

# Experimental Analysis of Effect of Charge Level on the Performance of Domestic Refrigerator

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**ABSTRACT:** Performance of the domestic refrigerator has a vital role in the power consumptions. This s mainly depends on the refrigerant and charge level of the refrigerant. In this work the COP and better cooling effect of the refrigerant has to be determined at different charge levels. Experimental analysis has been carried out for the two refrigerants such as R134a and R12 for the charge levels of 66gms, 77gms, 88gms, 99gms and 110gms. The COP of the refrigerator is maximum with the refrigerant R134a at 88gms charging. This method is very simple and accurate to determine the performance characteristics of the various refrigerants by changing the charge level.

**KEYWORDS:** refrigerator; charge level; COP; refrigerating effect; refrigerant

## I. INTRODUCTION

Performance of the refrigeration system becomes main issue and many researches are still ongoing to evaluate and improve efficiency of the system. The main objective of this study is to obtain the performance of refrigeration system in term of Refrigeration Capacity, Compressor work and Coefficient of Performance (COP).Refrigerator is a cooling appliance comprising a thermally insulated compartment and a refrigeration system is a system to produce cooling effect in the insulated compartment. Meanwhile, refrigeration is define as a process of removing heat from a space or substance and transfers that heat to another space or substance. Nowadays, refrigerators are extensively used to store foods which deteriorate at ambient temperatures; spoilage from bacterial growth and other processes is much slower in refrigerator that has low temperatures. In refrigeration process, the working fluid employed as the heat absorber or cooling agent is called refrigerant. The refrigerant absorbs heat by evaporating at low temperature and pressure and remove heat by condensing at a higher temperature and pressure. As the heat is removed from the refrigerated space, the area appears to become cooler.

The refrigeration process that employed in the domestic refrigerator is based on a vapour compression cycle as shown in Figure 1.1. There are three main parameter that were considered in this study; compressor power, refrigeration capacity and coefficient of performance (COP).

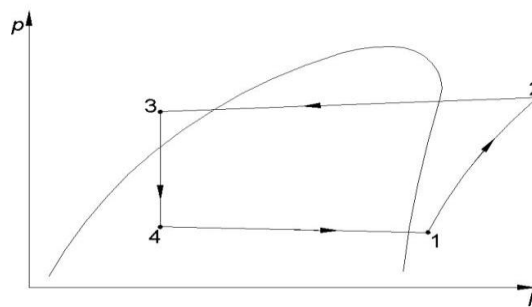


Fig 1.1 –p-h Diagram of refrigeration system

Process line from 1 to 2 represents compressor power. Compressor power is defined as the power needed to do the compression process in watt. The compressor power is determined by multiplying enthalpy change across the compressor to the mass flow rate, thus,

$$P=m (h_2- h_1)$$

Meanwhile, process from point 2 to 3 represents heat rejection through condenser. The amount of heat rejected is not significant in the present study. Process from point 3 to point 4 shows throttling effect through capillary tube whereby the working pressure of refrigerant will be reduced from discharge pressure to suction pressure. Refrigeration capacity, which is represented by process line 4 to 1, is defined as the amount of heat absorbed by a unit mass of refrigerant in evaporator. The refrigeration capacity can be obtained using equation below:

$$Q_{in} = m (h_1 - h_4)$$

The coefficient of performance (COP) is a measure of efficiency of the refrigerator. The COP of a domestic refrigerator is the ratio of the refrigeration capacity to the energy supplied to the compressor.

$$COP = \frac{\dot{Q}_{in}}{P} = \frac{\dot{m}(h_1 - h_4)}{\dot{m}(h_2 - h_1)}$$

## II. DOMESTIC REFRIGERATOR

A refrigerator is a reversed heat engine or a heat pump which takes out heat from a cold body and delivers it to a hot body. The applications of refrigeration for domestic purposes are mainly in the form of domestic refrigerators and home freezers. The main purpose of this type of refrigeration is to provide low temperature for storage and distribution of foods and drinks. A refrigerator is a reverse heat engine run in the reverse direction by means of external aid.

