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Experimental and Selection Criteria of Variable Refrigerant Flow (VRF) System with the help of Heat Load used in Air Condition System

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***Abstract*: Variable Refrigerant Flow (VRF)/Variable Refrigerant Volume (VRV) is for the most part know as Ductless smaller than normal Split system. Incorporates different indoor evaporators associated with a solitary consolidating unit. Ductless items are in a general sense unique in relation to ducted systems in that heat is exchanged to or from the space directly by flowing refrigerant to evaporators situated close or inside the adapted space. The term variable refrigerant flow alludes to the capacity of the system to control the measure of refrigerant flowing to the numerous evaporators (indoor units), empowering the utilization of numerous evaporators of contrasting limits and designs associated with a solitary consolidating unit. The game plan gives an individualized solace control, and concurrent warming and cooling in various zones. With a higher effectiveness and expanded controllability, the (VRF) system can help accomplish a manageable structure. Sadly, the structure of VRF systems is increasingly convoluted and requires extra work contrasted with planning a regular direct expansion (DX) system. Advancement relies upon the straight forward vapor compression cycle (same as common split cooling systems) yet empowers you to determinedly control and change the flood of refrigerant to different internal units.**

***Keywords*: Variable Refrigerant Flow (VRF), Variable Refrigerant Volume(VRV), direct expansion (DX), Condenser, Evaporator, Direct expansion**

1. Introduction

The VRF advancement/system was made and arranged by Daikin Industries, Japan who named and guaranteed the term variable refrigerant volume (VRV) system so extraordinary creators use the term VRF "variable refrigerant stream". For the most part both are same. The essential capacity of all cooling systems is to give warm solace to building inhabitants.

The principal of a cooling system is the utilization of a refrigerant to retain heat from the indoor condition and exchange it to the outside condition. In the cooling mode, indoor units are provided with fluid refrigerant. The measure of refrigerant flowing through the unit is controlled by means of an expansion valve situated inside the unit. At the point when the refrigerant enters the loop, it experiences a stage change (dissipation) that separates heat from the space, along these lines cooling the room. The heat removed from the space is depleted to the encompassing air. There are a wide extent of cooling systems available, start from the fundamental window-fitted units to the little part systems, to the medium scale group units, to the huge chilled water systems, and right now to the variable refrigerant stream (VRF) systems. The term VRF insinuates the limit of the system to control the proportion of refrigerant gushing to each of the evaporators, enabling the use of various evaporators of differentiating points of confinement and game plans, individualized solace control, simultaneous warming and cooling in different zones, and warmth recovery beginning with one zone then onto the following. VRF systems take a shot at the Direct Expansion (DX) decide suggesting that heat is traded to or from the space straight forwardly by flowing refrigerant to evaporators arranged close or inside the adapted space. Refrigerant flow control is the way to numerous focal points just as the real specialized test of VRF systems.

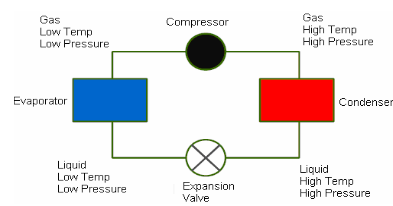

Fig. 1. Block Diagram VCR system

VRF systems may incorporate about double the refrigerant of similar roof-top units (RTUs), contingent upon the span of the structure territory served by one manufacturer. Concern has been raised about included expense related with substitution of this refrigerant, and with refrigerant breaks. A similar manufacturer reacted that their incorporated structure and quality control prerequisites, the utilization of restrictive segments as opposed to auxiliary market parts, and its preparation programs decrease this danger of refrigerant releases with respect to other utilization of refrigerant lines, for example, basic need story refrigerated case work, which is known to have considerable break issues. This study did not recognize any proof that the systems spill significantly.

2. Literature survey

Variable refrigerant flow (VRF) systems vary the refrigerant flow to meet the dynamic zone thermal loads, leading to more efficient operations than other system types. This paper introduces a new model that simulates the energy performance of VRF systems in the heat pump (HP) operation mode. The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There are a wide range of air conditioning systems available, starting from the basic window-fitted units to the small split systems, to the medium scale package units, to the large chilled water systems, and currently to the variable refrigerant flow (VRF) systems.

