HYDROFOIL BOAT FOR INDONESIAN WATERS.

Muhammad Alham DJABBAR 1)
1)Dept. Naval Architecture, Fac. Engineering, Hasanuddin University, Makassar, Indonesia
Email: alham.djabbar@eng.unhas.ac.id

Abstract
Indonesia with many islands and relatively vast country needs a protection of its sea products and good sea transportation. This is in line with the government plan of maritime axe as well as sea toll. To fulfill the plan, operating high speed (fast) boat including hydrofoil boat will be useful. A couple of researches / studies on hydrofoils had been done and published.

The objective is to see the possibility of constructing and operating hydrofoil boats across Indonesian waters optimally.

This study was based mainly on experience of the author sailing hydrofoil boat from Macau to Hong Kong, China in April, 2014. Several aspects were analyzed, i.e. convenience, cabin facility, and economy. The method of comparison (with other fast boats, different type) and matching with Indonesian waters condition was used. Island shape (distance between cities/ports), & rules / regulations on the boat are accounted. It is found that there is a possibility of constructing and operating hydrofoil boat in Indonesia.

Keywords: Hydrofoil boat, Indonesian waters, construction, operating.

Introduction
In Wikipedia [8], the free encyclopedia, hydrofoil boat were used for both military and passenger – Canada, USSR, U.S, and Italy are the builder/operator for military while Russian and Ukraine built for passenger for more than 20 countries. The Boeing 929 of U.S. made, was widely used in Asia including Japan, Korean peninsula, Hong Kong and Macau for Passenger.
Indonesia needs fast (speed) boat to secure marine products including fish. On top of that transporting passengers (between cities, islands as well as tourists), goods, etc. is very beneficial. Some papers of hydrofoil boat were published locally, nationally, and internationally (2011, 2012a, b, and 2013).

Generally in the field of naval architecture, boat, ship, vessel, are marine vehicle – boat usually relatively small ranging from several passengers / crews to about hundred. Vessel may be used for up to four hundred passenger capacity [15].

Typical behavior of a hydrofoil boat is at higher speeds, hull (body) emerging from the water surface. In shipping or naval architecture, speed unit is knot. One knot equal to one nautical mile (about 1.82 km) / hr. Boat with speed of about 30 knots may be grouped into high speed sea vehicle.

The objective is to see the possibility of building and operating hydrofoil boat in Indonesia. To see the suitable operating area, the map of Indonesia, Fig.1 is included.

Figure 1 Map of Indonesia [3]
Material & methods
Theory of hydrofoil boats consists of displacement type of Archimedes principle, at slow (low speed) and semi flying type of Bernoulli principle at high speeds, Fig. 2 with Eq. 1 and Eq. 2. General view of hydrofoil boat, indicated by Fig 3 (July, 2012).
In operational high speed, hull emerging on foils, can be seen in Fig. 4 ‘Jetfoil’ took by the author.

![Lifting force of foil](image)

**Figure-2 Lifting force of foil** [6]

Mathematical Statements (Theory)
Force equal to mass times acceleration, in x-direction Eq. 1

\[ \sum F_x = m \ a_x \]  \hspace{1cm} (1)

\[ a_x = \frac{du}{dt} \]

\[ u = u(x, y, z, t) \]
Marine vehicle hydrofoil lifting the body to increase speeds, based on Bernoulli Equation, eq. 2 derived from Eq. 1. (Lowe, 1979) \[ p_1 + \rho g h_1 + \frac{1}{2} \rho v_1^2 = p_2 + \rho g h_2 + \frac{1}{2} \rho v_2^2 \] (2)

Figure 3. General view, Fully submerged foil \[7\]

Figure 4 Hydrofoil Boat “Jetfoil” \[15\]

Fig. 5 shows the distance of about sixty km between Hong Kong and Macau. Hydrofoil boat sailing Macau – Hong Kong, China, April 2014, 1st (super) class \[13\], ticket for PTC324.00 (currency of macau), Fig.6 and Tricat 2nd (economy)
class, ticket for HK$144.00, Hong Kong - Macau, about 1 hour single trip or 2 hours return.
Comparison with similar fast boats of three-maran (tricat), Fig 7 (displacement type). Data of Indonesian waters, island shapes, as well as shipyard capability are taken into account to get results.

