Hydrocurrent™ Organic Rankine Cycle Module 125EJW –Compact and High-performance Waste Heat Recovery System Utilizing Low Temperature Heat Source –

Mitsubishi Heavy Industries
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A waste heat recovery system is installed in marine vessels to reduce their fuel consumption, which simultaneously can reduce the emission of pollutants such as CO_2. We have developed a compact and high-performance waste heat recovery system Hydrocurrent™ (Note) Organic Rankine Cycle (ORC) Module 125EJW in conjunction with Calnetix Technologies, LLC (Head office: Cerritos, California, U.S.A.; hereinafter referred to as Calnetix). This system can capture the heat from low-temperature heat sources such as the jacket cooling water of the main engine of the ship, which could not be used for this purpose, and convert it to electric power for shipboard consumption.

In this system, a radial turbine newly developed by Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd. is mounted in Calnetix's established standard system for waste heat recovery, which in itself has earned a solid reputation as onshore equipment of this kind. This new waste heat recovery system gained class approval from Nippon Kaiji Kyokai (NK) and Lloyd's Register (LRS), and was launched in the market as our next strategic product.

Note: Hydrocurrent™ is a trademark of Calnetix.

1. Product overview

The specifications and configurations of the system are given in **Tables 1** and **Figure 1**, respectively.

Table 1 System specifications

Model	Hydrocurrent™ ORC 125EJW
Rated output	125kW
Refrigerant	R245fa
Generator	Directly-coupled turbine-driven, permanent magnet synchronous generator
Heat source temp.	85°C
Rotating speed	Approx. 16,000 rpm (variable)
Output voltage	380V/440V
Frequency	50Hz/60Hz

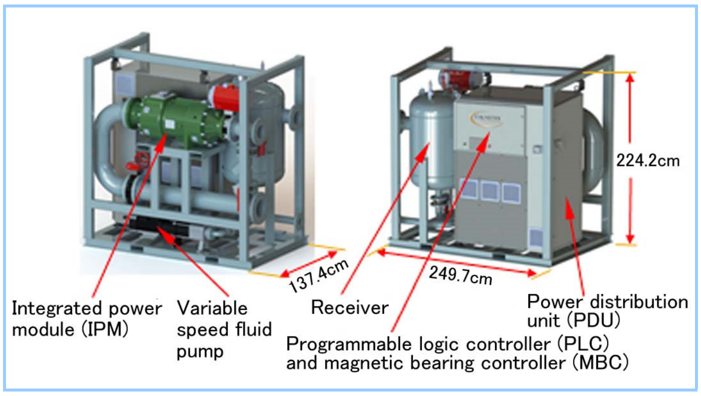

Figure 1 System drawing

The following are the features of this system.

(1) High efficiency

High efficiency is achieved by the supporting structure of the magnetic bearings with no frictional loss and the reduced leakage loss by the newly-developed radial turbine (**Figure 2**).

(2) Compact design

A compact generator is realized by integrating the radial turbine with the high-speed permanent magnet generator.

(3) Maintenance-free

No cooling/lubricating systems or a seal structure from the exterior environment is needed because of the module structure integrating a generator, a turbine and semi-permanent magnet bearings.

(4) Use of low-temperature heat sources

Heat from low-temperature sources (80-85°C) such as engine jacket cooling water is recovered and can be directly converted into electric power (maximum of 125kW).

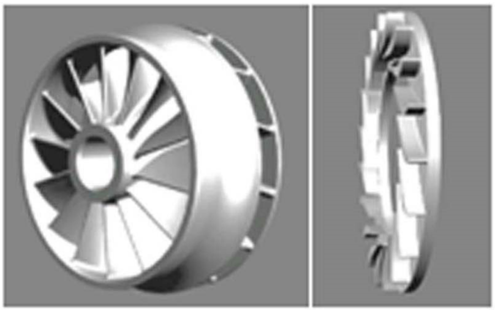

Figure 2 Newly-developed radial turbine and nozzle

2. How the Hydrocurrent™ ORC 125EJW works

In the heat recovery process of this system, an organic heat medium with a low boiling point (i.e., R245fa) is used as the working fluid and thermal energy is converted into mechanical power (**Figure 3**).

(1) The organic heat medium flows through the evaporator and exchanges heat with the heat source (engine jacket cooling water), turning into a superheated vapor.

(2) As the high-temperature vapor expands in the course of passing through the Integrated Power Module (IPM) (**Figure 4**), electric power is produced.

(3) The vapor with a lowered temperature exits the IPM and enters the condenser, to be cooled back to a liquid.

(4) The cooled organic heat medium returns to the evaporator through the refrigerant pump and the aforementioned cycle is repeated.

Figure 5 shows the relationship between power output of the Hydrocurrent™ ORC 125EJW generator and the amount of engine jacket cooling water.

