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REVIEW ARTICLE

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VARIABLE REFRIGERANT VOLUME SYSTEM OF TUNNEL TRAIN

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ABSTRACT

Variable refrigerant flow (VRF) is an air-condition system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones.

Currently widely applied in large buildings especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

With a higher efficiency and increased controllability, the VRF system can help achieve a sustainable design. Unfortunately, the design of VRF systems is more complicated and requires additional work compared to designing a conventional direct expansion (DX)

Key words:- VRV , VRF system

1.0 INTRODUCTION

VRF systems are similar to the multi-split systems which connect one outdoor section to several evaporators. However, multi-split systems turn OFF or ON completely in response to one master controller, whereas VRF systems continually adjust the flow of refrigerant to each indoor evaporator. The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermistor sensors in each indoor unit. The indoor units are linked by a control wire to the outdoor unit which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements. VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a somewhat higher cost. The modern VRF technology uses an inverter-driven scroll compressor and permits as many

as 48 or more indoor units to operate from one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in the total cooling/heating load as determined by the suction gas pressure measured on the condensing unit. The capacity control range can be as low as 6% to 100%.

Refrigerant piping runs of more than 200 ft are possible, and outdoor units are available in sizes up to 240,000 Btuh.

2.0 Literature Review

2.1 Study of variable refrigerant flow on comparison basis

In November 2010 Tolga N. Aynur, Yunho Hwang, , Reinhard Radermacher has simulate comparison of vav and vrf air conditioning systems in an existing building for the cooling season. Performance of two widely used air conditioning (AC) systems, variable air volume (VAV) and variable refrigerant flow (VRF), in an existing office building environment under the same indoor and outdoor conditions for an entire cooling season is simulated by using two validated respective models and compared. It was observed that the indoor temperatures could not be maintained properly at the set temperature by the VAV no-reheat boxes. However, it could be maintained by the VAV boxes with reheat with a significant energy consumption penalty. It was found that the secondary components (indoor and ventilation units) of the VRF AC system promised 38.0–83.4% energy-saving potential depending on the system configuration, indoor and outdoor conditions, when compared to the secondary components (heaters and the supply fan) of the VAV AC system. Overall, it was found that the VRF AC system promised 27.1–57.9% energy-saving potentials depending on the system configuration, indoor and outdoor conditions, when compared to the VAV AC system.

In flow systems and ground source heat May 2010 Xiaobing Liu, Tianzhen Hong was done the comparison of energy efficiency between variable refrigerant pump systems. With the current movement towards net zero energy buildings, many technologies are promoted with emphasis on their superior energy efficiency. The variable refrigerant flow (VRF) and ground source heat pump (GSHP) systems are probably the most competitive technologies among these. However, there are few studies reporting the energy efficiency of VRF systems compared with GSHP systems. In this article, a preliminary comparison of energy efficiency between the air-source VRF and GSHP systems is presented. The computer simulation results show that GSHP system is more energy efficient than the air-source VRF system for conditioning a small office building in two selected US climates. In general, GSHP system is more energy efficient than the air-source VRV system, especially when the building has significant heating loads. For buildings with less heating loads, the GSHP system could still perform better than the air-source VRF system in terms of energy efficiency, but the resulting energy savings may be marginal.

In Feb 2007 work of energy simulation in the variable refrigerant flow air-conditioning system under cooling conditions has been done by Y.P. Zhou, J.Y. Wu, , R.Z. Wang, S. Shiochi. As a high-efficiency air-conditioning scheme, the variable refrigerant flow (VRF) air-conditioning system is finding its way in office buildings. However, there is no well-known energy simulation software available so far which can be used for the energy analysis of VRF. Based on the generic dynamic building energy simulation environment, Energy Plus, a new VRF module is developed and the energy usage of the VRF system is investigated. This paper compares the energy consumption of the VRF system with that of two conventional air-conditioning systems, namely, variable air volume (VAV) system as well as fan-coil plus fresh air (FPFA) system. A generic office building is used to accommodate the different types of heating, ventilating, and air-conditioning (HVAC) systems. The work focuses on the energy consumption of the VRF system in the office buildings and helps the designer's evaluation and decision-making on the HVAC systems in the early stages of building design. Simulation results show that the energy-saving potentials of the VRF system are expected to achieve 22.2% and 11.7%, compared with the VAV system and the FPFA system, respectively. Energy-usage breakdown for the end-users in various systems is also presented.

