2. 조선 · 해양 기자재산업의 개발동향

(1) 일 본

The Japanese Marine Industry Today and Tomorrow

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Abstract

The Japanese marine industries have made great contribution not only to the Japanese shipbuilding industry but also to the shipbuilding industry of many countries, Marine industries cover many products and one of the major area is propulsion engines. In this paper the author describes about the present situation of the engine industry and anticipate the future of the industry considering present surrounding circumstances.

Key words : Marine industry, Marine engine, IMO, NOx, Future fuel, Environment

1. Introduction

The Japanese marine industries started in early 1900s. At that time, most of the products were manufactured under license agreement with European manufacturers. Now the most of the products are designed originally and leading world marine industries. This paper describes on the present situation of Japanese marine industries and the international

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contribution focusing about the propulsion engine.

2 Products of marine industries

Marine industries cover many products. Major products are as follows.

+Propulsion engines

Steam turbine, Diesel engine, Gas engine

+Shafting system

Propeller, Propeller shaft, Reduction gear, Water jet, Dumper, Coupling, Shaft generator

+Steering system

Steering gear, Fin Stabilizer

+Deck machineries

Deck Crane, Winch, Windlass

+Navigation equipment

Remote Control system, Rader, Communication equipment, DPS

+Auxiliary machineries

Boiler, Steam turbine, Cargo oil pump

+Components

Valve, Cock, Bolt and nut

Fig. 1 shows the total production of this industry. The output from these industries remains rather steady. It was roughly 800 Bil Japanese Yen through these ten years and it will continue for coming some more years. This means, basically, that Japanese shipbuilding industry is keeping very good market share. And, of course, it is more important that this industry made the best effort towards more attractive technical features and competitive market price.

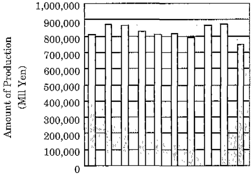

Fig. 1 The amount of total production of marine industries in Japan

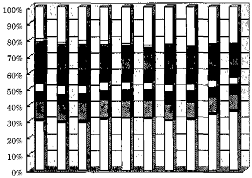

Fig. 2 Distribution of marine products

Fig. 2 shows the distribution of each product. It is also very clear that the weight of each product is staying unchanged. The major products are internal combustion engines, components and attachments and auxiliary machineries.

3. Marine propulsion engine

The propulsion engine is the most important component for ships both in terms of cost and safety.

3.1 Steam turbine

Before oil crises many large ships like VLCCs are powered by steam turbines. But twice of oil crisis brings higher fuel price and kick out all steam turbine plant and forced ship owners to replace with economical diesel engines

Only LNG carriers use steam turbine propulsion plants now. And this situation will continue. Now Mitsubishi Heavy Industries, Ltd. and Kawasaki Heavy Industries, Ltd and their licensees are the only suppliers in this field.

3.2 Diesel engines

At present, the marine propulsion engine market for ocean going ships is completely dominated by 2 stroke cycle slow speed direct coupled engines. Three designs, MAN-B&W, Wartsila and Mitsubishi, are on the market today.

Major suppliers are Japan and Korea as shown in Fig. 3. This situation will continue another some more years and the next country, possibly China, will soon come into this field as a major payer.

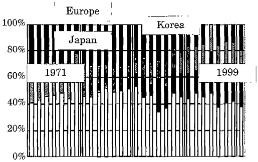

Fig. 3 Market share of marine propulsion engines by country

3.2.1 World alliance

manufacturing companies are forming worldwide alliances. Fig. 4 shows the present network of major engine companies.

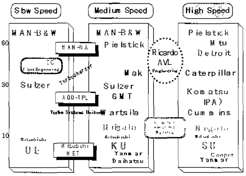

Fig. 4 World Alliance of engine builders

3.2.2 Technical achievement

As shown in Fig. 5, as one of the examples, we can see following three common tendencies of development on 2 stroke slow speed engines.

1) Increase of power output
2) Improvement of thermal efficiency
3) Extended piston stroke

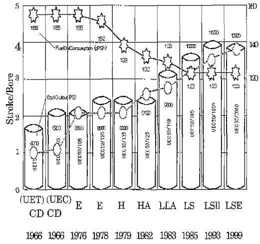

Fig. 5 Design change of slow-speed engines (Mitsubishi UE 50cm bore engine)

When comparing the engine output with almost the same size of bore, the modern engine has nearly two times bigger output with its extended piston stroke. At the same time engine designers are doing their best efforts to keep or rather increase engine reliability.

