121 The Fuel Saving Effect of Prime Mover's Rated Power in Hybrid Propulsion System

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1. Introduction

This paper clarified vessel speed tendency to discuss a new propulsion system of training and marine science investigation ship. Figure 1 shows its trend of Shioji-Maru and Seiyo-Maru belonging to Tokyo University of Marine Science and Technology as the training and investigation ship. The navigation speed is running mainly from 9kt to 11kt, on the other hands, the investigation is implemented in less than 8kt.

Figure 2 shows a histogram of propulsion power in the both ships. Requiring propulsion power by the both ships resulted in low to middle load rate. There are mainly two reasons. One is to save FOC (Fuel Oil Consumption) by decreasing ship speed. Another reason is to make the ship speed dead slow for marine science investigation [1].

In general, it is well known that main engine of thermal efficiency tends to be low in low load condition. It is difficult to improve fuel oil consumption by DD (Diesel Drive) system in training and marine science investigation ships. Therefore, this paper pays attention to HD (Hybrid Drive) system.

We have developed the simulation program to estimate SFC (Specific Fuel oil Consumption) and FOC of propulsion system and electric system [2]. This research gives simulation to optimize rated power of apparatuses in HD system.

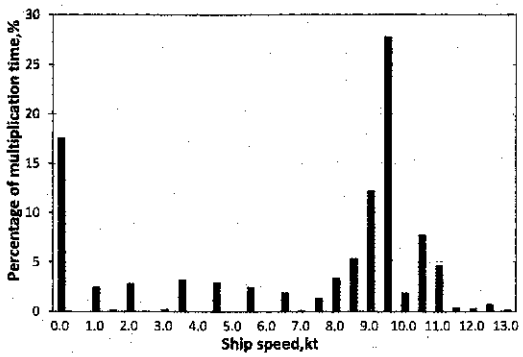

Fig.1 Ship speed trend
in Shioji-Maru and Seiyo-Maru

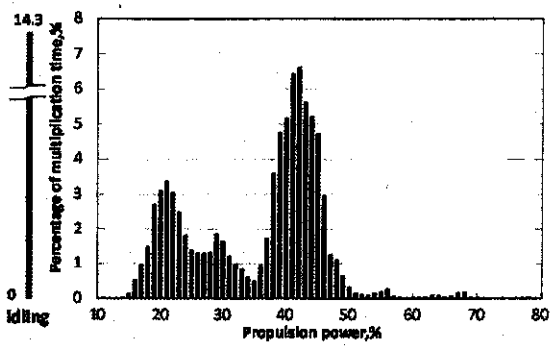

Fig.2 Histogram of propulsion power
in Shioji-Maru and Seiyo-Maru

2. Propulsion system

2. 1 Specification for propulsion system

This paper assumes that propulsion system has 2 shafts to realize high maneuverability. Since it is necessary to control propulsion power quickly from ahead to astern, CPP is proper. Total amount rated propulsion power is set 1600kW. As a result, the rated of one main engine is 800kW.

Figure 3 shows a line diagram of propulsion system in DD system which meets the specifications. The system configuration is simple because propellers are directly driven by the main engines.

2. 2 Hybrid Drive system

Figure 4 shows a line diagram of HD system. In this system, induction motors connect into propulsion system and generator one so that this system can choose DD operation or EP (Electric Propulsion) operation by requested ship speed. Generally, thermal efficiency of diesel engine is higher in high load. Taking this into account, DD operation is appropriate in condition that the requested propulsion power is middle to high in navigation. On the other hands, DD operation is not appropriate in condition that the requested propulsion power is low from the viewpoints of saving fuel oil and improving exhaust gas.

However, EP operation is expected to save fuel oil consumption because diesel generator can maintain high efficiency in high load condition.

