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Abstract

This paper investigates the effect using the ternary mixture of R22/R152a/R142b as substitute for R12.

In order to evaluate the essential properties using the mixture of R22/R152a/R142b as the replacement for R12, the measurements about a vapour pressure of this mixture in a range of temperature have been finished. The result illustrates the vapour pressure cure of the ternary mixture in a certain concentration closes to that of R12 very much.

Another test of refrigeration system using R22/R152a/R142b in various concentrations has been carried out.

It is proved that the ternary mixture under a certain concentration is a near-azeotropic mixture.

The tested results show that the ternary mixture has more capacity, lower discharge temperature and higher COP than R12.

For the above reasons the ternary mixture R22/R152a/R142b may be expected to become an alternative for R12 with the goal of suitability for equipment originally designed for R12, therefor it should be investigated further.

Introduction

It is well known that the ozone layer depletion and global warming are globular problems. In particular, R12 that is now widely used in small refrigeration systems and automobile air conditioning will be

phased out step by step.

Now, R134a is under very active consideration as a substitute for R12 . This is because R134a and R12 are fairly similar in thermodynamic properties, their boiling point difference is only a few degrees, their molecular weights differ by less than 20 percent and they are both non-flammmable. However, R134a must be run through a refrigeration system at a higher pressure than R12, so current refrigerators and air conditioners will have to be refitted with stronger compressor. With no changes in equipment, the refrigeration cycle efficiency of R134a is about 7.8 precent lower than that of R12. Thus, the energy consumption of systems contributes to increased emission of carbon dioxide by fossil fuel power plant. Carbon dioxide is a major contributor to the greenhouse effect. Another problem is R134a does not dissolve in mineral oil based lubricants currently used in refrigeration systems(1)(2) and is too expensive for most of the developing countries.

Zeotropes when they are used as alternatives have potential for improvement in energy efficiency and capacity adjusting, but the success of thire being used strongly depends on the system conditions. So we must modify the ordinary hardwares when we use them.

Near-azeotropes have a much great potential for development as alternative for R12. This is because the hardware system design using near-azeotrope is similar to that of either an azeotrope or a pure refrigerant. Therefore,we can expect to find a new near-azeotrope that may be used as an alternative for R12. This is our purpose in this paper.

The new ternary mixture:R22/R152a/R142b

The new ternary mixture that can be used as an alternative for R12 should be of :

1. the thermodynamic properties are similar to R12 to satisfy suitability for equipiment designed originally for R12,

2. higher cycle efficiency,

3. non-toxic and non-flammable,

4. satisfactory oil solubility,

5. lower ozone depletion potential and global warming potential.

According to our research results it is found that R22/R142b is a fair alternative for R12 in heat pump and refrigerator, but it has a certain gliding temperature during phase change. Although the gliding temperature can save compression energy, redesign is required for construction of refrigeration cycle system. It is also found that if the third compound having middle boiling point is mixed with the binary, the ternary will have less gliding temperature than the binary. Even it can be neglected in certain concentration to satisfy original system. R152a which has the perfect boiling point is the only selection.

We have noticed the ternary mixture of R22/R152a/R142b that may have been considered within the definition of near-azeotropic, have lower values of ozone depletion and global warming potential. The ternary satisfies above requirements so that it is expected to be a candidate of replacement in existing equipment for R12.

We can compare it with the ternary mixture of R22/R152a/R124 that has been investigated by Du Pont Company as an alternative in current equipment for R12,having low values ODP and GWP as well as the same energy consumption as R12. Because R142b is similar to R124 in chemical structure and thermodynamic property, their boiling point difference is only two degrees,it is more ordinary than R124 and also has a significantly lower ODP and GWP than R12 although it is not zero (table 1). R142b is currently a commercial product and undergone toxicity testing whereas R124 is a developmental product in China, especially the toxicity of which has not been fully evaluated. Commercial availability and known toxicity represent an advantage for R142b over R124.

Table 1 Typical physical properties of R124 and R142b[4]

physical properties	HCFC-124	HCFC-142b
Molecular formula	CHClFCF3	CClF2CH3
Normal boiling point(°C)	-11.95	-9.74
Critical temperature(°C)	122.2	137.1
Vapour pressure at 25°C (kPa)	383.42	338.63
Vapour pressure at 50°C (kPa)	775.98	687.12
Ozone depletion potential	0.016-0.024	0.05-0.06
Greenhous warming potential	0.092-0.10	0.34-0.93

In this new ternary mixture, each pure component may take individual effect. R22 is of great capacity, R152a may create higher energy efficiency and R142b may be used as a effect to reduce dischrge temperature.

Based on the preceding arguments, it will be expected that the ternary mixture of R22/R152a/R142b used as a substitute for R12 may exhibit better properties by adjusting concentration for specific property requirements such as proper system pressure,higher energy efficiency, lower discharge temperature, better oil solubility, non-flamability etc.

