Inventory Shaft and Propeller of Traditional Vessels in Gresik-East Java

A H Budiarto¹, A Winarno¹ and P D Setyorini¹

¹Department of Marine Engineering, Faculty of Engineering and Marine Science, Universitas Hang Tuah, Surabaya, Indonesia

Email : arif.winarno@hangtuah.ac.id

Abstract. Based on the map, parts of Gresik were known as coastal area. Condition of traditional vessel in development and application propulsion systems still use previous vessels as a references. Traditional vessel should follows Indonesia Classification Bureau (Biro Klasifikasi Indonesia or BKI) guidance, however Gresik traditional vessels hasn’t fulfill the BKI guidance. Hence, in this research aim to inventory shaft and propeller of traditional vessel and to calculate according the BKI. The research method is collect literature review, collect vessel data and calculate it according guidance. This research was carried out on vessel data collection in three sub-districts, namely Panceng sub-district, Ujung Pangkah sub-district and Gresik sub-district. There are 3 results in this research, the first one is minimum shaft diameter ($D_s$) which weren’t fulfill BKI guidance is Panceng Sub-district with 20% of 10 vessels. Second results is maximum bearings distance which weren’t fulfill BKI guidance is Panceng Sub-district with 40% of 10 vessels. And the last is all sub-district has fulfill minimum thickness 0,25 propeller radius ($r_2$). Based on the results, importance applying BKI guidance should be introduced for owner or crew of Gresik traditional vessels.

1. Introduction

Gresik district is a city in East Java. In general Gresik district is a low-land area with height two until twelve meters above sea level. Except Panceng subdistrict who has a twenty five meters above sea level. Based above condition, hence Gresik district has a many traditional vessel. The East Java statistic center bureau are noted Gresik district has a 455 traditional vessels with details 148 vessels without engine, and 297 vessels with engine[1]. In general,Traditional wooden vessel are generally built traditionally and are built based only on the craftsman expertise that is obtained from generation to generation[2]. This condition hasn’t know previous vessels design has fulfill or hasn’t with Indonesian Classification Bureau (Biro Klasifikasi Indonesia or BKI) guidance. Considering that condition, traditional vessels has a high risk who can bring about accident for vessels and crew.

Responding that conditions, The traditional vessel important section is propulsion system. Propulsion system has functions as a system that providing vessels thrust is related with resistance vessels, hence necessarily to be calculate in order that thrust can worked with optimality. Propulsion system is include a main engine, transmission system, and propeller. On transmission system there are shaft which has a function to continued rotation from main engine to propeller. Component of shaft is a stern tube and bearings. Propeller has a function receive the rotation from shaft and providing vessel thrust. The thrust is generated by rotation of main engine which is connected with shaft. Therefore
propeller selection and planning should be in accordance with engine power so that rotation resulted can be optimal. In reality many Gresik traditional vessels has a problem with shaft and propeller when or after sailing. It like are wear, fracture, deflection, corrosion, deformation and fatigue.

The importance applying BKI guidance is to guarantee safety of traditional vessels when or not are sailing. Rules BKI about traditional vessel is a part 3 special ships guidelines for FRP and Wooden Ships Up to 24 meters Volume A. 2015. The rules include minimum shaft diameter (Ds), maximum distance between bearings (lmax), and minimum thickness 0,25 radius of propeller (t0.25a). Hence from the background above this research aims to inventory shaft and propeller of traditional vessel in Gresik-East Java, then will be adaptability with BKI guidance. The research purpose can bring benefit for owner or crew of Gresik traditional vessels to choice or planning about propulsion system especially shaft, bearing and propeller.

2. Literature Review

2.1. Shaft
The shaft is a stationary part which can be rotating, usually with a round cross section, the elements such as gears, pulleys, flywheels, cranes, sprocket and other moving elements. The shaft can accept flexural loads, tensile loads, compressive loads or twisting loads which individually or in combination work[3].

2.1.1. Transmission Shaft. Transmission shaft will get a pure twisting or twisting and bending loads. The power transmitted to the transmission shaft is obtained from the clutch, gears, flywheel or sprocket chain[3].

