Experimental Study on Enhancement of COP of VCC Refrigeration System by using Diffuser after Compressor

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Abstract— This paper describes the experimental analysis of vapor compression refrigeration system by using the diffuser at inlet of condenser concept. A diffuser before inlet of condenser for a vapor compression system is provided. The diffuser has an inlet to accept a compressed liquid refrigerant from a compressor of a refrigeration system. The refrigerant coming out of the diffuser has higher-pressure level than that of refrigerant entering the diffuser. The purpose of a compressor in VCRS is to increase the pressure of the refrigerant. In the condenser, there is a drop in pressure across the tubes thereby increasing the power consumption of the compressor. This paper is an experimental study to minimize the compressor work by providing a diffuser at the inlet of the condenser. Diffuser converts the high velocity of liquid refrigerant coming out from the compressor into the pressure energy. Diffuser is a device which recovers the pressure without any work input. Refrigerant from the compressor discharge enters the diffuser and increases its pressure and temperature considerably.

Keywords: VCC, Diffuser, Condenser, Compressor

I. INTRODUCTION

Refrigeration process is the removal of heat from a space at a temperature lower than the surrounding temperature. The Coefficient of Performance, which is the ratio of refrigeration effect produced at the heat absorption section to the work input by the compressor. COP can be enhanced either by decreasing the work input of compressor or by increasing the refrigeration effect.

In this work, diffuser is installed in between compressor and condenser. In VCR system, condenser is used to remove heat from high pressure vapour refrigerant and converts it into high pressure liquid form. The condensers used for domestic application are air cooled. Heat is transferred from the refrigerant to the cooling fluid. Liquid refrigerant with high pressure flows through an expansion device to obtain low pressure refrigerant. Low pressure refrigerant flows through the evaporator. Liquid refrigerant in the evaporator absorbs latent heat of surrounding and gets converted into vapour refrigerant which returns to compressor. In this cycle, the vapor refrigerant leaves the compressor with very high velocity. This high velocity refrigerant directly strikes the walls of condenser which harmful to the system. Due to this vibration, pitting or erosion can occur. It results in undesirable splashing of refrigerant in the condenser coil. This is called as “liquid hump”. Liquid hump is the process in which an increase in the level of the condensed refrigerant liquid in the middle section of the condenser as compared to that of at the ends of the condenser.

A. Problem Statement:

This work is an experimental approach to reduce compressor work by providing diffuser in between compressor and condenser. Diffuser converts kinetic energy of refrigerant into useful pressure energy.

B. Proposed Work:

1) Designing and manufacturing diffuser
2) Development of experimental set up
3) Finding COP without diffuser
4) Finding COP with diffuser
5) Finding Refrigeration Effect and compressor work with and without diffuser.

II. METHODOLOGY

A. Manufacturing of Diffuser:

Fig. 1: Geometry of diffuser.

In VCR system in which a diffuser is used at inlet of condenser shown in figure 4. In this system two flow lines are used. One is for simple VCRS flow line without diffuser and other is for flow line with diffuser. Two pressure gauges are used in this experiment one is installed at diffuser outlet and other is at simple flow line to measure the pressure of the refrigerator at outlet of diffuser and pressure in simple VCRS flow line. In this experimental work need to calculate the pressure with and without diffuser. We can close or open both the lines with the help of flow control valves. Refrigeration effect is kept constant throughout the experiment. The experiment is performed by taking readings with and without diffuser and compared with each other.
III. EXPERIMENTAL SETUP

A Vapor Compression Refrigeration system is used to carry out the experimentation. Fig 4 shows the setup.

A. Equipments in Experimental Setup:

1) Compressor: It is most valuable part in VCRS. It takes almost 30-40% cost of system. Hermetically sealed compressor is used.
2) Condenser: The device used to condense a vapor refrigerant to its liquid phase by cooling it. It gives the latent heat to surrounding here air-cooled condenser is used.
3) Throttling device: it obstructs the flow of liquid. In this setup capillary tube is used. Diameter of capillary tube is 6mm.
4) Evaporator: This is the device used in low pressure side of VCRS. Latent heat of surrounding is absorbed by the refrigerant and liquid refrigerant gets converted into vapor phase.
5) Diffuser: It is a static device which having increasing cross sectional area. It converts the kinetic energy of liquid refrigerant to the pressure energy before entering condenser.
6) Refrigerant: refrigerant is a fluid used in a refrigeration system. In this work R134a is used as a refrigerant.

