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# Comparison of Second Law Efficiency of Halocarbon Refrigerants Ethane Series Influenced by Evaporator Temperature for Vapour Compression Refrigeration System

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**ABSTRACT: An analysis is usually done to improve the system and find out the sites of work lost. The sites having high energy destruction indicates the scope of improvement in specific sites in order to achieve overall improved, efficient system. This research work investigates the losses involved in process and overall cycle due to irreversibility in vapor compression refrigeration system with evaporator temperature as influential parameter by energy destruction and second law efficiency analysis. The present work analyzed the behavior of six halocarbon ethane series refrigerants R-123, R-124, R-125 R-134a, R-143a and R-152a with variation of evaporator temperature. From second law efficiency increases with evaporator temperature and for R-123 almost constant η with increases evaporation temperature and also same η at temperature 233K (-40$^{O}$C) comparison of R-134a.**

**Keywords-** Energy Destruction, Work Lost, Irreversibility, Exergetic Efficiency, Second Law Efficiency, Vapour Compression, Refrigeration System.

## I. INTRODUCTION

Refrigeration is a process in which work is done to move heat from one location to another Larsen [1]. The work of heat transport is traditionally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications including but not limited to household refrigerators, industrial freezers, cryogenics, T. Hovgaard *et al* [10] and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to refrigeration units. Energy efficiency under a specific operation condition [9]. The Cool Pack is especially suitable for supermarket refrigeration analysis for which we have well-defined component performance and need to catch the main system characteristics while neglecting some effects. The energy efficiency under different operating conditions direct the refrigerant through a condenser and an evaporator of the refrigeration.

Refrigeration has a large impact on industry, lifestyle, agriculture and settlement patterns. The idea of preserving food dates back to the ancient Roman and Chinese empires.

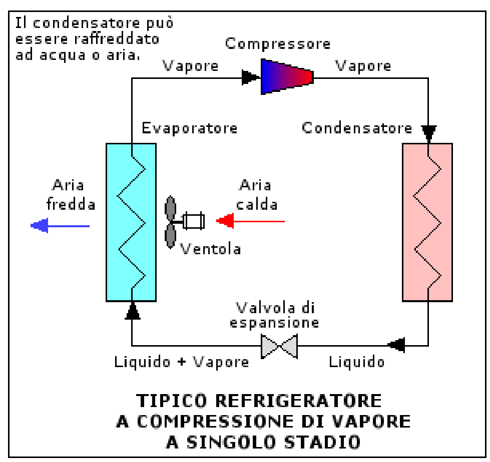



**Fig. 1.** Refrigeration system.

However, refrigeration technology has rapidly evolved in the last century, from ice harvesting to temperature-controlled rail cars Larsen *et al* [4].

The introduction of refrigerated rail cars contributed to the westward expansion of the United States, allowing settlement in areas that were not on main transport channels such as rivers, harbors, or valley trails. Settlements were also popping up in infertile parts of the country, filled with new natural resources. These new settlement patterns sparked the building of large cities which are able to thrive in areas that were otherwise thought to be unsustainable, such as Houston, Texas and Las Vegas, Nevada. In most developed countries, cities are heavily dependent upon refrigeration in supermarkets, M. Willatzen *et al* [6] in order to obtain their food for daily consumption.

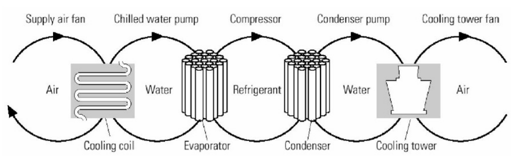



**Fig. 2.** Heat Transfer Loop in Refrigeration System.

There are several heat transfer loops in a refrigeration system as shown in Figure 2. Thermal energy moves from left to right as it is extracted from the space and expelled into the outdoors through five loops of heat transfer.