2.1.2. Axle Shaft. The axle shaft is mounted on the freight train wheels. Where hasn’t experience twisted loads, even in a condition shouldn’t rotate. Axle only get bending loads, exceptually it driven by drive element, hence axle will get twisting loads also[3].

2.2. Propeller
The propeller is connected to the shaft which has been connected with the main engine. If the main engine is turned on, the propeller shaft will rotate and continued to propeller[4]. Propellers themselves are divided into two types, namely fixed pitch propeller (FPP) and propellers with pitch that can be changed (Controllable Pitch Propeller). Fixed pitch propeller (FPP) has traditionally been the basis for propeller production for many years. As be expected, the material of this propeller varies greatly according to design and size. For larger propellers, more than 300 mm in diameter, the choice of non-ferrous materials dominates this type. Brass combined with Manganese and Bronze nickel-aluminum is the type of material most often used[5]. In its application to Gresik traditional vessels has choose fixed pitch propeller (FPP).

2.3. Indonesian Classification Bureau (BKI)
The Indonesian Classification Bureau (BKI) was established on July 1, 1964 and remains the only national classification bureau which appointed by Indonesian government to grant classes of Indonesian-flagged vessels. The task was then approved in Minister of Sea Transportation Decree No. Yr. 1/17/2, dated September 26, 1964. Vessels classification is an activity to provide a class based on hull, engine and electricity construction with the aim to assessing the vessels condition is suitable for sailing[6]. BKI has rules and regulations related to vessel which be classified. Regulations about fishing vessels are part 3 of special ships guide for FRP and wooden vessels up to 24m Vol. A 2015. The cruise category traditional vessel can be seen in table 1.
Table 1. Cruise Category Traditional Vessel by BKI [7]

| Category | Caption |
|----------|---------|
| III      | Travel along the coastline which is located at a distance of 20 marine mills, measured from the main land and or from offshore islands which are located at a distance not exceeding 40 marine mills from the main land / other islands. |
| IV       | Day trips between nearby ports along the coastline in a relatively protected area. However, shipping is limited to sea areas located at a distance not exceeding 3 marine mills, measured from the main land and or from offshore islands located at a distance of no more than 6 sea mills from the main land / other islands. |
| V        | Travel in inland waters and lakes. It also includes day trips offshore, limited to shallow and / or sea areas, a distance of no more than 0.75 marine mill, measured from the coast and / or main land. |

2.4. Gresik Traditional Vessels

Gresik district has three regions that constitute the fishing eagle, namely; Gresik Subdistrict the area is nearby Gresik harbour; the coastal area of Panceng Subdistrict, and the Bengawan Solo rivers area in the Ujung Pangkah Subdistrict. From these regions, there are 10 vessels per-region will be choosed to this research. The figure 1 showed a infographic figure about the subdistrict locate on this research.

![Figure 1. Infographic Subdistrict Locate](image_url)

2.4.1. Panceng Subdistrict. Panceng District is located at the westernmost tip of Gresik district directly adjacent to Lamongan district. According to Supriyanto (2019) who is one of the fishermen in the Panceng Subdistrict said that almost all traditional vessels in the Panceng Subdistrict were more precise in the Capmurejo Fish Auction Place (TPI) using 2 (two) machines installed flexibly, hence the shaft can be set the tilt. The size of the vessels has a length between 10 to 13 m. The figure 2 showed a traditional vessels in the Panceng District.
2.4.2. Ujung Pangkah Subdistrict. Geographically, Ujung Pangkah Subdistrict is located in the north of Gresik Regency, where in this region it is the estuary of Bengawan Solo. Traditional vessels or fishing vessels in the Ujung Pangkah sub-district are located in the Bengawan Solo Estuary (MBS) region. According to Sugeng (2019) who is one of the fishermen in the MBS region said that most of the traditional vessels in the MBS region have lengths of vessels between 8 to 12 m, using 1 (one) engine installed flexibly. The figure 3 showed a traditional vessels in Ujung Pangkah Subdistrict.

