# Some Trends of Marine Engineering and Shipbuilding in Asia

## (Reliability Investigation Works and Their Evaluation Indices)

Takeshi HASHIMOTO *

* Kobe University of Mercantile Marine
(5-1-1,Fukae-Minami-cho,Higashinada-ku,Kobe 658,JAPAN)

Abstract

In Asian countries the productions of ship building and marine engines have been increasing, specially Japanese marine industries have worked hard after 1960s and Korean ones after 1980s. Recently the other countries, as Taiwan and China, have been working so that these hour Asian countries are occuping the high level of shared ratio of productions for gross tonnages and horse powers, which are 74 and 64[%] of the world ones (8.6x10+6[GT],8.6x10+6[PS]) in 1994.

Korean industries had the highest shared ratio of production of tanker vessel and 2 stroke diesel engine as 45[%](2.2x10+6[GT]) and 37[%](1.0x10+6[PS]) which were more than those of Japan as 34 and 16[%] in 1989 respectively.

Some marine databases and their network links among Asian countries are propsed due to the posibility of collection and analyses with their own specifications by the marine industries and operators as well as Japanese ship reliability investigation works(SRIW) like SRIC in Japan. During 1966 and 1996 16 times of SRIW in Japan have been carried out by ship reliability investigation group(SRIG) in Japan. There have been collected and evaluated a great number of field data of failures and maintenances(700x10+3[occ],1.6x10+6[MH]) during running hours (13.4x10+6[Hrs]), from which many kinds of evaluation indices could be gotten as the three indices of occurring rate λ(52.2[occ/1000 Hrs]), average man-hour mh(2.29[MH/occ])and manning index MI (119[MH/1000Hrs]).

An estimation example having the three indices λ, mh and MI were shown by the SRIC 1990 Data Base in Japan for the two kinds of fuel oil suppling subsystems which are dual fuel oil one(DFOS) and mono fuel oil one(MFOS). Three indices MI, and mh for DFOS and MFOS results in 7.16 and 5.20[MH/1000Hrs], 2.63 and 2.06[occ/1000Hrs] and 2.63 and 2.06 [occ/1000 Hrs].Therefore the more simple subsystem MFOS can save approximately 30[%] of maintenance load.

Finally an utilization methods are shown for the SRIC in Japan by means of computer system and worlwide internet links.

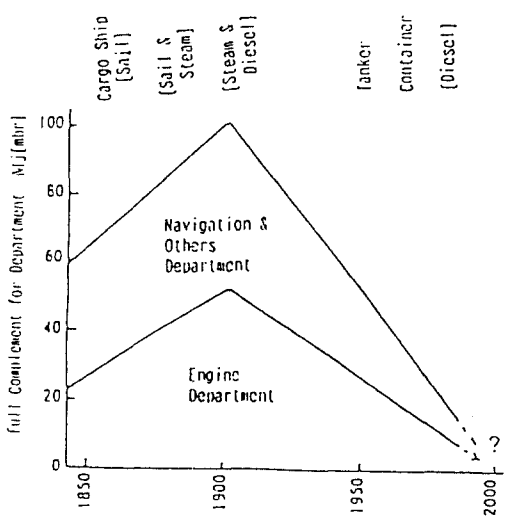


Fig 1 Transition in ship complement of engine department during the past 150 years (1850–2000) and its future

## 1. Introduction

After the beginning of this century there[1] have been developed several important innovations on ships and complements with an average decreasing rate of one person per year during the last 100 years by means of many kinds of technical developments of ship propulsive plants, ships kinds, education and training of crew and quantitative scale merits of ships tonnages and marine engines horse powers,etc(see Fig 1)[1]. And these innovations could be carried out by the three kinds ship automation levels on the marine engine system

key words;production of tonnage and horse power, ship automation, database of marine engine system, evaluation indices of reliability and maintainability

(MES) with respect to the three evaluation indices,ie reliability(R),maintainability(M) and manning index(MI) during 1955 and 1975,etc(see Fig 3,)[2].

This paper describes both the productions trends of the shared ratios of shipbuilding as tonnages for ship vessel and horse powers for marine diesel engines during 1984 and 1994, specially Asian four countries,ie Korea, Japan China and Taiwan, have been occuping the high levels of shared ratios which are approximately three forths and two thirds of the total world volumes respectively since 1984 (see Table I-1)[3].

Moreover since 1950 the seven kinds of automation levels for ships have developed and overcomed lots of problems; how to automate for a smaller complements;how to treat the worse oil, and how to pursue scale merits for economical returns (see Fig 2)[2].

An estimation example is introduced for two types of subsystems of mono fuel oil suppling(MFOS) and dual fuel oil supplying(DFOS) by using the Data Base of Ship Reliability Investigation Committee(SRIC) 1990 in Japan and some Ship Reliability Investigation Group (SRIG) have presented 16 time of SRIW with a great number of the informations of Data Bases during 1966 and 1996 (see Fig 7).[1]~[5]

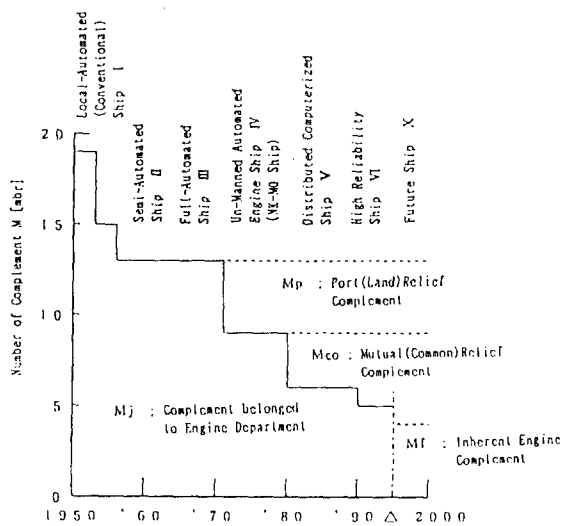


Fig 2 Transition in ship complement of engine department and ship automation levels during the past 50 years (1950–2000) and their future

