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Performance Analysis of Multi-Split Air-Conditioning System

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Abstract :A multi split air conditioning system comprises multiple indoor unit powered by one outdoor unit. They can be used for cooling and heating both purposes. The main advantages of this technology is that the efficiency of system is increased, running cost and noise is comparat ively low. In this paper multi-split air-conditioner IS used to cooling purposes only. For this purpose the three evaporators run by single compressor and condenser has been selected. It is required to maintain the temperature of three space at -10 ºC, 5 º C and 10 ºC. In this analysis the comparative analysis of two refrigerant R22 and R134a has been done by determining coefficient of performance (COP) of system. The performance of system has been also analyses with or with-out of sub-cooling. The multiple indoor cooling units having capacity 30TR, 20TR and 10TRare estimated to maintain the required temperatures in rooms.

Index Terms: Multi-split system, Multi-evaporative system, COP, HVAC, MEAC

1 Introduction

Multi-split or multi-evaporator cooling system is representative of complex, distributed nature of modern HVAC system. Multiple evaporator system are a variant of basic VCC system that allow different amounts of coo ling at different temperature to be delivered to different regions in the same overall system, such as apartment units or large building offices, with rarer losses from transporting chilled water. these multi -evaporator systems present significant control challenges due to cross coupling of advanced control strategies to these systems has the potential for increases in energy[1]. This is especially true of multiple evaporator, variable refrigerant flow system, where the correct combination of control input can have significant impact on energy consumption for a given amount of cooling performed [2, 3]. Multi-evaporator split air-conditioning system especially Variable Refrigerant Flow (VRF) system, are receiving increased attention in the marketplace, as an alternative to water -sources heat pump loops, room-by-room packaged terminal units, and even all-air systems. With the rapid increase in land cost and the increased number of high rise apartment buildings, a multi evaporator air conditioner (MEAC) presenting Variable Refrigerant Volume (VRV) technology has become increasingly attractive. A multi-evaporator VRV air conditioner, which is categorized by direct expansion (DX) cooling, resides of an outdoor condensing unit (a compressor, a condenser and its fan) and multiple

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indoor units. In each indoor unit, there are an evaporator, a throttling device and an indoor air circulating blower. So, it can reduce the space requirement for installing the outdoor unit and help improve the appearance of the buildings external façade when compared to using several traditional residential split type air -conditioning. In addition, it is more convenient and cost less to install and maintain a multi -evaporator air -conditioner [4] .Now days from a single outdoor unit multiple indoor units can be attached either by using split air -conditioning system or VRF system.

Currently widely applied in large buildings especially in Japan and Europe, and also introduce in U.S. The VRF technology/system was developed and design by Daikin industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufactures use the term VRF "variable refrigerant flow" and the both are same. With a higher efficiency and increased controllability, the VRF system can help achieve a sustainable design. The resolution and demand of energy saving for an air-conditioning system having independent unit's allocation separate zones in the same building has encourages the popularity of multi -evaporator (VRF) variable refrigerant flow system in case of commercial buildings such as offices, shopping centers, hotels, etc. The term variable refrigerant flow raises to the ability of the system to control the amount of refrigerant flowing to the multiple evaporator (indoor unit), enabling the use of many evaporators of differing capacities and configurations which is connected to a single condensing unit, the arrangement provides an individualized comfort control, and simultaneous heating and coding in different zones.

A multi evaporator VRF system, also known as multi-split VRF system, performing variable refrigerant flow technology, is refrigeration system consists of one outdoor and multi indoor units, adjusting refrigerant flow rate by the variable speed compressor in the outdoor unit and the electronic expansion valves located in each indoor unit to match the space cooling/h eating load in order to maintain the zone air temperature at the set-point by Aynur et al., 2009 [5]. The multi -evaporator VRF system is also so -called as VRF system and below for brevity. This system is claimed that, due to good part load performance and directly heat transfer from refrigerant to air, the VRF system has a better energy saving potential than the traditional HVAC (heat ventilation and air -conditioning) system such as the central air-conditioning system, the FPFA (fan-coil plus fresh air0 system, etc, by Zhou et al., 2007 [6]. The widespread application of the multi -split VRF system, only a limited number of studies and limited identified in open literature in the VRF system in the VRF systems, because of the differences in each indoor units operational conditions, the operation parameters in indoor unit are likely to influence those in the other indoor unit by Chen et al., 2005 [7]. Zhou et al., 2007 developed a modules for the VRF system in Energy Plus in an attempt to predict and evaluate the energy use level of the VRF air -conditioning system and hence to make comparisons with other HVAC systems. The model is developed by fitting the curves additional with various correction factors using the data provides by manufacturer [8]. Li et al., 2 009 studying the monthly and seasonal cooling energy consumption and the interruption of the total power consumption of a water-cooled VRF system [9]. However for the VRF system, the control is very important since the VRF system is complex and its operati on performance depends on the control wholly.

