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International Journal of Refrigeration 30 (2007) 282–289
REVUE INTERNATIONALE DU FROID
INTERNATIONAL JOURNAL OF
refrigeration
www.elsevier.com/locate/ijrefrig

Effects of accumulator heat exchangers on the performance of a refrigeration system

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Received 28 March 2006; received in revised form 10 July 2006; accepted 10 July 2006
Available online 11 September 2006

Abstract

An accumulator heat exchanger (AHX) consists of an accumulator and an inner heat exchanger (IHX) contained in a shell. The AHX has been used in multi-air-conditioners to obtain system reliability and high performance by providing liquid refrigerant into expansion devices and preventing wet-compression. Energy is exchanged between the evaporator exit and the condenser exit in the AHX. In this study, the heat transfer characteristics of the AHX were investigated experimentally, and the effects of the AHX on the performance of a refrigeration system using R22 were measured. The operating characteristics of the refrigeration system with the AHX were considerably different from those without the AHX. The AHX system showed higher refrigerant flow rate than the non-AHX system at a constant EEV (electronic expansion valve) opening because of higher subcooling, resulting in better performance and reliability of the refrigeration system. At 50% EEV opening, the cooling capacity and COP of the AHX system were higher than those of the non-AHX system by 7.5% and 3.2%, respectively.
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Keywords: R22; Refrigeration system; Air conditioning; Experiment; Heat Exchanger; Sous-refroidissement; Performance; COP

Impacts des échangeurs de chaleur à accumulation sur la performance d'un système frigorifique

Mots clés : R22 ; Système frigorifique ; Conditionnement d'air ; Expérimentation ; Échangeur de chaleur ; Sous-refroidissement ; Performance ; COP

1. Introduction

Multi-air-conditioners, which have multi-indoor units with one outdoor unit, use lengthy connecting pipes between indoor units or between indoor and outdoor units. As the length of the connecting pipe increases, the refrigerant may flash at the inlet of the expansion device, reducing the refrigerant mass flow rate and causing irregular distribution

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doi:10.1016/j.ijrefrig.2006.07.009

Nomenclature

COP	coefficient of performance
c_p	specific heat (kJ/kg °C)
CR	compression ratio
h	enthalpy (kJ/kg)
m	refrigerant mass flow rate (kg/h)
P	pressure (kPa)
Q	heat transfer rate (W)
SC	subcooling (°C)
SH	superheat (°C)
T	temperature (°C)
W	power consumption (W)

Superscripts

$'$	condition for AHX installation
$''$	condition for non-AHX installation

Subscripts

accum	accumulator
c	condensation
cond	conduction
comp	compressor
disc	discharge port of compressor
e	evaporation
i	inlet
o	outlet
r	refrigerant
suct	suction port of compressor
w	water

of refrigerant to the multi-indoor units. Therefore, the inlet of the expansion device should be subcooled appropriately to obtain the optimum system capacity and reliability. An accumulator heat exchanger (AHX), which is an accumulator containing an inner heat exchanger (IHX), has been applied in multi-air-conditioners to achieve this optimum subcooling level and to prevent wet-compression in the compressor. Since the AHX contains an IHX internally, an installation space can be saved.

The effects of the AHX and IHX on the cycle performance have been studied by several researchers. Meyer and Wood [1,2] developed a mathematical model for the heat transfer characteristics in an AHX. They experimentally verified their model and AHX design procedure [2]. Mei et al. [3] investigated the effects of an AHX on a window type air-conditioner. Navarro-Esbri et al. [4] tested the influence of an internal heat exchanger on the energy efficiency of a single-stage vapor compression unit working with R22, R134a and R407C. Klein et al. [5] analytically estimated the performance of a refrigeration system using liquid-suction line heat exchangers. Domanski et al. [6] also developed a theoretical model to estimate the effects of a liquid-suction line heat exchanger on the cycle performance. Aprea et al. [7] evaluated the possible advantages of a suction/liquid heat exchanger from a thermodynamic point of view.

The effects of internal heat exchangers on unitary refrigeration systems have been studied analytically and experimentally. However, experimental studies on the operating characteristics of the AHX and its effects on the performance of a multi-air-conditioner have been very limited. Especially, the influence of the EEV opening, which is an efficient flow control parameter of multi-air-conditioners, on the performance of the AHX system has been rarely reported in the literature. This study reports the heat transfer characteristics of the AHX with the variations of refrigerant mass flow rate and inlet conditions of the accumulator and IHX. In addition, the effects of the AHX on the refrigeration system were compared with those of the non-AHX system for various EEV openings.

2. Experimental setup and test procedure

2.1. Experimental setup

Fig. 1 shows the schematic of the experimental setup. This experimental setup was designed to evaluate the performance of the AHX and the effects of the AHX on the refrigeration system. The experimental setup consisted of a vapor compression refrigeration system, constant temperature baths, and a control-measurement system. The refrigeration system consisted of a scroll compressor, a water-cooled condenser, a receiver, an EEV, a water-heated evaporator and the AHX. Two constant temperature baths were used to supply hot water and chilled water to the evaporator and the condenser, respectively. The control-measurement system included an EEV driver, controllers, and a data acquisition system.

The hermetic scroll compressor using R22 had a compression volume of 49.5 cc per revolution. The rated cooling capacity and power input at the ARI test condition were 10.81 kW and 3.25 kW, respectively. The refrigerant flow rate was controlled by the EEV with an orifice diameter of 1.8 mm. The EEV had a maximum stroke of 2.65 mm and a full opening of 500 steps.

Fig. 2(a) and (b) show the configuration of the AHX and the thermodynamic process of the refrigeration system in a pressure–enthalpy diagram, respectively. Table 1 shows the specification of the AHX used in the experiments. The subcooling and superheat can be increased by the heat exchange between the condenser exit and the evaporator exit in the AHX. The increase of subcooling can prevent the generation of flashing gas at the inlet of the expansion device. Generally, flashing gas can be generated by the pressure drop or heat gain in the connecting pipes between the indoor

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