VRF is an advanced air conditioning system that is developed to manage load variability by controlling the compressor speed and the expansion valve opening.

A. Problem Statement

Depending upon load condition, working load on compressor is varied and consume more power and sometimes cooling load is not obtaining upto that level. (comfort zone). On summer loads on machines increases and in winter it reduces. If systems are old then due to leakage few amount of refrigerant was leak and leaves in atmosphere, at that time also loads comes on compressor**.**

B. Proposed Method/System

Proposed of this project is to save energy consumption and easy for maintenance purpose and minimizing cost of the unit. Using multiple expansion valve it varies load of the refrigerant so it will help to maintain comfort zone. Used multiple electronic expansion valve (EEV). The best ways for selecting the system first calculate heat load estimation depending upon building construction and peak time and orientations of building. According to heat load estimation VRF is useful for varying load condition.

3. Methodology

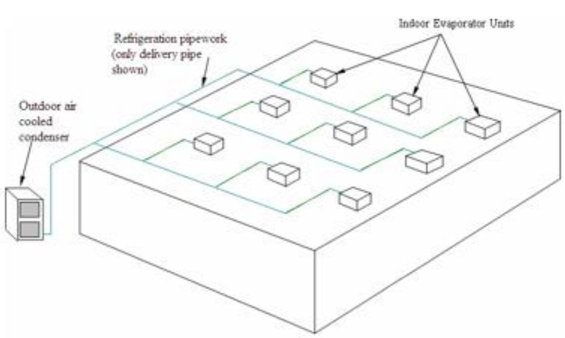

Fig. 2. Typical Multi-Split System

To finding heat load or block load we used carrier load sheet, first to know U value, K value, R value i.e. the rate of heat flow through wall, celling glass or floor of air condition space (BTU/HR SQFT Degree F) all the value will be taken on ISHRAE Handbook 2017. There are two of load calculation first is thumb rule and second is excel sheet load calculation in excel sheet single hours load calculation and full day calculation.

4. System Software

In this project we used Elite Refrigeration Software to find load estimation. In air conditioning load estimate first direction of sun and location of that place that unit is installed, finding area and volume, then finding solar heat gain through glass, then solar and transmission gain through walls and roof, so we used CLTD method means addition of Equivalent temp. difference and correction factor

Q=UA(dt)

Q=Amount of heat flow,

U=Thermal transmittance,

A=Area, dt =Temp difference.

Transmittance gain except wall and roof i.e. all glass in sq. ft. multiply by U value (U value is reciprocal of thermal resistance

Then find out internal load on people, power, lights Appliance which we used in given space and then apply factor of safety which will be 5 to 10%, then we consider the fresh air (outdoor air)

Outdoor air=CFM Ventilation x temp difference x bypass factor that will calculate effective room sensible heat, then latent heat that contains infiltration, people, appliances, etc.

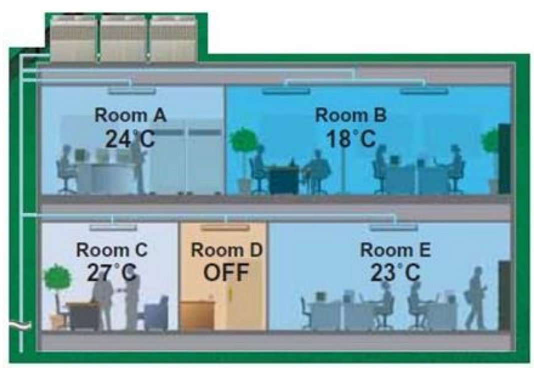

Fig. 3. Maintain Different Temp On Different Room

A. Types of VRF System

VRF heat pump systems: VRF heat pump systems permit heating or cooling in all of the indoor units but **NOT** simultaneous heating and cooling. When the indoor units are in the cooling mode, they act as evaporators; when they are in the heating mode, they act as condensers. These are also known as two-pipe systems. VRF heat pump systems are effectively applied in open plan areas, retail stores, cellular offices and any other area that require cooling or heating during the same operational periods.