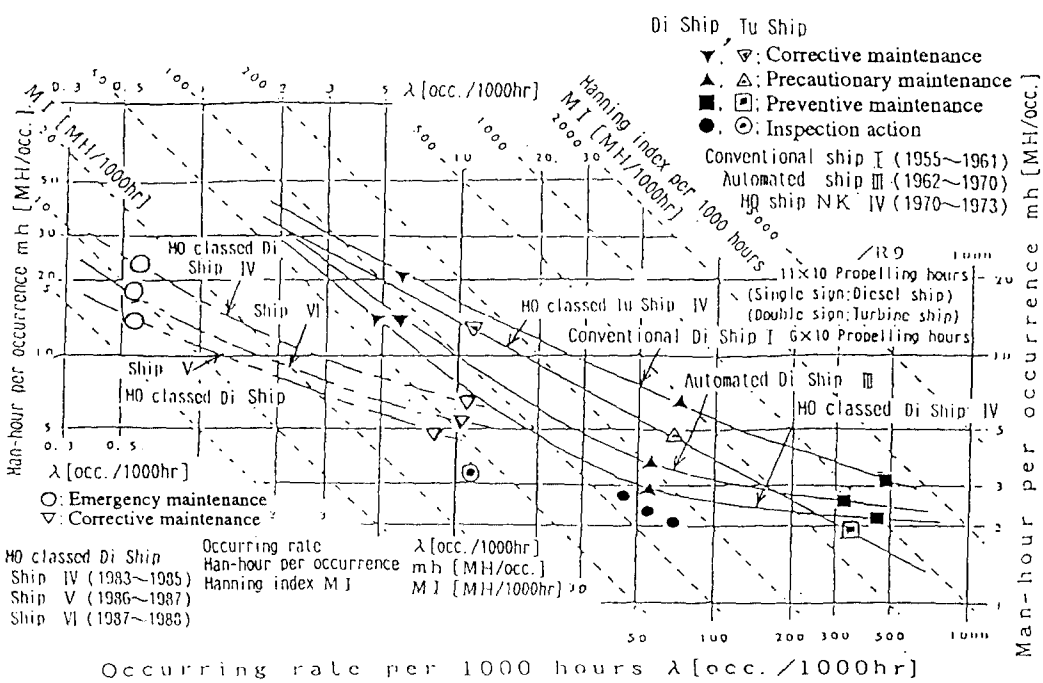


Fig 3 Multivariate evaluation for MES with reliability λ, maintainability mh and manning index MI, with respect to ship automation levels for ships I–VI (1955–1985)

## 2. Productions of Shipbuilding and Marine Diesel Engines

Some trends of productions of many kinds of shipbuilding have been shown [3] in Fig 4 since 1970 in the world and the shared ratios of all kinds of them to the world volumes produced by the four Asian countries, Korea, Japan, China and Taiwan, in Table I-1 at three times of 1984, 1989 and 1994. In Table I-2a and 2b those of tankers and bulkcarriers are shown. The total shared ratios of gross tonnages[GT] by the four Asian countries were approximately 70[%] to the world ones.(see Table I-1) Korean industry got the highest shared ratio of tankers as 45[%]( 2.24x10+6[GT]) which was more than that of Japan as 34[%] in 1989(see Table I-2a), and also has been increasing gradually the level of the shared ratio of bulkcarriers from about 5[%] in 1984, 16 in 1989 and 20 in 1994.

Table I-1 Tonnages[GT] of ship building of all the kinds with respect to Asian countries(Korea, Japan and China&Taiwan) and their shares[%] to the world volume (1984,1989,1994) [3]

| [GT] | Korea | Japan | China&Taiwan | Asia | World |
|---|---|---|---|---|---|
| 1984 | 1,472,897 | 9,711,381 | 1,535,842 | 12,720,120 | 18,334,061 |
| | (8.0[%]) | (53.0[%]) | (6.3[%]) | (69.4[%]) | (100.0[%]) |
| 1989 | 3,101,566 | 5,364,600 | 730,611 | 9,196,777 | 13,236,169 |
| | (23.4[%]) | (40.5[%]) | (5.5[%]) | (69.45%]) | (100.0[%]) |
| 1994 | 4,085,798 | 8,603,600 | 1,311,628 | 14,001,026 | 18,966,169 |
| | (21.5[%]) | (45.4[%]) | (6.9[%]) | (73.8[%]) | (100.0[%]) |

Table I-2a Tonnages[GT] of ship building of tankers with respectto Asian countries(Korea, Japan and China&Taiwan) and their shares[%] to the world volume (1984,1989,1994) [3]

| [GT] | Korea | Japan | China&Taiwan | Asia | World |
|---|---|---|---|---|---|
| 1984 | 379,015 | 742,870 | - | 1,121,885 | 2,108,000 |
| | (18.0[%]) | (35.2[%]) | ( - [%]) | (53.2[%]) | (100.0[%]) |
| 1989 | 2,244,038 | 1,693,846 | - | 3,937,884 | 5,013,000 |
| | (44.8[%]) | (33.8[%]) | ( - [%]) | (78.6[%]) | (100.0[%]) |
| 1994 | 1,797,476 | 2,146,476 | 344,376 | 4,288,328 | 5,635,658 |
| | (31.9[%]) | (38.1[%]) | (6.1[%]) | (70.1[%]) | (100.0[%]) |

