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Development of Scroll Compressor of Improved High-Pressure-Housing

by

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ABSTRACT

According to urgent demands of the environment issue and the problem of reduction of compressor's efficiency caused by the thermodynamic properties of HFC, a new scroll compressor with an improved high-pressure-housing (motor : high pressure side, behind fixed scroll : low pressure side) that improves efficiency was developed .

The new technologies using both R22 and R407c was investigated, such as an improved high-pressure-housing, an asymmetrical scroll wrapped with compliance axial and radical mechanism, a discharge gas flow of cooling a motor and a high efficiency oil separator in a compressor.

As a result , the volumetric efficiency was improved by about 10 % , and also the indicated efficiency was improved by approximately 4.5 % , then the newly developed scroll compressor gained around 13 % improvement in COP.

In conclusion, the authors succeeded in developing a high efficiency scroll compressor that is capable of using both R22 and R407C refrigerants, simply by exchanging the conventional lubricants for new one.

1. INTRODUCTION

Recently it is necessary for air conditioning systems to improve the efficiency of the refrigerant compressors, because of increasing demands for the energy-saving. As HFC refrigerants are used in the place of HCFC refrigerants, it becomes very important to get back the compressor efficiency loss caused by the difference of their thermodynamic properties and the mechanical loss caused by the difference between the ether's viscosity with R407c and mineral oil with R22. This paper shows the new technologies to get a high efficiency scroll compressor for alternative

refrigerants, R22 and R407c.

2. CHARACTERISTICS OF THE DEVELOPED COMPRESSOR

2.1 DESCRIPTION OF THE DEVELOPED COMPRESSOR

The section of the developed scroll compressor is shown in Fig 1. The motor is placed in the higher pressure camber , and the compression constituent is the lower pressure chamber. The rated motor outputs are 1.9 kw to 3.75 kw , and the refrigerating capacities are 27600 to 66200 BTU/H (at ARI , 60Hz) for series of the developed compressors.

3. NEW TECHNOLOGY FOR HIGH EFFICENCY

3.1 IMPROVED HIGH PRESSURE HOUSING

As for pressure of the housings, there are some types, such as the low pressure housing with discharge gas chamber, the low pressure housing with direct discharge gas, the high pressure housing with suction camber or with direct suction, and so on. Those different types have some advantages and disadvantages on efficiency, reliability and costs. Therefore, those characteristics was investigated at the point of the reduction of heat losses, considering thermodynamics.

As a result of these investigations, the improved high pressure housing type scroll is the best for the high cop, in the range of 2.2kw to 6 kw, as shown in Fig 2. (On the other hand, the low pressure housing is the best in the capacity range of over 7.5 kw.)

While the improved high pressure housing has good characteristics to get high efficiency and to reduce heat losses, disadvantages of cooling motor must be improved to keep high reliability. In order to cool the motor in the higher pressure chamber, all of discharge gas is let flow from the orbiting scroll into the gas passage of the crank shaft and it is let flow through the effective oil separator to lower side of a motor. These technologies can keep a propriety to reduce heat losses and motor's temperature and less oil carry over.

3.2 ASYMMETRICAL SCROLL

Fig 3 shows the section of asymmetrical scroll wraps. The two suction ports formed by the fixed scroll and the orbiting scroll were gathered on one side. The discharge port was modified to stagger the discharge timing of two compression chambers, and to adjust each compression ratio. One compressed gas was discharged from the discharge, before the other compressor gas was discharged from the same port. So the over compression loss was reduced in comparison with the conventional symmetrical scroll wraps. Fig 4 shows P-V diagram of an asymmetrical scroll wrap.

In addition, the thickness of asymmetrical scroll warps is increased gradually from out side to inside, and is used for axial and radical compliance mechanism to improve the indicated efficiency and to reduce the leakage loss on the compression process of constituents.

3.3 OIL SEPARATOR

As well as known, the high level oil circulation ratio from a compressor to air conditioning systems causes to decrease the performance of heat exchangers, and to increase the crisis of bearing's failure caused by lack of oil in oil sump. It is important for a high efficiency scroll compressor to keep a low level oil circulation ratio. Therefore the relationship between the oil circulation ratio and several prameters (mass flow rate of refrigerant, shaft speed, oil amount in the discharge gas, leakage oil from oil supply line) was investigated as follows.

Fig5 shows the gas flow, the oil flow and the leakage oil pass of the compressor. An lubricant oil in oil sump is picked up by an oil tube of a crank shaft and supplied to a upper journal bearing and roller bearings. After lubricating both bearings, an oil drops to oil sump through a motor.