<table>
<thead>
<tr>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point</td>
<td>-21.6°C</td>
</tr>
<tr>
<td>Auto ignition temp</td>
<td>770°C</td>
</tr>
<tr>
<td>Critical temp</td>
<td>122°C</td>
</tr>
<tr>
<td>GWP</td>
<td>1200</td>
</tr>
<tr>
<td>ODP</td>
<td>0</td>
</tr>
</tbody>
</table>

IV. CALCULATIONS

Fig 5 shows the pressure enthalpy chart of the system. The path 1-2-3-4 shows the VCRS without diffuser and path 1-2’-3’-4 shows the VCRS with diffuser at condenser inlet.

A. Design of Diffuser:

Fig 1. is referred for the design of diffuser.

$L = \frac{1}{2} \left( d_2 - d_1 \right) \tan \theta$
Experimental Study on Enhancement of COP of VCC Refrigeration System by using Diffuser after Compressor

B. COP:
Net refrigeration effect is kept constant. Compressor work, WD=h2 - h1
Diffuser work, WE=R2 - R1
Refrigeration effect=R1
Reduction in compressor work = (h2 - h1) - (R2 - R1)

COP without diffuser = \( \frac{\text{reduction in compressor work}}{\text{reduction in compressor work}} \)

COP with diffuser = \( \frac{\text{reduction in compressor work}}{\text{reduction in compressor work}} \)

V. RESULTS AND DISCUSSION

A. Without Diffuser:

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Refrigerant temp (°C)</th>
<th>Water temp (°C)</th>
<th>Refrigerant pressure( psi)</th>
<th>EMR (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
<td>T4</td>
</tr>
<tr>
<td>1</td>
<td>26</td>
<td>60</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>63</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>65</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>66</td>
<td>40</td>
<td>31</td>
</tr>
</tbody>
</table>

When system was run with keeping diffuser valve closed, it acts as a simple VCRS and we find the readings as mentioned in above table. Temperatures were recorded at compressor inlet, compressor outlet, temp at exit of condenser and exit of evaporator. Then suction and discharge pressure were taken to plot the p-h graph and COP was calculated.

B. With Diffuser:

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Refrigerant temp (°C)</th>
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<td>26</td>
<td>66</td>
<td>40</td>
<td>33</td>
</tr>
</tbody>
</table>

When system run with diffuser, discharge pressure was kept constant. Due to addition of diffuser pressure at suction will get by increasing value. Again the COP was calculated and found increasing.

C. Result and Discussion:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Without diffuser</th>
<th>With diffuser</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-134a</td>
<td>RE (kW) Wc (kWh) COP</td>
<td>RE (kW) Wc (kWh) COP</td>
</tr>
<tr>
<td>752.4</td>
<td>902</td>
<td>0.834</td>
</tr>
</tbody>
</table>

When diffuser added pressure rise from 2 to 2°, if diffuser is absent then compressor has to do additional work i.e. power consumption will increase to reach 2°. Here it is found that compressor work was 902kW without diffuser and it decreases up to 720kW using diffuser.

VI. CONCLUSION

By using diffuser after compressor, velocity of vaporized R134a is converted into pressure energy. Some part of required pressure increases in compressor so compressor work is decreases or power consumption is decreases. As COP is the ratio of refrigeration effect to work input, performance or COP increases. This experimental study shows that when diffuser is added to VCRS, power consumption or compressor work is decreased from 902kW to 720kW i.e. 20.18% decrease in compressor work. COP of the system is increased from 0.834 to 1.045 i.e. 25% increase in COP. So, it is concluded that COP of VCRS can be enhanced with diffuser in between compressor and condenser.

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REFERENCES