Table I-2b Tonnages[GT] of ship building of bulkcarriers with respectto Asian countries(Korea, Japan and China&Taiwan) and their shares[%] to the world volume (1984,1989,1994) [3]

| [GT] | Korea | Japan | China&Taiwan | Asia | World |
|---|---|---|---|---|---|
| 1984 | 446,017 | 6,245,226 | t527,865 | 7,219,108 | 9,404,000 |
| | (4.7[%]) | (66.4[%]) | (5.6[%]) | (76.8[%]) | (100.0[%]) |
| 1989 | 619,124 | 2,158,596 | t308,387 | 3,087,007 | 3,886,000 |
| | (15.9[%]) | (55.5[%]) | (7.9[%]) | (79.4[%]) | (100.0[%]) |
| 1994 | 1,275,569 | 3,768,666 | 733,825 | 5,778,050 | 6,335,871 |
| | (20.1[%]) | (59.5[%]) | (11.6[%]) | (91.2[%]) | (100.0[%]) |

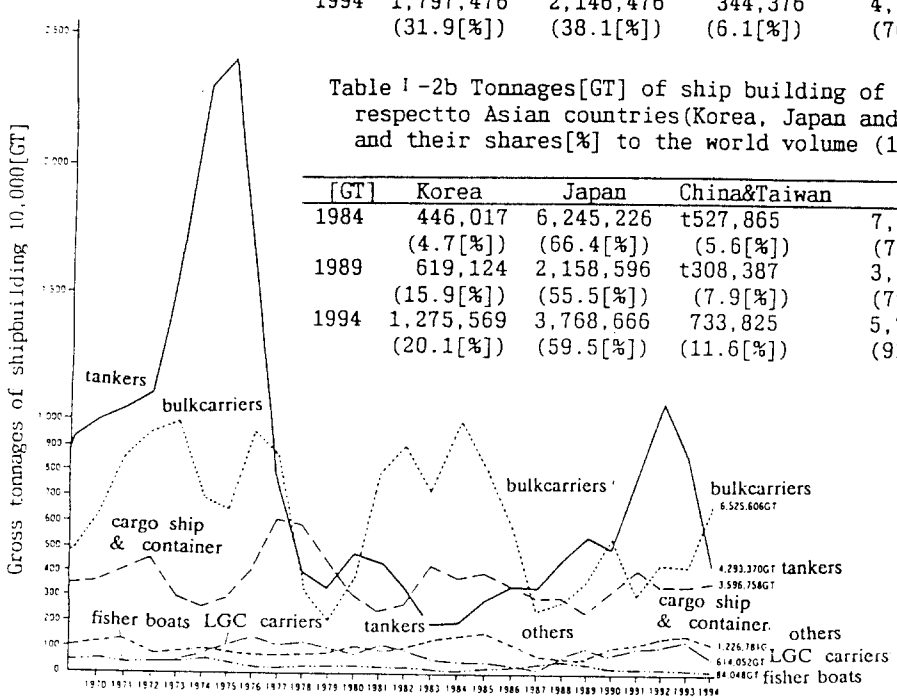


Fig 4 Some trends of many kinds of tonnages launched into the world since 1967 [3]
(more than 1000 [GT]) by Lloyds record

Therefore the total one by the four contries has been gradually from 77[%] in 1984, 80 in 1989 and more than 90 in 1994 too (see Table I-2b).

And some trends[3] of marine diesel engine(horse powers[PS])produced by the major countries in the world are shown in Fig 5 since 1975 and with respect to many types of engines in Fig 6 since 1974. And the shared ratios of all kinds of them to the world volumes produced by the four Asian countries, Korea, Japan, China and Taiwan,in Table Ⅱ-1 at three times of 1984, 1989 and 1994. In Table Ⅱ-2a the shared ratios of horse powers [PS] produced by the three countries, Korea, Japan and China, B&W and SULZER and the 7 types with respect to numbers of factories(f) and sets(s).

The total shared ratios of horse powers[PS] by the four Asian countries were approximately 60 [%] to the world ones.(see TableⅡ-1).

Table Ⅱ-1 Horse power[PS] of marine engine of all the kinds with respect to Asian countries(Korea, Japan and China&Taiwan) and their shares[%] to the world volume (1984,1989,1994)[3]

| [PS] | Korea | Japan | China&Taiwan | Asia | World |
|---|---|---|---|---|---|
| 1984 | 857,365 | 4,657,111 | 445,700 | 5,960,176 | 9,843,631 |
| | (8.7[%]) | (47.3[%]) | (4.5[%]) | (60.5[%]) | (100.0[%]) |
| 1989 | 1,039,471 | 2,121,909 | 326,163 | 3,487,543 | 6,722,037 |
| | (15.5[%]) | (31.6[%]) | (4.8[%]) | (51.9[%]) | (100.0[%]) |
| 1994 | 1,648,340 | 3,382,233 | 439,295 | 5,469,868 | 8,601,975 |
| | (19.2[%]) | (39.3[%]) | (5.1[%]) | (63.6[%]) | (100.0[%]) |