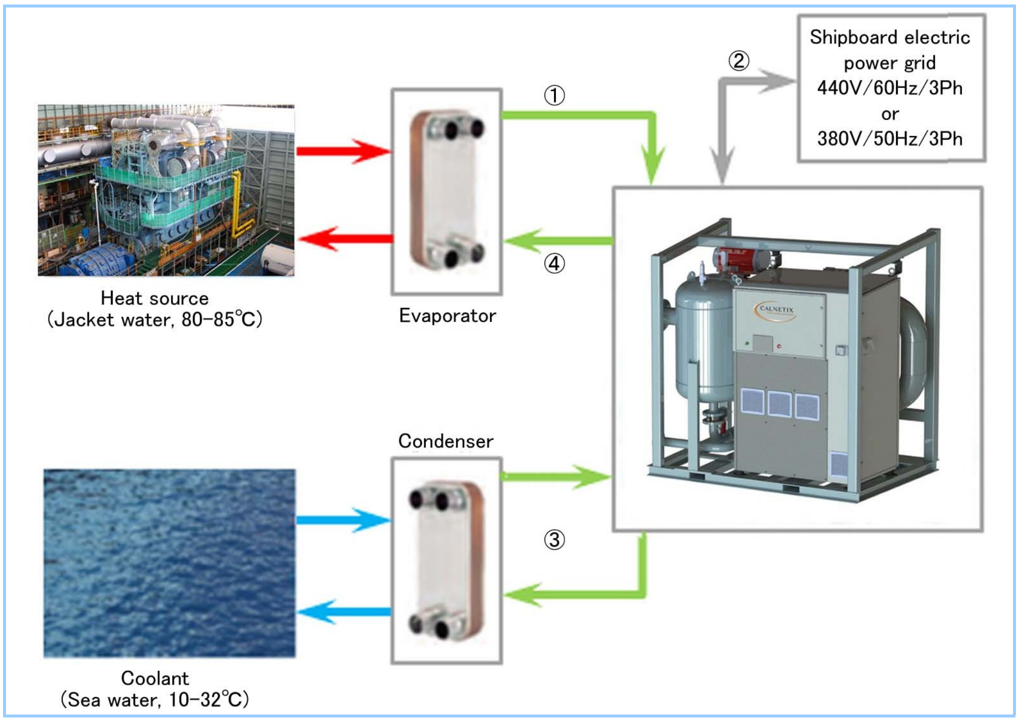

Figure 3 Heat recovery process of Hydrocurrent™ ORC 125EJW

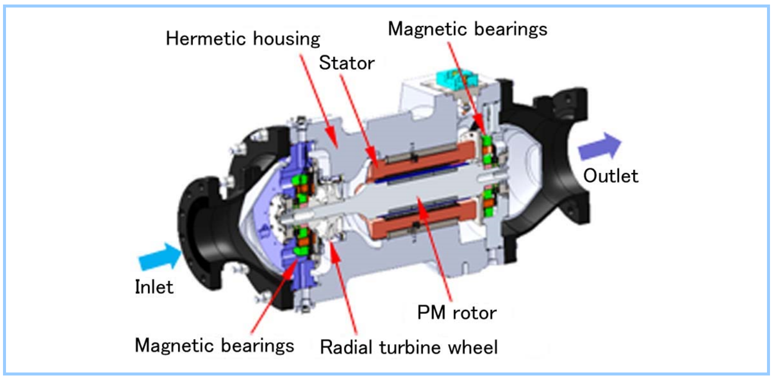

Figure 4　Integrated power module (IPM) schematic

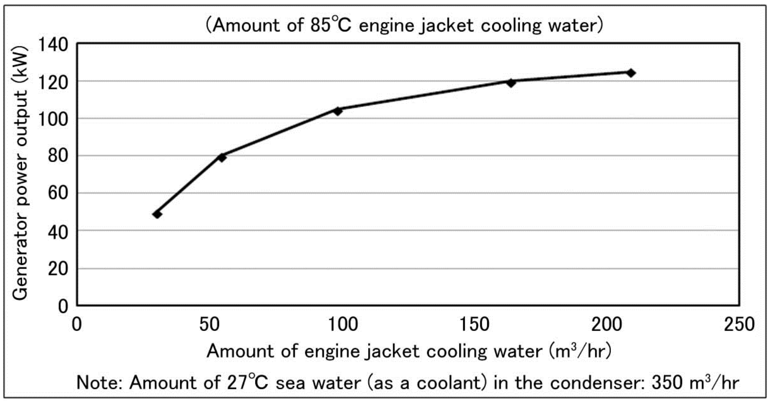

Figure 5　Relationship between generator power output and amount of engine jacket cooling water

3. Optimal heat and power solution for marine vessels

Because of the recent demanding atmosphere for economic ship operation and environmental regulations, marine vessels are mainly operated by slow steaming, which is highly effective in reducing both fuel consumption and the emission of air pollutants. Ironically, however, the waste heat energy that can be recycled has also been reduced, making it difficult for conventional steam turbine-driven waste heat recovery systems to function properly.

Because the Hydrocurrent^{TM} ORC 125EJW has been developed under the concept of enabling the utilization of low-temperature heat sources including the jacket cooling water of the main marine engine, its functionality during low-load operation can be further improved. Specifically, energy from other heat sources in the ship such as main-engine exhaust gas and air coolers, which were rendered unavailable when using conventional steam turbines, is also utilized through heat exchange to compensate insufficiency of heat sources (**Figure 6**).

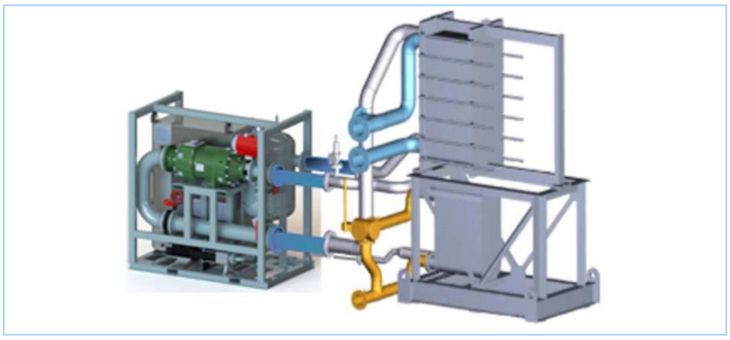

Figure 6　Hydrocurrent^{TM} ORC 125EJW and heat exchanger

Although it has been considered difficult to introduce waste heat recovery systems to small and medium ships, the need for such systems is expected to increase in the future. We will offer the optimal heat and power solution for marine vessels by actively promoting the use of the Hydrocurrent^{TM} ORC 125EJW to customers with such ships, etc.