and outdoor heat exchanger can match each other. Any module can convert their circulate mode freely through the appropriate conversion of the electronic expansion valve and the two position three way electromagnetic valve. The system can also convert cooling into heating or vice versa and meet the request of being cooled down or heated up respectively at the same time in indifferent rooms.

We can select a system with two indoor units to analyses the circulate mode of VRV air conditioning system heat recovery series. When the system is cooling and heating at the same time with one indoor unit (such as No.2 indoor unit) in the condition of cooling, then the heat exchanger (HE2) of it is evaporator; while the other indoor unit (No.1 indoor unit) is in the condition of heating. At that time the heat exchanger (HE1) of the No.1 indoor unit is condenser. The refrigerant that No.1 indoor unit needed is equal to the flux of the No.2 indoor unit. The outdoor heat exchanger is closed. Fig.2 shows the refrigerant's current direction in the systems.

3. ACTUAL ENGINEERING INSTANCE [6]

The Peking De Bao Hotel's building area is 27000 square meters, and the air conditioning area of it is 25000 square meters. The hotel meeting room, which is surrounded by the guest rooms, still needs to be cooled while in the transfer reasons and winter, because the heating load of it is big. Fig. 3 shows the distribution of the guest rooms' area and the meeting room in the hotel. We can know from Fig. 3 that the meeting room is in the inner zone of the hotel and the distance between it and the exterior protected construction is 8.2 meters.

Fig.4 shows the distribution of temperature in the inner and outer zone of the guest rooms' area. It shows that the air conditioning must provide cooling for the meeting room to eliminate the heating load and to assurance the normal temperature of the meeting room.

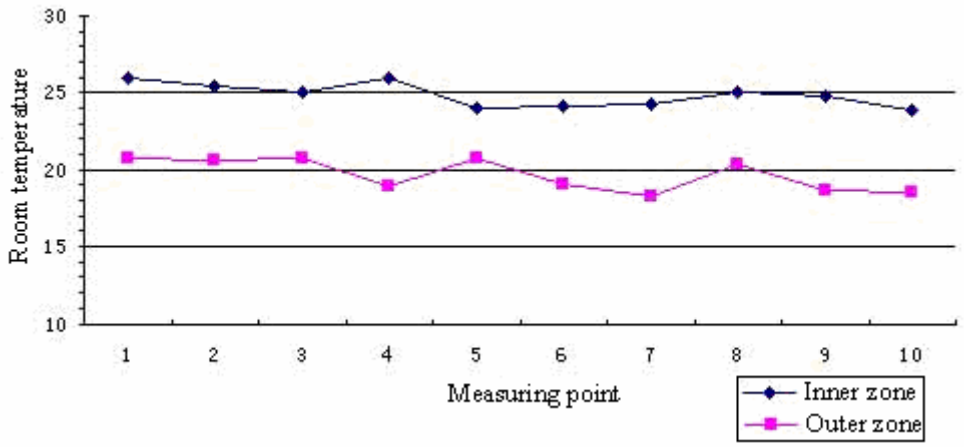

Fig .4 The temperature recording of De Bao hotel inner zone and outer zone in January 18

When the hotel was designed, the differences between the inner and outer zone's load hadn't been considered and the air conditioning system hadn't been designed separately. The air conditioning adopted two-pipe water system, which resulted in the comfortable temperature in the guest rooms however, the meeting room's temperature is very high and the guest feels uncomfortable and the complaint rate is rather high. Thus the task of the reception of the meeting can't be guaranteed. After the market investigation and on-the-spot inspection, it was decided that to adopt the fresh air and VRV air conditioning system heat recovery series to solve the heating load problem of the hotel inner zone in the transfer seasons and winter. The inner zone air conditioning area is 800 square meters. The design load is 84 kilowatts. The equipment is the product of the Shanghai Daikin Industries Co. Ltd.

The heating load problem of the inner zone at transfer seasons and winter were solved by the operation of VRV air conditioning system heat recovery series. At the same time, because the new system has sets the fresh air duct solo, the outdoor air load can resolve the inner zone heating load problem when there are not too many persons in some of the meeting rooms. Compared with the two pipe fan-coil with fresh air system, the single system can save about 40% of the power consumption a year. The reformation of this system is successful and energy saving.

4. ENERGY SAVING ANALYSIS

According to experiment[7], the VRV air conditioning system's SEER has a high numerical value when the part load rate varies between 45% and 70%.The max figure of some part load COP can achieve as high as 4.1. However, the COP of normal Air-Source Heat Pump Chiller is only under3.0 following the whole load operation and in the condition of part load operation[5], even under 2.0. According to the annual air conditioning load distributed data of the ASHRAE criterion 880-56 (shows in the table 1), the time that air conditioning load exceeds 80% only occupies less than 10% of total annual operation time. In other wards, the operation time of air conditioning system with part load exceeds more than 90% of total annual operation time. Thus, we can say that the application of the VRV air conditioning unit applies in buildings has the extremely good energy saving characteristic.

Tab.1 The annual air conditioning load distributed data

Cold load rate (%)	75~100	50~75	25~50	0~25
Running time rate (%)	10	50	30	10

The VRV air conditioning system heat recovery series is the very refinement of the air conditioning unit that the air-to air total heat exchanger has been added to the ordinary VRV air conditioning unit. It could choose heating or cooling each room freely according to the whole year heat load, and also could use the excess heat of the building effectively during the cooling and heating simultaneously.

Through the construction instance analysis, this kind of systems is obviously the energy saving, highly effective and complete heat heating/cooling system. It achieves the low load operation through the total heat recycling operation during the cool and heat operating condition simultaneously, and also causes the refrigerant to transmit the heat from the low load place to the high load place. For the building with the inner zone with big calorific which also need for cold capacity in transfer season or winter, compared to single heating and cooling operation ,this operation can save about 15% to 20% energy. And compared to the fresh air system, it can save about 28% energy[7].

5. CONCLUSION

This article describes the application of VRV air conditioning system heat recovery series in the construction inner zone, and has analyzed the energy saving characteristic of it with a construction instance. From the analysis, it can be clearly judged that this system has the following merit:

1) It could operate like the closed water loop heat pump system whose terminal units can realize the result of cooling and heating simultaneously and obtaining an optimal balance of the cold and heat energy in the construction. So the energy saving effect is remarkable;

2) It does not need a big refrigerating plant room or supplementary heat source. Thus it could save the construction area;

3) The diameter of refrigerant tubes is small, so it could be arranged easily and it is free from the restriction of the building store height;

4) The cold (heat) energy of the terminal units is not too large, therefore especially, it suits the building such as office building which has many rooms in the inner and outer zone;

5) The system independence is so good that in the case that any outdoor machine breaks down it was but the connected terminal with it could be affected, not the normal work of the whole system;

6) The time cycle of the designing and installation of the system is short. So especially it suits the reconstruction of old project.

The above analysis shows that the VRV air conditioning system heat recovery series can satisfy the heating and cooling request of many rooms while at the same time maintain a high energy using efficiency. This system reduces thermal pollution for the outdoor environment greatly. It is one kind of highly effective conversion and utilization mode of energy.

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