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Energy and exergy analysis on hydrofluoroolefin/ hydrofluorocarbon (HFO/HFC) refrigerant mixtures in low and medium temperature small-scale refrigeration systems

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Abstract

The new refrigerants such as HFO-1234yf and HFO-1234ze have been considered as long-term replacements for HFC-134a to comply with the Kyoto protocol. In small size refrigeration systems, these refrigerants have poor performance than HFC-134a besides their minor flammability. Previous studies reveal that the addition of HFC-134a in small quantity can improve the performance of a system without exceeding the global warming potential limit (150) prescribed by the European Union. However, this concept is not studied in small-scale refrigerators. Therefore, the performance of low and medium temperature systems of capacity 190 and 285 litre, respectively, working with different hydrofluoroolefin/ hydrofluorocarbon (HFO/HFC) mixtures, has been studied by mathematical simulation. The software tool 'MATLab' and the refrigerant property database 'REFPROP' have been used in the simulation. The results showed that the coefficient of performance (COP) of Hydrofluoroolefin (HFO) refrigerants and its mixtures decreases from 2.4 to 15.7% than that of HFC-134a. Among the mixtures, HFO-1234ze/HFC-134a (90/10) shows better performance and its predicted coefficient of performance (COP) and exergetic efficiency are 4–8.3% and 5.1–10.5%, respectively, higher than that of other mixtures considered in this study.

Keywords

HFO-1234yf, HFO-1234ze, refrigerant mixtures, exergy, MATLab

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Introduction

Global warming is at its peak and has become the biggest threat throughout the world. Most of the vapour compression refrigeration units such as domestic refrigerators, deep freezers and bottle coolers are using HFC refrigerants, which have high global warming potential (GWP). HFCs account for about 2% of global greenhouse gas emissions in 2015 besides 9–20% of CO_2 emissions by 2050.[1] According to the Kyoto protocol, the usage of HFC refrigerants including the existing refrigerant HFC-134a, which has a high GWP of 1430, should be reduced.[2,3]

United Nations Framework Convention on Climate Change asks for a reduction in the emission of HFC-134a, which is used primarily as coolants in refrigeration systems. The Kigali Amendment[4] insists the developed countries to start the necessary actions to phase-down HFCs by 2019, whereas the developing countries are expected to phase-down between 2024 and 2028. In 2012, the European Union has taken action to control F-gas emissions by two-third of today's level by 2030 and declared that the new refrigerants must have a GWP less than 150. So, looking for alternative refrigerants that are efficient and environmental friendly is of much significance.

The thermophysical properties of refrigerants HFO-1234yf and HFO-1234ze are close to HFC-134a and they have very low GWP. Hence they can be considered as best alternatives to HFC-134a. The

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