The first important technology is to keep the return oil away from the gas flow completely. Fig5 shows the result of the method to prevent the return oil around the upper bearing from leaking out of the high pressure chamber. Type A seal is the narrow gap seal, and Type B seal is formed with type A seal and the purge gas seal that a part of discharge gas is supplied to the gap between the housing and the crank shaft under the upper bearing. Type C seal is formed with Type B and a pressure groove around a shaft. As shown in Fig 6 , While high rotational speed of crank shaft increase an oil circulation ratio, Type C seal can keep the low level oil circulation ratio, because of the most effective method to keep the return oil away from the gas flow.

The second important technology is to separate the oil effectively from discharge gas. The discharge port of the crank shaft is surrounded by a newly developed demister, which is an oil separator made from rolls of fine wire net (the newly developed demister has dimples on its surface) . Fig 7 shows the result of those oil separator's characteristics. As increasing the oil amount in the discharge gas, the performance of demister is decreasing , so the oil circulation ratio is

increasing. Fig 6 also shows the difference of oil circulation ratio between with oil separator and without it.

As a result of these approaches, the oil circulation ratio was reduced by about 20 %, compared with the initial test result.

4. IMPROVED EFFICIENCY

Table 1 shows the result of efficiency of a newly developed scroll compressor of 2.5Hp and 5Hp, compared with a conventional scroll compressor. For example, the improved high-pressure-housing gained volumetric efficiency about 10 % . Asymmetric scroll wrap with compliant mechanism improved indicated efficiency by approximately 4.5 % .

As a result of these technologies, the newly developed scroll compressor gained around 13 % improvement in COP.

5.CONCULUTION

In conclusion, these approaches succeeded in improving the efficiency of scroll compressors and other technologies to keep high reliability of scroll compressors were also developed, such as nitriding roller bearings , dry bearings, preventing a liquid slugging with axial compliance mechanism, and so on. Then the high efficiency and reliability scroll compressor that is capable of using both R22 and R407c refrigerants was developed, simply by exchanging the conventional lubricants for new one.

6.REFERENCES

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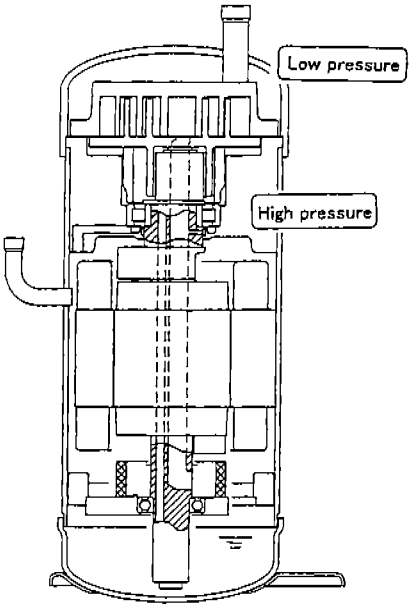