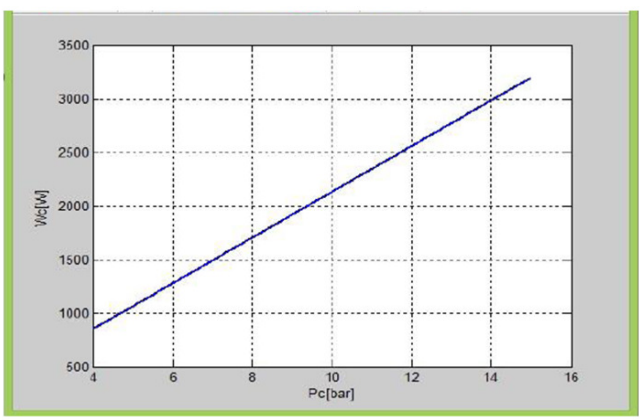



**Fig. 4.** Compressor Power & Condenser Pressure.

Optimization of condenser set points to minimise energy use requires a tradeoff between high compressor energy use at high head pressures and high condenser fan and Rawlings *et al* [8] pump energy use to achieve low head pressures. Multi-speed fans and variable speed drive (VSD) fan controls only give significant energy use reductions compared with on/off control if Rawlings *et al* [13] compressors operate highly unloaded and/or the condenser is grossly oversized. Oil separators, discharge and high pressure liquid lines, and expansion and other refrigerant control valves should be designed to operate satisfactorily across the full range of discharge pressures likely to be encountered if discharge pressure is floated. Most industrial refrigeration systems employ compressor discharge (head) pressure controls. Generally these controls modulate the condenser fans (for air-cooled or evaporative condensers) or water flow rates and cooling tower fans (for water-cooled condensers) to keep the head pressure within a specified range. Reducing fan speed or cooling water flow reduces the effective capacity of the condensers so that it equals the required heat rejection by maintaining a larger temperature difference between the refrigerant saturated condensation temperatures.

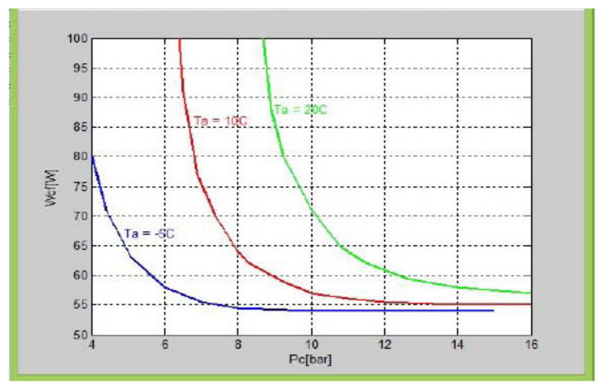



**Fig. 5.** Condenser Fan power & Condenser Pressure.

## EXPERIMENTAL WORK

The commonly referred to as the heart of the system, the compressor is a belt driven pump that is fastened to the engine. It is responsible for compressing and transferring refrigerant gas M. Diehl *et al* [12]. The A/C system is split into two sides, a high pressure side and a low pressure side; defined as discharge and suction. Since the compressor is basically a pump, it must have an intake side and a discharge side. The intake, or suction side, draws in refrigerant gas from the outlet of the evaporator. In some cases it does this via the accumulator. Once the refrigerant is drawn into the suction side, it is compressed and sent to the condenser, where it can then transfer the heat that is absorbed from the inside of the vehicle.