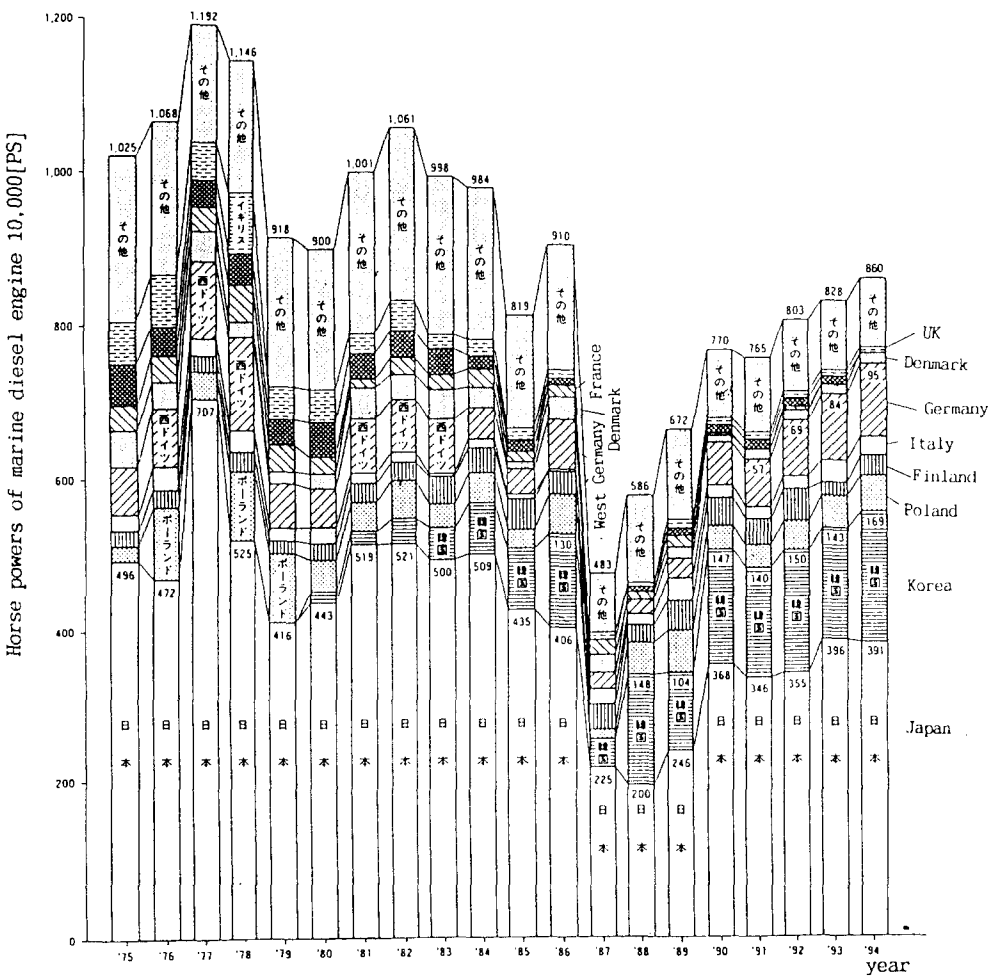


Fig 5 Some trends of engines horse powers[PS] with respect to major countries in the world since 1975
by Motor Ship before 1979 Lloyds record after 1980 [3]

The total shared ratios of only three Asian countries, Korea, Japan and Chana, 82 [%] and 52 [%] of B&W and SULZER respectively in 1994 (see Table II-2a).

In the cases of the other 7 types engines major countries were shown as J(Japan), F(Finland), and G(Germany) in front of production volume[PS].

Table II-2a Production of 2 & 4 stroke diesel engine and 9 kinds of types 3)

| 1994 | Korea 1 | Japan 2 | China 3 | Taiwan | Asia 1 | World-1 |
|---|---|---|---|---|---|---|
| B&W | 1,539,441 | 1,458,722 | 239,265 | - | 3,237,428 | 3,916,729 |
| | (39.3[%]) | (37.3[%]) | (6.1[%]) | - | (82.7[%]) | (100.0[%]) |
| | (3f/90s) | (5f/122s) | (3f/24s) | - | (11f/236s) | (20f/299s) |
| SULZER | Korea 5 | Japan 1 | China 7 | | Asia 2 | World-2 |
| | 154,820 | 1,200,467 | 23,850 | - | 1,379,137 | 2,632,255 |
| | (5.9[%]) | (45.6[%]) | (0.9[%]) | - | (52.4[%]) | (100.0[%]) |
| | (1f/4s) | (3f/49s) | (2f/2s) | - | (6f/55s) | (13f/120s) |

| ①MITSUBISHI UE | ②SEMT | WARTSILA | MAK | ③HANSHIN | MAN |
|---|---|---|---|---|---|
| J836,713 | J 207,186 | F218,438 | G124,205 | J107,800 | G58,544 |
| (100.0[%]) | (76.1[%]) | (100.0[%]) | (100.0[%]) | (100.0[%]) | (100.0[%]) |
| (3f/73s) | (2f/9s) | (1f/32s) | (1f/21s) | (1f/38s) | (1f/5s) |
| W836,713 | W272,486 | W218,438 | W124,205 | W107,800 | W58,544 |

| ④AKASAKA | Asia 3(①,②,③,④) | World 3 | T-Asia | T-World |
|---|---|---|---|---|
| J36,713 | 1,188,412 | 1,654,899 | 5,804,977 | 8,203,883 |
| (100.0[%]) | (94.8[%]) | (100.0[%]) | (74.4[%]) | (100.0[%]) |
| (1f/16s) | (8f/136s) | (10f/194s) | (125f/427s) | (435f/613s) |
| W36,713 | W1,253,712 | | | |

