3. Steam Turbines and Boilers

3.1. Steam Turbines

3.1.1 Steam turbines as a main engine

In 2016, Kawasaki Heavy Industries, Ltd. (KHI) delivered a URA Type Marine Propulsion Turbine for an LNG carrier to its Sakaide Shipyard. No new steam turbines produced by the company came into operation in 2016.

Mitsubishi Heavy Industries Marine Machinery & Equipment Co., Ltd. (MHI-MME) delivered one MR-II steam turbine for use as a main engine to Mitsubishi Heavy Industries Shipbuilding Co., Ltd. (MHISB) in Nagasaki area and three to Hyundai Heavy Industries respectively. Its two new steam turbines were brought into operation in 2016.

MHI-MME also received an order for three reheat-type MR-II steam turbines to be delivered to MHISB. These reheat-type turbines aim to give additional power to one screw of ships with a twin-screw propulsion configuration, and they are more compact than existing MR-II steam turbines.

KHI has repeatedly added improvements to its URA Type turbines from its first URA model. It has checked performance levels of the URA Type delivered in 2014 during sea trials on two LNG carriers.

Up until now, diesel-electric propulsion systems have widely been adopted as the main type of propulsion units. But the adoption of an electric propulsion system can lead to a build-up of maintenance costs. Given the introduction of tougher IMO environmental regulations, a shift to gas injection diesel propulsion systems may proceed. Another alternative includes the combination of a steam plant and an electric propulsion system for twin screw ships. This can improve cost performance of the ship. Furthermore, the future direction of this sector is expected to be affected by the results of long-term operational assessment of ships with high efficiency reheat-type steam turbines (Fig.3.1), which have been in operation in recent years, as well as above-mentioned twin screw ships with a steam plant and an electric propulsion system.

3.1.2 Auxiliary steam turbines

In 2016, Shinko Ind. Ltd. delivered a total of 551 auxiliary steam turbines, including cargo pump turbines and turbine generators, to its factories. MHI-MME completed delivery of five turbine generators to its factories. Since the dry bulk market is showing a sign of recovery, the market for container ships is beginning to pick up as well. However, this has not been reflected in recent orders that Shinko has received for tankers, LNG carriers and other vessels.

Overall, ship owners have remained reluctant to place orders for auxiliary turbines for any type of vessels. This trend is being accelerated by a shipping volume reduction, caused by China’s economic slowdown, and a response to an upsurge in demand before the introduction of NOx Tier III requirements that regulate exhaust gas emissions from ships.

Under such circumstances, Chinese and South Korean shipyards are offering a discount to ship owners in efforts to stimulate their desire to order auxiliary turbines.
Weaker demand for turbine generators is also influenced by improved efficiency of main engines and the fact that more ships are operating in slow steaming mode. In response, demand for Waste Heat Recovery Systems (WHRS) is generally shrinking. But energy conservation and the protection of the environment, including the need to reduce CO2 emissions, continue to serve as big challenges to the marine sector. Under these circumstances, demand for WHRS that incorporate the trend toward slow steaming is actually increasing.

Both Shinko and MHI-MME continue to work hard for the development of a turbine system allowing the recovery of waste heat at the maximum possible level. MHI-MME developed with a US partner the ‘HydrocurrentTM Organic Rankine Cycle (ORC) Module’ that factored in the trend toward slow steaming, and completed a test run aboard the ship in April 2016. Additionally, it is proposing to offer their customers an improved ORC system with lighter weight, more compact size and a reduced price. It is more than 20 percent lighter and over 70 percent smaller than the conventional ORC Module, making it possible for ship operators to use limited spaces within ships more effectively (Fig.3-2).

The compactness of the new ORC model allows it to be installed on small and medium-sized vessels, and it is also possible to mount more than one ORC system on large container ships with surplus heat sources. Thus, the new ORC Module can offer opportunities to save energy for a variety of ship types. MHI is currently receiving inquiries about the product from customers at home and abroad, and it is hoped that the new ORC system will be installed on vessels around the world in the future.

