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Performance analysis on a multi-type inverter air conditioner

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Abstract

An analysis was conducted for a multi-type inverter air conditioner with a linear electronic valve as the expansion device and a variable speed compressor. The system performance was analyzed with variations of operating frequency of the compressor, cooling load imposed on the system and cooling load fraction (i.e. load ratio) between rooms in which is installed an evaporator. The optimum opening of the electric expansion valve (EEV) was calculated when the compressor operating frequency was specified at a given cooling load. As compressor operating frequency increased with cooling load increment, the EEV should have adjusted to get wide openings to get an optimum COP of the system. While total cooling load of the system was constant, the cooling load fraction changed due to the cooling load differences between each room in the multi-type air conditioning system with a number of evaporators and EEVs. The operating frequency of the compressor was increased with increment of the load ratio, and consequently, the power consumption of the compressor increased. The increment of the load ratio, which means increasing the load difference between each room, causes a reduction of the system performance (COP), although the total cooling capacity was constant.

Keywords: Multi-type air conditioner; Variable speed compressor; Electric expansion valve; Load ratio

1. Introduction

Air conditioners are the necessities of life at home and in public areas due to the large demand for comfort in the thermal environment of living space in modern society. The conception of air conditioning has now developed from one air conditioner for one house to independent air conditioning for separate rooms. A multi-type air conditioner is the system that could distribute

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Nomenclature

A	area (m)
C_D	coefficient of discharge for orifice equation
D	diameter (m)
F_{sh}	superheat correction factor
F_v	volumetric efficiency correction factor
g	gravity (m/s^2)
h	enthalpy (kJ/kg)
$\dot{m}$	mass flow rate (kg/s, lb m/h)
P	pressure (Pa)
T	temperature (K)
v	specific volume (m^3/kg)
$\dot{W}$	compressor power (kW)

Greeks

ρ	density (kg/m^3)
γ	specific weight (kgf/m^3)

Subscripts

act	actual
c	condenser
e	evaporator
map	map data
i	inlet
isen	isentropic
r	refrigerant
sat	saturation
o	outlet

cooling capacity to different spaces. The system consists of a number of indoor units and only one outdoor unit. The electric expansion valves (EEVs) control the capacity of the system with varying refrigerant mass flow rates passing through the evaporators according to the cooling loads of each evaporator. Fig. 1 shows a schematic diagram of the multi-type air conditioner with two evaporators.

The load of the system is widely changed due to the system having a number of evaporator with only one outdoor unit. The performances of the compressor and the expansion device are affected by those load variations. A variable speed compressor was used in order to cover the load variation. The system with the variable speed compressor can control the cooling capacity by changing its operating frequency. However, there should be limits of control when the system uses constant area expansion devices, such as a capillary tube or a short tube orifice. Variable area expansion devices (like an EEV) are needed in multi-type inverter air conditioners to control the mass flow rate of the refrigerant concerning the variable speed compressor.