(IJITR) INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY AND RESEARCH
Volume No.5, Issue No.3, April – May 2017, 5992-5994.

VRF in Heating Mode

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Abstract:- **Variable refrigerant flow (VRF) air conditioning system has become attractive due to better energy performances than traditional air conditioning systems. However, the shortcoming of no outdoor air (OA) intake has not been solved thoroughly. A new VRF and outdoor air processing unit combined air conditioning system is proposed and simulated. The first obstacle is that there is no well-known simulation tool for VRF unit in heating mode**.

A VRF model of condenser-number independence is developed and validated first. The combined system is modeled by integrating the individual sub-system or component models into a complete system. The average error of the developed model to predict heating capacity, input power and COP are 7.87%, 12.45% and 6.19% respectively.

I. INTRODUCTION

Variable refrigerant flow (VRF) systems, which were introduced in Japan more than 20 years ago, have become popular in many countries, yet they are relatively unknown in the United States. The technology has gradually expanded its market presence, reaching European markets in 1987, and steadily gaining market share throughout the world. In Japan, VRF systems are used in approximately 50% of medium-sized commercial buildings (up to 70,000 ft^2 [6500 m^2]) and one-third of large commercial buildings (more than 70,000 ft^2 [6500 m^2])

Although vigorous marketing of VRF systems in the U.S. began only two to three years ago, several thousand systems likely will be sold in the U.S. this year, amounting to tens of thousands of tons of capacity. Of course, the market is still very small compared to the chiller market, but VRF systems are marketed in the U.S. by at least five manufacturers.

The success of the VRF in other countries, and its historically limited market presence in the U.S.,

II. APPLICATION

VRF systems are generally best suited to buildings with diverse, multiple zones requiring individual control, such as office buildings, hospitals, or hotels. A VRF system does not compete well with rooftop systems in a large low-rise building such as a big box retail store. Although VRF heat pumps operate at ambient temperatures as low as 0°F (–18°C), as in all heat pumps, their efficiency drops off considerably at low temperatures, so they are less cost effective compared to gas heating in very cold climates.

III. MARKET ACCEPTANCE ISSUES

Previous studies and recent experience in marketing the VRF, as well as focus groups conducted with engineers, contractors, and facility managers, have revealed several important concerns regarding the application of VRF systems in the U.S Information about building:

Critical information of the building.

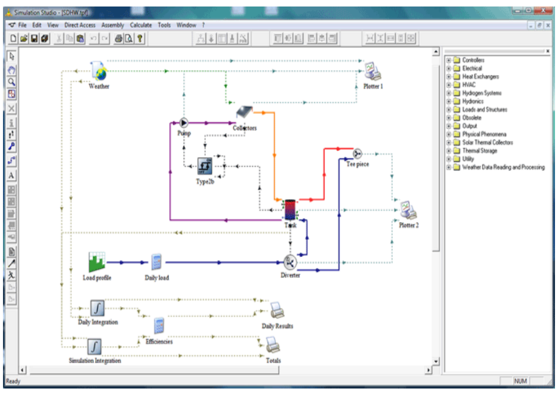
Item	Description
Building location	India, China
Building type and storeys	Office building, 6-story above ground
Gross floor area (air conditioned area)	4700 m2
Typical floor area and height	28 m × 28 m, floor-to-floor
height	3.5 m
Zone height (m)	2.7 m
Solid wood door size width × height	1.0 m × 2.0 m
Windows and shading	Low-e double pane glazing. Window width × height 1.8 m × 1.5 m; sill height = 0.80 m; no shading device

An office building of frame structure is designed to accommodate the combined air conditioning system. The building has six floors in total above ground. Each floor of the building is divided The OA processing part consists of a DX rooftop unit and the VAV OA supplying system. In each branch supply duct, there is a VAV box to regulate the OA flow in response to the zones' demand.

The air conditioning zones in one typical floor are numbered from zone 1 to zone 25 for conveniently identifying their positions. As is determined by the usage of the building, internal heat gains are mainly from the sources of occupants, lighting and equipment into six conditioned thermal zones, corresponding to four outdoor exposures (east, west, south and north), an interior zone (including a ring-shaped corridor), and a center zone.

In heating mode, the air source multi-split VRF unit functions as a heat pump (and noted as VRF-HP hereinafter for brevity) that transfers heat from ambient air at lower temperature to zones at higher temperature. The conventional single condenser air source heat pump (ASHP) has long been interested since early 1950s both in experimental and numerical investigations. for observing the temperature and energy response, start-up and shutdown behavior, regular and advanced control, etc.

However, in contrast to a large body of literatures for the conventional ASHPs, fewer improvements have been achieved in numerical investigation of VRF-HPs. The more complexity of the VRF unit in heating mode than that in cooling mode results in a failure when the algorithm developed in the cooling mode is applied to the heating mode. Therefore it is important and worthwhile to develop a simulation for both energy and control analysis of the VRF-HPs for heating mode use As the DX rooftop unit of the OA processing part can be treated as a VRF unit with only one indoor unit, it is the best choice to develop a system model to be generic with condenser-number independence to simplify the modeling process. A schematic diagram of the VRFHP is shown in Fig. 3. Models from the components to the entire system are developed accordingly.



TRNSYS (pronounced 'tran-sis') is an extremely flexible graphically based software environment used to simulate the behavior of transient systems. While the vast majority of simulations are focused on assessing the performance of thermal and electrical energy systems, TRNSYS can equally well be used to model other dynamic systems such as traffic flow, or biological processes.

The simulation model is validated by the data reported in literature . A typical VRF-HP with two condensers is used for the validation system. The rated heating capacities for the outdoor and indoor units of the VRF system are 25.0 kW and 12.5 kW (2 sets) respectively. The conditions of the two rooms including the light, equipment and occupants are treated the same just as the experimental set in the literature

The heat generated by the light and the equipment are designed the same for each zone. Fig. 8 depicts schedules of the light and the equipment. The light schedule (0–1) describes the possibility of maximum lighting load to mimic those offices with intensive light that one can turn some of them on and off conveniently

IV. CONCLUSION

This project presents a simulation of a new air conditioning system combining VRF with OA processing unit in heating mode. After the illustration of the combined system and its control strategies, simulation models are developed and validated.

The simulation model is validated using the experimental data reported in literatures. The simulation model accuracy to predict daily heating capacity, energy consumption and COP are about 7.87%, 12.45%, 6.19%, respectively. Moreover, it is found that when the accuracy of heating capacity is increased or decreased, the accuracy of simulated energy consumption is also increased or decreased following, which indicates that more attention should be paid on the relative error difference between the heating capacity and energy consumption, rather than the relative error itself.

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