Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 109 (2017) 425 – 430

Energy Procedia

International Conference on Recent Advancement in Air Conditioning and Refrigeration, RAAR 2016, 10-12 November 2016, Bhubaneswar, India

Experimental Studies of a Domestic Refrigerator Using R290/R600a Zeotropic Blends

Neeraj Agrawal [a,*], Shriganesh Patil [a], Prasant Nanda [b]

[a] *Department of Mechanical Engineering, Dr. B. A. Technological University Lonere, Raigad Maharashtra, India*

[b] *Department of Mechanical Engineering, Veer Surendra Sai University of Technology Burla, Orissa, India*

Abstract

System performance of an existed 134a domestic refrigerator with propane/isobutane (50/50%) zeotropic blend is measured as a drop-in substitute. An in-house experimentations test facility was developed. The experiments are conducted under various charge condition to find optimum charge. Experiments were conducted at constant load condition. The optimum charge is measured as 60 g with R290/R600a (50/50%) zeotropic blend and the lowest temperature is recorded as -3.5°C.

Peer-review under responsibility of the organizing committee of RAAR 2016.

Keywords: Hydrocarbons, zeotropic blends, refrigerator

1. Introduction

CFCs and HCFCs are the potential contributor to the global warming. There is an urgent need to phase out traditional refrigerants (CFCs and HCFCs). Hydrocarbons can be the option for the replacement of CFCs and HCFCs. Hydrocarbons have good thermo dynamical properties [1] and they are universally available at low price. The absence of chlorine atoms from hydrocarbons results in zero ozone depletion potential and negligible GWP [2]. Further, by blending of the hydrocarbon in the proper proportionate, properties can be tailor made and used as the drop in substitute.

* Corresponding author. Tel.: 91 2140275142; fax: 91 2140275140.
E-mail address: neeraj.titan@gmail.com

Peer-review under responsibility of the organizing committee of RAAR 2016.
doi:10.1016/j.egypro.2017.03.051

A sizable amount has been done to find the suitable replacement for R12, R22 and R134a. Richardson and Butterworth [3] demonstrated propane/Isobutane mixture can be used as 'drop in' replacement for R12 in VCC system and can achieve higher level of COP. Jung et al. [4] tested a propane/isobutane (R290/R600a) mixture in domestic refrigerator. 465 L unit required only 85 g which is 44% of the CFC12 charge while 299 L unit required only 90 g, which was 58% of the CFC12 charge. Bodies et al. [5] carried thermodynamic study of domestic refrigerators with propane/butane mixture.

Suryawanshi et al. [6] reported propane (R290) can be a replacement for R22 in window air conditioner. They reported that with the same COP, the specific refrigeration capacity of R290 is about 40% greater than R22. Rahman and Rahman [7] studied the hydrocarbon as refrigerant for window air conditioner. It is reported that use of R290 refrigerant reduces energy consumption up to 11%. Amount of refrigerant required by R290 is relatively half of that required by R22 refrigerant.

Sattar et al. [8] investigated the butane, isobutane and their mixture as an alternative to R134a in domestic refrigerator. The results show that the compressor consumed 3% and 2% less energy than that of HFC-134a at 28°C ambient temperature. Fatouh and Kafafy [9] reported that propane/isobutane/n-butane mixture with 60% propane is the best drop in replacement for R134a in domestic refrigerator. Dalkilic and Wongwises [10] compared the performance of vapour-compression refrigeration system using various non-azeotropic mixed refrigerants. It is shown that HC290/HC600a (40/60 by weight %) and HC290/HC1270 (20/80 by weight %) are good alternatives for R12 and R22, respectively.

In the present work an experimental studies are carried out on an existed 134a domestic 165 litre refrigerator charged with R290/R600a (50/50%) zeotropic blend and 134a with the optimization of the charge in the hot and humid conditions.

2. Development of test facility

2.1. Experimental setup

An in-house test facility (Fig. 1) is developed on a R134a domestic refrigerator of 180 L capacity consists of an evaporator, wire mesh air-cooled condenser and hermetically sealed reciprocating compressor and necessary measuring instruments. Temperature is measured by employing RTD PT-100 thermocouple at the different locations and pressure measurement is done by conventional bourdon pressure gauge (Fig. 1). Power consumption is measured by a wattmeter (Model EM306A) in each test run. Charge is measured by weighing machine (Model SF 400A).

2.2. Charge selection

The standard charge amount is 140 g R134a of the chosen existed domestic refrigerator. It is reported that the quantity of charge required is just half with hydrocarbon refrigerants in comparison to R134a refrigerant owing to high latent heat of hydrocarbons [1].

In order to charge the zeotropic mixture, isobutane which is a less volatile component (and lower vapour pressure than R290) is charged in gas state first and later propane is added to make a desired mixture. All the working fluids must possess purity of more than 99.5%.

2.3. Test procedure

The system was evacuated and kept for 15 minutes before charging. The experiments are performed after reaching steady state at desired evaporator temperature with consideration of constant ambient temperature.

Initially 120 g R134a was charged in the refrigerator. Subsequently, charge amount was increased by 20 g for every next test. Four sets of test were conducted using 120 g, 140 g, 160 g and 180 g quantity of charge and performance parameters were calculated. Latter the refrigerator was charged with R290/R600a (50/50%) blend starting with 40 g charge and incremented by 20 g. In each test load was kept constant in the freezer and ambient conditions were also constant.