2 Methodological and Thermodynamic Analysis

For this analysis we used single outdoor unit with two different types of refrigerants e.g., R22 and R134a. T he three evaporator s having capacities 30TR, 20TR and 10TR and to maintain this temperature we used -10ºC, 5ºC and 10ºC. The condenser temperature 40ºC and the leaving condenser sub-cooled temperature is 30ºC.
The layout of system is shown in fig. 1. Let Q1, Q2 and Q3 are required cooling of three evaporators installed in rooms.

(a)Mass of refrigerant flowing through each evaporator

$$m_1 = \frac{210Q_1}{h_9 - h_8}\ \mathrm{kg/min}$$

$$m_2 = \frac{210Q_2}{h_7 - h_6}\ \mathrm{kg/min}$$

$$m_3 = \frac{210Q_3}{h_5 - h_4}\ \mathrm{kg/min}$$

Total mass of refrigerant flow 'm'=m1+m2+m3

(b) Power required driving the compressor.
The condition of refrigerant after mixing and entering into the compressor. The enthalpy at this point is

$$h_1 = \frac{m_1 h_9 + m_2 h_7 + m_3 h_5}{m}$$

(c) C.O.P of the system.

We know that total refrigerant effect,

$$C.O.P = \frac{\text{Refrigerant effect}}{\text{work input}}$$

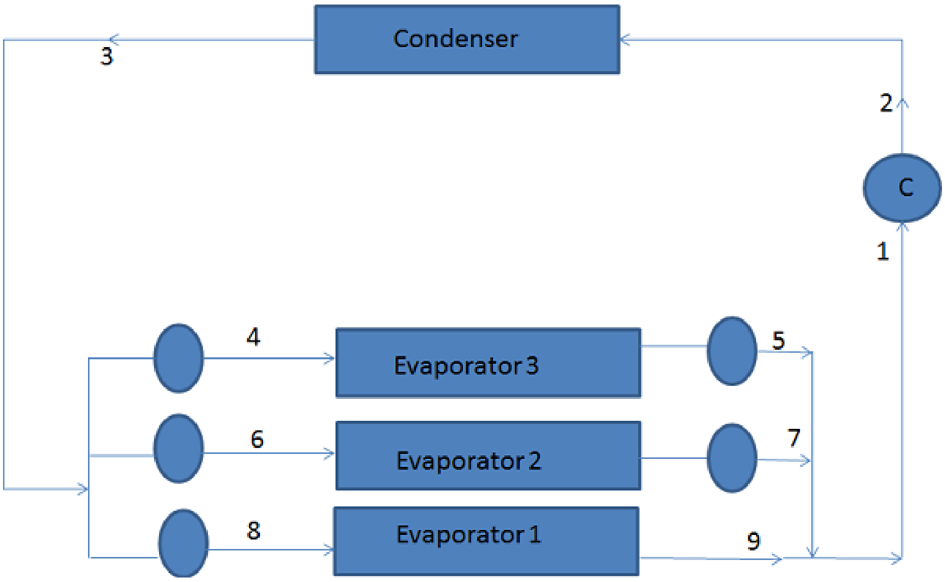
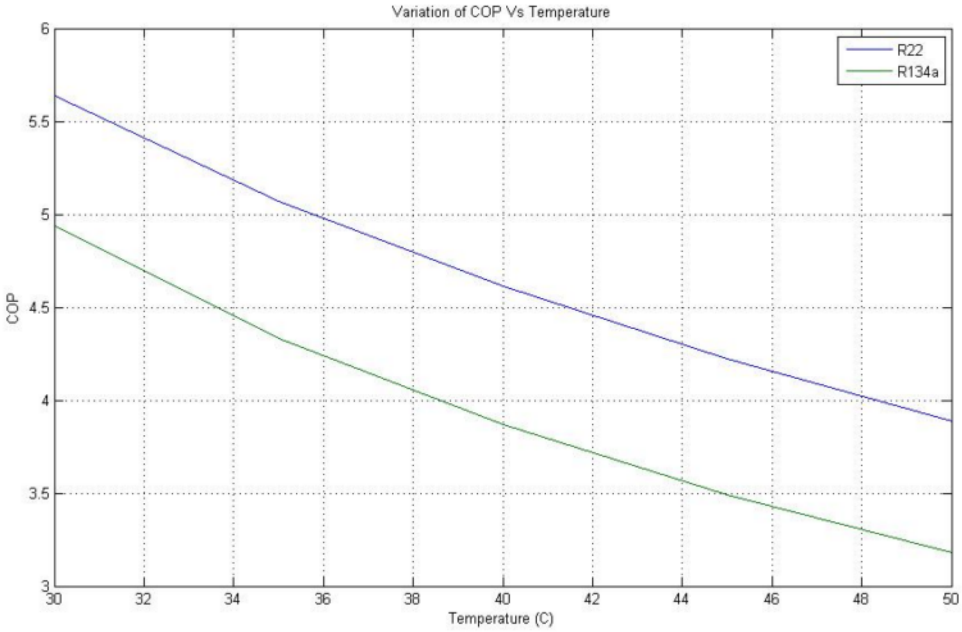


