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ABSTRACT

In order to realize a sustainable society, the switch from combustion heating to heat pump heating is greatly accelerating from consideration for environmental considerations, mainly in North America and Europe.

As problems of heat pumping, realization of high period efficiency and securing of high heating capacity at low outside air temperature are mentioned. Our original swing compression mechanism can realize high period efficiency from a structure with little refrigerant leakage, but in order to ensure high heating capacity at low outside air temperature, it was necessary to increase the refrigerant circulation amount under high differential pressure conditions. As a technology that enables this, an injection mechanism is adopted in the scroll compressor, but with a rotary compressor that compresses one at one turn, and a swing compressor, it is difficult to realize an injection mechanism that secures a sufficient injection amount due to factors such as high compression speed and difficulty securing the flow path area.

In response to this problem, the injection mechanism was installed on the side of the cylinder to increase the diameter and increase the amount of refrigerant circulation. Furthermore, by applying the check valve structure to the inside of the compressor, we have developed a swing compressor that minimizes volume loss and achieves high period efficiency.

1. INTRODUCTION

From the global warming and energy saving point of view, environmental protection is becoming a very important issue. Therefore heat pump type of heating is now greatly replacing combustion heating with environmental considerations in order to realize a sustainable society, mainly in North America and Europe.

It is necessary to achieve the high seasonal efficiency, operation with high condensation temperature (Tc) and high heating capacity at low ambient temperature, applying heat pump for heating equipment.
Figure 1 shows the change in heating capacity when the ambient temperature drops when using heat pump heating, and Figure 2 shows the maximum Tc that can be operated. When the ambient temperature drops, the heating capacity and the maximum Tc also drops.

A compressor with a large cylinder volume would increase heating capacity, but it reduces the seasonal efficiency and cannot operate with high Tc because of high temperature inside the compressor.

An injection mechanism, which is the technology that puts low temperature refrigerant during compression, is adopted with the scroll compressor to work out the issues above. But since rotary compressors and swing compressors compress once at one turn, compression speed is high and also sufficient flow passage is not assured, which made it hard to realize the injection mechanism with enough injection amount. Therefore, we installed an injection mechanism (side port injection) on the side of the cylinder to increase the diameter and the refrigerant circulation. In addition, we applied the check valve structure inside the compressor to minimize volume loss and developed the swing type compressor with high seasonal efficiency. High compression ratio operation and heating capacity are assured with this injection mechanism.

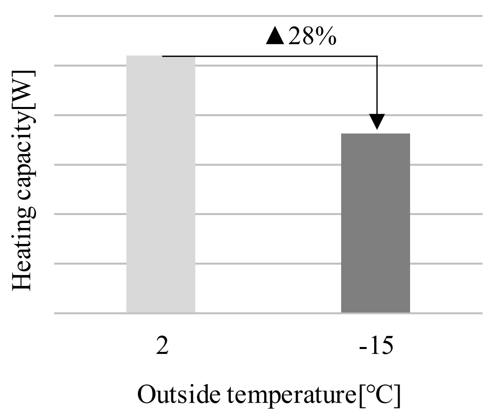

Figure 1: Relationship between heating capacity and outside temperature

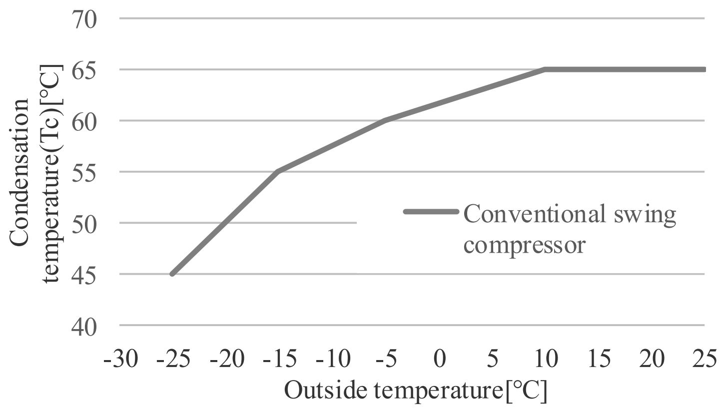

Figure 2: Relation between heating capacity and condensation temperature (Tc)

2. OVERVIEW OF SWING TYPE COMPRESSOR WITH SIDE PORT INJECTION

Figure 3 shows the mechanism of rotary type compressor and swing type compressor. Swing type compressors ensure high reliability and high efficiency by integrating vane and roller. Figure 4 shows a cross section of a swing type compressor with a side port injection mechanism.

