Generator-driven Type Transportation Refrigeration Heat-Pump Unit for Trailers

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Along with global initiatives to reduce environmental impact, the implementation of such measures is also being promoted in the logistics industry. In terms of transportation refrigeration units, there is a strong need to reduce CO_2 emissions through efforts such as improved energy-saving features and lowering the noise level during operation/transport in urban areas or at night. In response to such demands for lower environmental impact, Mitsubishi Heavy Industries Thermal Systems, Ltd. has developed the TFV150GA transportation refrigeration unit for trailers with a generator-driven heat pump, to make both silent operation and energy conservation simultaneously possible.

1. Product outline

A “generator-driven system” in which the refrigeration unit engine is equipped with a generator has been adopted. By operating the engine at a low rotation speed and using an inverter to control our proprietary hermetic 3D scroll compressor, we have realized refrigeration operation that is powerful yet silent. Through the use of a heat pump cycle system, heating performance and fuel economy have been markedly improved.

2. Product features

2.1 Lower environmental impact

(1) Substantial noise reduction from the existing model

The biggest external source of noise is the refrigeration unit engine. To realize silent operation, the refrigeration unit engine is run at constant low rotation speed and the engine is enclosed in a soundproof structure that also enables proper engine intake and heat dissipation to take place (**Figure 1**). For the external fan (which is the next biggest source of noise), a scimitar propeller fan with serrations with a proven record of use in air conditioners has been adopted. A four-pole AC motor is used to operate it at a low speed to reduce the noise level (Figure 1). With these features, the noise level has fallen by 9 dB(A) from our existing model, realizing the lowest noise level in the industry.

With inverter control, the refrigeration capacity can be adjusted by freely changing the number of compressor revolutions despite the engine rotating at a constant speed. Thus, “silent” yet “powerful” operation has been realized, something that was not possible with conventional models because the compressor contained therein was connected to the engine by a belt. Even in urban areas sensitive to noise pollution, therefore, deliveries can be made while operating in always-silent mode. This reduces the burden on drivers who otherwise have to select the delivery route carefully.

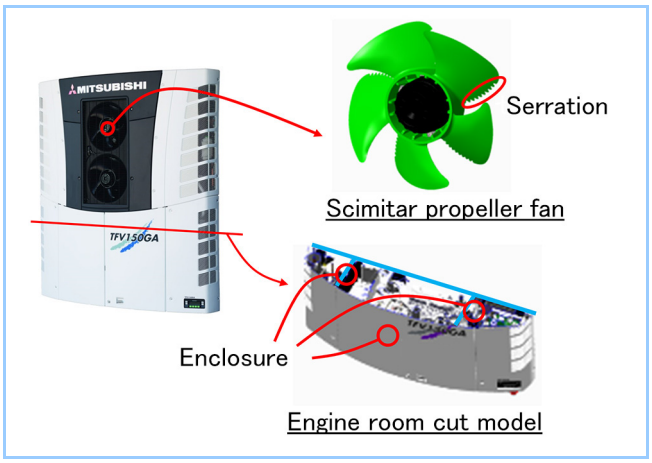

Figure 1 Actual example to reduce the noise level

(2) Improved energy-saving performance

The inverter is used to control the number of compressor revolutions in such a way as to always enable the refrigeration unit to operate with high efficiency in terms of energy consumption (**Figure 2**). The use of the heat pump cycle system has improved the heating operation efficiency. Together with the refrigerating/heating capacity controllable by the inverter, the state-of-charge monitoring of the lead storage battery for engine start-up eliminated the need for uneconomical engine operations such as idling for charging when cooling is not needed (**Figure 3**), thus decreasing the engine operating rate. As a result, a substantial reduction in the actual annual fuel consumption (-25% from that of the existing model) has been realized.

(3) Adoption of a refrigerant with lower environmental impact

By adopting R410A, the global warming potential (GWP) of the refrigerant has been reduced to 2090 from the GWP (3920) of the R404A refrigerant currently used in many transportation refrigeration units. This represents a 47% reduction, thereby helping to mitigate global warming.

