TEJ35AM Electric-driven Transport Refrigeration Unit with Heat-pump Heating Function to Be Used on EV Trucks to Achieve Energy Savings and CO_2 Reduction

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Trucks installed with transport refrigeration units are widely used in the food distribution and logistics industries to transport goods which require temperature control, such as food and pharmaceutical products, and play an important role in ensuring the safety of food and the reliability of pharmaceutical products.

Truck transportation in its entirety, including trucks installed with such transport refrigeration units, must address the issue of CO_2 emissions and their impact on climate change, and initiatives to reduce CO_2 emissions are underway. In this context, electrification, in other words the promotion of EVs, is one promising method. Therefore, it was necessary to develop a refrigeration unit for transportation that could maximize the advantages of EVs in transportation requiring temperature control, and to cooperate with EV trucks.

This report introduces TEJ35AM electric-driven transport refrigeration unit with heat-pump heating function, which was developed by Mitsubishi Heavy Industries Thermal Systems, Ltd. (hereinafter MTH) for the mass-production of EV trucks by Japanese automobile manufacturers.

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1. Overview of TEJ35AM electric-driven transport refrigeration unit

Among transport refrigeration units, there is the electric-driven type (**Figure 1**) described in this report, as well as the vehicle-engine-driven type (**Figure 2**), which obtains power from the truck's vehicle running engine to the compressor of the transport refrigeration unit installed in the engine compartment of the truck via a belt.

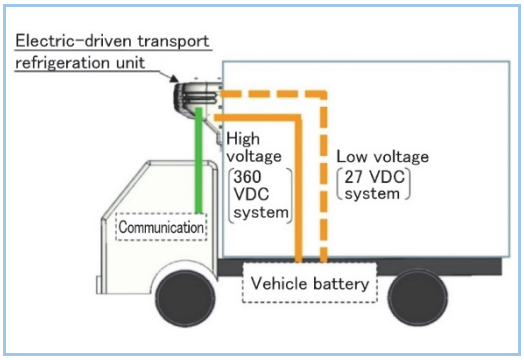

Figure 1 Electric-driven transport refrigeration unit

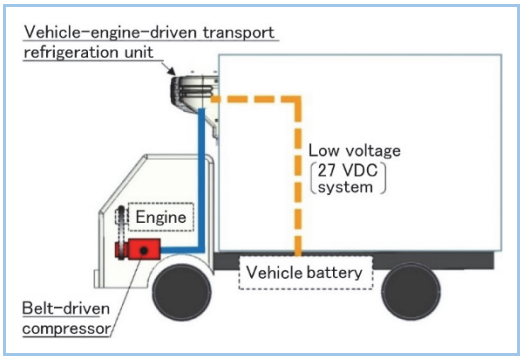

Figure 2 Vehicle-engine-driven transport refrigeration unit

Most electric-driven transport refrigeration units are powered by electricity supplied from the EV truck. In this case however, in order to effectively use the electricity from the EV truck, the vehicle and the transport refrigeration unit are in constant communication for coordinated control,

achieving both vehicle operation and temperature control of the goods by the transport refrigeration unit.

TEJ35AM is electric-driven and, at the same time, has a multi-system with a heat-pump heating function to achieve high efficiency and temperature control of two cargo compartments, thus satisfying customer needs for CO_2 reduction, energy savings, and simultaneous transport of goods requiring different temperature controls.

2. Features

2.1 Technology for electrification

While the EV truck must operate for a long period of time and at the same time maintain the goods at an appropriate temperature, the electricity supplied by the EV truck is limited. Therefore, it is important to use such electricity efficiently.

To enable quick temperature control at maximum capacity immediately after the start of operation and to operate at high efficiency after the target temperature is reached, the electric transport refrigeration unit realizes variable compressor speed control according to the state of heat load by applying air conditioner inverter control technology using power semiconductors and uses electric power without waste (**Figure 3**).

Furthermore, in situations where electricity usage needs to be reduced, the unit responds to the power limitation request by coordinating with the vehicle.