Fig1. Schematic of a multi-split VRF system.

Variations of COP v/s. Temperature (with-out Sub-cooling) Table 1.0

Condenser Temperature °C	Coefficient of Performance	
	R22	R134a
30 °C	5.64	4.94
35 °C	5.07	4.33
40 °C	4.61	3.87
45 °C	4.22	3.49
50 °C	3.89	3.18

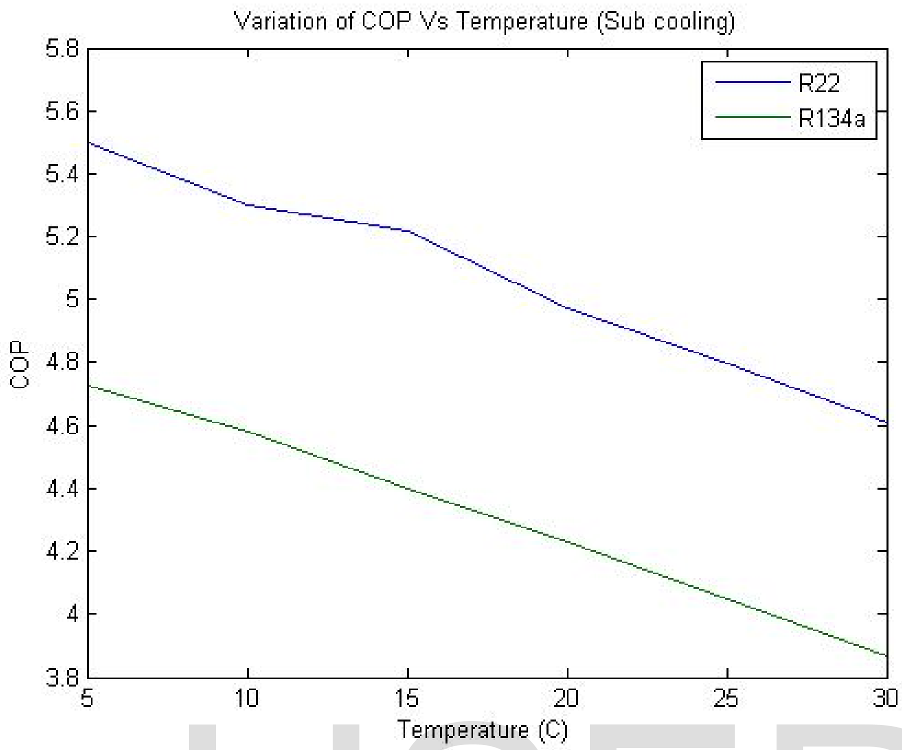
Figure 2.0



Variations of COP v/s. Temperature (Sub-cooling) Table 2

Sub-cooling Temperature ºC	Coefficient of Performance	
	R22	R134a
5 ºC	5.50	4.75
10 ºC	5.30	4.58
15 ºC	5.22	4.40
20 ºC	4.97	4.23
25 ºC	4.80	4.05
30 ºC	4.61	3.87

Figure 3.0



Result and Discussion

We take three evaporator having capacity 30TR, 20TR and 10TR to maintain the temperature we used -10 ºC, 5 ºC and 10 ºC. The condenser temperature 40 ºC and the leaving condenser sub - cooled temperature is 30 ºC. We calculated the mass of refrigerant in eac h evaporator m1, m2 and m3 and th e total mass of refrigerant flow in air - conditioner for both the cases R22 and R134a. After that we calculated the power required drive by the compressor, the condition of refrigerant after mixing and entering into the comp ressor. The enthalpy at this point is h1. On third we calculated the COP of the system R22 and R1364awith or without sub -cooling at different temperatu re which shows in Table 1.0 and Table 2.0 and also shows Graphically Figure 2.0 and Figure 30.

CONCLUSION

This work focus on to run a split type air - conditioner system by using multiple evaporators of different Refrigerant R22 and R134a. In this work we calculated COP of the system with or without sub -cooling at different temperature which shows Graphically Figure 1.0 and Figure 2.0.

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