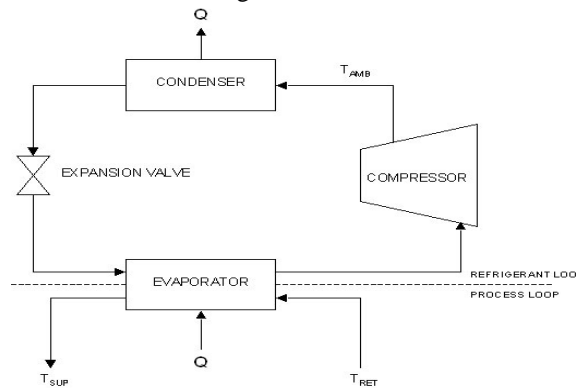


Figure 2.1: Layout of refrigerator

## III. REFRIGERANT

A heat carrying medium in a refrigeration system absorbs heat from a system which is in lower temperature and delivers it to a system which has a greater temperature than first one.

A refrigerant is a substance used in a refrigeration cycle should have enhanced efficiency, phase transition from a liquid to a gas and gas to liquid. In previous days fluorocarbons and chlorofluorocarbons are used as refrigerants, but they are out of usage due to their ozone depletion effects. Some other common refrigerants used in various applications are ammonia vapour and non-halogenated hydrocarbons such as propane. Many refrigerants are important ozone depleting and global warming inducing compounds that are the focus of worldwide regulatory scrutiny.

Most of refrigerants used in vapour Compression system were Chlorofluorocarbon (CFC) and Hydro Chlorofluorocarbon (HCFC) which contains chlorine.

A substance which has capable of absorbing heat from another required substance can be used as refrigerant.

Classification of refrigerants:

The refrigerants are classified into two groups:

(1) Primary refrigerants

- i. Halocarbon Compounds
- ii. Azeotropes
- iii. Hydro-Carbons

(2) Secondary refrigerants.

- i. ice
- ii. Water
- iii. Air or brine.

TABLE I  
 PROPERTIES OF REFRIGERANT

	R134a
Class	HFC (HydroFluoroCarbon)
Chemical Name	Tetrafluoroethane CH <sub>2</sub> FCF <sub>3</sub>
Formula	R-134a (100%)
Boiling Point	-26.6 <sup>0</sup> C
Critical Temperature	100.6 <sup>0</sup> C
Toxicity	Medium
Refrigerant Flammability (auto-ignition temperature)	No (~800 <sup>0</sup> C)
Lubricant Flammability (auto-ignition temperature)	Yes (~200 <sup>0</sup> C)
Refrigerant + Lubricant Flammability	Yes
Global Warming Potential (20years/100years)	3100/1300
Ozone Depletion Potential	None
Cooling Performance @ 40 <sup>0</sup> C	Marginal
Energy Efficiency	Normal
Power Consumption	High

IV. EXPERIMENTAL SETUP

TABLE II  
 DETAILS OF EXPERIMENTAL SETUP

S.no	Components	Specification	Quantity (no's)
1	Refrigerator	165 liters	1
2	Pressure gauge	0-500 psi	2
3	Digital thermometer	-65 - 75 <sup>o</sup> c	5
4	Weight machine	1 g - 7000 g	1

5	Stop watch	digital	1
6	R12 refrigerant gas (tin)	Gas	1 kg
7	R134a refrigerant gas (tin)	gas	1 kg
8	R12 gas's lubricating oil	liquid	0.6 litre
9	R134a gas's lubricating oil	liquid	0.6 litre
10	Energy meter	Single phase	1

**V. RESULTS AND DISSCUSSION**

The performance of the domestic refrigerator were analysed with the different charge levels by using R12 and R134a refrigerants. The following curves show the different performance characteristics of domestic refrigerator.

