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Compressor efficiency with cylinder slenderness ratio of rotary compressor at various compression ratios

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ABSTRACT

When the air conditioning and heating systems operate in low speed regions, the efficiency of inverter compressor is relatively low, owing to the reduction in motor efficiency. Nevertheless, the annual operating time of compressor is largely occupied by low speed regions. Hence, experimental and numerical analyses were conducted to improve compressor efficiency in these regions, and various pressure conditions were considered. The significant difference in the volumetric efficiency with compression ratios was observed through the experiments. To reduce the decrease in volumetric efficiency at high compression ratio, a geometric combination of the compression part was considered through a numerical analysis. The numerical results showed that the volumetric efficiency at small cylinder slenderness ratio was relatively high and increased by about 6.3% at a compression ratio of 7. Then the cooling capacity increased by 8.77%, while the input work showed a relatively small increase of 2.44%.

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Rendement d'un compresseur avec rapport d'élancement cylindrique d'un compresseur rotatif à divers taux de compression

Mots clés : Taux de compression ; Rendement volumétrique ; Compresseur rotatif ; Paramètre de conception ; Élancement cylindrique

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Nomenclature

A	flow area [m^2]
B_t	vane thickness [m]
F_n	normal force between the vane tip and roller [N]
F_t	tangential force between the vane tip and roller [N]
F_h	gas force on the vane side [N]
F_d	gas force on the vane back side [N]
F_m	inertial force of the vane [N]
F_{fl}	film load [N]
h	enthalpy [kJ kg^{-1}]
H_c	cylinder height [m]
H_r	vane height [m]
k	specific heat ratio
l_v, l_{v2}	vane length protruding into the cylinder [m]
l_{total}	total vane length [m]
l_{slot}	cylinder slot length [m]
m_v	mass of vane [kg]
$\dot{m}$	mass flow rate [kg s^{-1}]
M_b	friction moment at roller face [N]
M_c	friction moment between the roller and eccentric [N]
N	revolution per minute [rev min^{-1}]
P	pressure [kPa]
P_{in},P_{out}	suction and discharge pressure [kPa]
P_r	compression ratio
R	gas constant [J kg^{-1} K^{-1}]
R_c	cylinder radius [m]
R_r	roller radius [m]
R_{ecc}	radius of eccentric [m]
R_1,R_2,$R_{t1}$$R_{t2}$	reaction force on the vane [N]
T	temperature [K]
T_{in},T_{out}	suction and discharge temperature [K]
V	volume [m^3]

Greek letters

θ	angular position of the crankshaft [rad]
δ_a	clearance between the roller face and bearing [μm]
δ_b	clearance between the roller and eccentric part [μm]
ε	eccentricity ratio
μ	friction coefficient
η	efficiency
ω	eccentricity ratio
ω_p	angular velocity of the roller [rev s^{-1}]

Subscripts

ad	adiabatic
b	suction chamber
c	compression chamber
comp	compressor
cl	clearance volume
cb	flow between suction chamber and compression chamber
con	control volume
dis	flow between clearance volume and muffler
eb	flow between back of vane and suction chamber
ec	flow between back of vane and compression chamber
lc	lower cavity
m	muffler
mech	mechanical
rb	flow between crank shaft and suction chamber
rc	flow between crank shaft and compression chamber
sp	suction pipe
uc	upper cavity
vb	flow passing through top and bottom of vane
v	volumetric

1. Introduction

Due to the increased interest in energy efficiency, inverter system instead of the conventional on/off control is being used in air conditioning and heating systems (Adhikari et al., 2012; Aprea et al., 2009; Chen et al., 2008; Qureshi and Tassou, 1996; Vittorini and Cipollone, 2016). According to the use of inverter system, the analysis of compressor characteristic at variable speeds has also become important. Fig. 1 shows the efficiency and annual operating time for the frequency changes of a DC inverter rotary compressor. The compressor efficiency is usually decreased according to the rise of compression ratio and decrease of operating speed. This behavior is attributed to the characteristics of the motor efficiency, lubrication and the leakage (Ekren et al., 2013; Futani and Shida, 1994; Inada et al., 2000; Piazza and Pucci, 2016; Yang et al., 2011). On the other hand, the annual operating time of a DC inverter rotary compressor tends to be concentrated in the low speed region because of the fine control of room temperature. Therefore, the

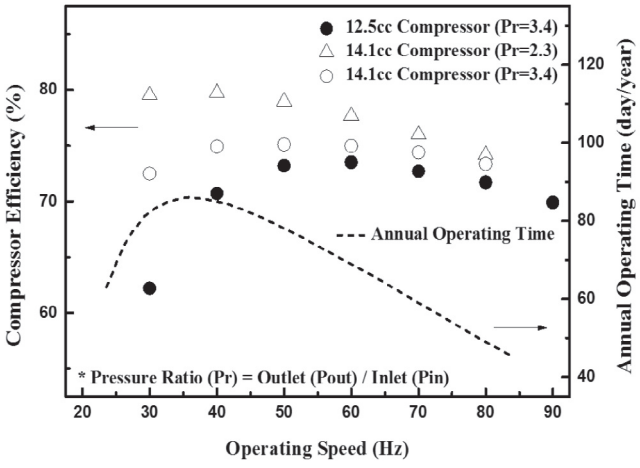

Fig. 1 – Compressor operating hours and inverter compressor efficiency. (●: experimental data for a 12.5 cc rotary compressor, △○: experimental data for a 14.1 cc rotary compressor).

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