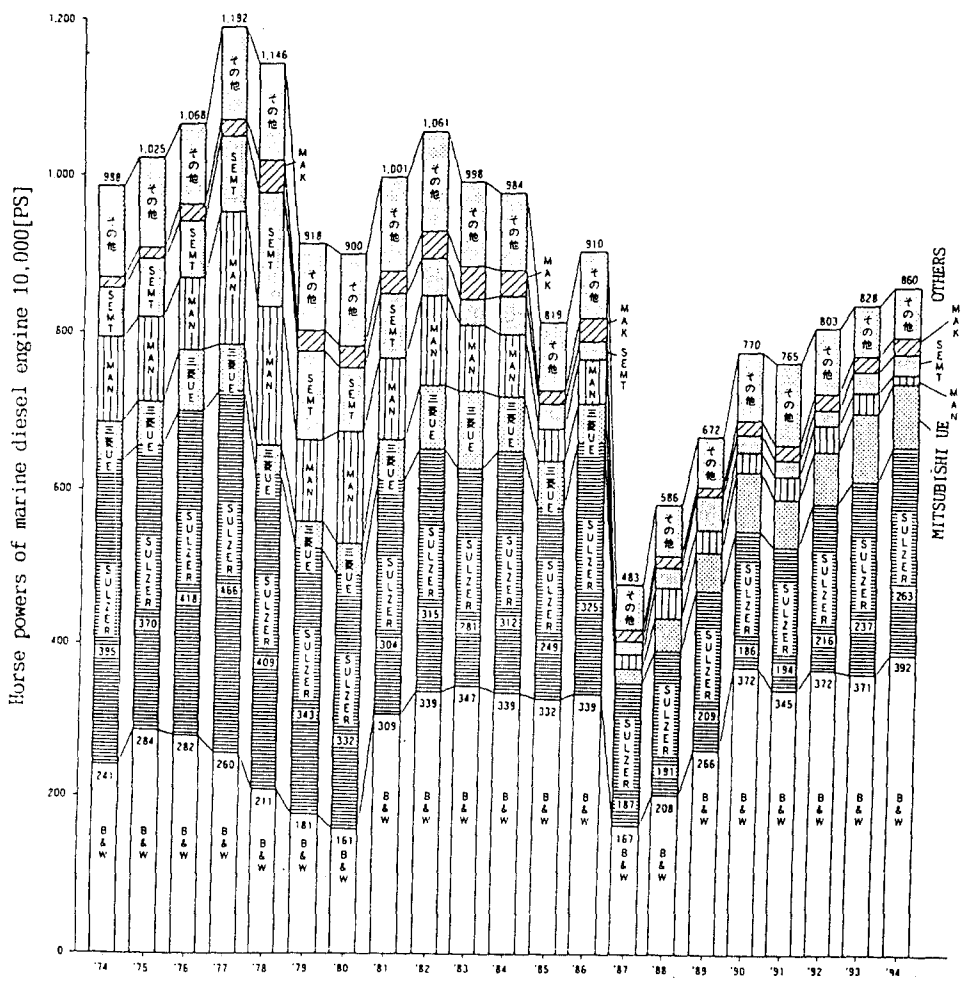


Fig 6 Some trends of many kinds of horse powers[PS] in the world since 1974 by Motor Ship before 1979 Lloyds record after 1980 3)

## 3. Considerations

In this chapter some considerations induced by both the production trends of shipbuilding and marine engines in Asian countries which are Korea,Japan,Taiwan and China during 1984 and 1994 whose shared ratios of tonnages about 70[%](9.20~14.0x10+6 [PS])which were approximately half of peak ones(20x10+6[PS])in 1974. And moreover some construction of maritime database of marine engine system should be proposed among their countries.

### Some considerations on the shipbuilding and marine engines

There have been produced a great part of the productions of the shipbuildings and marine engines in the major Asian countries during 1984 and 1994. Both the total shared ratios of gross tonnages [GT] and horse powers [PS] of all the kinds produced by Korea, Japan, Taiwan and China were approximately 70 and 50[%] of the world ones respectively since 1984 (Table Ⅰ-1 & Ⅱ-1).

Specially it is very remarkable trends that Korea has been increasing the high level of ratio in both the productions of them since 1980s as well as Japanes since 1960s. In Korea both the shared ratios of production tonnages and porse powers in 1988 were four times and two ones of those in 1984 respectively. On the other hand both the Japanese shared ratios had decreased from more than 50 and 40[%] in 1984 down to 40 and 30 [%] in 1989 respectively.

According to both the high ratios level of about 70 and 50[%] in the Asian four countries their peoples meight be good at production of shipbuilding and marine engine, which need much manpowers and endeavor for marine big architectures and sophisticated machineries.

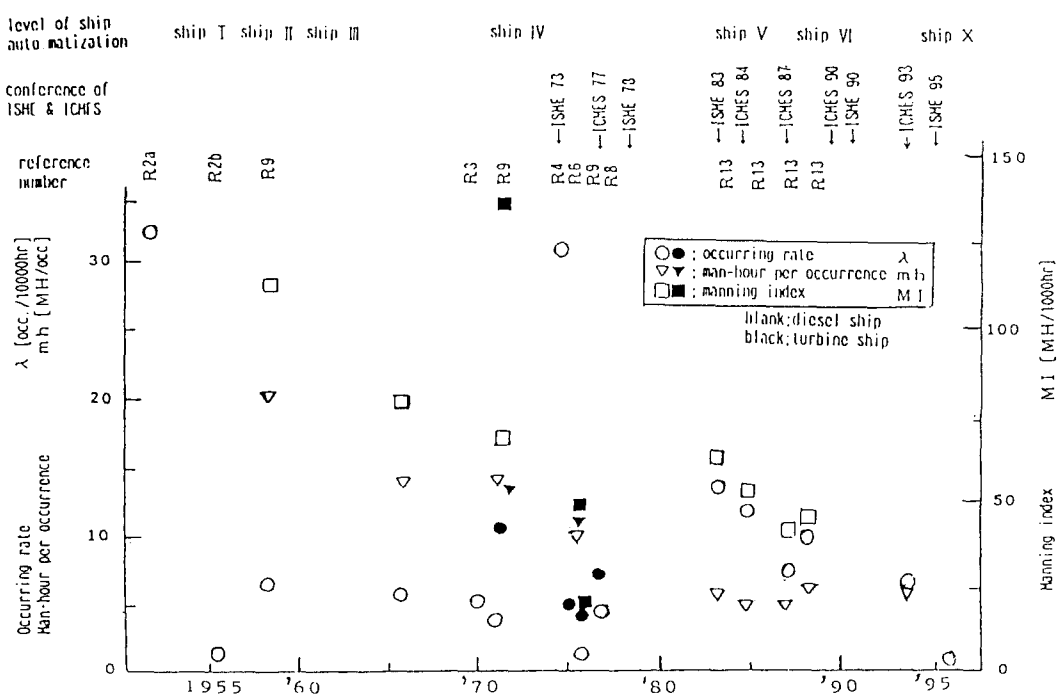


Fig 7 History of three evaluating MESs during the past 30 years (1955–1985) in Japan for ships I–X; ie reliability λ (occ/1000h); maintainability mh (mh/occ); and manning index MI (mh/occ) for corrective maintenance

The high level of both the above ratios during the past decate since 1984 give us the following thoughts;

T1; Most of ships and main engines produced by Asian countries have been cruising and working around the world, and will be able to do in the future too.

