Expansion of Products Equipped with Small, Highly Efficient 3D Scroll Compressors

HAJIME SATO
HIROYUKI KOBAYASHI
HISAO MIZUNO
TETSUZO UKAI
MAKOTO TAKEUCHI
YOSHIYUKI KIMATA

1. Introduction

Global efforts toward conserving energy have grown due to rising concerns about global warming. Because most energy consumed by refrigeration and air-conditioning appliances goes to the compressor, its efficiency must be improved to save energy.

Meanwhile, the installation space of refrigeration and air-conditioning appliances is often restricted. Reduction in the size and weight of each component, including the compressors, is therefore required to enhance installation flexibility.

Mitsubishi Heavy Industries, Ltd. (MHI) uses scroll compressors featuring high efficiency and low vibration in its major refrigeration and air-conditioning products to meet the demand for energy conservation. To improve efficiency even further while reducing size and weight, MHI has developed its innovative three-dimensional (3D) compression mechanism (3D scroll [note]) that adds axial compression to conventional radial compression. 3D scroll compressors are now in production for a variety of refrigeration and air-conditioning products.

This paper describes the features of the 3D scroll and the application of the 3D scroll compressor to refrigeration and air-conditioning products.

Note: "3D scroll" is a registered trademark of MHI.

2. Features of the 3D scroll

Figure 1 shows a cross-sectional view of the 3D scroll compressor for a commercial air-conditioner. The scroll compressor compresses the refrigerant using the mutual eccentricity of one fixed and one orbiting scroll, each composed of end plates and wrapped scroll blades. **Figure 2** shows cross-sectional views of conventional and 3D scrolls.

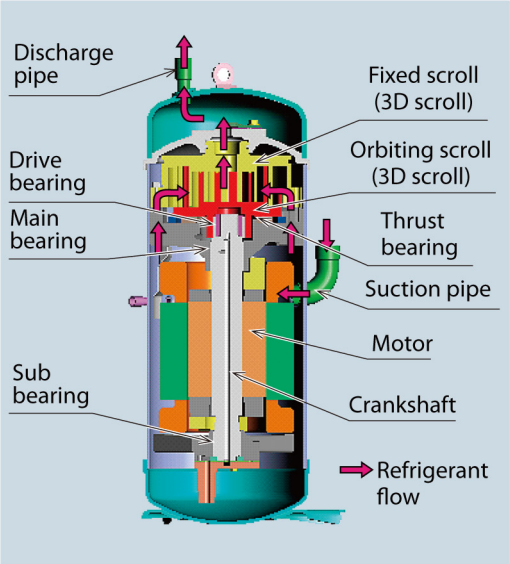

Figure 1 3D scroll compressor

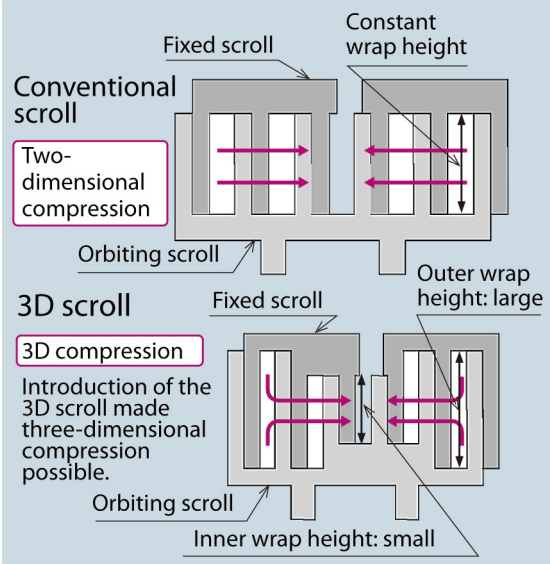

Figure 2 Cross-sectional view of conventional and the 3D scrolls

In conventional scrolls, the wrap height is constant throughout the compression process, and the refrigerant is compressed two-dimensionally from the outer to the inner sides. For the 3D scroll, the outer wrap is made higher than the inner wrap by installing steps in the scroll tips and the end plates. The 3D scroll is thus able to compress the refrigerant three-dimensionally in the axial as well as the radial directions. The 3D scroll has the following features.

- A high compression ratio is possible by radial and axial compression.
- The scroll is stronger and more reliable because of the reduced height of the inner wrap, which receives a heavy load.
- The scroll has a large capacity because the height of the outer wrap is greater, while the outer diameter of the scroll remains unchanged. The 3D scroll is therefore smaller and lighter.