In a long term, the fuel oil consumption, even if only a small amount of difference, directly affect the running cost of the ship. Today marine diesel engines have highest thermal efficiency of more than 50% as single unit of a prime mover.

The shipyards requested to the engine designer to deliver longer stroke engines to have better propeller efficiency. The stroke to bore ratio is more than 4 in the modern engines, except engines for container vessels

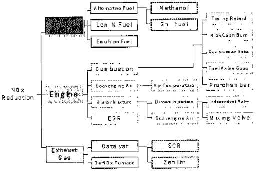

Fig. 6 Various method of NOx control

that has propeller diameter restriction

In addition to the above mentioned technical features, we are now facing to the another technical competition area for the future. That is the area of emission control. As shown in Fig. 6, we have many ideas to reduce NOx from diesel engines.

To the level of IMO regulation, it is not so difficult to clear the line. Actually many engines already have " Statement of Compliance" which will be considered when submitting IAPP certificate in the future. However, it is expected that the next step of IMO regulation will come soon. Of course this surely have much more stricter level. It will be hard to cope with the next stage regulation without additional system like water injection or SCR.

If we succeed to develop the new technology to reduce NOx, with heavy fuel oil at lowest cost, we can expect the longer domination of slow speed diesel engines in marine market. Otherwise we have to switch the fuel to cleaner fuel like methanol, LNG, LPG and DME. In that case we do not need the slow speed engines. We will use less expensive medium speed engines or another primze movers like gas turbines and fuel cells.

In the big city area of Japan, it is prohibited to use heavy fuel oil. Car industry is moving towards fuel cell that will use methanol, DME or hydrogen itself as fuel. This may have some impact on marine fuel market.

3.2.3 Items to be improved

The reliability of slow speed engines at present is relatively well improved. However these engines still have some problems to be solved. For many years, the weak point of diesel engines was hot components. This is still true.

One of the working group of JIME (Japanese Institution of Marine Engineering) studied the problems of the engines by asking questionnaire to ship owners. As shown in Fig. 7, troubles around piston rings, cylinder liners and pistons occupy more than 50% of all engine troubles reported.

The higher feed rate of cylinder lubricating oil is something different type of engine

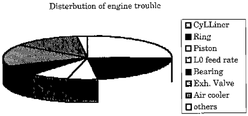

Fig. 7 Engine trouble distribution

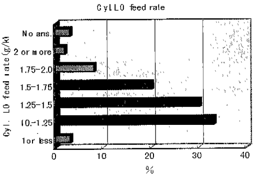

Fig. 8 Cylinder lubricating oil feed rate

problem. But to the ship owners, this will be the most serious problem. Higher feed rate means continuous money consuming and amount of money is not negligible. As shown in the Fig. 8, actually applied feed rate is mainly distributed between the range from 1 g/PSh to 1.75 g/PSh and almost no vessel are running at less than 1 g/PSh feed rate.

The cylinder lubrication is one of the most complicated areas of the engine technology. We must lubricate the area where combustion takes place. Many factors are involved to this problem. The censer technology and electronic devices may help to solve this problem in the near future.

4. Contribution to IMO activities

As a major supplier of marine engines, Japan has supported IMO activities by offering necessary information and by taking part in the discussion.

4.1 NOx technical code

Japan has been deeply involved to the NOx discussion at IMO. It took almost 10 years to finalize the present NOx Technical Code of IMO. We started from collecting necessary data of NOx from marine diesel engine. JSMEA (Japanese Marine Equipment Association) and EUROMOT (The European Association of Internal combustion engine Manufacturers) closely worked together.

It has been agreed between IMO member countries that IMO's final target is to have one equal NOx limit for every type of engines. And also it is agreed to review the code every 5years after it comes into force.

Fig. 9 shows author's anticipation for future NOx regulation by IMO. Already USA, once proposed 30% less NOx limit from present

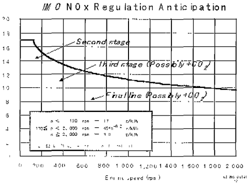

Fig. 9 Anticipation of NOx regulation by IMO

value. And CO2 will be the next emission to be regulated. The best way to reduce CO2 is reduce fuel oil consumption.

4.2 NOx monitoring guideline

The NOx Technical Code of IMO is still under developing. IMO/DE(Design and Equipment) is now developing a new guideline for NOx monitoring by forming a corresponding group under the leader of USA.

Japan is very positively supporting this group. At present we are conducting the long term (one year) continuous monitoring test using a VLCC and a large container ship under financial support from Japan Shipbuilding Research Association. We are intending to expand this project by adding one more vessel (PCC) next year.

