Small-size and Wide-range Scroll DC Inverter Compressor

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Mitsubishi Heavy Industries, Ltd. (MHI) is installing two high-efficiency scroll DC inverter compressors for 12 HP or higher multi air conditioner outdoor units. Now MHI has developed a small-size and wide-range scroll DC inverter compressor that has the best performance in the industry and can be used alone in air conditioner systems with capacities of up to 16 HP. This developed compressor attains significant improvement in the mountability of outdoor units, as well as reliability and resource conservation.

1. Introduction

MHI has been continuously improving the efficiency of compressors in order to reduce the power consumption (energy conservation) of air conditioning systems. In addition, space saving and resource saving of outdoor units are in higher demand in recent years. The trend in the industry is moving toward the downsizing and wider range (capacity enhancement) of the compressor.

MHI mounts more than one compressor on large multi air conditioning systems with a capacity of 12 HP or higher to ensure necessary capabilities. Now MHI has developed a small-size and wide-range scroll DC inverter compressor that has the best performance in the industry and can be used alone in air conditioning systems with capacities of up to 16 HP.

This paper reports on MHI's efforts on the developed compressor for the expansion of its range of operating capabilities, the improvement of efficiency and the enhancement of reliability.

2. Features of MHI's scroll compressors

2.1 Downsizing

Figure 1 shows a comparison of the external dimensions and weights between the developed small-size and wide-range scroll DC inverter compressor and existing compressors. The developed compressor results in space saving of 50% and a 25% weight reduction compared with the existing pair of compressors.

In addition, as we install the developed compressor, we can reduce the number of driver units to one, simplify the piping, and eliminate the oil equalizing control. Therefore the developed compressor is much more suitable for mounting on an outdoor unit, more reliable, and saves more resources.

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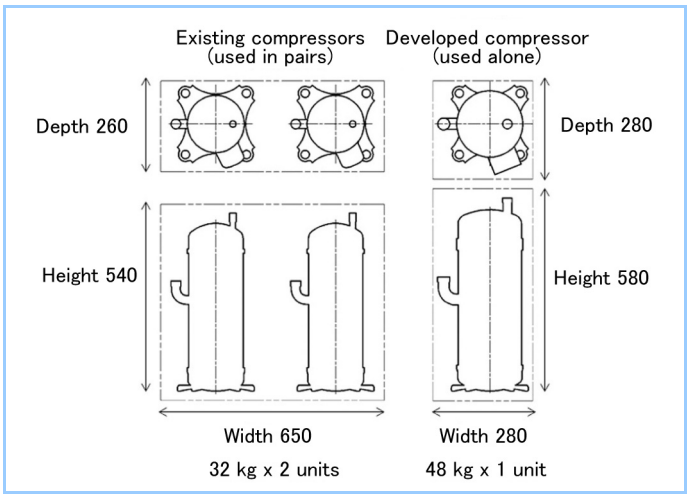

Figure 1 Comparison of physical size

2.2 Adaptability for wider range

Figure 2 shows the internal structure of the developed scroll compressor. This compressor uses the discharge cover as a bulkhead between the high and low pressure area. It has a low-pressure housing structure that contains the bearings and the motor in the low-pressure side.