(4) Use of European standard Stage V engine

From 2019, the European Stage V emission regulation (EU Stage V) standards for non-road diesel engines are in effect. The engine installed in our transportation refrigeration unit is compliant with these standards and is therefore environmentally sound. By restraining NOx and PM emissions, it contributes to preventing the expansion of air pollution.

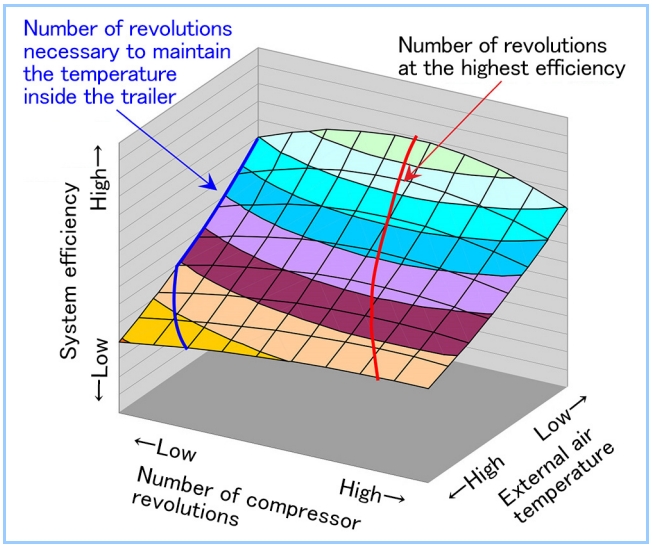

Figure 2 Control map for the number of revolutions at the highest efficiency

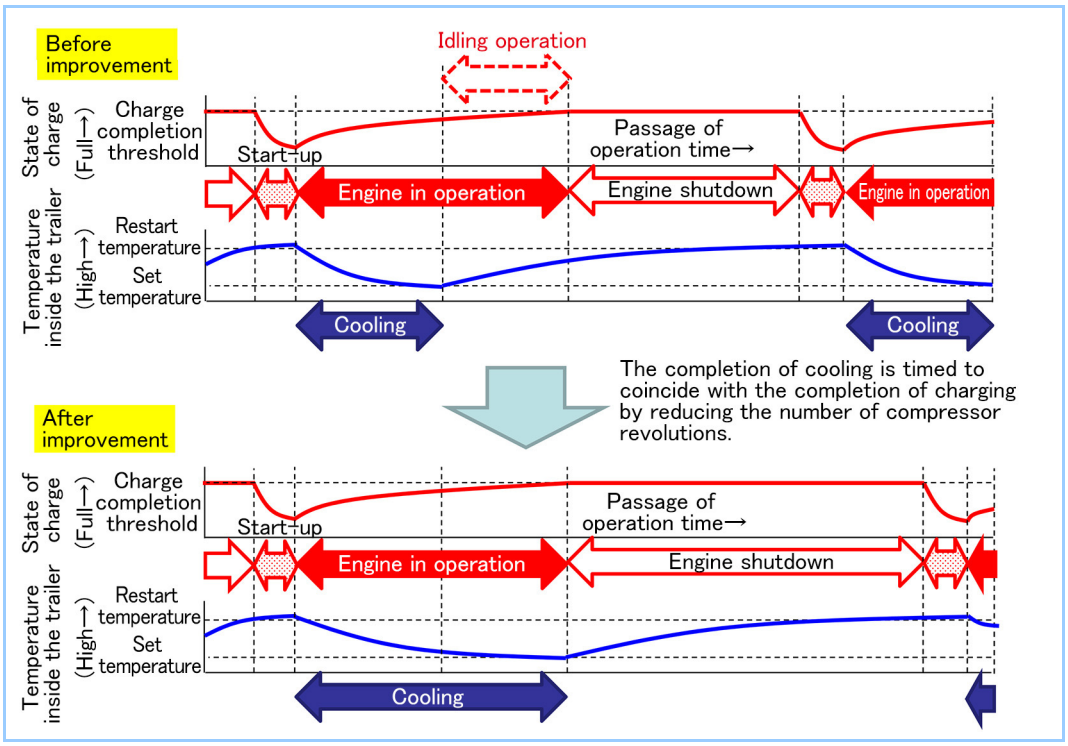

Figure 3 How to reduce the engine operation rate by eliminating the need for idling operation

(5) Lightweight refrigeration unit

With fewer parts and a simplified frame structure to which the parts are fitted, this transportation refrigeration unit is 110 kg lighter than our existing model. The consequent increase in the load carrying capacity and the improved logistics efficiency lead to lower logistics costs and reduced CO_2 emissions.

