Achieving Carbon Neutrality with Large Capacity Electric Compressors for Air-Conditioning Systems of Electric Vehicles

Mitsubishi Heavy Industries Thermal Systems, Ltd.

Carbon neutrality is a global trend, and the movement towards its achievement is accelerating. The automotive industry is no exception, and the electrification of vehicles, such as hybrid vehicles, electric vehicles (EVs) and fuel cell vehicles, has been in progress since the 2000s. Today, it is firmly believed that the market for EVs will grow and the key to their popularization is to extend their driving range on a single charge. While installing a large-capacity battery is one solution, the heat generation of the battery during rapid charging is a major issue. Therefore, a large-capacity thermal management system that controls the battery at an appropriate temperature is becoming essential. In addition, highly efficient cabin air conditioning is also required.

With the above background, Mitsubishi Heavy Industries Thermal Systems, Ltd. (MHI Thermal Systems) introduced electric compressors to the market in 2007 for use in air conditioning systems for hybrid electric vehicles[*1]. In response to recent new needs such as maintaining a proper battery temperature (cooling) during rapid charging by utilizing the refrigerating cycle for air conditioning and expanding heat pump heating capacity in cold conditions, we have developed a new series of high-efficiency, large-capacity electric compressors[*2]. These product technologies are improving the practicality of EVs and promoting their widespread use, which contributes to the automobile industry's efforts to promote carbon neutrality.

This report introduces the features of the new large-capacity electric compressor, which is the core of the technologies, as well as our approach to life cycle assessment.

*1: Refer to "Development of Electric Compressor for Air Conditioning System of Hybrid Electric Vehicles", Mitsubishi Heavy Industries Technical Review Vol. 54 No. 2 (2017).

*2: Refer to "Large Capacity Electric Compressor for Air Conditioning System of Hybrid Electric Vehicles", Mitsubishi Heavy Industries Technical Review Vol. 56 No. 4 (2019).

1. Product features

Figure 1 compares the features and appearance of the newly developed electric compressor with the current one.

The layout of the inverter, motor and scroll compression section of the new compressor follows the design of the current one, but the compression mechanism adopts an improved 3D Scroll profile[*3] to meet market demands for larger capacity (increasing the displacement[*4]). In addition, the new design includes a change in motor specifications and an increase in the electrical load capacity of the inverter, so that the effect of the increased capacity can be maximized.

By designing the drive system components, such as bearings, in the same size as the current compressor, the compressor body diameter is kept nearly unchanged and the increase in the overall length is minimized even with the above modifications, aiming for packaging that would be less restrictive when installed on vehicles.

For motors and inverters, increasing the voltage will decrease the current and reduce the heat generation of the equipment provided that their power is constant. Therefore, there has been a strong need in the automotive industry for higher rated voltage for EVs. The developed new compressor is also available in a higher voltage specification (twice as high as the current one) to

meet this need.

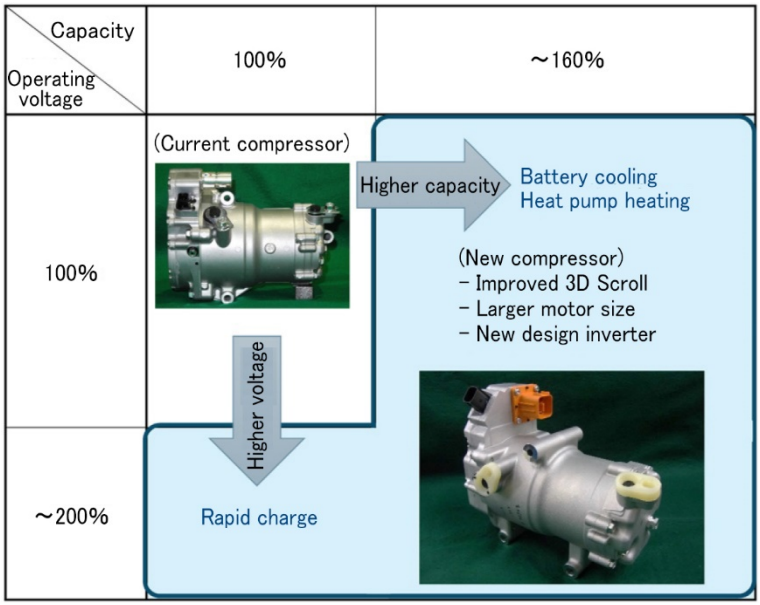

Figure 1 Comparison of features and appearance between current and new compressors

*3: High-efficiency 3D Scroll with reduced leakage in the compression process.
"3D Scroll" is a registered trademark of Mitsubishi Heavy Industries Thermal Systems, Ltd. in Japan.
*4: The volume that can be sucked in by the scroll per rotation of the shaft.

2. Increasing capacity

As described above, from the viewpoint of the packaging flexibility on vehicles, the new compressor has the same body diameter as the current one, but its capacity (displacement) is increased by adjusting the overall length.

Figure 2 compares the refrigerating capacity between the current and new compressors. This figure shows the overall compressor length ratio with respect to the refrigerating capacity ratio using those of the current compressor length and refrigerating capacity as a base of 100%.