![Fig.3-1 MHI-MME Reheat steam turbine](image1)

![Fig.3-2 Space-saving type ORC module](image2)

(Written by Seiji Utoh)
3.2 Boilers

3.2.1 Boilers in general

The following is the results of a survey conducted on six major marine boiler manufacturers, namely MHI-MME, KHI, Miura Co., Ltd., Osaka Boiler MFG. Co., Ltd., Alfa Laval K.K. and Tortoise Engineering Co., Ltd. about the development of their new boiler products, their recent topics and technical developments for FY2016.

(1) Mitsubishi Heavy Industries Marine Machinery & Engine
   ① New products and development
      · Delivering MAC-90BF dual fuel boilers
      Mitsubishi Heavy Industries Marine Machinery & Engine (MHI-MME) has manufactured and delivered 90ton/h × 1.5MPa combination dual fuel re-gas boilers whose orders the company received in FY 2015. Floating storage regasification units (FSRUs) store liquefied natural gas (LNG) and transfer it to on-land pipelines after re-gasifying LNG, and re-gas boilers are used to supply heat sources (steam) necessary for regasification. These boilers incorporate a waste gas recirculation system to meet NOx regulations (Max.100mg/Nm³ NOx at 3% O2). The boiler system on the ship contains an economizer for waste heat recovery, and a study found that when the MAC-90BF was gas-fired, the overall efficiency of a boiler plant showed an about 12.5 percent improvement compared to a conventional boiler.

   ② Recent topics and technical development
      Demand was growing for auxiliary boilers installed on commercial tankers, and MHI-MME manufactured more than 90 MAC type boilers in FY2016. Demand was also robust for boilers mounted on LNG carriers. MHI-MME manufactured six reheat boilers used for propulsion and two auxiliary boilers to dispose of boil-off gas.

   ③ Possible trend in FY2017
      Weaker demand is expected for auxiliary boilers for tankers and reheat boilers installed on LNG carriers. Meanwhile, the market for offshore floating production storage and offloading (FSPO) vessels and FSRU systems is on a recovery path, and more ship owners are expected to require dual fuel boilers. In the lead-up to the introduction of tougher sulfur content regulations in wider areas starting from 2020, there is a growing need to use ultra-low heavy fuel oil (ULHFO) and low sulfur diesel oil (LSDO) as well as to install a SOx scrubber system on ships. Accordingly, ship operators are likely to call for technical improvements in marine boilers to deal with new challenges posed by the popularity of low sulfur fuels and SOx scrubber systems.

(2) KHI
   ① New products and development
      Kawasaki Heavy Industries Ltd. (KHI) has continued modification work since last year so that ships can be fired by low sulfur gas oil (LSGO) in response to tighter environmental regulations in emission control areas (ECAs).

   ② Recent topics and technical development
      Demand has basically subsided for modification work for LSGO-fired American and European ships operating in emission control areas. However, an increasing number of similar work has been requested by Japanese shipping companies in the lead-up to the enforcement of new sulfur regulations in 2020.

   ③ Possible trend in FY2017
      The number of requests for work allowing boilers to be LSGO-fired from Japanese shipping agents is
expected to be on the rise.

(3) Miura

1. New products and development
   - Miura Co., Ltd. delivered auxiliary boilers and composite boilers (evaporative capacity of 2 t/h or less) with proportional control burners that can use high viscosity oil.
   - The company delivered G/E exhaust gas heat recovery unit for hot water.

2. Recent topics and technical development
   N/A

3. Possible trend in FY2017
   The production of boilers is expected to be equivalent to last year.

(4) Osaka Boiler

1. New products and development
   N/A

2. Recent topics and technical development
   Due to the recent slowdown in the dry bulk shipping market, a more variety of ships, including container ships and tankers, are being built rather than bulk carriers alone. Accordingly, the shipment of and new orders for exhaust gas economizers used for main engines and auxiliary engines for power generation are on the increase.

3. Possible trend in FY2017
   It is expected that more ship operators will consider installing dual fuel boilers on LNG-fueled ships in line with the future application of SOx regulations to all oceans.