3. Application of the 3D scroll to refrigeration and air-conditioning products

As described above, the 3D scroll is a high-performance compression mechanism with higher efficiency, greater reliability, smaller size, and lighter weight than conventional scrolls. This makes it suitable for specific applications such as refrigerators that require a high compression ratio and automotive air-conditioners in which miniaturization is essential. As shown in **Figure 3**, MHI has achieved significant improvement in efficiency and miniaturization in its current use of the 3D scroll in commercial air-conditioners[1], gas heat pump (GHP) air-conditioners[2], reefer truck refrigeration units[3], and automotive air-conditioners[4]. We discuss some examples of these improvements below.

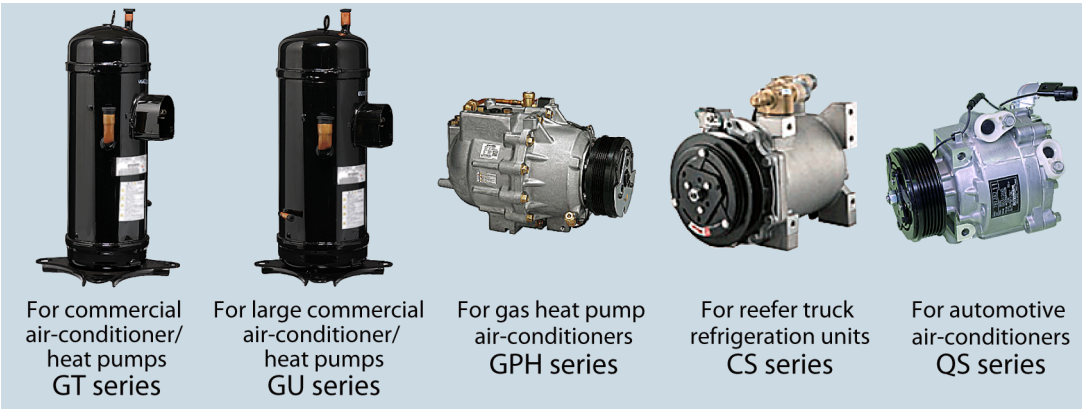

Figure 3 Compressor products equipped with the 3D scroll

3.1. Efficiency improvement

Figure 4 compares the efficiency of the conventional compressors with that of developed compressors equipped with the 3D scroll. The increase in compression ratio using the 3D scroll reduces the loss due to an insufficient compression ratio, and improves the efficiency under high compression ratio conditions. Creating a mechanism to bypass the gas in the compression process makes it possible to maintain high efficiency under low compression ratio conditions, resulting in high compression performance throughout the operating range[1]. Thus, use of the 3D scroll resulted in a 6% improvement in efficiency compared to conventional scroll compressors and a 15% improvement compared to conventional reciprocating compressors.

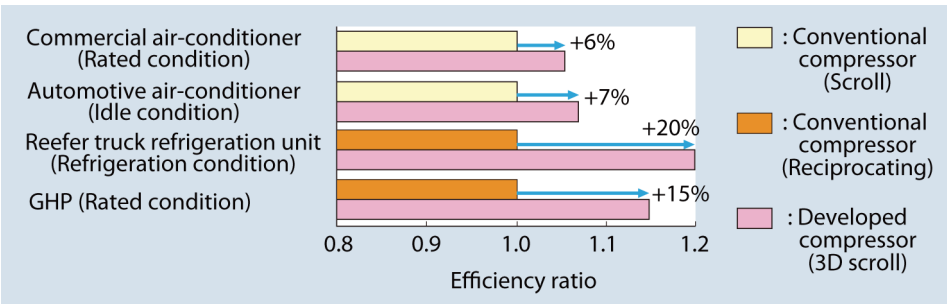

Figure 4 Comparison of efficiency with conventional compressors

3.2. Size and weight reduction

Figure 5 compares the outside dimensions of conventional compressors with those of the newly developed 3D scroll compressors. The capacity of the scroll compressor is determined mainly by the diameter of the scroll and the wrap height. In a conventional scroll compressor, any increase in the wrap height decreases the strength of the inner side of the scroll, so scroll diameter must be increased to increase the capacity. However, the introduction of the 3D scroll made it possible to increase the outside wrap height without increasing the inner wrap height. Thus, the capacity of the 3D scroll compressor was increased without enlarging the diameter of the scroll. Using this technology, the compressor size and weight are significantly reduced compared to conventional compressors, resulting in improved installation flexibility.

