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Design of HVAC System Using VRF Technology

Abdul Khalid[1], Ali Ahmed[2]
[1]M.Tech, [2]Assitant Professor, NSAKCET, Mechanical Engineering, J.N.T.U-Hyderabad

Abstract: The name variable refrigerant flow generally refers to the ability of the system to control the quantity of refrigerant flowing to the different type of evaporators (indoor units), which enables the use of many evaporators of differing type of capacities and different configurations connected to a single outdoor unit/condensing unit. This type of arrangement provides an individualized comfort control and simultaneous heating and cooling of the system in different zones. With the higher efficiency and increased controllability, the VRF system can help to achieve a solid sustainable design.
Keywords: VRF Technology, H VAC Systems, Design Consideration, Outdoor Units, The Simultaneous Heating & Cooling, Indoor Units.

I. INTRODUCTION

Variable refrigerant flow (VRF) systems generally vary the stream of refrigerant to internal indoor units based on requirement. This capability to control the quantity of refrigerant that is provided to Fan Coil Units located overall the building makes the VRF technology ideal for application with altering/varying loads or where there is requirement of zoning. Currently VRF system are widely applied in large to moderate size buildings especially in Japan and different European countries, these systems are just starting to be introduced in the United States also. VRF technology/system was first developed and designed by the Daikin Industries Japan, which is one of the leading HVAC industries, who named and protected the term variable refrigerant volume (VRV) system so that the other manufacturers can use the term VRF "variable refrigerant flow". VRF systems are very much similar to the most common multi-split systems which connect to one outdoor section unit to several inside 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 controls in this type of system are generally achieved by continually fluctuating the flow of refrigerant through the pulse modulating type valve (PMV) for whose the opening is determined by microprocessor collecting information from the thermistor sensor in every indoor unit. The indoor units are generally linked by a control connection wire to the outdoor unit which mainly responds to the demand from the indoor units by changing/varying its compressor speed to match the total cooling or heating requirement.

II. TYPES OF VRF SYSTEMS

This system is generally categorised into three types according to their capability to heating or cooling.
They are as follows:

A. Cooling only system

This system are generally less popular system, this system can only cool. The heating is not available or applicable for this system type. Fan and Dry modes are mainly available for Each and every indoor Unit Independently.

B. Heat Pump System

This system are generally most popular system, In this all the indoor units can either heat or cool but not simultaneously heat or cool at the same amount of time. The simultaneous heating or cooling is not available or applicable for this system type. Fan and Dry modes are mainly available for Each and every indoor Unit Independently.

C. Heat Recovery System

This system are generally most sophisticated ones among all, in this system simultaneous cooling and eating is available by each and every indoor unit independently at the same time.

III.DESIGN OF HVAC SYSTEM

When choosing the VRF system for a new/rework (retrofit) purpose, the following opinion jobs should be carried out:
Determining the serviceable and operational needs by assessing the cooling load and load profiles including location, hours of operation, number/type of occupants, equipment being used, etc.

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Determine the necessary required system constitution in terms of the number of indoor units and the outdoor condensing unit capability by taking into account the total capacity and operational desires, reliability and maintenance consideration, Building a load profile helps determine the outdoor condensing unit compressor capacity. For example, if there are many hours at low load, it is beneficial to install multiple compressors with at least one with inverter (speed adjustment) feature

The collective cooling capacity of the indoor area can be matched or can be exceed, or even be lower than the capacity of the outside area attached to them. But as a standard practiced. The outdoor condenser unit is particularly choose based on the total load report of the facility which will be the peak load of total zones combine at any one given time. The important thing here is that it is very unlikely that every zones will peak at a given time so an element of diversity is considered for economic sizing.

Summing up the peak load for every indoor unit and using that total number to size the out-of-doors unit will result in an unreasonably oversized condensing unit. even though an oversized condensing unit with different type of multiple compressors

A. Design Considerations

Decision of what type of HVAC system best suits your application will depend on several variables such as building characteristics; cooling and heating load requirements; occurrence; simultaneous heating and fresh air needs; cooling requirements; accessibility requirements; minimum and maximum outdoor temperatures; acoustic characteristics; and sustainability.

B. Sources of Heat Generation

It is essential to know about the heat sources and their nature before taking the job of design of air-conditioning system. The air-conditioning system used has to carry out two types of loads known as sensible-heat load and latent heat load. Sources, which contribute to sensible heat, are listed below:

Heat flow through the exterior walls, ceilings, floors windows and doors due to the temperature differences between their two sides.