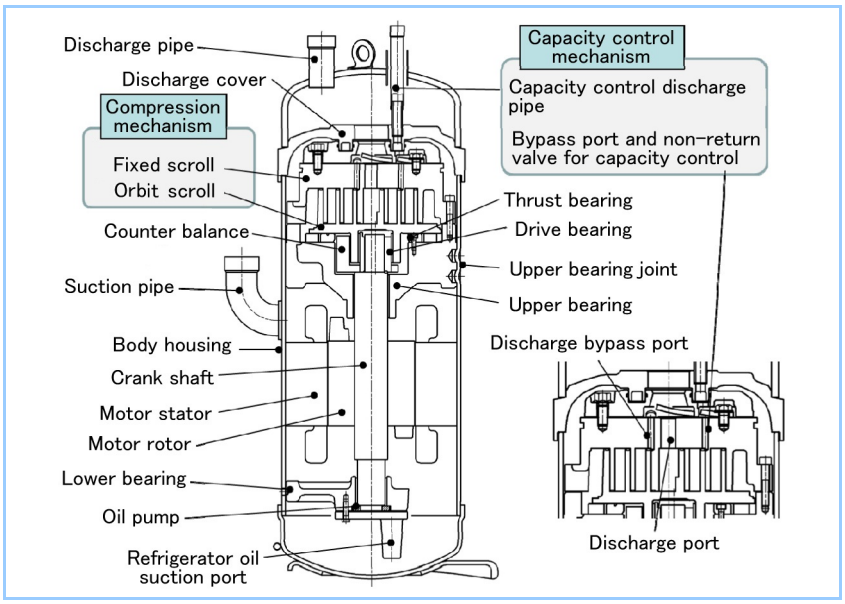

Figure 2 Internal structure of scroll compressor

The developed compressor enhances its capability by 70% compared with the existing compressor due to the enlargement of the scroll displacement volume and the use of a high-power DC motor. This enhancement of capacity results in an increase in the load borne on components and therefore requires ensuring reliability.

For example, for the joint between the upper bearing and the body housing, we increased the number of jointing points from three to six to cope with the increase in load, and suppressed stress generation to the same level as the existing compressor or lower, using strength analysis technology by finite element method (FEM), while maintaining mass productivity by manufacturing technology. In addition, the rigidity of the upper bearing itself is improved, resulting in reliability improvement of the entire shaft supporting system and a reduction of vibration and noise. **Figure 3** shows an example of FEM analysis of the upper bearing. **Table 1** shows the difference in stress generation resulting from comparing the upper bearing jointing methods.

Furthermore, by optimizing the bearing specifications, the oil pump capacity, the oil paths and other elements, reliability are higher than the existing compressor, even with the enhanced capacity.

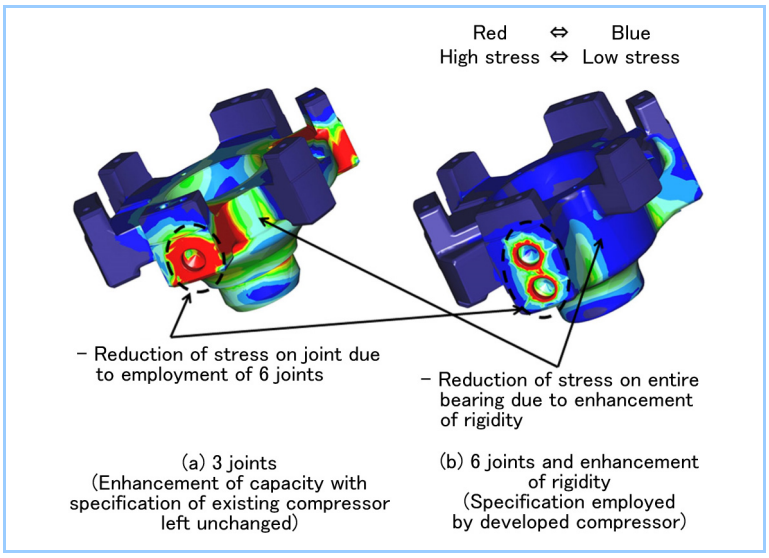

Figure 3 Comparison of stress on upper bearing

Table 1 Comparison of stress generation between jointing methods of upper bearing