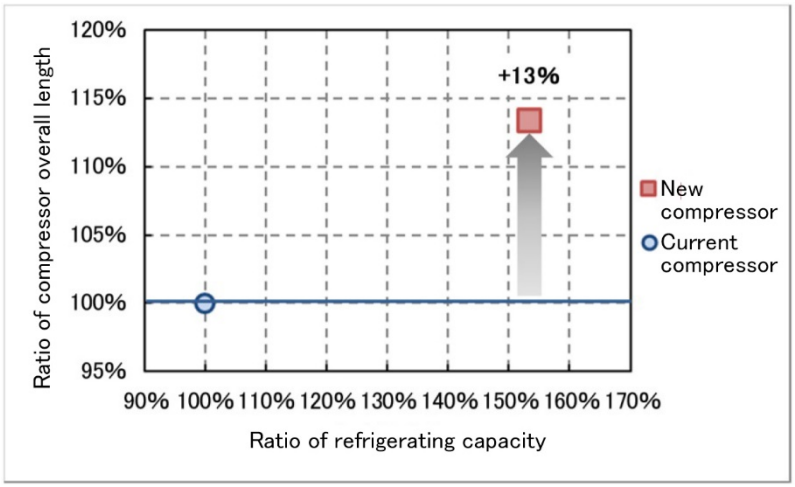

Figure 2 Comparison of refrigerating capacity and overall length between current and new compressors

The refrigerating capacity of the new compressor is increased by 53% compared to the current one, but the increase in its overall compressor length is suppressed to 13%.

This is due to the adoption of an improved 3D Scroll profile and the optimization of the compressor's internal structure including the suction path, which significantly increases the refrigerating capacity beyond the increase in overall length.

Figure 3 compares the noise level between the current and new compressors. This figure shows the noise level with respect to the refrigerating capacity ratio using the maximum capacity of

the current compressor as a base of 100%.

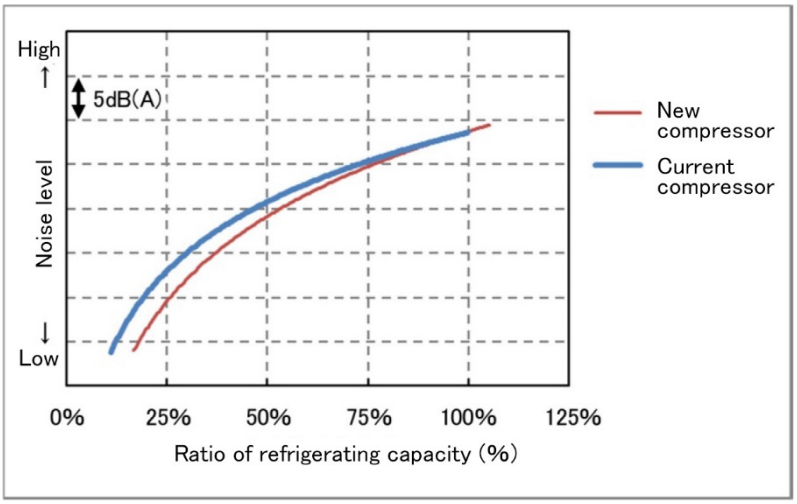

Figure 3 Comparison of noise between current and new compressors

The new compressor has achieved the same or lower noise level across the entire refrigerating capacity range compared to the current one.

Figure 4 summarizes our electric compressors by generation and their major technologies. Since the introduction of the first generation in 2007, our compressor has steadily made improvements such as higher efficiency, higher reliability, lower noise, smaller size, lighter weight and higher capacity.

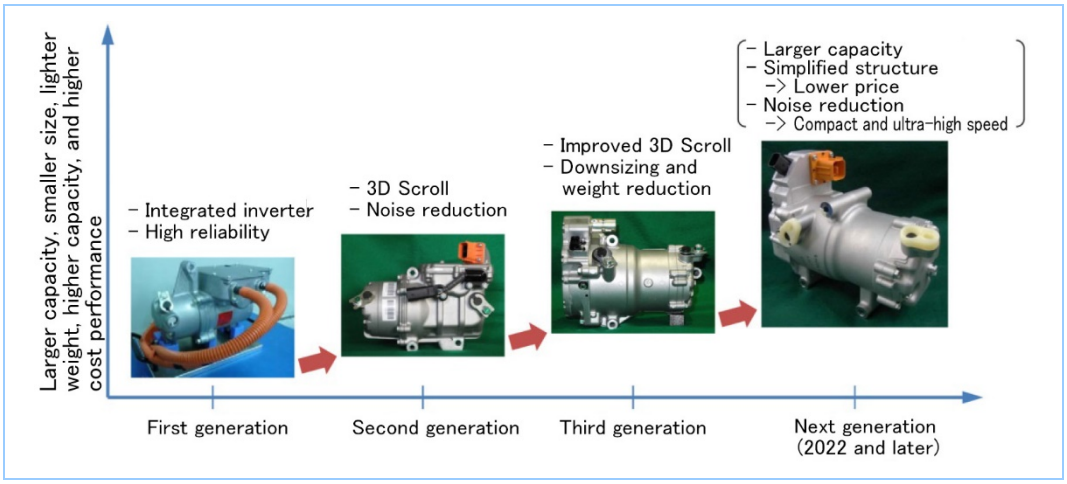

Figure 4 Our electric compressors by generation and their major technologies

3. Life cycle assessment

This chapter presents our efforts to reduce CO_2 emissions from the perspective of product life cycle assessment (LCA). The case example to be introduced here is the amount of contribution to CO_2 emission reduction in the customer usage and manufacturing phases of an electric compressor.