**BD35DC12V/24V/36V**

| | | |
|---|---|---|
| **Place of origin** | : | China (Mainland) |
| **Brand name** | : | Millie |
| **Application** | : | Refrigeration parts |
| **Type** | : | Refrigeration Compresso |
| **Displacement** | : | 3.0 ml |
| **Refrigerant** | : | R-134 (a) |
| **Rotation (r.p.m.)** | : | 2500/2750/3000 |
| **Capacity (W)** | : | 60-110 |
| **Current (Amp)** | : | 12V/6Amp. 24V/3.5 Amp |
| **Input power** | : | 60 W |
| **C.O.P** | : | 1.3 |

## EVAPORATOR

The evaporator provides several functions. Its primary duty is to remove heat from the inside of your vehicle. A secondary benefit is dehumidification. As warmer air travels through the aluminum fins of the cooler evaporator coil, the moisture contained in the air condenses on its surface. Dust and pollen passing through stick to its wet surfaces and drain off to the outside. On humid days you may have seen this as water dripping from the bottom of your vehicle. Rest assured this is perfectly normal. The ideal temperature of the evaporator is 32° Fahrenheit or 0° Celsius K. Edlund *et al* [14]. Refrigerant enters the bottom of the evaporator as a low pressure liquid. The warm air passing through the evaporator fins causes the refrigerant to boil (refrigerants have very low boiling points). As the refrigerant begins to boil, it can absorb large amounts of heat. This heat is then carried off with the refrigerant to the outside of the vehicle.

**Dimension = 30 cm x 41 cm x 28.5 cm**

**Total surface Area = 2( l w+wh+hl) = 6507 square cm**

The various types of sensors are used to measure temperature. One of these is the thermostat, or temperature-sensitive resistor. Most thermostats have a negative temperature coefficient (NTC), meaning the resistance goes up as temperature goes down.

**Fig. 6.** Evaporating Coils.

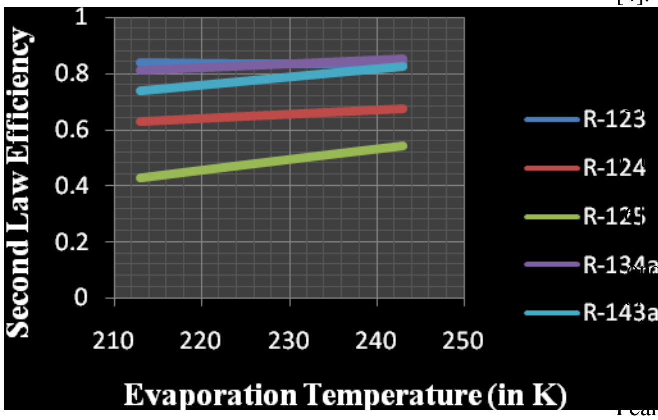
Of all passive temperature measurement sensors, Jakobsen *et al* [15] thermostats have the highest sensitivity (resistance change per degree of temperature change). Thermostats do not have a linear temperature/resistance curve.

**Fig. 7.** Compressor Coils Winding.

## RESULTS ANALYSIS

| Second Law Efficiency (η) | | | | | | |
|---|---|---|---|---|---|---|
| Refrigerants / Temperature range (Te→Tc) K | R-123 | R-124 | R-125 | R-134a | R-143a | R-152a |
| 243→313 | 0.834 | 0.674 | 0.540 | 0.852 | 0.826 | ≥1 |
| 233→313 | 0.835 | 0.660 | 0.503 | 0.838 | 0.797 | ≥1 |
| 223→313 | 0.832 | 0.645 | 0.466 | 0.824 | 0.766 | ≥1 |
| 213→313 | 0.830 | 0.630 | 0.427 | 0.809 | 0.736 | ≥1 |

**Table 1: Second law efficiency of different refrigerants.**




## CONCLUSION

A comparative second law efficiency analysis of the different refrigerants impact on the operation and performances of a single stage vapor compression refrigeration system was presented. The effects of evaporating temperature and pressure on vapor compression refrigeration system studied on the operation and performances. Based on the theoretical and practical analysis destruction rates were estimated for each component of the system in a comparative manner for refrigerants. The evaporating temperature increases from (243→313)K then the second law efficiency of R-134a is higher as compare to other halocarbon refrigerants ethane series but the temperature range is (223→313)K and ( 213→313)K refrigerant R-123 is higher II$^{nd}$ law efficiency as compare to other refrigerants.

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