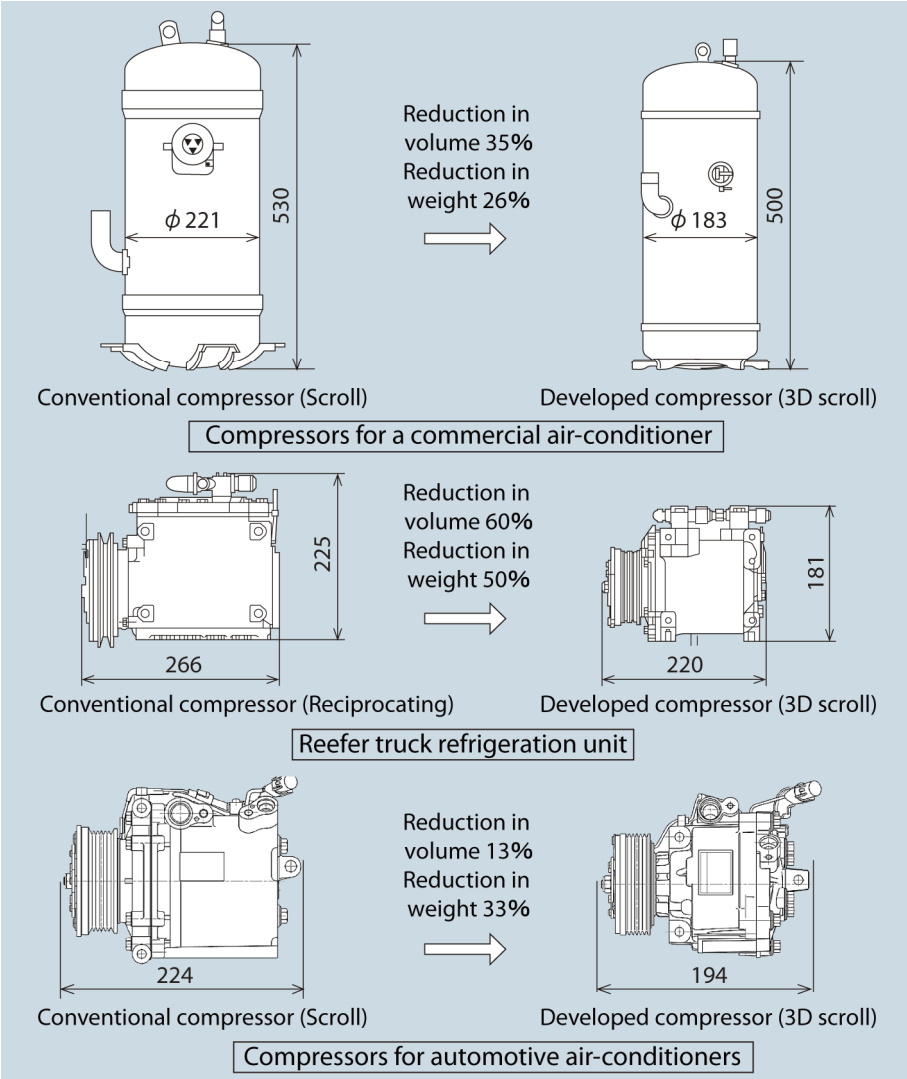

Figure 5 Outlines of conventional and the 3D scroll compressors

4. Conclusion

The development of MHI's new 3D scroll compression mechanism has resulted in a substantial improvement in efficiency, as well as a reduction in size and weight compared to the conventional scroll. The introduction of the 3D scroll to a wide variety of products has been a major step for energy conservation in the refrigeration and air-conditioning industry. These activities have been internationally recognized, and MHI was awarded the "2007 Climate Protection Award"[note] by the Environmental Protection Agency and the "Japan Society of Refrigerating and Air Conditioning Engineers Technology Prize" in 2007 and 2008. MHI is expanding its scope of development to contribute to the preservation of the global environment through eco-friendly refrigeration and air-conditioning products.

Note: Joint prize with Mitsubishi Motor Corporation

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Authors

Hajime Sato
Machinery Laboratory
Nagoya Research & Development Center, Technical Headquarters

Hiroyuki Kobayashi
General Manager,
Air-Conditioner Designing and Engineering Department
Air-Conditioning & Refrigeration Systems Headquarters

Hisao Mizuno
Manager,
Air-Conditioner Designing and Engineering Department
Air-Conditioning & Refrigeration Systems Headquarters

Tetsuzo Ukai
Manager, Automotive Thermal Systems Designing & Engineering Department
Air-Conditioning & Refrigeration Systems Headquarters

Makoto Takeuchi
Manager,
Machinery Laboratory
Nagoya Research & Development Center, Technical Headquarters

Yoshiyuki Kimata
Air-Conditioner Designing and Engineering Department
Air-Conditioning & Refrigeration Systems Headquarters