	3 joints	6 joints
Existing compressor	100%	N/A
Developed compressor	137%	91%

The minimum capability of an indoor unit for multi air conditioning systems is unchanged regardless of whether the capability of the coupled outdoor unit is high or low, because one outdoor unit is coupled with multiple indoor units. Therefore compressors for multi air conditioning systems must satisfy their maximum capability for dealing with the high capacity of the outdoor unit, and minimum capability simultaneously for dealing with situations where only one indoor unit is operated. To satisfy the requirements for the minimum capability operation, the developed compressor had capacity control added, which bypasses the refrigerant suctioned in the scroll to the outside of the scroll during compression. This results in a reduction of the capability while avoiding unnecessary consumption of compression energy. The developed compressor has a bypass port for capacity control in an optimized size and position, which maintains high efficiency and simultaneously enables a minimum capability 30% lower than that of a single existing compressor. The minimum capability operation of the existing compressor is performed by repeatedly turning on and off the compressor, and therefore the room temperature fluctuates, resulting in a loss of comfort. In contrast, the developed compressor can perform continuous minimum capability operation and maintain a constant room temperature, resulting in an improvement of comfort. **Figure 4** shows the relationship between the maximum and minimum capabilities of an existing compressor and the developed compressor.

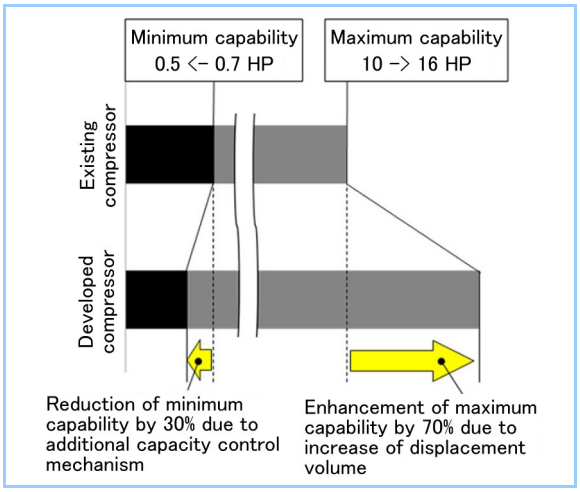

Figure 4 Comparison of minimum and maximum capabilities

2.3 Efficiency improvement

The developed compressor is designed so that refrigerant leakage loss during the compression process can be reduced by rigidity enhancement of the scroll and optimization of the leakage clearance inside the compression chamber, and also over-compression loss can be reduced by the employment of the discharge bypass port for avoidance of over-compression during the compression process. For dealing with the increase of refrigerant circulating volume because of the enhancement of capacity, the discharge port of the fixed scroll and the suction and discharge pipes of the compressor are optimized to suppress the increase of pressure loss in each path. In addition, the dimensions of the sliding components such as the journal bearing and the thrust bearing are optimized to reduce mechanical loss.

Due to these efforts, an improvement of cooling and heating average COP by approximately 6% and a 10% increase in APF have been attained compared with the existing compressor as shown in **Figure 5**.

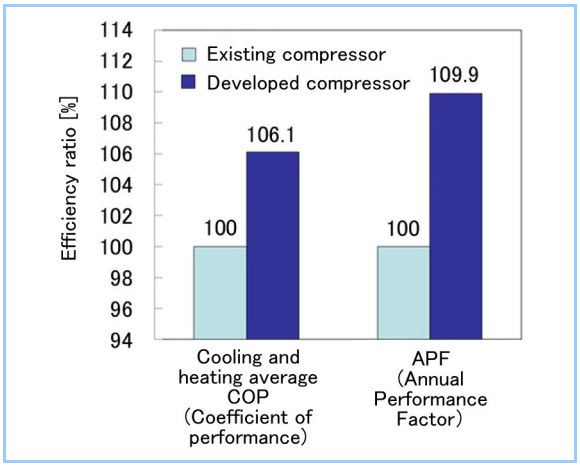

Figure 5 Comparison of efficiency

3. Conclusion

The developed small-size and wide-range scroll compressor allows one single compressor to deal with up to 16 HP multi air conditioning systems and attains significant improvement in mountability in outdoor units, the enhancement of reliability, resource conservation and industry-leading energy-saving performance. The developed compressor is used for the multi air conditioner KXZ series that will be launched in the spring of 2014.