Figure 5 shows the amount of CO_2 emission reduction of our electric compressor in the customer usage phase. For this comparison, the annual power consumption conditions weighted originally based on the vehicle usage conditions (climate, vehicle speed, air conditioning settings and etc.) of TEWI (Total Equivalent Warming Impact) was used.

The third-generation compressor reduces CO_2 emissions in the customer usage phase by about 24% compared to the first-generation compressor (2007) by adopting our original 3D Scroll and improving the motor and inverter.

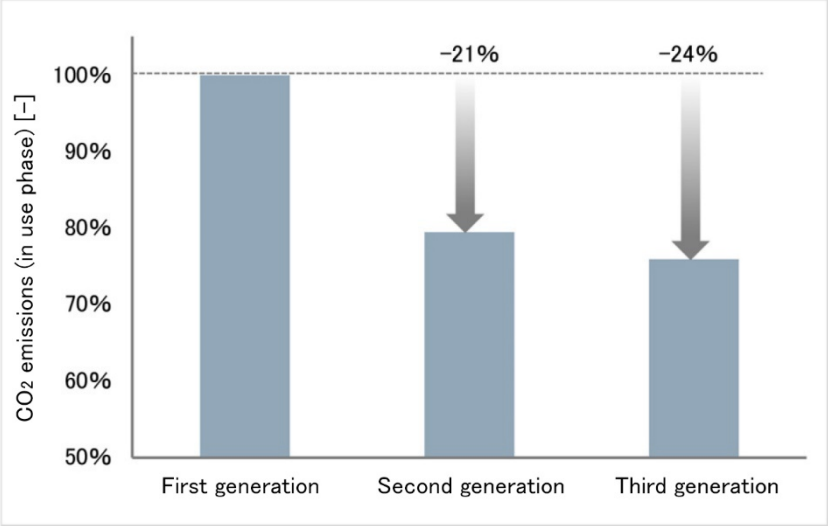

Figure 5 CO_2 emissions reduction by generation of our electric compressors (in customer usage phase)

Figure 6 shows the amount of CO_2 emission reduction of our electric compressor in the manufacturing phase due to reducing the materials.

This figure compares the same-capacity (same-displacement) compressors between the generations by converting their reduction in the major material usage into the CO_2 emissions reduction based on the Ministry of the Environment's DB[*5]. The third-generation compressor reduces CO_2 emissions by about 29% compared to the first-generation compressor.

The next-generation, new compressor is expected to further reduce CO_2 emissions by simplifying the structure and reducing the weight due to the smaller size.

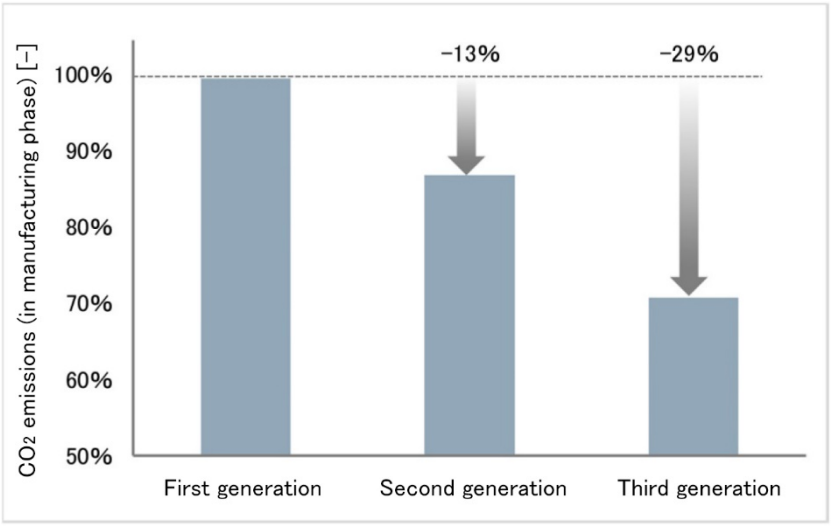

Figure 6 CO_2 emissions reduction through generation of our electric compressors (in manufacturing phase)

*5:“Emission Intensity Database for Calculating Greenhouse Gas Emissions of Organizations through Supply Chains Ver. 3.2 (in Japanese)”, Ministry of the Environment website

4. Future prospect

As shown in Figure 4, we aim to bring the new compressor introduced in this report to market in 2022 or later. In addition to the capacity increase described above, we plan to incorporate structural simplification and further noise reduction technologies into this new compressor.

We will continue to contribute to the achievement of carbon neutrality in the automotive industry through the development of air-conditioning and refrigeration products that meet market needs.