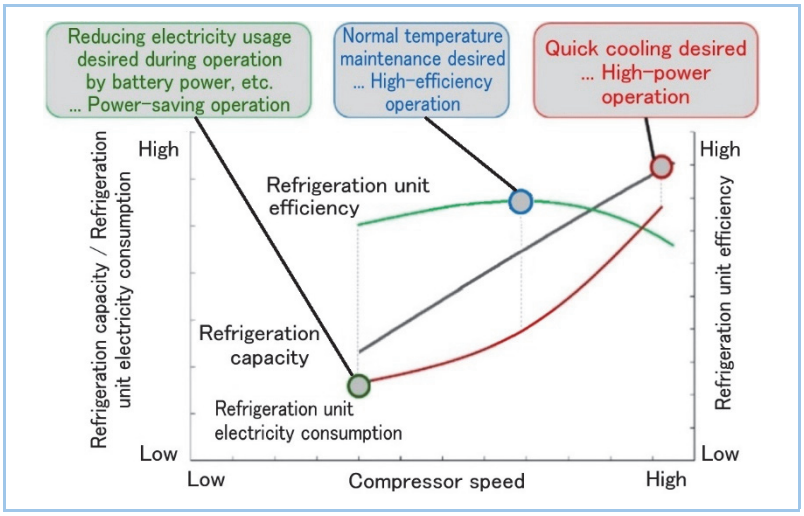

Figure 3 Illustration of compressor rotation control

2.2 High-efficiency operation by multi-system with heat-pump heating function

(1) For the efficient delivery to customers such as convenience stores who handle a wide range of products, simultaneous delivery of perishables (target temperature: +5°C) and rice products such as lunch boxes (target temperature: +20°C) is required. TEJ35AM responds to this demand by using a multi-system with a heat-pump heating function that can control different temperatures in each of the two cargo compartments of the truck.

As shown in **Figure 4**, the heat pump cycle performs cooling and heating by freely pumping heat between the inner and outer units by switching the role of each unit depending on the season and other factors. On the other hand, when the outside air temperature is between the target temperatures of the two compartments during the spring and fall, heat pumped by the evaporator in the low-temperature cargo compartment (cooling compartment) is dissipated by the condenser in the high-temperature cargo compartment (heating compartment), resulting in significantly high energy-saving performance and reducing consumption of the EV truck's battery electricity, which is limited (**Figure 5**).

(2) The energy-saving effect of a multi-system with a heat pump heating function was calculated under MTH's specified conditions assuming product delivery, and the results showed that the average annual energy consumption of the refrigeration unit for transportation was reduced by 18% compared to a vehicle engine-driven system without a heat pump cycle (**Figure 6**).

This reduction in energy consumption also means a decrease in CO_2 emissions.