Load due to solar radiation is divided into two sides Heat transmitted directly by radiation through windows and ventilators. Heat from the sun will be absorbed by the walls and roofs and later on transferred to room by conduction.

Heat received from occupants

Heat received from different equipment, which are commonly, used air-conditioning building.

Miscellaneous heat sources, which include.

Heat gain by the ducts carrying the conditioned air and passing through unconditioned space.

Heat transferred through interior partition of rooms in the same building, which are not air-conditioned.

The sources which contributes to the latent heat load are ,

The latent heat load from the air entering into the air conditioned space by infiltration

The latent heat load from the occupants

Moisture passing directly into the air conditioned space through permeable walls where the water vapour pressure is high.

1) Heat Gain Through Conduction

$Q = U \times A \times \Delta T$

To find ΔT for the glass through conduction= (outside temp – Inside temp)

$U = 1/\Sigma R$

$\Sigma R = Ri+(R1X1)+(R2X2)+\ldots\ldots\ldots\ldots..+(RnXn)+Ro$

A = Area of glass.

2) Heat Gain Through Radiation

$Q = U \times A \times \Delta T$

Requirements:

1)Orientation of the building

2) Latitude of city

3) Month in which city faces summer

4) Timing at which the heat transfer via glass is more

U = solar factor can be taken from design hand book

A = Area of glass

3) Heat Gain Through Wall

A To find heat gain through wall requirements are

a) Orientation of the building

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b) Timings
c) Wall thickness

$Q = U \times A \times \Delta T$
$U = 1/\Sigma R$
$\Sigma R = Ri+(R1X1)+(R2X2)+\ldots\ldots\ldots\ldots+(RnXn)+Ro$
A = Area of wall
ΔT wall = Equivalent temperature + correction factor (from design data book)

4) Heat gain through Roof

$Q = U \times A \times \Delta T$
$U = 1/\Sigma R$
$\Sigma R = Ri+(R1X1)+(R2X2)+\ldots\ldots\ldots\ldots+(RnXn)+Ro$
A = Area of Roof
ΔT wall = Equivalent temperature + correction factor (from design data book)

5) Heat gain through Lightings: The heat given up by the lights, both incandescent and fluorescent, is not affected by the room temperature. It depends on the electricity consumed. Each watt of electricity generates 3.4 BTU/Hr. The total wattage of incandescent lights is very close to the rating given on the lamp. Fluorescent light however require extra power in the ballast, as an estimation the ballast consumers about 25% of rated of the fluorescent lamp.

$Q = 3.4 \times W \times B.F \times CLF$
Where:
Q = Heat gain through lightings in BTU/hr
W = Lighting capacity in watts
3.4 = conversion factor to convert watts into BTU/hr
CLF = Cooling load factor for Lighting
BF = It is a ballast factor for light
Note:
BF for florescent lights = 1.25
BF for Incandescent lights = 1

6) Heat gain through People: One of the most important sources of internal heat is people. People in the room give off both sensible heat and latent heat. The exact amount is determined by the activity of the people and the room conditions. Some typical application are a theater or auditorium where people seated at rest give off less amount of heat than compared with the people doing physical activities like dancing excising, bowling.

The heat gain through people is composed of two parts
Sensible heat (Qs) &
Latent heat (QL)
$Qs = qs \times n \times CLF$
$QL = qL \times n$
Equation for sensible heat gain
$Qs = 1.1 \times CFM \times \Delta T$
Equation for Latent heat gain
$Q_L = 0.68 \times CFM \times \Delta W$

7) Ventilation load

Some outside air is usually bought into the air-conditioned space through the mechanical ventilation equipment in door to maintain indoor air quality. Mechanical ventilation systems for large building are usually designed and operated so that facts create a slightly positive air pressure in the building. This will reduce or even prevent infiltration.

When it is felt that building is relatively tight and pressurized, no allowance for infiltration is made, only the outside air ventilation load is included.

8) Heat Gain through infiltration: Infiltration is the un-intentional or accidental introduction of outside air into a building, typically through cracks in the building envelope and through use of doors for passage. Infiltration is sometimes called air leakage.

Equation for sensible heat gain
$Qs = 1.1 \times CFM \times \Delta T$

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Where
Qs = Sensible heat gain from infiltration, BTU/hr
CFM = Air infiltration flow rate, ft^3/min.
ΔT = Temperature change between indoor and outdoor, air.

