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Optimization of an oil charge amount on electric driven scroll compressor for eco-friendly vehicle

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ABSTRACT

The purpose of this study is to optimize the amount of oil charge in the electric driven scroll compressor for eco-friendly vehicles. R134a is used as the refrigerant in the vehicle and Polyolester (POE) oil as the compressor oil. The initial amount of oil was increased at 20 g intervals from 40 g to 120 g, and at each initial amount of oil charge, the back pressure is measured at each step of the complex durability test and under each condition of the performance test. Throughout the test, it is found out that the optimum amount of oil is determined by the back pressure, which is 80 g in this test. The performance of a system is compared with pull-down tests in the actual air conditioning system, and the optimum amount of oil was confirmed. A complex durability test was also evaluated and verified for the durability of the compressor with the confirmed amount of oil.

Optimisation de la quantité de charge d'huile d'un compresseur à spirale électrique pour véhicule écologique

Mots clés : Compresseur à spirale ; Quantité optimale d'huile ; Système de conditionnement d'air à contre pression

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Nomenclature

POE	Polyolester
EEV	Electric expansion valve
OCR	Oil circulation ratio
EVA.	Evaporator
Cond.	Condenser
FSP	Field Simulation Pattern
P_d	Discharge pressure
P_s	Suction pressure
P_b	Back pressure
T	Temperature
T_s	Suction temperature
T_d	Discharge temperature
RH	Humidity
SH	Super heat
SC	Sub-cooling
$\dot{m}$	Mass flow rate
ρ	Density
V_{th}	Stroke Volume
N	Rotation speed of compressor
η_V	Volumetric efficiency

1. Introduction

Since the scroll compressor was introduced in 1983, demand for it and its application range have grown due to its high efficiency and reduced noise compared to other types of compressors (Tojo et al., 1984). In particular, in response to global environmental problems, the research and development has been focusing on hybrid and electric vehicles along with advanced air conditioner systems. Unlike the conventional gasoline engine, in a hybrid electric vehicle, the electric driven compressor is mounted in the air conditioning system.

The scroll compressor should be designed to circulate the appropriate amount of oil to the moving parts to reduce friction. The oil in the compressor prevents abrasion between parts and leakage of the refrigerant from the scroll compressor. In a back pressure type scroll compressor, the oil in the compressor is especially important both for performance and reliability because the hermetic sealing around the axial leakage gap is controlled by the back pressure force of the orbiting scroll bottom. However, compressor oil is discharged to the system when the refrigerant gas is compressed and released out of the system along with the discharge gas. Once oil from the compressor flows into the evaporator of the system, the heat transfer coefficient of the heat exchanger decreases and the overall performance of the refrigeration system declines. Thus, since the initial amount of oil in the compressor affects the oil circulation rate in the A/C system and system performance, the appropriate amount of oil should be determined for the best performance and durability of both the overall system and the air conditioning system (Sarntichartak et al., 2006).

In scroll compressors, various kinds of compliance mechanisms for axial and radial leakage are used. The eccentric or sliding bush is used for radial compliance, and a tip seal or back pressure type is used for axial compliance. A pressure chamber installed on the back side of the moving scroll part produces thrust against the other scroll part (Kim, 2002). A chamber in a back side of the orbiting scroll creates axial sealing between the two scrolls. The back pressure chamber is filled with mid-pressure controlled by a back pressure control valve. If back pressure force is less than axial gas force, the orbiting and fixed scrolls separate. Consequently, enlarged axial clearance results in leakage loss. If back pressure chamber force is excessively large, friction between the orbiting and fixed scrolls increases, resulting in mechanical loss and wear. Hence, proper design of back pressure is one of the most important factors in designing scroll compressors (Tojo, 1986; Bush, 1992, Lee, 1996; Tojo, 1998; Koo, 2008).

The initial amount of oil also affects air conditioning performance for electric driven scroll compressors. Too much oil decreases efficiency, and too little decreases the durability of the compressor. In addition, the weight of the compressor changes depending on the initial oil level. The weight of each automotive parts is very important for reducing fuel consumption.

Many studies have been carried out on the lubrication system and oil for a hermetic compressor in an air conditioning system (Drost, 1992; Shin, 1998; Bernardi, 2000). With regard to electric driven scroll compressors for vehicles, studies are rare in the open literature.

Therefore, the objective of the present study is to determine the appropriate amount of oil in the electric driven scroll compressor in the A/C system of real vehicles for environmentally friendly hybrid or electric vehicles. For the experiment, R134a is used as the refrigerant in the vehicle and Polyolester (POE) oil as the compressor oil. The temperature cross-over method was used to determine the optimum amount of refrigerant charge level for the system (Wandell et al., 1997). The oil amount was evaluated at 20 g intervals from 40 g to 120 g. The experiment was performed under conditions with the complex durability test steps and performance test of the A/C system of the actual vehicle. A complex endurance test of the compressor was carried out while charging the appropriate amount of oil, and durability was evaluated. The back pressure of the orbiting scroll lower part was measured at the stabilization range of the compressor motion. In addition, through a pull-down test of the air conditioner system, differences in the vent temperature for each amount of oil were measured. Based on the results, the minimum amount of oil was determined. The method of determining the proper amount of oil is also presented.

2. Experimental facility and procedure

2.1. *Experimental facility*

Fig. 1 shows the schematic diagram of the bench system of the vehicle air conditioning system for the experiment. The bench system is a device for measuring the back pressure at intervals under performance conditions and the complex durability test at the determined appropriate amount of oil. As described, the electric driven scroll compressor is used, which includes an AC/DC converter for operating the compressor. For the test,