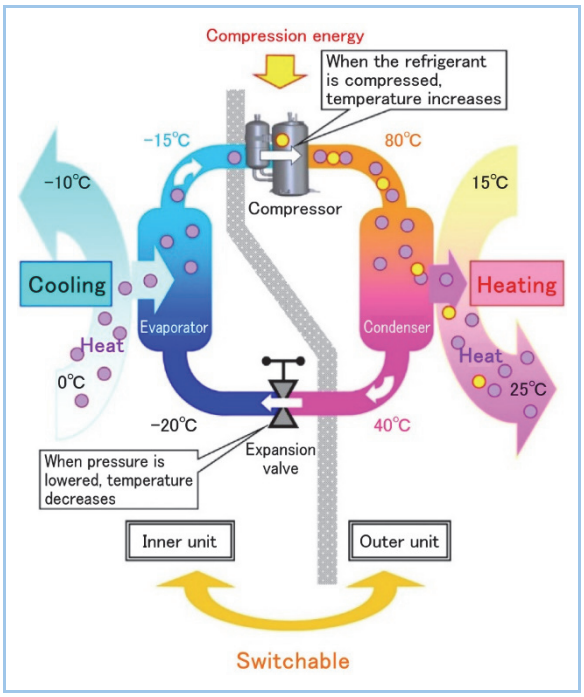

Figure 4 Schematic diagram of the heat-pump cycle

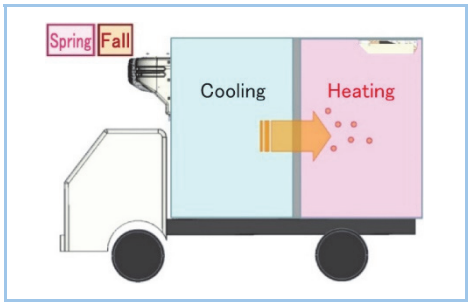

Figure 5 Heat pumping in spring and fall

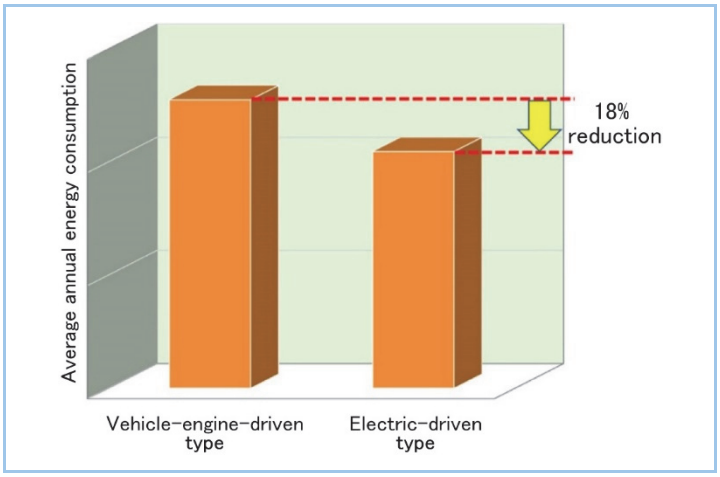

Figure 6 Comparison of average annual energy consumption

2.3 Stable, constant-temperature transport, independent of vehicle operating conditions

TEJ35AM, which receives electricity from the EV truck, can operate according to the electricity supply mode from the vehicle and can adjust the temperature of the cargo compartment regardless of whether the vehicle is running, stopped (vehicle switched off), or being charged. Compared to the vehicle engine-driven type, which depends on the vehicle engine remaining in operation, this product can easily maintain stable temperature in the cargo compartment.

In actual operation, when pre-cooling (pre-heating) the cargo compartment temperature before loading products, the engine-driven type may require engine idling even though the vehicle is not in operation, whereas the electric-driven type can operate even while the vehicle is charging. Eliminating engine idling contributes to a reduction in CO_2 emissions.

2.4 Combination with various power sources

In addition to lithium-ion batteries, installation of various power sources can be expected on vehicles in the future, including fuel cells. TEJ35AM is equipped with voltage specifications, communication, and cooperative control specifications that take into account the combination of various power sources, and contributes to the expansion of future power sources.

3. Specifications

Specifications of TEJ35AM are shown in **Table 1**, and a vehicle installed with TEJ35AS is shown in **Figure 7**.

Table 1 Specifications of electric-driven transport refrigeration unit

Model			TEJ35AM
Operating temperature range	Internal temperature	°C	-30 to +30
	External temperature	°C	-20 to +40
DC power source	High voltage	DC-V	Rated 360 (variable from 250 to 400)
	Low voltage	DC-V	27.0 (variable from 20.0 to 32.0)
External dimensions	Front compartment	mm	W1,780 x H774 x D630 (outer 530, inner 100)
	Rear compartment	mm	W1,216 x H155 x D722
Weight		kg	166

Figure 7 A vehicle installed with the developed product

4. Future prospects

Transport of goods requiring temperature control is an important infrastructure closely linked to our daily lives. To continue to fulfill this role, both response to the global environment and ease of use are required.

Aiming to achieve carbon neutrality, MTH will continue to improve the performance of its transport refrigeration units in response to customer feedback, and develop and provide environmental- and human-friendly transport refrigeration units.