

Toward the Successful Development of Small Size Plug-in Hybrid Boat

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Executive Summary

In this paper, it is pointed out that the battery contained plug-in hybrid boat, PHEB, has high potential for the real electrification of the small boat providing outstanding performances. The purpose of this paper is encourage the spread of such useful PHEB system for small cruising, fishing and working boats. The PHEB system equips internal combustion engine, electric motor, battery, electric charger for the shore power receiving system. For the practical use of PHEB, it is also suggested to equip electric generators. According to our experience, the PHEB's work very well with the silence, low pollution, and low CO₂ emission during the electric mode together with the ICE's usefulness represented by the robustness of the fuel infrastructure, high energy density. The produced three PHEB's are introduced to show the usefulness of boating.

1 The Advantages of the Hybrid Boat and the Usefulness of PHEB

1.1 The Advantages of the Hybrid Boat

It is possible to categorize the electric boats as shown in Table 1. The PHEB is specified as the use of three power sources of the grid, the internal ICE generator and the ICE direct propeller driving. Speaking of hybrid boat is the battery less series hybrid boat. Such a so-called hybrid boat has 11 advantages, which will be discussed in the full paper.

1.2 The Usefulness of PHEB

In addition to the advantages of the hybrid boat (series hybrid boat), the PHEB has the following advantages.

- PHEB can be a pure electric boat, so that it has advantages of the quietness of the electric ship, no exhaust gases and the advantage of no vibration.
- It has safety and robustness because it can be an engine boat. Even without a charging station, there are oil stations in ports all over the world.
- The existing ship can be remodelled, and the system can be converted into the PHEB at low cost.
- Available as an excellent electric boat at the right place.
- Using power-line system power as much as possible, it can also contribute to the reduction of oil consumption.

- It is possible to improve the fishing environment by taking the advantages of no exhaust gas emission of idle stop operation of PHEB. The environment of the sea area where many fishing boats gather is usually suffered by the diesel engine.
- During fishing, as an electric ship, it is possible to stop idling. The idle stop function shows great effect for the environment of fishing, especially when the *Ippon-zuri* fishing method (a way of fishing where a fishing line and a hook is used) is performed.
- The Plug-in hybrid boat contains very high electric battery energy compared with ordinary ICE boat. By using part of the electric energy, electric power can be stably supplied to all the electronic equipment required for the ship. It can realize a high-tech ship that can demonstrate how much effective reduction and high efficiency of fishing can be demonstrated.

2 The Examples of the Produced PHEB

2.1 Proto-type Small PHEB, PHEB-1

We have made a plug-in hybrid boat (length of 22 ft) driven by an electric motor and a diesel engine [1]. We have named this proto-type boat as “Plug-in hybrid electric boat-1” or PHEB-1.

The PHEB-1 system was produced based on our past feasibility studies and experimental researches [2][3]. This system shows good performance of silence, little vibration and no pollution characteristics as well as the reliability of diesel engine. A block diagram of this boat (PHEB-1) is shown in Fig. 1. This hybrid boat has 10 kW of electricity power using stored battery of 10 kWh and can utilize external electric energy from a grid. One single propeller is driven by either electric motor or diesel engine (65 kW). The electric motor can be used as a generator also [4].

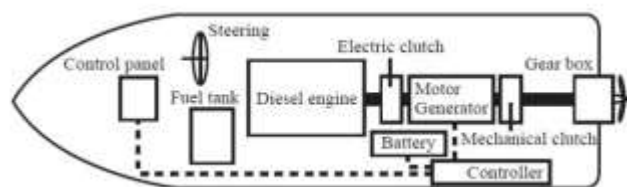


Figure 1: A block diagram of PHEB-1

2.2 A Fishing PHEB, PHEB-2

In principle, to spread the type of PHEB-1, it is necessary to modify used boat instead of new one, because the quantity is important to contribute to the energy saving and clean the environment. The way to utilize used boats results better cost merit than new boat. Recently in Japan, only about 2000 new boats are released per year in the market. Japan has about 200,000 small boats to be modified as PHEB.

A new type of PHEB system has been developed. As shown in Fig. 2, an electric propulsion system is installed independently with the previously installed diesel engine propulsion system. This system can be applied for different boat propulsion systems. To show the performance of PHEB-2, a 4 tons of existing 38 ft diesel (140 kW at maximum output power) inboard propeller fishing boat is used. An electric motor driving system with a stern drive, a propeller, and helm station are installed. By such a method, the electric motor system (an induction motor of 50 kW at maximum and an inverter) does not influence the performance of diesel engine system installed previously. A photograph of PHEB-2 is shown in Fig. 3 [5][6].

The purpose of the construction of PHEB-3 is to demonstrate the usefulness of the plug-in hybrid boat to gain revitalization of marine industries to the future. The PHEB-3 is used in public to show the excellent performance of such plug-in system of quietness and no polluted gas emission from the electric drive train. The easy operation of the continuing cruising for almost all day long is demonstrated as an established fact in September 2016 at Wakayama River cruising in Japan. People on board of almost 30 each cruise reported enjoyable trip throughout the campaign.

3 Discussion and Conclusion

The remarkable reduction of the oil consumption is due to the high efficiency of the electric motor and the idling stop function during the fixed fishing operation. The PHEB-2 system by modifying normal diesel engine fishing boat would have a high potential to spread because of the easier and the lower cost for productions. The PHEB-2 has a generator of 10 kW, so that it is possible to send electricity to the island when a natural disaster happens.

The PHEB-3 system for cruising is examined by the newly developed 30 passengers' river cruising plug-in hybrid boat. The result shows a successful performance of technological usefulness as well as passenger's full satisfaction to the river cruising. The energy density of the battery is still very low for the long range as well as high speed boating. For the reliability point of view, such pure battery boat cannot be the showcase for the future spread of boat. Actually in Holland 2016, we have seen many pure battery electric boats. The country has luckily many marinas to charge battery!

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