PERFORMANCE ANALYSIS OF FIN TUBE EVAPORATOR USING VARIOUS REFRIGERANTS

by

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Refrigeration systems have been widely used to maintain reduced temperature for specific applications. The work deals with modifying the existing design by installing fins in evaporator which acts as the key factor in refrigeration system. A study has been carried out with HC and R134a refrigerants which are commonly used in typical refrigeration system. Comparison studies has been made on the cooling capacity of the two refrigerants in hourly basis, so as to check the compatibility of the alternative refrigerant in working conditions with reduced global warming effect and power consumption. This can be achieved by increasing the heat transfer rate.

Key words: *fin, evaporator, global warming, power consumption, cooling capacity*

Introduction

In the refrigeration system, basically three components are used: condenser, compressor, and evaporator. In that the evaporator is modified by using fins in order to increase the heat transfer rate. The R134a is the most commonly used refrigerant in the refrigerators. It causes difficult inhalation while breathing and it has high global warming effect, and also the power consumption is high [1-4]. It is necessary to choose an alternate refrigerant for reducing global warming and power consumption. So, that the HC is the alternate refrigerant to overcome this drawbacks. In recent days, vapor compression cycle has been tested with different refrigerants under different blends [5]. It recorded that the COP can be increased by varying the percentage of different refrigerants. Refrigerants such as CFC 22, CFC 12, HFC 134a, R600a, R290, *etc.*, has been used as alternative refrigerants [6-9].

Various parameters such as COP, compressor work done, and the effect of refrigerant have been studied. It has been inferred that the effect of refrigeration and COP shall be in-

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creased by increasing the evaporation temperature and condensation temperature [10]. It is also been inferred that the work done reduces with the increasing evaporation temperature. Global warming is one great threat which is caused due to improper selection of refrigerants. Green refrigerants such as HC have very low global warming potential (GWP) and almost an ozone depletion potential (ODP) value of 0 [11]. The COP and energy factor can also be increased by increasing the capacity of cooling. The COP for HC 134 shall be increased upto 36.42% and that of energy factor upto 3.78%.

In this work, the evaporator is attached with fins to enhance the heat transfer rate by increasing the surface area. The temperature is recorded every 10 minutes for both R143a and HC refrigerants. The COP is calculated to evaluate the refrigeration effect.

Experimentation

A typical finned refrigeration system is shown in fig. 1. Fins are attached to the system to improve the capacity of heat transfer between the substance and the refrigerant. Initially, the pressure, temperature, and power consumption of the refrigerator is noted down by using the existing refrigerant. Then the evaporator is finned to increase the heat transfer rate and power consumption is analyzed. The refrigerant in the compressor is changed to decrease the GWP and GHG emission. Finally the same parameters are analyzed by using the alternate refrigerant. By using these parameters the refrigeration effect of each refrigerant is calculated. The work input of the refrigerator is determined by using the ammeter and voltmeter reading for each refrigerant. Finally the COP is calculated by using the refrigeration effect and work input.

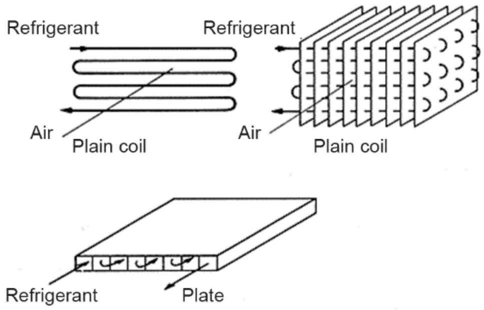

Figure 1. Typical finned refrigeration system

Result and discussion

Refrigerant is considered to be an important part of any kind of refrigeration system as heat transfer takes place through them. The recorded readings for every 10 minutes are shown in fig. 2 and tab. 1. In case of R134a, the medium has a specific enthalpy of 28.68 kJ/kg in liquid state and 238.01 kJ/kg in vapor state. While entering the evaporator, liq-

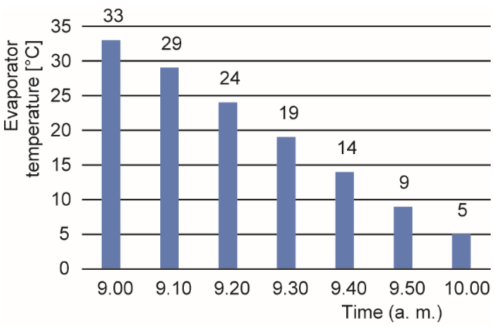

Figure 2. Evaporation temperature variation with time for R134a refrigerant

Table 1. Temperature reading for R134a refrigerant

S. no.	Time (a. m.)	Evaporator temperature, [°C]
1	9.00	34
2	9.10	29
3	9.20	24
4	9.30	19
5	9.40	14
6	9.50	9
7	10.00	5

uid R134a having very low energy gets transformed to vapor state by absorbing heat energy from the substance loaded in evaporator. Here, the temperate drops from 33 °C to 4 °C in about a time of 1 hour. This shows the ability of R134a to absorb heat at a pressure of 10 bar with a work input of 0.48 kW. The time taken for achieving the cooling effect increased the power consumption during cooling.

