INTERNATIONAL JOURNAL OF REFRIGERATION 33 (2010) 553–557

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ijrefrig

Nucleate boiling heat transfer coefficients of R1234yf on plain and low fin surfaces

*Ki-Jung Park, Dongsoo Jung**

Department of Mechanical Engineering, Inha University 253 Yonghyun-dong, Nam-gu, Incheon, 402-751 Korea

ARTICLE INFO

Article history:
Received 30 July 2009
Received in revised form
14 December 2009
Accepted 21 December 2009
Available online 4 January 2010

Keywords:
Heat exchanger
Evaporator
Experiment
Measurement
Heat transfer
Nucleate boiling
R1234yf
Plain surface

ABSTRACT

In this study, nucleate boiling heat transfer coefficients (HTCs) of HFC134a and R1234yf were measured on a flat plain and low fin surfaces. All data were taken at the liquid pool temperature of 7 °C on a small horizontal square copper plate (9.53 mm × 9.53 mm) at heat fluxes from 10 kW m^{-2} to 200 kW m^{-2} with an interval of 10 kW m^{-2}. Test results show that the nucleate boiling HTCs of R1234yf are very similar to those of HFC134a for two surfaces tested. Conventional boiling correlations can be used for the design of evaporators and boilers with R1234yf.

Coefficients de transfert de chaleur lors de l'ébullition nucléée de R1234yf sur des ailettes basses à surface lisse

Mots clés : Échangeur de chaleur ; Évaporateur ; Expérimentation ; Mesure ; Transfert de chaleur ; Ébullition nucléée ; R1234yf ; Surface plane

1. Introduction

For the past few decades, CFCs have been widely used in various refrigeration and air-conditioning applications. They, however, were found to be responsible for the destruction of the stratospheric ozone layer and thus in 1987, the Montreal protocol was proposed to phase out the ozone depleting substances (UNEP, 1987). Thanks to the Montreal protocol,

* *Corresponding author*. Tel.: +82 32 860 7320; fax: +82 32 868 1716.
E-mail address: dsjung@inha.ac.kr (D. Jung).
0140-7007/$ – see front matter © 2009 Elsevier Ltd and IIR. All rights reserved.
doi:10.1016/j.ijrefrig.2009.12.020

Nomenclature

A	heat transfer area of flat test section (without fins) (m^2)
GWP	global warming potential
h	heat transfer coefficient (W m^{-2} K^{-1})
k	thermal conductivity (W m^{-1} K^{-1})
LCCP	life cycle climate performance
MAC	mobile air-conditioner
ODP	ozone depletion potential
P	pressure (kPa)
Q	heat flow rate (W)
q	heat flux (kW m^{-1})
T	temperature (K or °C)

Greek letter

μ	viscosity (Pa s)
σ	surface tension (N m^{-1})

Subscripts

f	saturated liquid
g	saturated vapor
l	liquid
r	reduced property
s	surface of flat test section (without fins)
sat	saturation

CFCs were entirely phased out in developed countries from 1996 while they will be completely removed from 2010 in developing countries.

In order to fill the gap caused by the phase out of CFCs, refrigeration and air-conditioning industry has carried out extensive research and development activities to find alternative refrigerants whose ozone depletion potential (ODP) is 0. As a result of these efforts, HFC134a has been successfully developed and adopted in new mobile air-conditioners (MACs) for the past decade. HFC134a is known to have a similar vapor pressure and performance as CFC12. Recently, global warming has been the one of the most important issues facing mankind and in 1997, Kyoto protocol was proposed to control greenhouse gases including HFCs (GECR, 1997). Consequently, HFC134a was identified as one of the controlled greenhouse gases. The global warming potential (GWP) of HFC134a is 1430 as compared to that of CO_2. Therefore, it needs to be replaced by more environmentally friendly refrigerant in the near future. In fact, EU F-Gases Regulation and MAC directive bans the use of HFC134a from 2011 in MACs of newly manufactured vehicles for environmental protection (OJEU, 2006). The same MAC directive specifically prohibits the use of fluorinated greenhouse gases whose GWP is greater than 150.

Recently, R1234yf has been proposed as a possible alternative refrigerant for HFC134a (Minor and Spatz, 2008; Zilio et al., 2009). R1234yf has zero ozone depletion potential (ODP) and excellent Life Cycle Climate Performance (LCCP) compared to HFC134a. The 100 year GWP of R1234yf is 4 as compared to carbon dioxide (Nielsen et al., 2007) and hence R1234yf meets the EU regulations.

Since R1234yf is a new refrigerant, measured heat transfer data are not available in the literature. For fast conversion of MACs and other refrigeration systems with R1234yf, boiling heat transfer coefficients (HTCs) are needed for evaporator design. The objectives of this paper are to measure nucleate boiling HTCs of R1234yf on a flat plain and low fin surfaces and to provide the data to the refrigeration industry for the design and manufacture of high efficiency evaporators.

2. Experiments

2.1. *Experimental apparatus*

Fig. 1 shows the schematic of the experimental apparatus for nucleate pool boiling heat transfer tests with high vapor

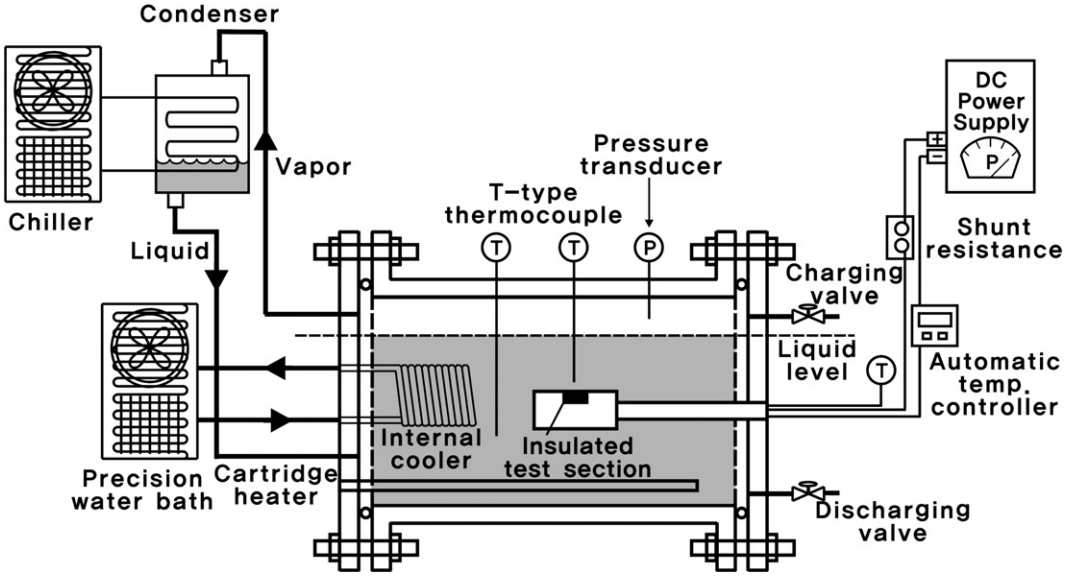

Fig. 1 – Schematic of pool boiling test facility using a small flat heater.