The vapour pressure curve of the ternary blend of R22/R152a/R142b

In order to evaluate the essential properties using the ternary mixture of R22/R152a/R142b as the replacement for R12,the measurements about a vapour pressure of this mixture (40% / 20% / 40%) in a rang of temperature have been finished as figure 1. The result illustrates the vapour pressure cure of the ternary mixture in certain concentration closes to that of R12 very much.

The experiment using ternary mixture: R22/R152a/R142b(40% / 20% / 40%) as the alternative for R12

The test about vapour compression refrigeration system using the ternary mixture in various concentrations has been carried out.

Fig.2 shows the temperature distribution along the tubes of heat exchanger of R12 and the ternary mixture under the same cold tank and heat tank condition. The result has proved that the ternary mixture under certain concentration has only 1-3 °C temperature difference during phase change process, hence it is also a near-azeotropic mixture.

Table 2 is tested result comparing R12 and the ternary mixture of R22/R152a/R142b(40% / 20% / 40%).

Table2 The tested result of R12 compare with that of R22/R152a/R142b

tested point				R12	ternary	R12	ternary
cold tank	inlet	temperature(°C)		12.0	12.2	13.0	12.6
cold tank	outlet	temperature(°C)		22.0	22.5	22.2	22.6
heat tank	inlet	temperature(°C)		50.2	49.9	54.8	54.8
heat tank	outlet	temperature(°C)		39.3	39.6	44.3	44.4
evaporator	inlet	temperature(°C)		8.0	7.7	7.0	8.2
evaporator	outlet	temperature(°C)		18.0	9.5	20.0	9.8
condenser	inlet	temperature(°C)		83.0	64.0	93.0	70.0
condenser	outlet	temperature(°C)		49.0	47.1	52.0	52.5
evaporator	inlet	pressure	(bar)	3.89	3.90	3.72	3.94
condenser	outlet	pressure	(bar)	12.56	13.25	13.94	14.82
heat	supplied		(kW)	2.61	2.75	2.49	2.78
COP				3.258	3.428	2.875	3.145

The tested result shows that this new ternary mixture under testing composition is of several features, they are as follows:

(1) The new ternary alternative have a little more specific capacity than R12. The increase values of capacity on tested working conditions is about 5.4-11.6 percent.

(2) The COP of the new ternary alternative when it is used in heat pump increases 5.2-9.5 percent at given working conditions.

(3) The discharged temperature of compressor is lower than R12

when it is used.

Conclusion:

This ternary mixture of R22/R152a/R142b (40% /20% /40%) is a near-azeotropic mixture. It has better properties that close to R12. It may be expected to become an alternative for R12 with the global suitability for equipments originally designed for R12 such as air conditioning,refrigerator, heat pump ect, therefor we should investigate further.

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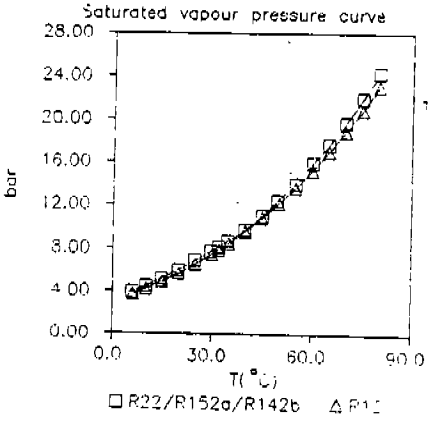

Fig.1:Comparision of the vapour pressure curve between the ternary and R12

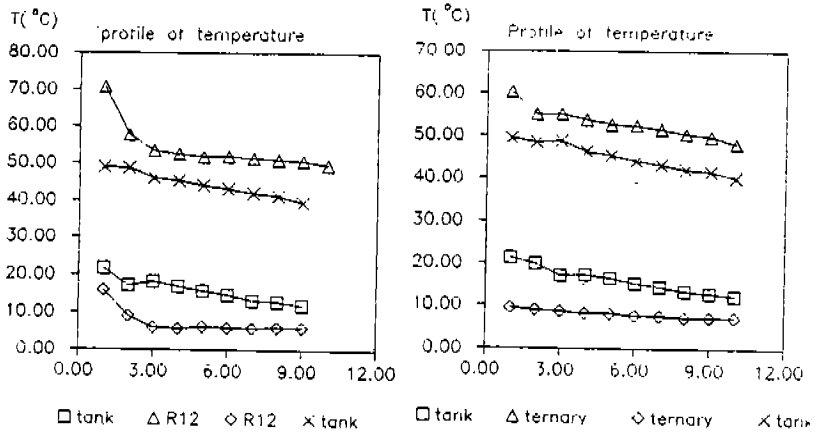

Fig.2:Comparision of the temperature distribution along the heat exchanger between R22/R152a/R142b and R12