2.2 Study of variable refrigerant flow on Experimental basis

In 2004 Shuangquan Shao, Wenxing Shi, Xianting Li, , Huajun Chen are study and prepare

Performance representation of variable-speed compressor for inverter air conditioners based on experimental data. Variable speed control of compressors is one of the best methods to regulate the capacity of heat pumps and air conditioners. An analysis is conducted for modeling the variable speed compressor for simulation of inverter air conditioner and heat pump. Having scattered the real operation performance of inverter compressor into infinite operation performance of constant speed compressor, the map-based method is utilized to fit the performance curves of inverter compressor. The model is built at the basic frequency and the map condition as the second-order function of condensation temperature and evaporation temperature. Then it is corrected by the compressor frequency as the second-order function of frequency and by the actual operating condition as the actual specific volume of the suction gas. This method is used to set up simulation models of three different compressors. Compared with the data provided by the compressor manufacturers, the average relative errors are less than 2, 3 and 4% for refrigerant mass flow rate, compressor power input and coefficient of performance (COP), respectively. This model of variable speed compressor is suitable for the simulation of inverter air conditioner and heat pump systems. Based on the experimental data and simulation model, the frequency at zero mass flow rate and power input at zero frequency are discussed and the relation between COP and compressor frequency is analyzed.

In Jan 2011 Dongliang Zhang, Xu Zhang, , Jun Liu are Experimental study the performance of digital variable multiple air conditioning system under part load conditions. An experimental study on performance of digital variable multiple air conditioning system under part load conditions in hot summer and cold winter zone was conducted in this paper. The effects of outdoor air temperature and on-unit ratio on total power consumption in 1 h, hourly heating performance factor or hourly energy efficiency ratio were analyzed by experiments. The variations of hourly heating performance factor (or hourly energy efficiency ratio) and total power consumption in 1 h with part load value under different outdoor air temperature were obtained. The results indicate that digital variable multiple air conditioning system can keep economical and reliable operation under part load conditions. And it is necessary to study the index which may reflect the seasonal energy consumption of digital variable multiple air conditioning system.

2.3 Study of Improved variable refrigerant flow system

In June 2010 Tolga N. Aynur, Yunho Hwang, Reinhard Radermacher were integrate the refrigerant flow and heat pump desiccant systems for the cooling season. Energy saving and indoor air condition enhancing potentials by integrating the variable refrigerant flow (VRF) and heat pump desiccant (HPD) systems were investigated in a field performance test during a cooling season. Three different operating modes: non-ventilated, HPD ventilation assisted and HPD ventilation–dehumidification assisted VRF systems were investigated. The HPD systems operated in the ventilation–dehumidification mode dehumidify the outdoor air and supply it to the indoor air during the ventilation. It was found that the VRF systems provided an average of 97.6% of the total cooling energy for the HPD ventilation assisted mode. The remainder was the recovered cool by the HPD systems during ventilation. The VRF systems provided an average of 78.9% of the total cooling energy for the HPD ventilation–dehumidification assisted mode. The remainder was covered by the HPD systems which provided additional sensible and latent cooling. Overall, among the three operating modes, it is concluded that the HPD ventilation–dehumidification assisted VRF outdoor units consume less energy than the HPD ventilation assisted ones, but more than the non-ventilated ones, while providing the best indoor thermal comfort and indoor air quality conditions. For the total system, the HPD ventilation–dehumidification assisted VRF systems consume less energy than the HPD ventilation assisted ones.

In Feb 2005, Chen Wu, Zhou Xingxi, Deng Shiming are developed the control method and dynamic model for multi-evaporator air conditioners (MEAC)Interference between operation parameters among the different evaporators makes the desirable control of MEAC hard to realize. A novel control strategy is herein proposed. The suction pressure was taken as the controlled variable to modulate the speed of its compressor, and at the same time, the room air temperatures were taken to regulate the openings of individual electronic expansion valves (EEV). A self tuning fuzzy control algorithm with a modifying factor was incorporated in the controller. A controllability test was conducted with a dynamic thermodynamic model developed with a special modeling methodology. The controllability test has shown that the control strategy and algorithm are feasible and can achieve desirable control results.