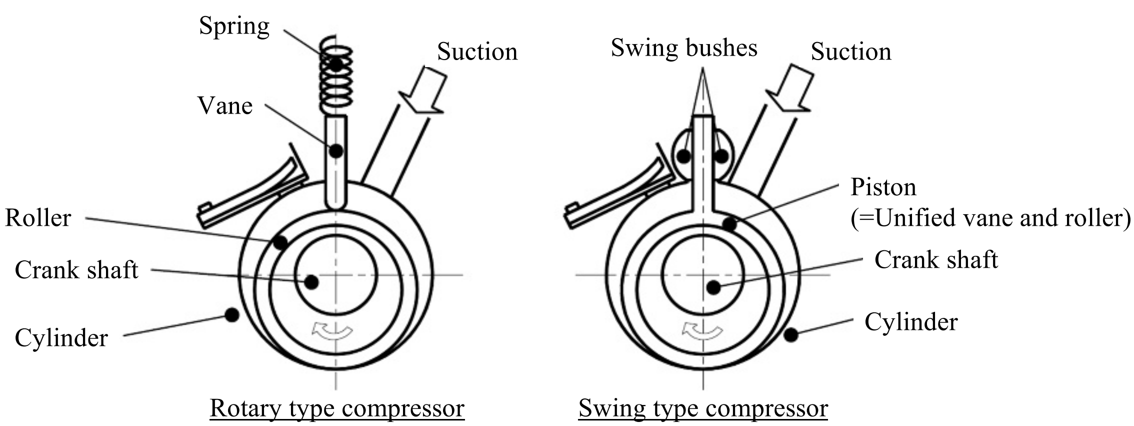

Figure 3: Mechanism of Rotary and Swing type compressor

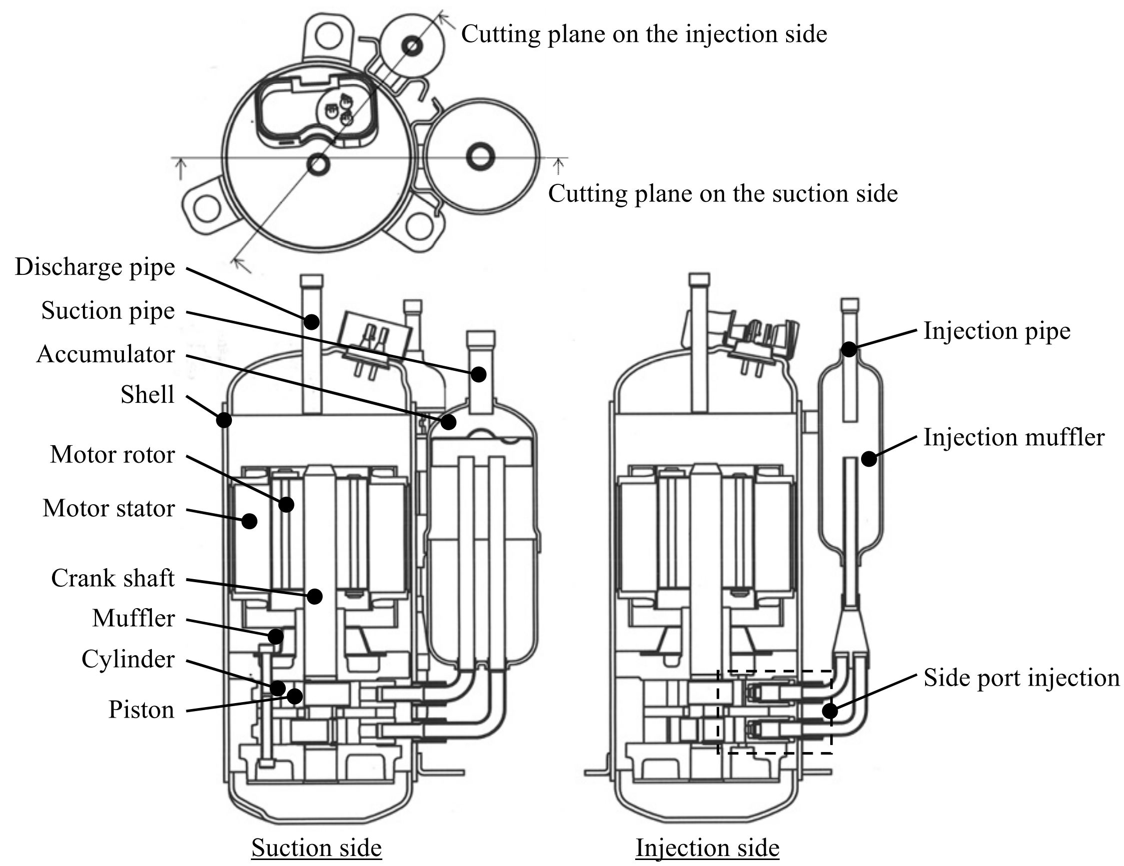

Figure 4: Cross sectional view of Swing type Compressor with side port injection

2.1 Features of side port injection mechanism

Figure 5 details the side port injection mechanism.