The recorded readings for every 10 minutes are shown in fig. 3 and tab. 2. The HC refrigerant proposed in this work had increased the COP of system. Without any modification to the existing system, replacing the refrigerant has drastically reduced the power consumption during cooling process by 50%. Here, the cooling effect is achieved within 30 minutes of time period with the help of low specific enthalpy of proposed refrigerant at liquid state. This tends to eliminate the sub cooling effect with uniform circulation of refrigerant throughout the system. Hence, COP has increased from 7.58 to 8.08.

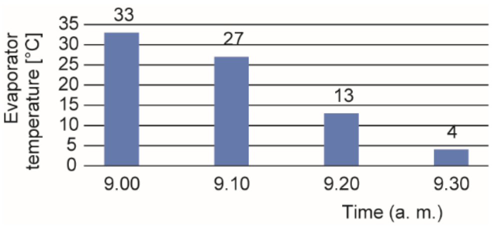

Figure 3. Evaporation temperature variation with time for HC refrigerant

Table 2. Temperature reading for HC refrigerant

S. No.	Time (a. m.)	Evaporator temperature, [°C]
1	9.00	33
2	9.10	27
3	9.20	13
4	9.30	4

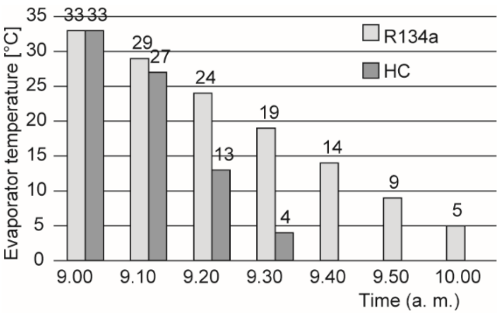

Figure 4. Comparison of refrigerant performance

Table 3 (fig. 4) shows the COP values and refrigeration effect for both the refrigerants. There is an increase refrigeration effect and COP when the HC refrigerants are preferred instead of R134a. It is observed that the pressure has reduced the time for reduction of temperature to 5 minutes for HC refrigerants which, in turn, increases the refrigeration effect resulting in increase in COP. Figures 5(a) and 5(b) compare the COP and refrigeration effect of R143a and HC. Approximately 6.59% increase in overall performance of system had been achieved for COP.

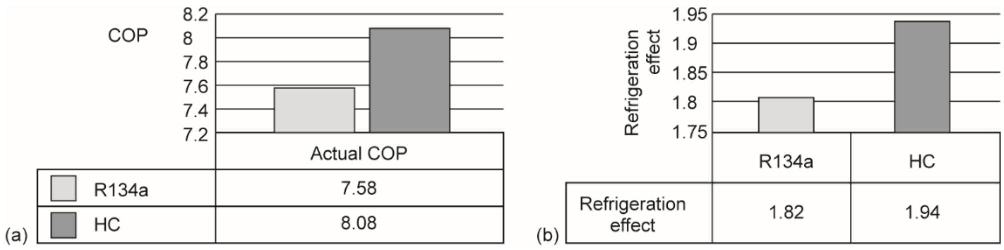

Figure 5. (a) The COP comparison (b) refrigeration effect comparison

Table 3. Performance of different refrigerants

Refrigerant	*T*1 [°C]	*T*2 [°C]	*T*3 [°C]	*T*4 [°C]	*P*1 [bar]	*P*2 [bar]	Time to decrease 5 °C of temperature [minutes]	Refrigeration effect	Actual COP
R134a	–4	65	40	4	23	186	10	1.82	7.58
HC	–4	57	35	4	10	175	5	1.94	8.08

Conclusions

The performance of both the refrigerants was compared in terms of refrigeration effect and COP. It is being inferred that domestically used R134 a refrigerant shall be replaced with HC for the following reasons.

- The same refrigeration effect while using R134 a refrigerant has been obtained with 50% of time when HC refrigerants are used. The R134a took 1 hour to reach the lowest temperature of 4 °C while the HC took only 30 minutes.
- The COP has increased from 7.58 to 8.08 when the R134a refrigerant was replaced with HC. It is approximately 6.9% increase.
- The power consumption has also been reduced to 50% when compared to R134a refrigerant.

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