Heat Recovery VRF system (VRF-HR): Variable refrigerant flow systems with heat recovery (VRF-HR) capability can operate simultaneously in heating and/or cooling mode, enabling heat to be used rather than rejected as it would be in traditional heat pump systems. VRF-HR systems are equipped with enhanced features like inverter drives, pulse modulating electronic expansion valves and distributed controls that allow system to operate in net heating or net cooling mode, as demanded by the space.

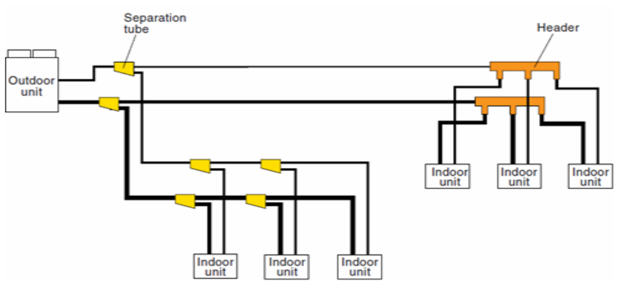

Fig. 4. Connection diagram

Each manufacturer has its own proprietary design (2-pipe or 3-pipe system), but most uses a three-pipe system (liquid line, a hot gas line and a suction line) and special valving arrangements. Each indoor unit is branched off from the 3 pipes using solenoid valves. An indoor unit requiring cooling will open its liquid line and suction line valves and act as an evaporator. An indoor unit requiring heating will open its hot gas and liquid line valves and will act as a condenser.

Typically, extra heat exchangers in distribution boxes are used to transfer some reject heat from the superheated refrigerant exiting the zone being cooled to the refrigerant that is going to the zone to be heated. This balancing act has the potential to produce significant energy savings

Compliance with ANSI/ASHRAE Standard 15-2001: VRF systems must comply with ASHRAE Standard 15-2011 - Safety Standard for Refrigeration Systems (ANSI approved). ASHRAE Standard 15-2001 guides designers on how to apply a refrigeration system in a safe manner, and provides information on the type and amount of refrigerant allowed in an *occupied space*. While installing this project we check flexibility of project, Design Flexibility, Flexible Installation

Using Electronic Expansion Valve (EEV): With an electronic expansion valve (EEV), you can tell the system what superheat you want and it will set it up. The primary characteristic of EEV is its ability to rotate a prescribed small angle (step) in response to each control pulse applied to its windings. EEV consists of a synchronous electronic motor that can divide a full rotation into a large number of steps, 500 steps/rev. With such a wide range, an EEV valve can go from full open to totally closed and closes down when system is satisfied.

EEV in a VRF system functions to maintain the pressure differential and also distribute the precise amount of refrigerant to each indoor unit. It allows for the fine control of the refrigerant to the evaporators and can reduce or stop the flow of refrigerant to the individual evaporator unit while meeting the targeted superheat.

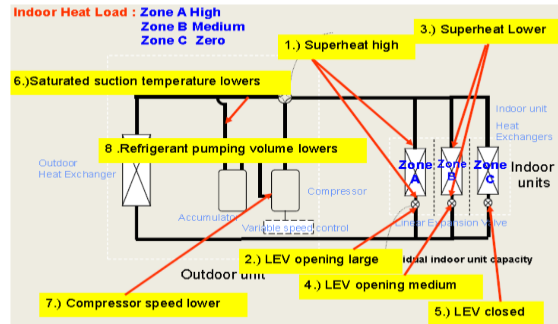

Fig. 5. Combined indoor and outdoor capacity control

Specification of parts & units:

Heat load will help to find out the capacity of condenser as well as evaporators

Compressor: The compressor is highly efficient scroll type and capable of inverter control. The inverter compressor changes the speed in accordance to the variation in cooling load requirement. The inverter compressor shall preferably be reluctance DC inverter compressor for higher efficiency and improved reliability.