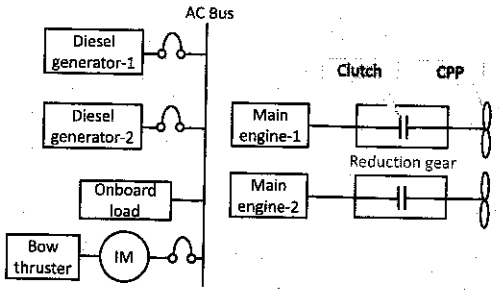

Fig.3 Line diagram of propulsion system in DD system

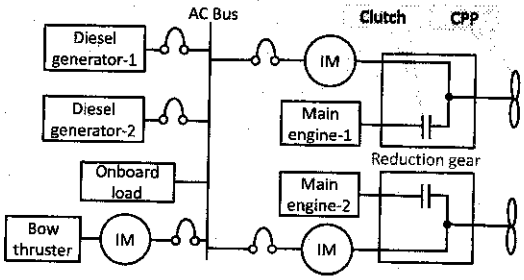

Fig.4 Line diagram of propulsion system in HD system

3. FOC simulation on condition

3. 1 Rated D/G in DD system and onboard load

Supposing on that rated of D/G (Diesel Generator) in DD system is 530kW from the relation between the gross tonnages and the rated of D/G.

Average demanded electric power of navigation in training and investigation ship is low and its average load factor is about 28%. To simplify computation simulation, average onboard load in this study is 530kW × 0.28 ≈ 150kW.

3. 2 Rated D/G and motor in HD

The faster ship is able to go in EP operation, the larger propulsion motor and D/G are necessary. Maximum ship speed in EP operation is very important to improve fuel saving effect in HD system. In this paper, the maximum ship speed is set at 4 conditions as a parameter in EP operation. As for the range of this ship speed, it is supposed that the required power is proportional to cubic of the ship speed. Rated of propulsion motor was determined by these conditions.

Although average onboard load is set as 150kW, estimated load electric power is 265 kW if demanded ratio is 50%. The rated of D/G is determined so that total power of estimated electric load and propulsion power does not exceed over 85% of D/G rated. Consequently, whole power which includes the propulsion power and onboard load is supplied by one D/G in EP operation.

Table.1 Maximum speed and necessary rated of propulsion motor and D/G in HD system

Ship speed[kt]	11.0	10.0	9.0	8.0
Rated of motor[kW]	492	370	270	210
Rated of diesel generator[kW]	1450	1150	900	725

4. Simulation result

Figure 5 shows HD system SFC ratio operated by EP. SFC of DD system is indicated as 100%. Consequently, the efficiency of HD system is improved when SFC ratio is less than 100%.

The SFC ratio is low, so that the rated of D/G is small. Thermal efficiency of generator's prime mover is improved because designing the rated of D/G as small result in high load factor. However, efficiency of DD system is higher than HD system one when the requested ship speed is high, because main engine thermal efficiency is high.

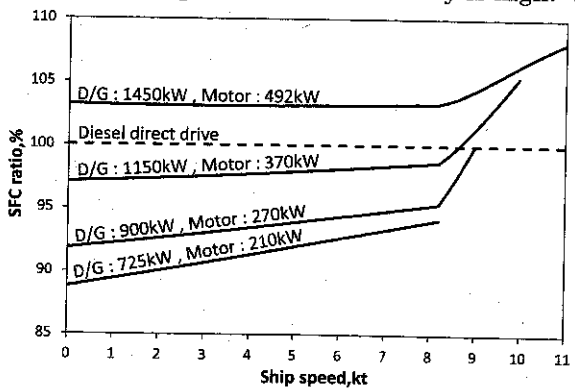

Fig.5 SFC ratio in electric drive and diesel drive

References

(1) Takato Suzuki, Hiroyasu Kifune, "Analyzing Load Fluctuation of Main Engine and Generators on Training Ship", Proc. of 85th JIME Conference, pp. 133-134, 2016

(2) Hiroyasu Kifune, Takaaki Nishio, "A Study of Fuel Consumption Model Using Tugboat's Propulsion System", Proc. of Vol.50 No4,JIME Conference, pp. 129-136, 2015