T2; Therefore most of many kinds of informations of ship and engine systems with their own specifications can be collected, held and analyzed by the shipyards and industries of Asian countries.

T3; At the same time some useful and powerful databases of ships and engines would be able to be constructed and utilized by theirselves as far as many kinds of informations of ship and engine systems could be cooperated among Asian countries.

T4; According to both the shared ratios of each kind of ships and main engines

a) Korean industry got the highest shared ratio of production of tanker vessel as 45[%](2.24x10+6[GT]),which is more than that of Japan as 34[%] in 1989.(TableI-2a)

b) Korean industry also got the highest shared ratio of production of 2 stroke diesel engine as 37[%](1.04x10+6[PS]), which is more than that of Japan as 16[%] in 1989.

This leads to the fact that Korea industries have been gradually increasing the shared ratio of all kinds of marine engines from about 9[%] in 1984,16[%] in 1989 and 20[%] in 1994.(Table II-1)

c) Concerning the other shared ratios of shipbuilding and marine engines both the Japanese industries have the highest shared ratios due to the other data, whose kinds are ships; bulkcarriers, cargo ships, container ships, LGC carriers and fisher boats and engines; B&W, SULZER, MITSUBISHI UE, SEMT and MAN.

Table III-1 The History of Reliability Investigation Works on Marine Engine System (MES) with Three Indices ,mh,MI in Japan during the past Three Decates (1966~1996)

| | Investigation Working Groups & issued year | Total Running Hours T 10 [Hrs] /Surveyed Ships n[vessel] | No. of Trobles N[occ.]/ Occurring Rate [occ./1000Hrs] | Maintenance Total Man-Hours MI /Average Man-Hours mh [MH/1000Hrs]/[MH/occ.] |
|---|---|---|---|---|
| R1 | SR 85 Committee of JASR 1966 | 346 /28 | 10,959;trbls /31.67 | - |
| R2 | MESJ 1967 (Koizumi) | 903 /72 | 830;falrs / 0.89<br>299;majr m. / 0.33 | - |
| R3 | MESJ 1971 (Hashimoto,Ishizuka) | 187 /11 | 830; / 4.440<br>245;majr m. / 1.31 | - |
| R4 | MESJ 1973 (Tsuruoka,Tamura) | 11[years] / 2 | 6,408;prev m. / 7.87<br>1,192;falrs / 1.46 | - |
| R5 | JASR 1974 (Hashimoto,Ishizuka) | 1,114 /46 | 7,500;falrs / 6.73 | - |
| R6 | MESJ 1975 (Tsuruoka,Tamura) | 485 / 2 | 75;majr m. / 0.15 | - |
| R7 | MESJ 1975 (Murayama,Hashimoto) | 165 /17 | 3,343;alrms / 20.26<br>6,190;falrs / 37.52 | 81,404/15.23<br>- |
| R8 | MESJ 1976 (Hashimoto) | 1,861 /63 | 13,483;falrs / 7.25<br>2,111;majr m./ 1.13 | 179,978/16.17<br>- |
| R9 | ICMES 1977 (Hashimoto,Murayama) | 105:(502) /57: :(64) | 7,825;insp a./ 74.5<br>46,350;prev m./441.43<br>8,315;prec m./ 79.2<br>4,778;falrs) / (9.52) | 224,084/ 3.79 |
| R10 | MESJ 1980 (Hashimoto,Kaneko) | 108:(514) /52 :(72) | 46,311;prev m./428.8<br>8,989;prec m./ 83.2<br>(1,734;falrs) / 3.37<br>( 364;majr m.)/ 0.67 | 183,800/ 3.50 |
| R11 | MESJ 1981 (Hashimoto,Kaneko) | 723 /44 | 25,035;insp a./ 34.6<br>236,858;prev m./327.6<br>98,677;prec m./136.5 | 559,871/ 1.71 |
| R12 | SRIC 1990 (MOT Japan) | 5,995 /148 | 3,343;alarms / 0.56<br>1,734;falrs / 9.47 | 2[years]<br>1,034[occ.] |
| R13 | MESJ 1992 (Kido,Hashimoto) | 1,276 /38 | 30,644;alarms /24.0<br>56,787;falrs /44.5 | 22,746/ 1.62<br>10,745/19.1 |
| R14 | ICMES 1993 (Kiriya) | 9[years] /133 | 67,875;falrs / 6.80 | 339,947/ 5.01 |
| R15 | MESJ 1996 (Hori) | 10[years] | 7,500;sampling/0.75 (for analysis of aging wear effects) | |

trbls;troubles, falrs;failures,majr m.;major maintenance,prev m.;preventive maitenance, alrms;alarms,insp a.;inspection action, prec m.;precuationary maitenance

## 4. The example of evaluating of fuel oil suppling subsystems

Here using the occurring rate λ and man-hour per mh desribed in the SRIC Data Base in Japan the example of evaluating of two types of fuel oil supply subsystems are demonstrated comparison with DFOS(dual fuel oil subsystem) and MFOS(mono fuel oil one). DFOS and MFOS consist of some machineries(No 501~510) with each three evaluation indices (λij,mhij,MIij) from the SRIC Data in Japan 1990 shown in Table Ⅲ-2.

