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Transient behavior evaluation of an automotive air conditioning system with a variable displacement compressor

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Abstract

In order to simulate the transient behavior of the automotive air conditioning (AAC) system with a variable displacement wobble plate compressor (VDC), a dynamic model which is consisted of a VDC, a finned tube evaporator, a parallel flow type condenser, a cross and absorptive charge H type thermal expansion valve, and a suction pipe is developed. Both the simulation results of control valve and experimental data of VDC indicate that transient process inside VDC can be ignored and the steady state model of VDC can be used in the dynamic simulation of AAC system. The method to calculate the variation of piston stroke length is proposed in the numerical solution procedure for dynamic simulation of AAC system. A test system is built with original components from an actual AAC system and the dynamic simulation results are compared with the experimental data. It is shown that the predicted results with the dynamic model agree well with the experimental data. Further simulation results show that: (1) whether the piston stroke length changes or not is determined by not only the changing values but also the changing direction of external parameters in the AAC system; (2) the variation of piston stroke length usually has a time lag when the external parameter varies; (3) there is a greater counter-regulation for the refrigerating capacity and compressor power consumption when the compressor rotary speed changes suddenly due to the adjustment of piston stroke length, which is different from the AAC system with a fixed displacement compressor.

Keywords: Air conditioning; Automotive; Variable displacement compressor; Transient behavior; Modeling

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Nomenclature

A	area (m^2)
A_i	interior surface area of heat transfer per meter pipe length (m^2/m)
$A_{i,tp}$	interior surface area of two-phase region in condenser (m^2)
A_o	exterior surface area of heat transfer per meter pipe length (m^2/m)
A_v	flow area of thermal expansion valve (m^2)
C_f	flow coefficient of thermal expansion valve
c	specific heat (J/(kg K))
d	diameter (m)
F	force (N)
f_s	friction factor
G	mass flux (kg/(m^2 s))
h	convective coefficient of heat transfer (W/(m^2 K))
i	enthalpy (J/kg)
K	heat transfer coefficient (W/(m^2 K))
k	elastic coefficient (N/m)
L	total length or arm of force (m)
l	length (m)
M	mass flow rate (kg/s) or force moment (N m)
m	mass (kg)
N_c	compressor rotary speed (r/min)
n	cylinder number
P_i	indicated power (kW)
Pr	Prandtl number
p	pressure (Pa or MPa)
Q	heat transfer rate (W or kW)
q	heat flux (W/m^2)
Re	Reynolds number
r	latent heat of vaporization (J/kg)
S_p	piston stroke length (mm)
T	temperature (°C)
t	time (s)
V_{tp}	volume of two-phase region in condenser (m^3)
v	specific volume (m^3/kg)
X	opening of TEV (m)
x	refrigerant quality

Greek symbols

α	void fraction
$\bar{\alpha}$	mean void fraction
Δp	pressure loss (Pa)