2.2 Markedly enhanced heating capacity

By adopting a heat pump cycle system with a long, proven record of use in our air conditioners, we have succeeded in markedly improving the heating capacity. This system enables not only quick heating, but also heat exchanger defrosting within a considerably shortened period of time even during refrigerating operation, thereby contributing greatly to the improvement of refrigerating operation efficiency.

2.3 Better visibility and operability

Because of where the refrigeration unit is installed in the trailer, the controller is located above the driver's eye level and is therefore designed to have a screen tilted downward at the bottom. The full-dot liquid-crystal display that is used can display information such as the internal temperature of the trailer in a large text size, resulting in considerably improved visibility. Function keys are attached below the display, which enables intuitive operation with fewer manipulations. There is also a presetting function by which four different set temperatures can be saved, thereby making it easier for the driver to manipulate the controller (**Figure 4**).

2.4 Solution for vehicle electrification application

By making all the components (e.g., compressor and fan motor) electrically-driven and building a system that can be controlled electrically by the inverter, we have realized a transportation refrigeration unit that is suitable for use in hybrid/electric trailers or regenerative power supply systems (**Figure 5**).

Figure 4 Better controller visibility and operability

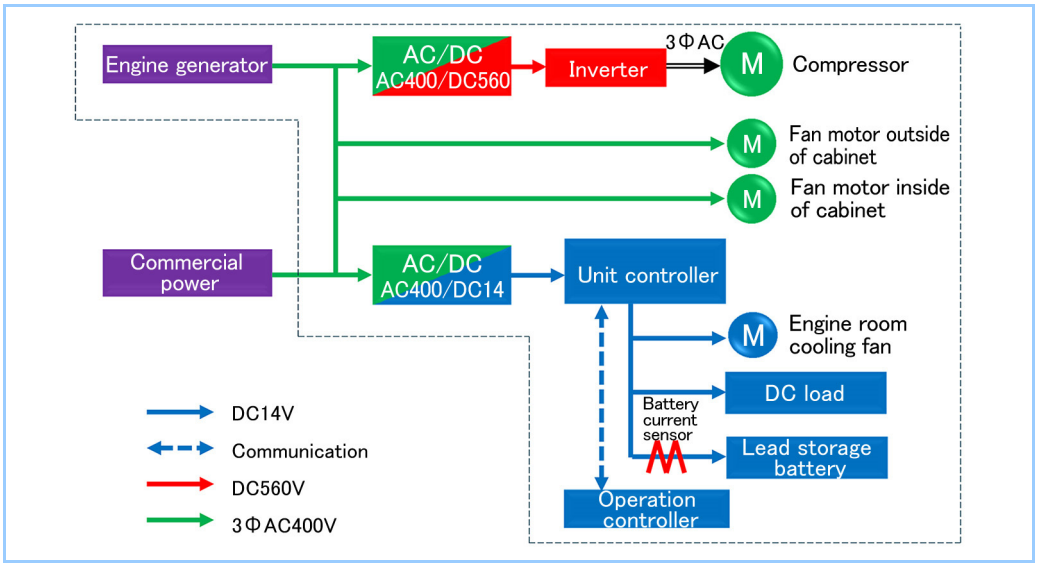

Figure 5 TFV150GA power block diagram with three-phase AC 400 V as a power source

3. Specifications and configuration

Table 1 shows the specifications of the TFV150GA, while **Figure 6** illustrates the configuration.