λi,MIi and mhi of an higher level subsytem (DFOS and MFOS) which sonsists of k number lower level items with nij can be calculated by the following equations;

$$\lambda i = \sum_{j=1}^{k} nij \cdot \lambda ij \qquad (1)$$

$$MIi = \sum_{j=1}^{k} nij \cdot \lambda ij \cdot mhij \qquad (2)$$

$$mhi = \frac{MIi}{\lambda i} = \frac{\sum_{j=1}^{k} nij \cdot \lambda ij \cdot mhij}{\sum_{j=1}^{k} nij \cdot \lambda ij} \qquad (3)$$

In Table Ⅲ-2 theestimated results of three indices for both comparable DFOS and MFOS are tubulated and relationships between each three indices for both subsystems are plotted in Fig 8. According to the results shown in Table 8 and Fig. 8 the multivariate evaluations of DFOS and MFOS are observed;

DFOS could be estimated to have three indices MI, λ and mh which were 7.16 and 5.20[MH/1000Hrs],2.63 and 2.06[occ/1000Hrs] and 2.63 and 2.06[occ/1000 Hrs]. So the more simple subsystem MFOS can save approximately 30[%] of maintenance load due to both the elimination of four machineries 506 509 and a reduction of 0.85 units of machinery 510 on list of MFOS shown in Table Ⅲ-2.

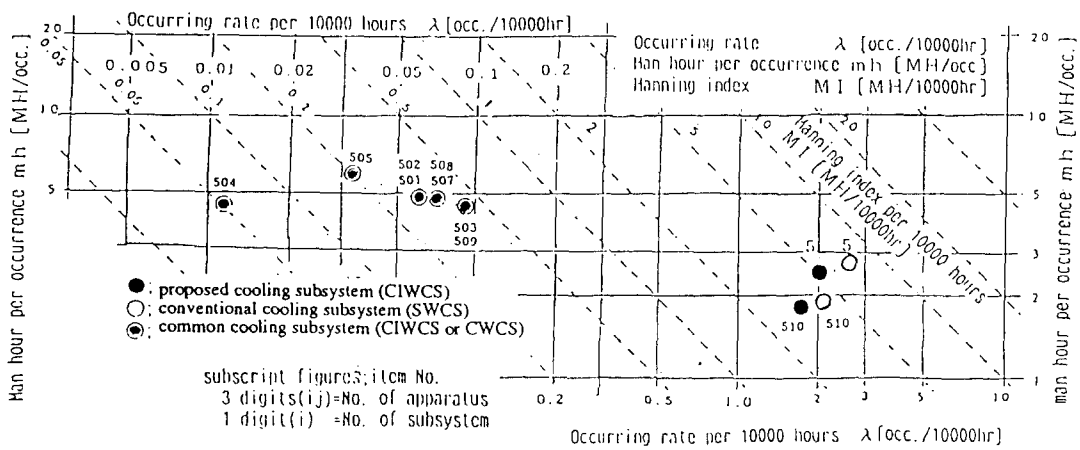


Fig 8 Multivariate evaluation for MES with reliability λ, maintainability mh and manning index MI of the two fuel oil supply subsystems DFOS and MFOS

Table Ⅲ-2 Input data base and estimated results for three evaluation indices λ, mh, MI of dual fuel oil subsystem (DFOS) and mono fuel oil subsystem (MFOS)

| No | Machinery | λij (Occ x 10-4h) | mhij (mh/occ) | MIij (mh x 10-4h) | Conventional DFOS nij | nijλij (Occ x 10-4h) | MIij (mh x 10-4h) | mhij (mh/occ) | Proposed MFOS nij | nijλij (Occ x 10-4h) | MIij (mh x 10-4h) | mhij (mh/occ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 501 | FO feed pump | 0.0388 | 5.1 | 0.1979 | 2 | 0.0776 | 0.40 | 5.1 | 2 | 0.0776 | 0.40 | 5.1 |
| 502 | FO circ pump | 0.0388 | 5.1 | 0.1979 | 2 | 0.0776 | 0.40 | 5.1 | 2 | 0.0776 | 0.40 | 5.1 |
| 503 | FO heater | 0.0452 | 4.9 | 0.2264 | 2 | 0.0924 | 0.45 | 4.9 | 2 | 0.0924 | 0.45 | 4.9 |
| 504 | Visco cont device | 0.0119 | 4.5 | 0.0536 | 1 | 0.0119 | 0.05 | 4.5 | 1 | 0.0119 | 0.05 | 4.5 |
| 505 | DO supply pump | 0.0388 | 5.1 | 0.1979 | 1 | 0.0388 | 0.20 | 5.1 | 1 | 0.0388 | 0.20 | 5.1 |
| 506 | G/E viso cont device | 0.0119 | 4.5 | 0.0536 | 1 | 0.0119 | 0.05 | 4.5 | 0 | 0.0000 | 0.00 | 0.0 |
| 507 | G/E FO feed pump | 0.0388 | 5.1 | 0.1979 | 2 | 0.0776 | 0.40 | 5.1 | 0 | 0.0000 | 0.00 | 0.0 |
| 508 | G/E FO circ pump | 0.0388 | 5.1 | 0.1979 | 2 | 0.0776 | 0.40 | 5.1 | 0 | 0.0000 | 0.00 | 0.0 |
| 509 | G/E FO heater | 0.0452 | 4.9 | 0.2264 | 2 | 0.0924 | 0.45 | 4.9 | 0 | 0.0000 | 0.00 | 0.0 |
| 510 | Valves, pipes etc *1 | 2.0740 | 2.1 | 4.3554 | 1 | 2.0740 | 4.36 | 2.1 | 0.85 | 1.7629 | 3.70 | 2.1 |
| | Total (λi, MIi), Average (mhi) | | | | 16 | 2.6318 | 7.16 | 2.7 | 8.85 | 2.0612 | 5.20 | 2.5 |

Remarks:
1. Input data of λi and mhi for each machinery item refer to the SRIC Data Base 1990 in Japan.
2. For the machinery which is not described in the SRIC Data Base 1990, applicable data are tabulated referring to the other corresponding machinery item.
3. The figures of nij for the piping and valves are applied as follows:
(*) Valves, pipes, etc (item 510) of DFOS whose length and sets are 440m and 94 sets in total corresponding to normalised 1.0 unit, and the same of MFOS are 425m and 94 sets corresponding to 0.85 unit [ = ((425/444) + (69/94))/2].