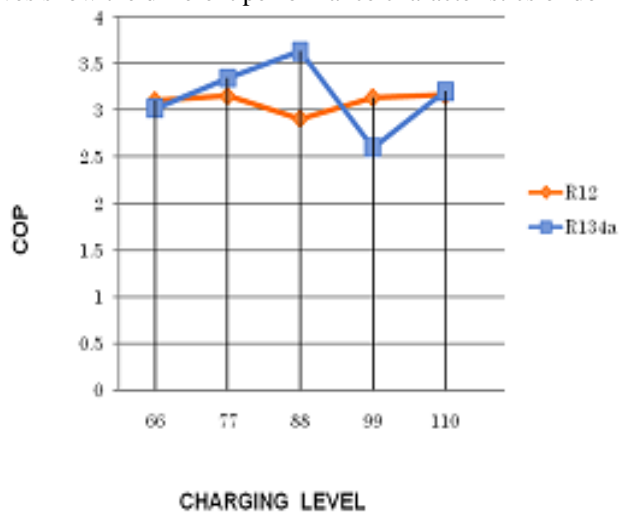


Fig 4.1 - Graph for Charge level Vs COP

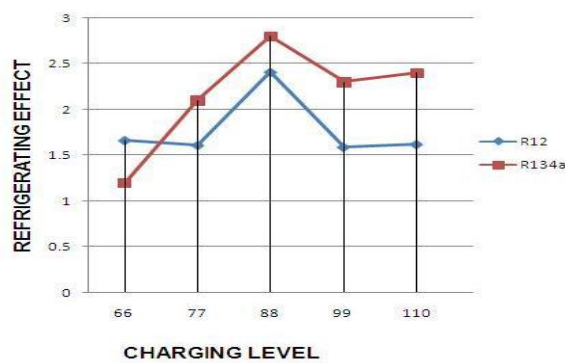


Fig 4.2 - Graph for Charge level Vs Refrigerating Effect

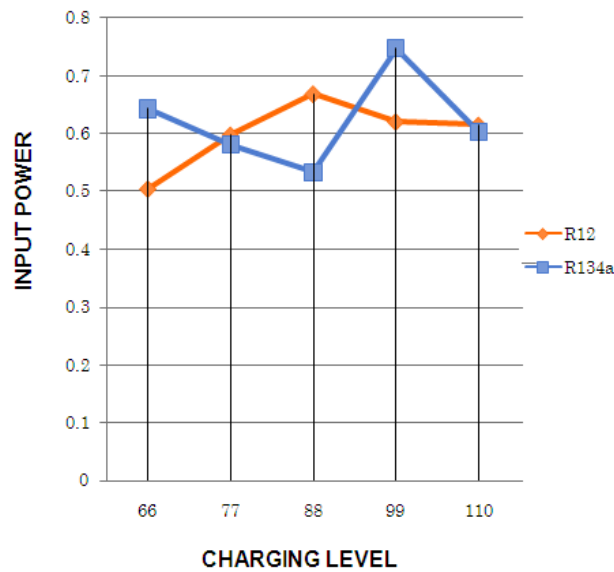


Fig 4.3 - Graph for Charge level Vs Input Power

- The above result shows that when using the refrigerant R134a has maximum COP at the charging level of 88 grams and the refrigerant R12 has maximum COP at the charging level of 99 grams.
- The above graph of charging level Vs refrigerating effect shows the results that the maximum refrigerating effect is obtained only for the refrigerant R134 at charging level of 88 grams and the maximum refrigeration effect is obtained for the refrigerant R12 at same charge level of 88 grams.
- Even the R12 give the maximum refrigerating effect at the charge level of 88 grams it consumes more input power than R134a.

## VI. CONCLUSION

In this project work, the performance of domestic refrigerator with R12 and R134a refrigerant were studied with parameters like COP, refrigerating effect, work input to the compressor are recorded and the results confirmed that the refrigerant R134a gives maximum COP and refrigerating effect with minimum power intake than the refrigerant R12. This work may be extended for different refrigerants with various charge levels.

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