Table 1 TFV 150GA specifications

Model				TFV150GA
Temperature range of use	Internal temperature of the trailer		°C	-30 to +30
	External air temperature		°C	-20 to +40
Refrigeration capacity	External: 30°C/Internal: 0°C	Engine-driven	W	14,600
		Commercial power-driven	W	14,700
	External: 30°C/Internal: -20°C	Engine-driven	W	8,080
		Commercial power-driven	W	8,090
Heating capacity	External: -10°C/Internal: 12°C	Engine-driven	W	17,100
		Commercial power-driven	W	15,900
	External: -20°C/Internal: 12°C	Engine-driven	W	12,000
		Commercial power-driven	W	12,100
Refrigerant			kg	R410A, 5.7 kg
External dimensions (width × height × depth)		External	mm	2000 × 2216 × 430
		Internal	mm	1680 × 1150 × 100
Weight (excluding the lead storage battery)			kg	770

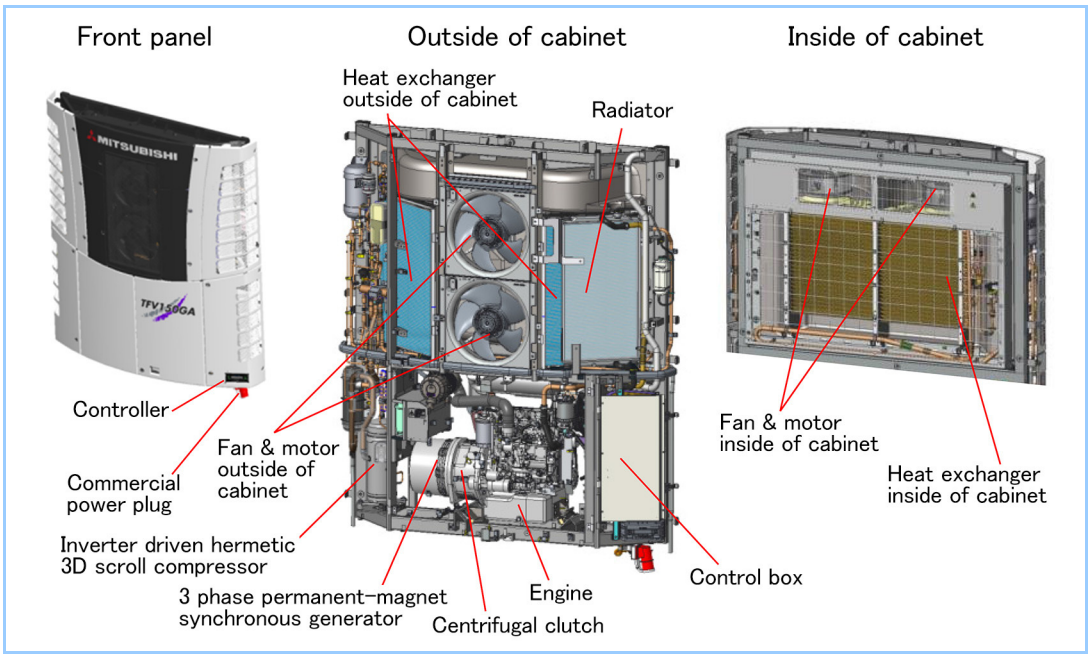

Figure 6 System configuration diagram of the TFV150GA refrigeration unit

Conventionally, when a commercial power supply was used, the capacity of the refrigeration unit was several dozen percent lower than the case of engine power supply. However, by enabling the inverter to freely control the number of compressor revolutions in either power supply system, the refrigeration unit capacities of these two power supplies have become comparable to each other. The external dimensions are in accordance with the prescribed European trailer dimensions (Directive 96/53/EC) for acceptance in the European market.

4. Future development

While improving the performance of electric transportation refrigeration units, we will also take up the challenge of collaboration and the expansion of our product line-up to be responsive to global trends of vehicle electrification such as hybrid/electric trailers and regenerative power supply systems. We look to improve people's lives by lowering environmental impact in the cold chain, reducing the burden on drivers and enhancing the quality of transportation.