This project has following two targets. (Fig. 10)

1) Establish more practical monitoring system.
2) Make clear the effect of a nitrogen contents in fuel on actually generated NOx from engine.(So called fuel NOx)

The conversion rate of the nitrogen contents in fuel on generated NOx from engine is not clear yet.

However, if this rate is relatively high, we have to consider either to revise the NOx Technical Code of IMO or to revise ISO8217

(Marine Fuel Oil). The simple constant volume combustion chamber shown in Fig. 11will be used for measuring NOx from different nitrogen contents in fuel.

The monitoring system should be as simple as possible and very practical from every aspects. We selected a zirconia censer for this purpose. Table 1 shows the list of test ships.

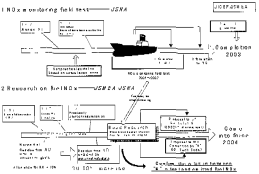

Fig. 10 Continuous NOx monitoring projectx

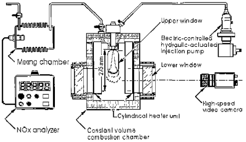

Fig. 11 Constant volume combustion chamber

The test results are not yet enough to evaluate the whole system so far. However we are getting useful information from the test.

When we have the results of the ship tests, we will submit an information paper to IMO and try to reflect on the monitoring guideline. The target date of completion of NOx monitoring guideline is the year of 2003. Until then, we are expecting to be able to collect many useful information through this ship test. Fig. 12 shows one example of monitoring data

Table 1 List of test vessels

	No. 1	No. 2	No. 3
Name of ships	Ikomasan	NYK Antares	Medr'nean Highway
Owner	MOL	NYK	K line
Type of Vessel	VLCC	Container	PCC
Delivery	Sept. 2000	Oct. 1997	Feb. 2002
Shipyard	Mitsui	IHI	Imabari
Engine	MES-B&W 8S80MC 34,100 PS 68 rpm	DU-Wartsila 11RTA96C 72,467 PS 94 rpm	Kobe-MHI 8UEC60LS 18,953 PS 99 rpm

from "NYK Antares"

We welcome any suggestions and requests from any parties who are interested to this project.

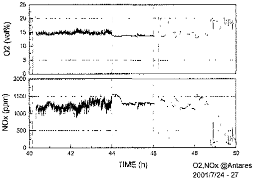

Fig. 12 Test results form NYK Antares

5. Future of marine engines

When we look back the history of marine propulsion engines, it started from man power and moved to wind power, coal fired boilers with steam reciprocating engines, steam turbines. Today most of ocean going vessels are propelled by 2-stroke cycle slow speed engines. The reason is very simple. This type of engines is able to cope with very low graded fuel oil that has cheapest price in the market giving the biggest competitiveness to the vessels.

However, like in the land market, it is

becoming difficult to use this kind of fuel from environmental aspects. Already car industry is targeting fuel cells for the prime mover of the next generation. Some car companies have announced that they will bring them in mass production by the year of 2004.

Table 2 Anticipation of the future

	Present	Near Future	Future
	Gasolin Engine Diesel Engine	Hy-brid Engine Direct Gasolin Injection	Fuel Cell (2004~)
	Diesel Engine	(What we can do?) Environment Technology Electronic Technology	Fuel Cell (2030~)
 Power Generation	(Key Plant) Re-powering Combined Cycle (On-site Plant) Co-generation	(Key Plant) Nuclear re-powering Ceramics Gas Turbine (On-site Plant) Co-generation (Small On-site Plant) Micro Gas Turbine Gas Engine	(Key Plant) Fuel Cell (Small On-site Plant) Fuel Cell Solar Energy

Many people anticipate that in the year of 2030, main engine for vessels will be not the conventional diesel engine but may be fuel cells. Table 2 shows the author's view for the future.

6. Conclusion

In the field of marine propulsion engines, the market has been dominated by the two stroke cycle slow-speed engines for many years. The major reason was its compatibility to the use of very low graded fuel oil that has very attractive price for ship owners and operators.

However the requirement for cleaner exhaust emission is rapidly increasing for not only land based engines but also for marine engines. This brings the difficulty to continue using very low graded fuel oil in the future as before.

If we can develop technology that reduces NOx level dramatically with lowest cost for ships using heavy fuel oil, then we will be able to enjoy the age of slow speed engine. But it seems that it is the time to start to prepare for the next stage of marine propulsion engines.

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References

[1] Annual report on statistics of marine industries Published by JSMEA, Nov. 2000

[2] T.Kumagai, K.Kiyokawa Research on de-rated engine Journal of the JIME, Vol36 No.9