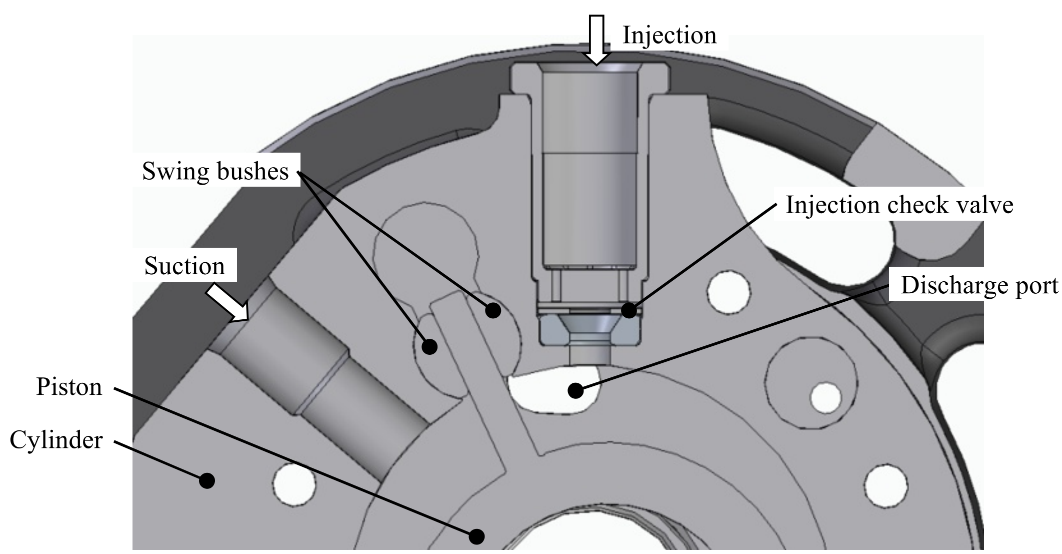

Figure 5: Details of side port injection mechanism

This mechanism is installed near the discharge port in the cylinder, and the injection refrigerant is put into the cylinder through this path. There is the injection check valve inside the injection mechanism to control the inflow of the injection refrigerant. Specifically, when the pressure of the injection refrigerant is higher than the compression chamber in the cylinder, the injection check valve opens so that the injection refrigerant flow into the compression chamber. Conversely, when the injection refrigerant pressure is lower than the compression chamber, the injection check valve closes to prevent refrigerant backflow from the compression chamber to the injection path.

