3. Steam turbines and boilers

3.1. Steam turbines

3.1.1 Steam turbines as a main engine

In 2015, 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 have come into operation in 2015.

Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd. (MHI-MME) delivered three MR-II steam turbines for use as main engines to Mitsubishi Heavy Industries Shipbuilding Co., Ltd. (MHISB) in Nagasaki area. Its two new steam turbines were brought into operation in 2015. MHI-MME also received an order for five reheat-type MR-II steam turbines to be delivered to its Nagasaki Shipyard. Theses 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 latest URA Type during sea trials on two LNG carriers, which was delivered in 2014.

Up until now, diesel-electric propulsion systems have widely been adopted as the main type of propulsion units. But the adoption of these systems 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.

Fig. 3.1   Sectional drawing of reheat turbine

3.1.2 Auxiliary steam turbines

In 2015, Shinko Ind. Ltd. delivered a total of 336 auxiliary steam turbines, including cargo pump
turbines and turbine generators, to its factories. MHI-MME completed delivery of 10 turbine generators to its factories. Shinko faced difficulties in receiving orders for bulk carriers, container ships and LNG carriers. Although the company was receiving some orders for tankers, they remained at a low level.

Overall, the market for auxiliary steam turbines stayed stagnant regardless of vessel types. This trend was triggered 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.

Shipbuilders are shifting production from bulk carriers and tankers due to the declining dry bulk market, and turbine manufacturers are pinning their hopes on a possible rise in the number of business deals on tankers.

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 exhaust heat recovery systems (MERS) 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 exhaust heat recovery systems 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 has developed with a US partner the ‘Hydrocurrent™ Organic Rankine Cycle (ORC) Module’ that factored in the trend toward slow steaming. The first ORC Module was installed on a ship owned by a marine shipping company in Europe. After a test run aboard the ship was completed in April 2016, marine engineers confirmed that the ORC Module achieved the required power generation efficiency.

The ORC Module is a unique and highly efficient marine system that allows the generation of electricity by recovering and capitalizing on low temperature heat sources as effectively as possible as shown in Figs. 3.2 and 3.3. It utilizes the waste heat of the main engine jacket cooling water (about 85°C). By doing so, the Module can reduce the load on the vessel’s main generator, cut CO2 emissions from the vessel and improve overall energy efficiency.

![Fig. 3.2 Organic Rankine Cycle (ORC) Module and Heat Exchanger](image)
3.2 Boilers

3.2.1 Boilers in general

The depreciation of the yen is contributing to an increase in shipbuilding orders to Japan, and boilers are no exceptions. But various issues are constantly changing the situation facing the marine boiler market. They include the slowing Chinese economy, the impact of a drop in crude oil prices and the environmental issue together with the presence of air pollution materials.

The following is the results of a survey conducted on seven major marine boiler manufacturers, namely MHI, KHI, Miura Co., Ltd., Osaka Boiler MFG. Co., Ltd., Alfa Laval K.K., Tortoise Engineering Co., Ltd. and IMEX Co., Ltd., about the development of their new boiler products, their recent topics and technical developments for FY2014. In recent years, IMEX has not usually produced marine boilers.

(1) Mitsubishi Heavy Industries Marine Machinery & Engine
①New products and development
  ·Auxiliary boilers (MAC: Two-drum water-walled auxiliary boilers)
  Receiving orders for the latest model of the MAC HB Series: Mitsubishi Heavy Industries Marine Machinery & Engine received orders for six MAC-H45B boilers (one boiler for six ships each)
  ·Receiving orders for MAC-90BF dual fuel boilers
  Receiving orders for 90ton/h × 1.5MPa combination dual fuel boilers (two boilers for two ships each)
  One of the two ships adopts 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 17% improvement compared to a conventional boiler.

②Recent topics and technical development
The weaker yen has helped increase orders for auxiliary boilers for merchant vessels.
③ Possible trend in FY2016
The popularity of combination oil/gas boilers is growing and this trend is likely to continue into FY2016.

(2) KHI
① New products and development
Under environmental regulations that have been effective since 2015, heavy fuel oil has not been allowed to be used in emission control areas (ECAs). This situation has remained unchanged since FY 2014, and boilers need to be fired by low sulfur gas oil (LSGO) in these areas. Given this situation, KHI has completed delivery of newly designed LSGO-fired boilers.

② Recent topics and technical development
This is not anything to do with LSGO described above, Exxon Mobil Corporation and other oil majors have newly developed low sulfur fuel oil (LSHFO). Unlike LSGO, LSHFO can be burnt without undergoing major piping modification work only by changing various parameters and burner parts when necessary. If LSHFO comes into the mainstream, demand for LSGO may weaken. As there is some speculation that tighter environmental rules may be introduced in China, many ship owners in Asia have contacted KHI to ask about LSHFO.