IV. CONCLUSIONS

For the smaller type systems that is up to the capacity range 100 to 250 TR with a limited Outdoor Units (ODUs) and Indoor Units (IDUs), then the VRF system will be and can be a good solution for the above mentioned (TR) tonnage requirements and as for the smaller central plant system the space availability for the huge chillers will be not practically accepted and the Air Handling Units (AHUs) may not be available for such venues. Also, for such small systems the VRF system can remain simple with the limited refrigerant piping and without much complexity

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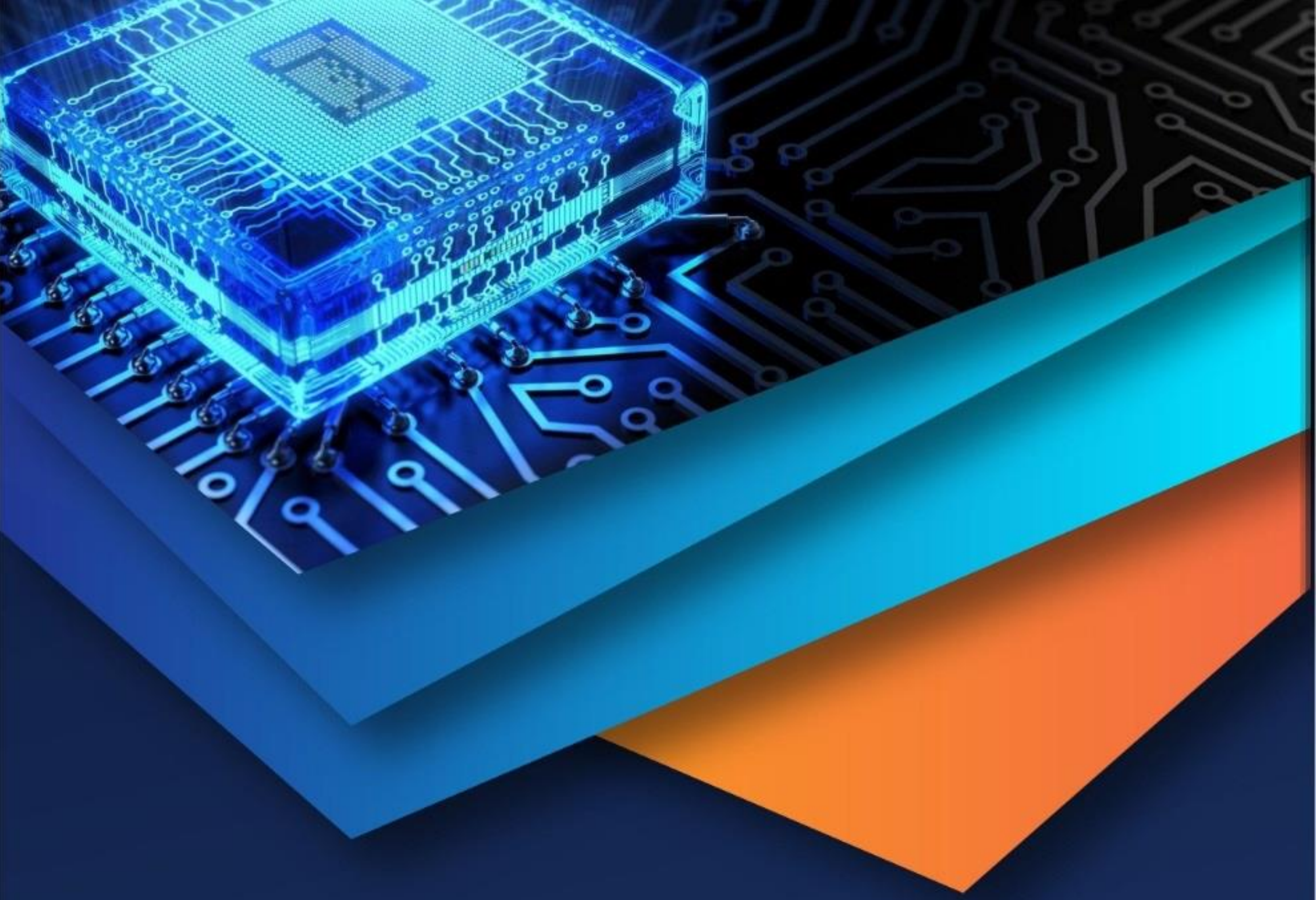

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