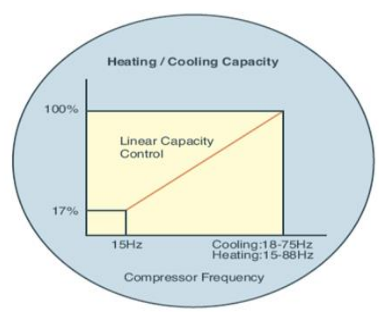

Fig. 6. Compressor Frequency

Heat Exchanger: The heat exchanger is constructed with inner grooved copper tube mechanically bonded to aluminum fin to form a cross fin coil. The aluminum fins covered by anti-corrosion resin film (blue coated). Heat exchanger will provide with necessary number of direct driven low noise level propeller type fan arranged for vertical discharge. And each fan has a safety guard.

General: The fan has dual suction, aerodynamically designed turbo, multi blade type, statically & dynamically balance to ensure low noise and vibration free operation of the system. The fan will be direct driven type, mounted directly on motor shaft having supported from housing.

Cooling coil will have made out of seamless copper tube and have continuous aluminum fins. The fins will be spaced by collars forming an integral part. The tubes will be staggered in the direction of airflow. The tube is hydraulically/mechanically expanded for minimum thermal contact resistance with fins and each coil will be factory tested at 21 kg/sqm air pressure under water.

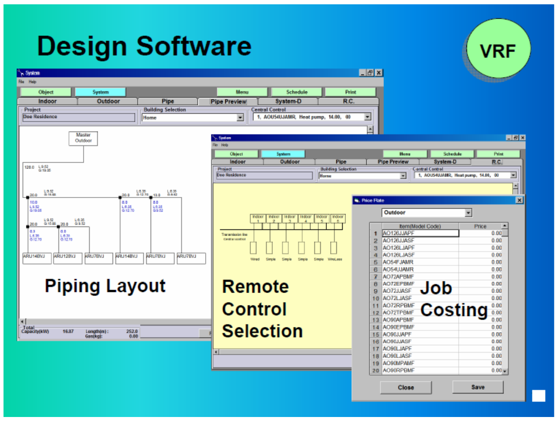

Fig. 7. Pipe Insulation

Refrigerant piping: Refrigerant pipe and drain pipe will have insulation, the whole of the liquid and suction refrigerant lines including all fittings, valve and strainer bodies, etc. will be insulated with 19mm for outside installation and 13mm thick for inside installation with elastomeric nitrile rubber will used. And drain pipe carrying condenser water will be insulated with 6mm thick insulation.

5. Result and discussion

A. Experimentation procedure and calculation

In this project, first I visit site location make some design consideration about Building characteristic, Configuration, Outdoor design condition, Indoor design condition, Operating schedules.

First calculate space sensible load calculation i.e. solar load, transmission and conduction load, lighting load, equipment load, people load.

In Solar load is depending upon direction and where you are located, depend upon area of glass, shading co-efficient, solar heat gain factor of that location and time, cooling load factor,

As per site condition calculate outside temperature and room temperature i.e. dry bulb temperature, wet bulb temperature Relative humidity, absolute humidity at ISHRAE DATA BOOK 2017 PAGE NO 1.5 and table no 1.2 and also we calculate from elite psychometric chart.

For sample example
Usage of space office location
Occupancy-15 people
Equipment -15 computer
Lighting-2 w/ft^2 of floor area fluorescent type
Door, window schedule
D1 =7 ft. X 3 ft.
W1=window 4 ft. X 4 ft.
W2=window 4 ft. X 6 ft.

Celling height is 10 ft., space on ground floor, wall are made brick ½ inch plaster on both side, roof is made of concrete 6 inch thick.

Outside:
Ambient dry bulb temperature 93 °F
Wet bulb temperature 84 °F
Absolute humidity =0.023*7000=161 gr/lb
Room
Dry bulb temperature 93 °F
Relative humidity=55%
The above all data will given from ISHRAE handbook
Absolute humidity=0.0101*7000=70.7 gr/lb

Difference between=outdoor dry bulb temp.-Room dry bulb temp. =93-75
=18^{0}F

Difference between=outdoor absolute humidity-room absolute humidity =161-70.7
=90.3 gr/lb

Outside air ventilation: 15 people X 5 cfm/person= 75
1500 ft area X 0.06 cfm/ft^2 =90

75+90=165cfm (the above data will taken ISHRAE Handbook 2017 page no 1.60, table no 1.53 For office occupancy category)

For lighting load =1500 ft^2 X 2w/ft^2
=3000 watts

For equipment i.e. 15 computer present=15 X 100=1500 watts.