In April 2010 Tinveolga N. Aynur, Yunho Hwang, and Reinhard Radermacher were Integrate the variable refrigerant flow (VRF) and heat pump desiccant (HPD) systems was investigated in a field performance test for a heating season. The HPD systems use only the moisture in the outdoor air and return air to humidify the indoors during ventilation in the heating season. Three different operating modes: non-ventilated, HPD ventilation assisted and HPD ventilation–humidification assisted VRF systems were investigated. It was found that the VRF systems provided an average of 93.5% of the total heating energy for the HPD ventilation assisted mode. The remainder was the recovered heat by the HPD systems during ventilation. The VRF systems provided an average of 46.8% of the total heating energy for the HPD ventilation–humidification assisted mode. The remainder was covered by the HPD systems which provided additional sensible and latent heating. Overall, among the three operating modes, it is concluded that the HPD ventilation–humidification assisted VRF outdoor units consume less energy than the HPD ventilation assisted ones (about the same energy as the non-ventilated ones), while providing the best indoor thermal comfort and indoor quality conditions. For the total system, the HPD ventilation–humidification assisted VRF systems consume less energy than the HPD ventilation assisted ones.

J Xia, E Winandy, B Georges are Experimental analyze of the performances of variable refrigerant flow systems .In his paper they presents a testing methodology applicable to variable refrigerant flow (VRF) equipment. A test bench is presented: it consists of a set of six calorimeters, each one fully instrumented and controlled in such a way to compensate almost all combinations of sensible, latent, heating and cooling loads. This test bench is used for a three-pipe VRF system with indoor units and one outdoor unit. Examples of testing results are presented in the paper, in order to illustrate the methodology and also validate a simulation model. The (heating or cooling) emission of each indoor unit is identified thanks to a very accurate `air' balance inside each calorimeter. Refrigerant side (pressure and temperature) measurements are used in order to identify the refrigerant flow rate and the characteristics of the compressors (isentropic effectiveness) and of the terminal units (heat transfer coefficients) in different regimes. Examples of global performance evaluation are also presented in the paper.

VRF provides an alternative realistic choice to traditional central systems. It captures many of the features of chilled water systems, while incorporating the simplicity of DX systems.

Salient Features:

3. Conclusion

- Refrigerant flow rate is constantly adjusted by an electronic expansion valve in response to load variations as rooms require more or less cooling. Also, if reversible heat pumps are used, the heating output can be varied to match the varying heat loss in a room;

- An expansion valve or control valve can reduce or stop the flow of refrigerant to each indoor unit, thus controlling its output to the room;
- This type of system consists of a number of indoor units (up to 48 and varies per the manufacturer) connected to one or more external condensing units;
- The overall refrigerant flow is varied using either an inverter controlled variable speed compressor, or multiple compressors of varying capacity in response to changes in the cooling or heating requirement within the air conditioned space;
- A control system enables switching between the heating and cooling modes if necessary. In more sophisticated versions, the indoor units may operate in heating or coolingmodes independently of others;
- A VRF system uses inverters or scroll compressors. They are efficient and quiet. and are usually hermetically sealed. Small to medium size units may have 2 compressors;
- Refrigeration pipe work up to 500 feet long is feasible;
- Refrigeration pipe work level differences between indoor and outdoor units up to 150 feet is possible;
- Ozone friendly HFC refrigerants; R-410-A and R-407-C are typically used;
- COP's (Coefficient of Performance) may be as high as 3.8;
- Refrigerant liquid lines tend to be about 3/8" in diameter and gas lines about 5/8" to 3/4" in diameter;
- Central control of a VRV system can be achieved by centralized remote controllers.
- VRV/VRF technology is based on the simple vapor compression cycle but the system capabilities and limitations must be fully understood and evaluated carefully to determine its suitability

4.0 References

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