## 4. Proposals for maritaime database of marine engine system in Asia

Some useful and powerful database of marine ships and engine system could be constructed because even four Asian countries since 1984 procuced most of tonnages and horse powers whose shared ratios of world volumes were 74[%](14.0x10+6[GT])and 50[%](5.5x10+6[PS]) in 1994 respectively. Therefore their own specifications of ships and engine systems could be collected and managed by their industries and authorities.

Now I would like to propose some system of maritime information network and data base banks among the Asian countries. Before costruction of the information network some reliability investigation works can be set up among them by the marine industry and ship owners with many kinds of investigation works shown in Table Ⅲ−1, And then some marine database banks could be founded by them who would manage the information network by means of the worldwide internet links shown in Fig. 9.[4]

Table Ⅲ-1 shows the history of reliability investigation works on marine engine system (MES) with three indices during the past three decades in Japan. The three indices are occurring rate of failures and maintenances $\lambda$[occ./1000Hrs], average man-hour mh[MH/occ.] and manning index MI[MH/1000Hrs].

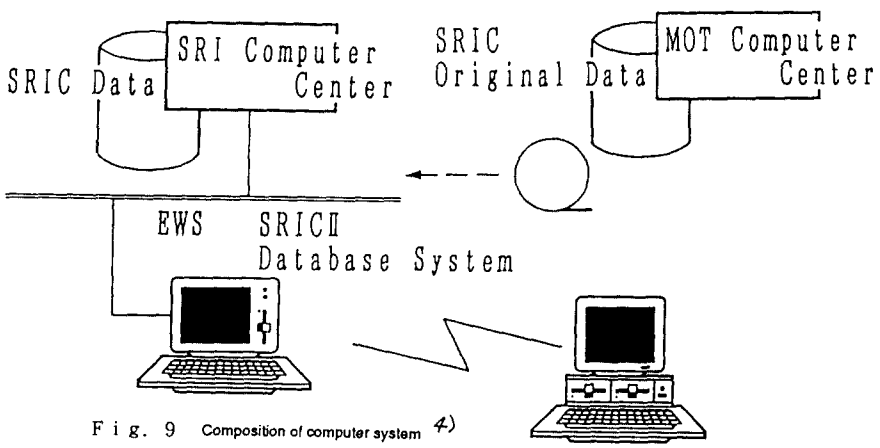


Fig. 9 Composition of computer system [4]

## 5. Conclusions

Making a survey of trends of productions of marine engineering and ship building in Asian four countries(Korea, Japan, China and Taiwan) during 1984 and 1994, and their high level of shared ratios of ship vesels tonnage and marine diesel engines horse power give the following results:

1. The complement level on board has been dereasing gradually from 100 to 10 since the beginning of this century till 1990, due to many kinds of technical innovations.
2. Both the total shared ratios of gross tonnages [GT] and hors powers [PS] of all the kinds produced by Korea , Japan, Chian and Taiwan were approximately 70 and 50[%] of the world ones respectively.

a. Korean industry got the highest shared ratio of production of tanker vessel as 45[%](2.24x10+6[GT]) which was more than that of Japan as 34[%] in 1989.

b. At the same time in 1989 Korean industry also did the highest one of production 2 stroke diesel engine as 37[%](1.04x10+6[PS]) more than that of Japan as 16[%].

c.Therefore the above fact has been increasing gradually the level of ratio of all kinds of engines by Korea from about 9[%] in 1984, 16[%] in 1989 and 20[%] in 1994.

d.Concerning the other shared ones of shipbuilding and marine engines Japanese industries had both the highest ones, whose kinds are ships; bulkcarriers, cargo ships, container ships LGC carriers and fisher boats and engines; B&W, MITSUBISHI UE, SEMT and MAN.

3.SRIW(ship reliability investigation work) included SRIC(ship reliability investigation committee in Japan have been carried out 16 times During 1966 and 1996. A great number of field data of failures and maintenances have been collected as (700x10+3[occ],1.6x10+6[MH]) during running hours (13.4x 10+6[Hrs]). From these data base many kinds of evaluation indices could be gotten as the three indices of occurring rate (52.2[occ/1000 Hrs]), average man-hour mh(2.29[MH/occ]) and manning index MI (119[MH/1000Hrs]).

4.By the SRIC 1990 Data Base in Japan DFOS(dual fuel oil subsystem) and DFOS (mono fuel oil one) could be estimated to have three indices MI, $\lambda$ and mh which were 7.16 and 5.20[MH/1000Hrs], 2.63 and 2.06[occ/1000Hrs] and 2.63 and 2.06[occ/1000Hrs]. Therefore the more simple subsystem MFOS can save approximately 30[%] of maintenance load.

## References

1) T. Hashimoto, ICMES 93, Hamburg, 1993, Sept., 271~272
2) T. Hashimoto et al, ICMES 77, Paris, 1977, May, 15~27
3) Marine Indusry Society in Japan, Annual Report, 1984, 1989, 1994
4) N. Kiriya, MESJ 93, Vol. 28, No. 2, 1993, Feb., 136~155
5) H. Tmanaki, ICMES 90, New castle upon tyne, 1990, Sept., 31~38