ISHRAE Handbook page no 1.45, table 1.30 Recommended heat gain from typical computer equipment.

Table 1
Solar Heat gain from Glass (ISHRAE handbook page no 1.33, table 1. 10)

Exposure	Area of quantity ft^2	Sun gain or temp. diff BTU (Hr/ ft^2)	U-factor	Equal Btu/hr
North glass	48	14	1	672
West glass	32	164	1	5248
South	32	12	1	636

Table 2
Solar transmissions gain from wall and roofs(CLTD) (ISHRAE DATABOOK Page no. 1.41, table no1.21)

North wall	50*19-48	4+ 3.5	0.37	1254
West wall	268	(12+3.5)	0.37	1537
South	443	12+3.5	0.37	3196

Table 3
Transmission gain

All Glass	133	18^0 F(Temp. diff)	1.13	2705
Partition	(15+15) * 10	18-5	0.42	1638
Ceiling partitions	(25+25)*15	18-5	0.29	2827

Table 4
Internal heat (sensible heat) (hand book page no 1.43, table no 1. 24)

People	15 people	245	3675 btu/hr
Lightning	3000	3.4	12750 btu/hr
Equipment	15 computer	3.4	5100 btu/hr
subtotal			49611 btu/hr

Factor of safety=5% of subtotal=2480 btu/hr

Room sensible heat(RSH)= Addition of all internal heat+ FOS

=52091 Btu/hr

Loss=supply duct heat gain+leak loss+fan hp

=3% + 3% + 3%

=9% * RSH

=4688 Btu/hr

Effective Room sensible heat(ERSH)=RSH + Loss

=56779 btu/hr

Latent Heat=

=15 people * 205

=3075 btu/hr

Factor of safety=5% of subtotal=154 btu/hr

Subtotal=3229 btu/hr

Outdoor air=165 CFM * 90.3 grains/lb * bypass factor* 0.68

=1013 Btu/hr

Effective Room latent heat(ERLH)=RLH + Loss + outdoor

=4339 btu/hr

Effective Room total heat(ERTH)=ERSH + ERLH

= 61118 Btu/hr

Outdoor air heat=sensible heat + Latent Heat

=12031 btu/hr

Grand total heat=61118+12031

=73149 Btu/hr

9% loss of Grand total heat=6583 btu/hr

Refrigeration load=73149 + 6583

=79732 btu/hr.

=6.65 TR

Above is sample example of calculation of heat load estimation. With the help of this calculation we have to select best capacity of evaporator, condenser, etc. this sample example estimation will help to understand sheet. Once we get the cfm from the heat load sheet then we select the fan as the selection software which depend on velocity and throw of air and drop of air.

After completing this project hence, we have to conclude that, with the help of VRF we have to improve the aesthetics of building outlet, orientations, construction. VRF systems benefits from the advantages of linear step control in conjunction with inverter and constant speed compressor combination, which allows more precise control of the necessary refrigerant circulation amount required according to the system load.

The inverter technology reacts to indoor and outdoor temperature fluctuations by varying power consumption and adjusting compressor speed to its optimal energy usage. Inverter provides superior energy efficiency performance and also allows for a comfortable environment by use of smooth capacity control

A VRF system minimizes or eliminates ductwork completely. This reduces the duct losses often estimated to be 10% to 20% of the total airflow in a ducted system.

6. Conclusion

From this paper we implement VRF with targeted deployment in a subset of new buildings and major retrofits of existing buildings based on the potential cost-effectiveness. Projects should be evaluated carefully with energy modeling and cost assessment during design, and with actual operating energy and maintenance costs. Energy usage should be monitored so that HVAC energy can be separated from other energy uses. Occupant comfort should also be assessed. Reduced Noise Levels, Reliability, Continuous operation is possible even if trouble occurs at an indoor unit.

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