(5) Alfa Laval

1. New products and development
   Alfa Laval included Aalborg Micro, a compact exhaust gas heat exchanger widely used on land, in its line-up of exhaust gas economizers for marine applications.

2. Recent topics and technical development
   The company carried out its third work to expand its testing and training center in Aalborg, Denmark. Another 1,100 m² was added to the center to enable experiments with LNG and other alternative marine fuels. The newly added components included a directional flame (DF) burner system, an inert gas system and a gas combustion unit (GCU).

3. Possible trend in FY2017
   - A wider range of DF boilers and burners may become available in the future for use in LNG-fired ships.
   - In parallel with this, boilers and burners may need to equip themselves with gas combustion units on board these ships.

(6) Tortoise Engineering Co., Ltd.

1. New products and development
   N/A

2. Recent topics and technical development
   Tortoise Engineering Co., Ltd. manufactures and sells composite boilers that can generate steam from main engines, power generators and burners. It also delivered exhaust gas economizers that use waste heat from generators.

3. Possible trend in FY2017
   While demand for composite boilers is expected to weaken, orders for boilers and exhaust gas economizers installed on tankers may rise in the future. But requests from customers to prepare cost estimates are decreasing.
3.2.2 Major developments

The Japan Institute of Marine Engineering’s Research Committee for Energy Systems has been conducting a survey on major Japanese marine boiler manufacturers about their production and order intake results for main and auxiliary boilers. Details of these boiler type-based orders are as follows.

(1) Marine main boilers and F-LNG boilers
In FY 2016, two 40t/h steam output boilers and four 50t/h steam output boilers (reheat boilers 10MPa, 565°C) were produced. The total production number was six, and one order was received for marine main boilers.

With regard to floating liquefied natural gas (F-LNG) boilers, one 14t/h boiler for floating, storage and re-gasification units (FSRU) and four 90t/h boilers were produced. The total production number was five, and one order was placed for 14t/h boilers.

(2) Marine auxiliary boilers
The Fig.3.2.1 shows production and order received of marine auxiliary boilers (oil-fired boilers) in Japan for FY 2016 on a boiler capacity basis. During the year, marine boiler manufacturers produced a total of 225 units, and the number surged from 162 units marked in the previous year. These manufacturers received orders for 192 units in total (when manufacturers failed to report their order numbers, these numbers were substituted by their production numbers for calculation purposes), and the number of boilers with steam output of 11t/h to 25t/h increased sharply. The Fig.3.2.2 highlights production and order received of composite boilers for FY 2016. Composite boilers were produced for 321 units and orders received for 270 units. Composite boilers with a steam capacity of 1.1t/h to 3.0t/h were produced more than other steam capacity categories, and this trend has continued from the previous year. The production of smoke tube composite boilers far outnumbered that of water tube types. The number of composite boilers produced was 321 units in FY2016, 370 units in FY2015, 363 units in FY2014, 351 in FY2013 and 399 in FY2012. The number of composite boilers ordered was 270 in FY2016.

![Fig.3.2.1 Production and order received of marine auxiliary boilers](image1)

![Fig.3.2.2 Production and order received of marine composite boilers](image2)
(3) Exhaust gas economizers
The Fig.3.2.3 shows production and order placement levels of exhaust gas economizers for FY2016. Manufacturers produced a total of 132 exhaust gas economizers (one of which was a large-scale economizer that can drive turbine generators) and the number is reduced about 15% from 152 units (six of which were large-scale economizers driving turbine generators) in FY 2015. The ordered number was 184 units in FY 2016 (three of which were large-scale economizers that can drive turbine generators).

![Fig.3.2.3 Production and order received of exhaust gas economizers](Fig3.2.3)

(4) Marine thermal oil heaters
The total of 29 units marine thermal oil heaters were produced in FY2016, of which 9 units were large capacity types with heat output of 1,201 to 3,500 kW, and 13 units had small capacity with heat output below 600 kW. The total production number was 23 units in FY2015.

(Written by Yuji Nakamura)