Fig 1 Cross section

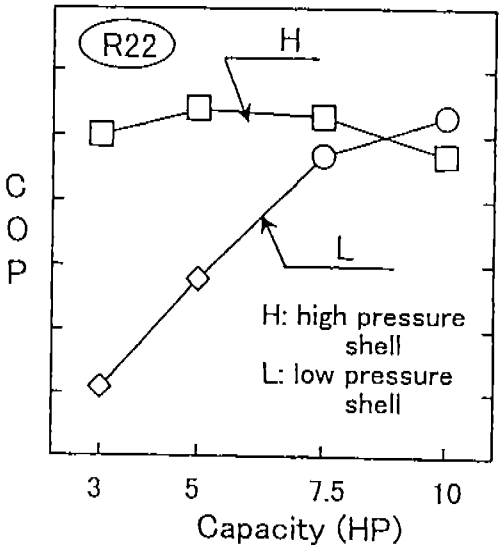

Fig 2

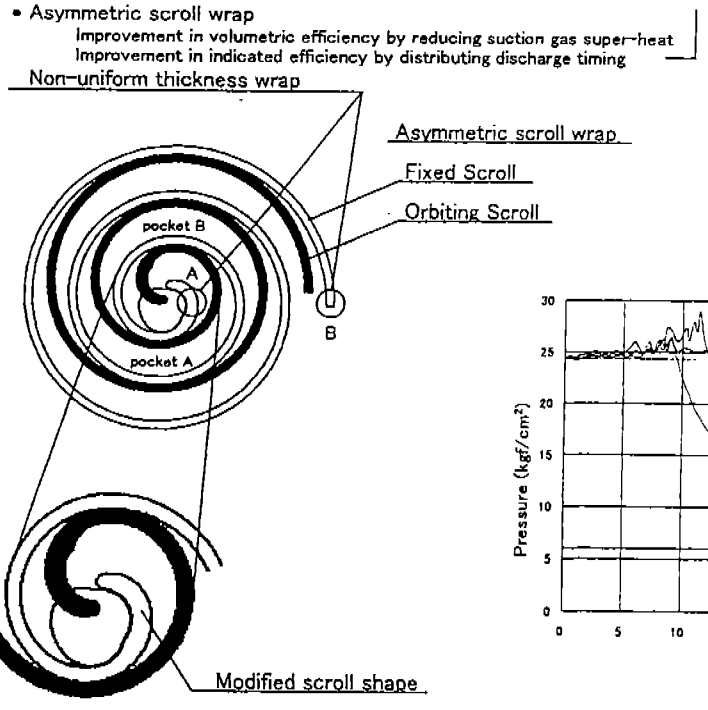

Fig 3

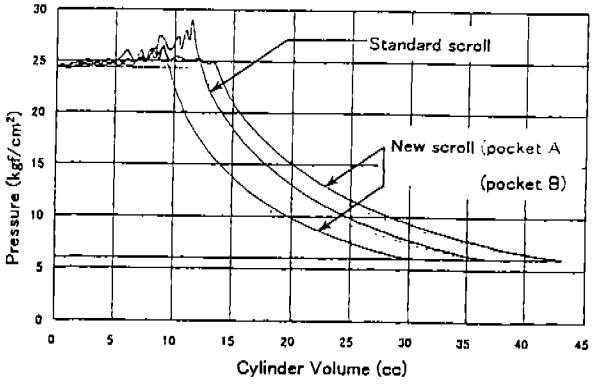

Fig 4

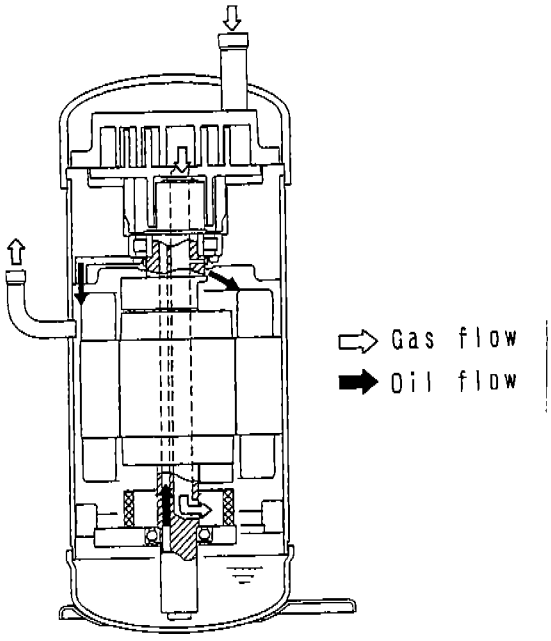

Fig 5 Gas and oil flow

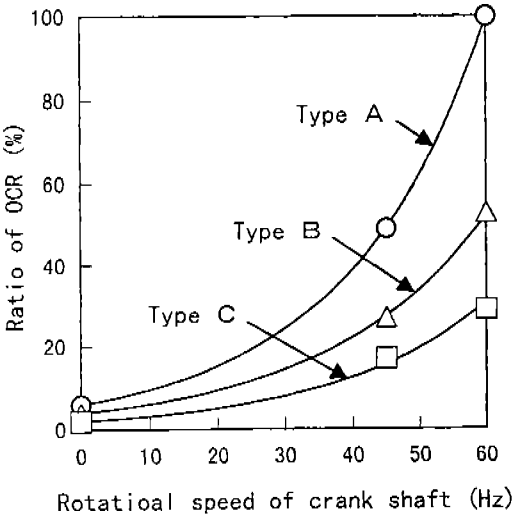

Fig 6 Relationship between OCR and rotational speed of crank shaft

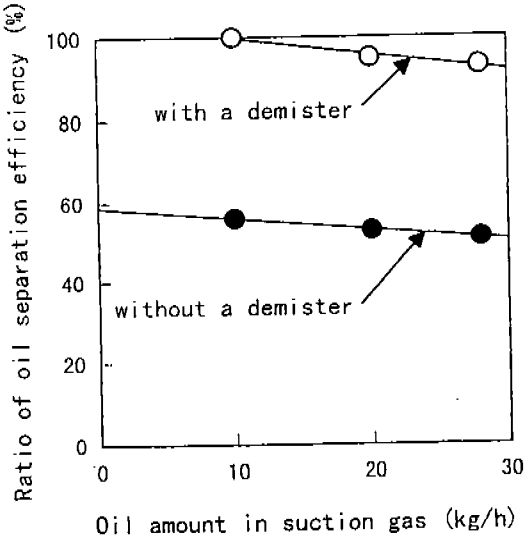

Fig 7 Effect of demister

	2.5 Hp	5 Hp
Volumetric Efficiency	110.3	107.8
Indicated Efficiency	104.5	103.3
Mechanical Efficiency	98.9	98.9
Motor Efficiency	98.9	98.9
COP	112.9	108.1

Table 1. Efficiency ratio to the conventional Scroll (= 100 %)