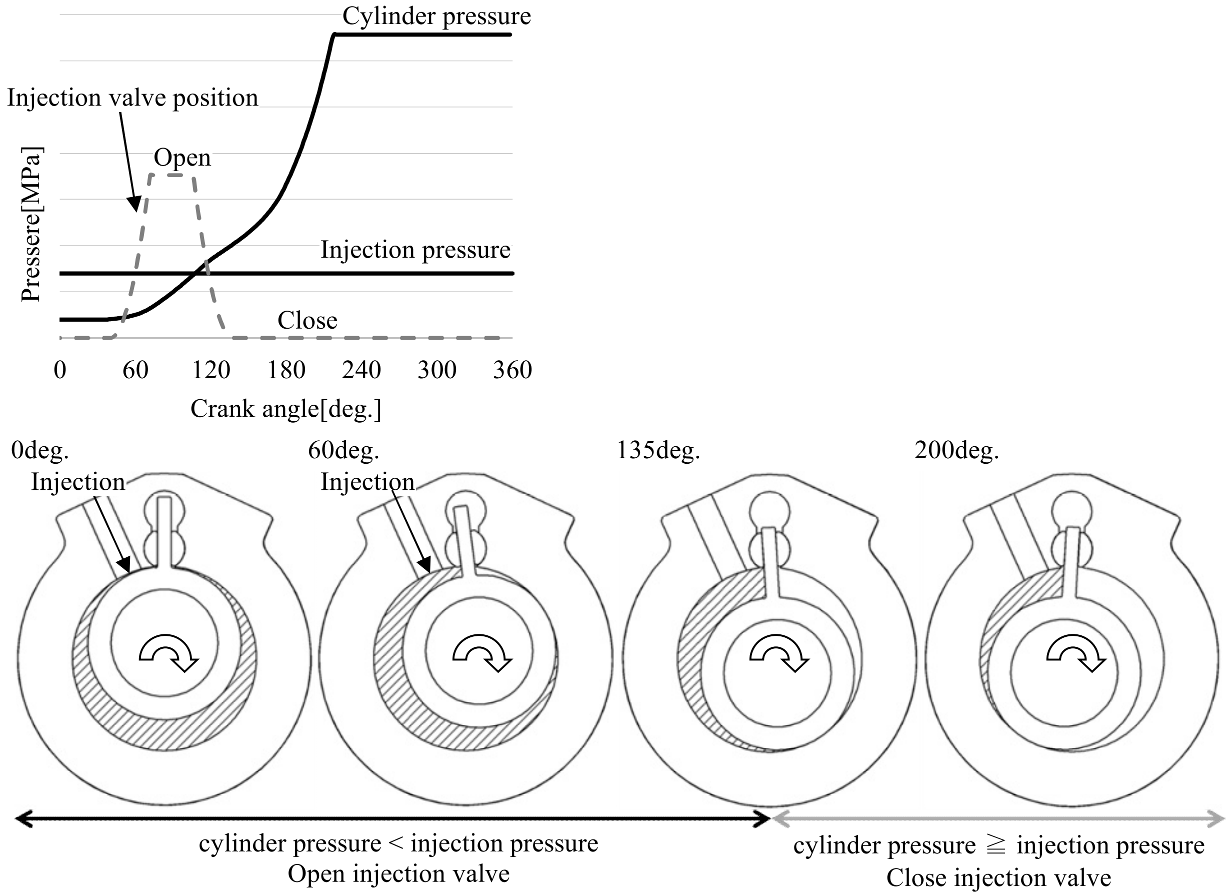

Figure 6: Relation between opening and closing of injection valve and cylinder pressure during one rotation

The port diameter is enlarged by installing a port on the side of the cylinder. The heating capacity is improved by enlarging port diameter. In addition, efficiency under high compression ratio conditions improved, adopting an injection check valve on the injection path to suppress the reduction in efficiency and to minimize dead volume.

Figure 7 shows the relationship between the injection port area and the amount of inflowing injection refrigerant. As the injection port area is increased, the amount of injection refrigerant gradually increases and reaches the maximum in a certain port area. On the other hand, if the port area is increased, the dead volume will increase and the efficiency will decrease. Therefore, we designed the injection port with the smallest diameter within the range where the amount of injection refrigerant required to secure the heating capacity can be obtained.

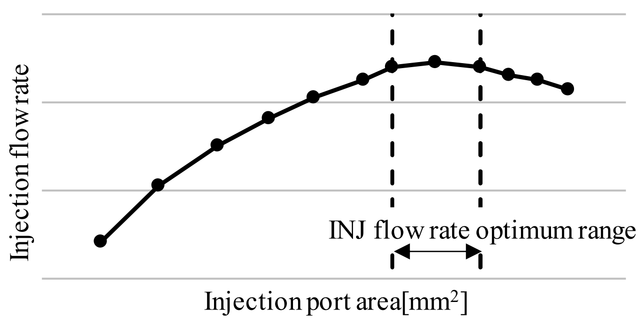

Figure 7: Relation between opening and closing of injection valve and cylinder pressure during one rotation

Table 1 shows the comparison data to the traditional injection mechanism. The port diameter enlarged and an injection check valve is applied, comparing the cylinder end face injection of the conventional model with the side port injection.

Table 1: Features of injection mechanism

	Traditional injection mechanism	**Developed injection mechanism**
Injection port position	Cylinder end face	Cylinder side
Injection port area size ration	1.0	7.8
Injection port opening / closing method	By the rotation of the piston	Check valve (By the difference between the injection pressure and the inside cylinder pressure)
Injection port check valve	None (Cannot be installed)	Yes
Injection port dead volume	Large volume	Very small volume

2.2 Improvement Result

Figure 8 shows heating capacity change by applying designed side port injection. The data in Figure 8 shows the heating capacity ratio at outside air temperature of minus 25 degrees Celsius with a compression ratio condition of 8 without injection. The heating capacity was improved 30% by employing side port injection.