Figure. 5 Hong Kong and Macau [4]
Results and Findings.
Passengers need good seating/space and excellent services. Convenience (less motion) in medium wave sea of hydrofoil boat resulting from foil lifting ability, Fig. 4. The author took Tricat, from Hong Kong to Macau, on same day as sailing the hydrofoil boat (Macau to Hong Kong), Fig. 6. I felt that on the hydrofoil boat were...
more convenience. As a matter of fact, tricat boat experiencing higher motion in oblique waves. Both Tricat and hydrofoil boats were belong to Turbo jet, Hong Kong based company \cite{8,15}. Facility of seat and bath room / toilet were excellent.

Economically, ticket price for Hong Kong – Macau, one hour sail, first class, about Rp400.000,-, second, about Rp200.000,-. Batam – Singapore, ticket, Rp215.000,-, 45 minutes. Comparison indicates that the difference is not significant for economy class, meanings that it is possible to operate the boat in Indonesian waters, provided with good management. Facility of the hydrofoil boat, sailing Macau – Hong Kong is better than speed boat, sailing Batam – Singapore. Fast boat sailing Kupang – Rote island with the ticket price of about Rp3.000 / nautical mile may be as comparable supporting use of the boat in Indonesia.

Performance of hydrofoil boats, suitability in operation in certain area in Indonesia are considered. A couple of places, for instance between Makassar, South Sulawesi to Majene, West Sulawesi the boat will be suitable due to shorter distance (compared with land) and road conditions (Djabbar et al. 2012). Some other places in Indonesia are similar to the route.

The possibility of constructing the boat in Indonesia is high. Quite a few shipyard in Indonesia, for instance PT PAL in Surabaya is able to construct the boat. Beside long experience it has advanced devices, Another shipyards are in Jakarta and Batam. In Batam more than 100 shipyards are capable of constructing various type of boats (ships) \cite{14}.

Just like general construction, by rules\cite{1} boat structure must be strong enough during sailing in rough sea as well as safe navigation. The institution of classification society is in charge of the examination and certification of the boat. Most of maritime countries have the institution, the oldest is Lloyd Register (LR) in UK. In Indonesia it is called Biro Klasifikasi Indonesia (BKI). It has many rules, hydrofoil boat is categorized as high speed boat, and should be built under the rules for classification and construction of high speed craft. In the rules of edition 2000, there are two special requirements for scantling i.e. hydrofoil hull
structures, and air-cushion vehicle hull. Some requirements for hydrofoil are the size of length same or less than 35 m, max speed 40 knots; hard chine hulls, significant dead rise bottom, bow foil within 1/3 length, foils of fixed or lifting type and partially submerged Vee (narrow or wide self stabilizing or completely submerged, horizontal non-self-stabilizing fitted with automatic stabilizing devices. For other characteristics, the Society reserves the right to require appropriate additional calculations and models tank test. There are two requirements, i.e. longitudinal strength and local strength. Longitudinal strength covers allowable stresses -midship section modulus while the latter covers shell and deck plating (minimum thickness); bottom, side and deck structures; primary transverse frames; watertight bulkheads; foils.

Since the building (advanced devices) and operational cost is high, for short term it is recommended to buy first, followed with Indonesian design and construction. Latest rules are 2015 edition\(^\text{[16]}\) should be applied for efficient and effective new building hydrofoil boat.

![Figure. 8 Fully Submerged Hydrofoil Boat](image)

**Specifications**

<table>
<thead>
<tr>
<th>Length, m</th>
<th>31.3</th>
<th>Crew, people</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range, km (24 tons of cargo)</td>
<td>200</td>
<td>Vessel’s speed, knots</td>
<td>55</td>
</tr>
</tbody>
</table>
Fig. 8 Shows other hydrofoil boat, higher speed may used as a comparison in designing the suitable one for Indonesian waters.

**Conclusion and Recommendation.**
Hydrofoil boat is categorized as special craft of high speed, widely used around the globe. The study was based on the experience of the author sailing the boat between Hong Kong and Macau vise versa, in 2014.
It was found that there is a possibility of operating and constructing hydrofoil boat in Indonesia.
It is recommended to operate the boat by firstly buying and secondly building the boat in Indonesia. Study of the boat including boat price, operational cost, latest rules, edition 2015 will be meaningful.

**References**
6. [http://www.google.co.id](http://www.google.co.id), Wikipedia, 2009
10. __________ and A.H. Muhammad, 2011, Fast Ship Serving Makassar, South Sulawesi to Majene, West Sulawesi, International conf.,CRISU & CUPT, Unsri, Palembang,

12. Suandar, Iqbal, Bachrun, Wardina, 2013, Fully Submerged Foil Resistance Approximation SENTA2013, ITS, Surabaya


15. Turbo Jet, 2014, Vessel Information, Horizon magazine, April 2014, Hong Kong