③ Possible trend in FY2016
Boiler manufacturers’ focus on their main product line-up has shifted from steam boilers to electric propulsion types. For this reason, KHI expects that it will not receive an order for new boilers for the time being. However, it plans to carry out numerous modification work to make its boilers installed on existing ships more environmentally friendly, as it continued to do in 2015.

(3) Miura
① New products and development
Miura has developed an evaporator used in a binary cycle power generation system that Miura and two other companies jointly developed. It was mounted on the system itself.

② Recent topics and technical development
· In FY 2015, the shipments of its marine auxiliary boilers and composite boilers were larger than the previous year, due to greater demand before the introduction of exhaust gas regulations.
· As the manufacturer predicted last year, demand for its boilers to be mounted on ships carrying chemical products is on the rise.

③ Possible trend in FY2016
Ship owners are likely to change their ship type-based construction plans, and as a result, demand for auxiliary boilers will become more specific to ship types.

(4) Osaka Boiler
① New products and development
N/A

② Recent topics and technical development
Orders for very large crude carriers (VLCCs) have begun to be placed again. The suffering of the dry bulk shipping market has negatively affected business plans to order boilers. South Korea has dominated the global large container ship market up until now. But orders began to trickle in Japan, particularly for ships with 14,000TEU or more. Nevertheless, the container ship market is generally shifting downward.
③ Possible trend in FY2016
Orders for boilers are expected to diminish significantly due to an unprecedented scale of the decline in the dry bulk shipping market. There are three main reasons for this: (1) a backlash from the sudden demand increase; (2) the application of the new Harmonized Common Structural Rules (H-CSR); (3) tightened NOX emission regulations targeting ships whose construction is to begin after January 2016, or expected cost increases including the installation of a NOX reduction device and other compliance costs. At this stage, many ship owners are attempting to change ship types and postpone delivery dates. Even preparations are underway at some ports for some bulkers to be put in ‘cold lay-up’ based on requests from ship owners.

(5) Alfa Laval
① New products and development
Alfa Laval has developed an HPE economizer for exhaust gas recirculation (EGR).

② Recent topics and technical development
It opened a testing and training center in Aalborg, Denmark.

③ Possible trend in FY2016
A wider range of combination boilers may become available in the future for use in LNG-fired ships. In parallel with this, boilers may need to become more accommodated to gas combustion units in these ships. Heat sources are expected to become more diversified and smaller in size.

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 ship type-based orders are as follows.

(1) Marine main boilers and F-LNG boilers
The Fig. 3.4 shows production and order intake numbers of main boilers in Japan for FY 2015. MHI produced two 450t/h steam output boilers and four 500t/h steam output boilers (reheat boilers 10MPa, 565°C). It received orders for five 400t/h boilers. KHI produced two 500t/h steam output boilers (reheat boilers 12MPa, 565°C), but did not receive any new order. This means that Japanese manufacturers produced a total of eight main boilers and received orders for five in FY 2015.
With regard to floating liquefied natural gas (F-LNG) boilers, MHI manufactured two 12t/h steam output boilers and one 14t/h boiler for floating, storage and re-gasification units (FSRU). It also produced two 20t/h steam output boilers and one 42t/h boiler for floating, production, storage and offloading (FPSO) systems, and one 20t/h boiler for a floating offshore structure (FOS), and four 15t/h boilers for floating storage units (FSU). The company received orders for one 14t/h steam output boiler and four 90t/h boilers for the FPRU.

(2) Marine auxiliary boilers

The Fig.3.5 shows production and order intake levels of marine auxiliary boilers (oil-fired boilers) in Japan for FY 2015 on a boiler capacity basis. During the year, seven major marine boiler manufacturers produced a total of 162 units, and the number surged from the 112 units marked in the previous year. The seven manufacturers received orders for 249 units in total, and the number of boilers with steam output of 11t/h to 25t/h rose sharply.

The Fig.3.6 highlights production and order entry numbers of composite boilers for FY 2015. Three hundred and seventy composite boilers were produced and orders for 345 units were placed. 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 363 units in FY2014, 351 in FY2013 and 399 in FY2012.

(3) Exhaust gas economizers

The Fig.3.7 shows production and order placement levels of exhaust gas economizers for FY2015. Manufacturers produced a total of 152 exhaust gas economizers, and the number was up 45% from FY2014 (105 units). But the number of large-scale economizers that can drive turbine generators was down to six in FY2015 from 23 in the previous year.

(4) Heat medium boilers (thermal oil heaters)

A total of 23 heat medium boilers (thermal oil heaters) were produced in FY2015, of which 11 units were large capacity types with heat output of 1,201 to 3,500 kW, and the remaining 12 had a small capacity with heat output below 600 kW. The total production number edged up from 22 in FY2014 when most of units manufactured were small capacity types. Heat medium boilers with large heating capacities, which are used mainly for domestically operating ships, are often installed on heavy oil tankers that require heating.