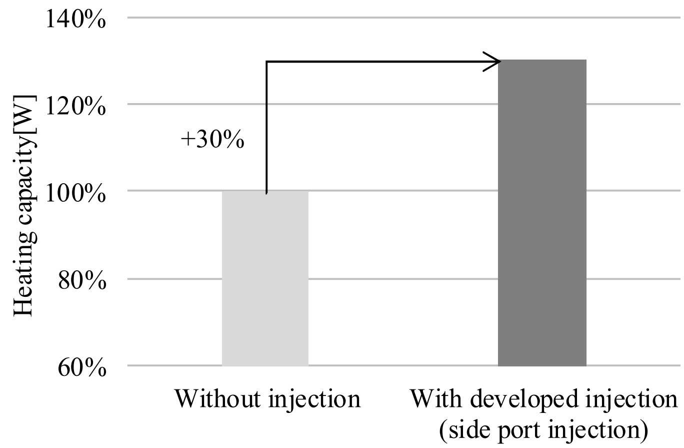

Figure 8: Heating capacity between with/without injection

In addition, the change in the maximum Tc that can be operated is shown in Figure 9.
By injecting a low temperature refrigerant, the internal temperature of the compressor can be lowered, and it is possible to operate without lowering the condensation temperature even at outside air temperature of minus 15 degrees Celsius.

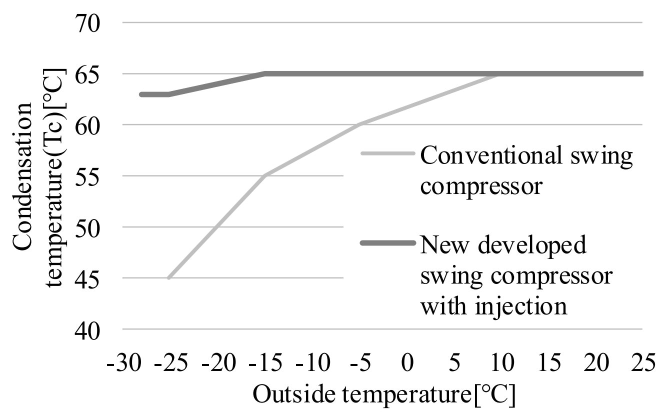

Figure 9: Heating capacity between with/without injection

Figure 10 shows the efficiency of compressors which has side port injection. The data in Figure 10 shows the efficiency of compressor at an outside air temperature of minus 15 degrees Celsius with a compression ratio of 11 without injection. The efficiency of compressor was improved 20% by employing side port injection.

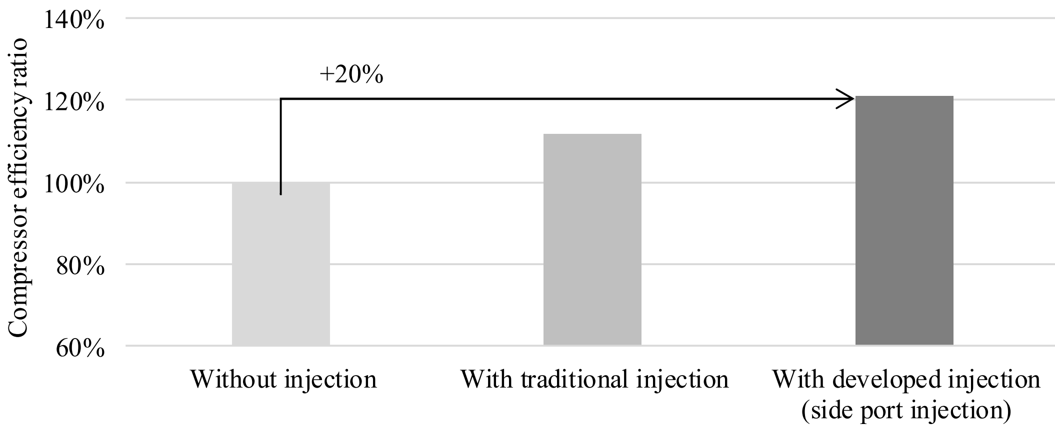

Figure 10: Efficiency ratio between with/without injection

3. CONCLUSIONS

Here is the summary of improvement for swing compressor employing the side port injection mechanism with check valve.

・Compared with the traditional model, the heating capacity of low outside temperature was improved by side port injection mechanism with check valve.
・By employing the side port injection mechanism with check valve, the efficiency was improved at low outside temperature and high compression ratio.

The improvement of heating capacity could be accomplished with technologies mentioned above.

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