Efficient Air-Condition Unit By Using Nano-Refrigerant

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Abstract—This research mainly focuses on CNT-based nanolubricant in the refrigeration system. CNT Nanoparticles introduced into the system through lubricant to improve its heat transfer performance. A concentration of 0.01-0.1wt% of CNT-Polyester Oil was tested along with suitability and environmental friendly refrigerant R134a. Results show that CNT nanoparticle concentration of 0.1wt% is optimal and gives highest heat transfer enhancement and improve the coefficient of performance (COP) by 4.2%

Keywords— nanolubricant, refrigeration, heat transfer, coefficient of performance, polyester oil.

1. Introduction

Concept of Nano-lubricant came from the idea of Nano refrigerants which are a relatively new category of refrigerants consist of a conventional refrigerant with Nano-sized particles mostly (range between 1nm to 100nm) suspended within them. Nano refrigerant is also called Nanofluid; Nanofluid is famous because of its unique type with remarkable thermal conductivity in refrigeration and air-conditioning systems. Nanofluid was first proposed by Choi [1].

Carbon Nanotubes (CNT) are famous because of its great thermal-physical properties and extremely high thermal conductivity reported by researchers recently. Extensive research in the last two decades shows that nanofluids are a new generation of heat transfer fluids. Due to small size and large specific area of nanoparticles, nanofluids holds superior properties such as high thermal conductivity, minimal clogging in flow passage, long-term stability and homogeneity [2].

Refrigerants are widely used in refrigeration and air-conditioning equipment in industries, offices and domestic & commercial buildings, consuming huge amount of energy. Nano-refrigerants have potential to enhance heat transfer rate thus making heat exchanger of air-conditioning and refrigeration equipment compact. This, consequently, will reduce energy consumption in these sectors along with reduction in emission, global warming potential and greenhouse-gas effects [3].

CNT were observed to have relatively high thermal conductivity (~3000W/mK) over other nanoparticles such as CuO, Al₂O₃, SiO₂, diamond and TiO₂ [4]. Patel et al.[5] used R113a as a base refrigerant and significant evidences of performance improvement of the system was observed in the extensive research using CNT nanoparticles. The recent studies have found that the CNT based nanofluids have higher thermal conductivity compared to conventional refrigerants [5].

Recently, several research studies conducted on a refrigeration system using different refrigerants, lubricants and nanoparticles showed significant reduction in power consumption and improvement in coefficient of performance (COP) of the system. Sendil et al. [6] used hydrocarbon refrigerant and mineral lubricant suspended with Al₂O₃ nanoparticles and showed better lubrication and heat transfer performance. Furthermore study shows that 60% R-134a and 0.1 wt % Al₂O₃ nanoparticles were optimal. Hence, the power consumption drops by 2.4% and COP increased by 4.4% [6].

2. Methodology

2.1. Preparation of Nano lubricants

CNT nanoparticles are added to refrigerant by dispersing in the host lubricant POE (Poly Ester) in the compressor of the air-condition unit. POE is widely used in the industry for refrigeration and air-condition. CNT Nanoparticles with concentration of 0.01wt%, 0.05wt% and 0.1wt% were measured by digital weight balance. Each mass fraction of nanoparticles is mixed with base lubricant and the amount of each sample of nanolubricant prepared was 700 grams. Resultant nanolubricant was homogenized for 15 minutes followed by sonication for up to 4 hours using a water bath sonicator.

2.2. Charging of the system

A Refrigeration laboratory unit (R713) purchased from P. A. Hilton Ltd was used for the conduction of experiments for this research. First of all, system was isolated from electricity. Existing refrigerant and lubricant was evacuated from the system by the service ports provided in the compressor using vacuum pump. 650gm of nanolubricant oil was filled in the compressor through the service port. Then the refrigerant gas of 550g in the system was recharged by using precision electronic balance. The same procedure was followed for all mass fractions of CNT nanoparticle in lubricant.

2.3. Performance Test

The performance test was conducted for all samples of CNT-Lubricant oil mixture of 650gm and pure R-134a of 550g, which are treated as the basis for comparison with other results. In order to obtain repeatability each experiment was conducted 3 times.

3. Results and Discussions

To evaluate the efficiency of refrigeration cycle is the main objective of this research and it is expressed in terms of coefficient of performance (COP). The main purpose of refrigerator or air-condition is to remove heat, Qᵣ, from the refrigerate space. In order to accomplish the heat removal it requires a work input W_net, in [7]. Then COP of a refrigerator can be expressed as in equation 1.

Table 1. Temperature and Enthalpy reading in 3 different regions of refrigeration cycle with different concentration of nanoparticles.

<table>
<thead>
<tr>
<th>T°C</th>
<th>POE Oil with CNT and without CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>hkJ</td>
<td>Pure</td>
</tr>
<tr>
<td>1</td>
<td>18.86</td>
</tr>
<tr>
<td>260.99</td>
<td>260.98</td>
</tr>
</tbody>
</table>
Table 1 show that there are three readings for each nanoparticle concentration in lubricant. Reading 1 and 2 are the inlet and outlet temperature of the compressor unit and reading 3 is in the evaporation region of the system where heat has been rejected thus, temperature drops in this region. Temperature readings converted to enthalpy values by using saturated refrigerant R-134a - Temperature Table. Therefore, enthalpy values of these three regions were used to calculate heat rejection from the system and work input to the system. Hence, COP was calculated using equation 1 as shown in section 3.1 below.

### 3.1. Formulas and Equations

The coefficient of performance of the refrigeration cycle can be calculated by using the equation 1.

\[
COP = \frac{Q}{W}
\]  

(1)

where,

- \( Q \) is the heat supplied to or removed from the reservoir.
- \( W \) is the work done by the compressor.

Data reveals that, when nanoparticles are introduced in the open (reciprocating compressor or driven belt compressor) it travels into the whole system along with refrigerant due to miscibility between refrigerant and lubricant oil. Therefore, CNT nanoparticles improved the heat transfer performance of the system because of its remarkable thermo-physical properties due to their large surface area.

COP is related to power consumed by the system, higher the COP of the system lesser the power consumption of the system. It was found that, as the concentration of the CNT in lubricant increases the COP will also increase. Highest COP value was obtained at 0.1wt%, which was highest nanoparticle composition of this study.

![wt% CNT vs COP](image)

Fig. 1 illustrates that higher the concentration of CNT higher will be the efficiency of the system. However, more research need to be carried out to determine the optimum concentration of CNT nanoparticle which can show highest efficiency.

### 4. Conclusions

Addition of CNT nanoparticles into POE lubricant reveals improvement in coefficient of performance (COP) of the refrigeration system. Using nanoparticles reduce the power consumption and cost effective. COP of the system increase with increase of CNT weight percent in base lubricant. The highest COP value obtained was 3.757 at 0.1% of CNT.

Apart from that, Preparation of homogeneous suspension remains a technical challenge since the nanoparticles always form aggregates due to very strong van der Waals interactions.

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### References