2.4.3. Gresik Subdistrict. In Gresik Subdistrict, the region which is a group of traditional vessels and fishing vessels is located in the west of the port of Gresik and also nearby gresik petrochemical port. According to Yahya (2019) who is the head of the fishermen's association in Balai Keling, said that the length of the vessels it ranges from 7 m to 11 m, with an average width of 2 m and also many fishermen have switched function that collect the fish is become to service for delivering passengers and cargo to vessels in the middle sea. Traditional vessels in Gresik Subdistrict use 1 (one) permanently installed engine. The figure 4 showed a traditional vessels in Gresik Subdistrict.

Figure 2. Panceng Subdistrict Traditional Vessels

Figure 3. Ujung Pangkah Subdistrict Traditional Vessels

Figure 4. Gresik Subdistrict Traditional Vessels
3. Research Method

3.1. Fish Bone Research Method

What a problem?
- a vessel without BKI guidance

Data Collect
- Vessels Principle Dimension
- Measure Shaft, bearings, and Propeller

Vessel (shaft and propeller) has fulfill BKI guidance

Calculate data according BKI guidance

Figure 5. Fish Bone of Research Method

3.2. Data Collection

On this section, there are three subdistrict to get traditional vessels data, namely; Panceg Subdistrict, Ujung Pangkah subdistrict, and Gresik Subdistrict, with 10 vessel per-Subdistrict. There are some data points must be collected. It can be seen in figure 6, 7, 8 is a detail of data points that should be collected.

Distance between bearings

Figure 6. Shaft Diameter Geometry

Figure 7. Vessel Geometry

Figure 8. Propeller Geometry
3.3. Calculate Data According BKI

There are three thing which can standarization according BKI guidance, there are; Minimum shaft diameter ($D_s$), Maximum distance between bearings ($l_{\text{max}}$), and Minimum thickness of 0.25 propeller radius ($t_{0.25R}$). The following bellow is a formula accord Indonesia Classification Bureau (BKI) 2015 Part 3 Special Ships: Volume A, Guidance For FRP and Wooden Fishing Vessel Up to 24m.

### 3.3.1. Minimum Shaft Diameter ($D_s$).

The formula which mentioned on BKI guidance is on bellow

The minimum propeller shaft diameter ($D_s$) can be determined as a guidance as equation (1):

$$D_s = K_3 \sqrt{C \frac{P}{n^2}} \quad [\text{mm}]$$  \hfill (1)

Where:

- $P$ = propulsive power [kW]
- $n_2$ = propeller shaft revs. [min-1]
- $k$ = 100 for shafts of non-corrosion-resistant steel not protected against seawater
- $= \ 90$ for shafts of corrosion-resistant steel, wrought copper alloys, nickel alloys (Monel) or for non-corrosion resistant steel if the shaft is protected against contact with seawater
- $C = 1.2$ for vessel in operating category III with one propulsion line
- $= 0.8$ for vessel in operating categories IV and V
- $= 1.0$ for vessel with two propulsion units and operating category III

### 3.3.2. Maximum Distance Between Bearings ($l_{\text{max}}$).

Propeller shafts permanently installed in the hull are to be so supported that displacement of individual bearings caused by flexing of the hull does not cause excessive bearings pressures in the adjoining bearings or in the gear bearings. bearings should be as wide apart as practicable [8]. As a guidance for the maximum distance between bearings the equation (2) may be applied:

$$l_{\text{max}} = C_4 \sqrt{\frac{d}{n}} \quad [\text{mm}]$$  \hfill (2)

Where:

- $l_{\text{max}}$ = maximum distance between bearings
- $d$ = shaft diameter [mm]
- $n$ = shaft revs. [min-1]
- $C = 12000$ for steel shafts
= 8 000 for bronze shafts

Where engine and gear are flexibly mounted and with the stern tube bearings of rubber, the C-value in above formula should be at least \( C = 6000 \) if the propeller shaft is led directly from the gear output flange to the propeller. In such cases flexible mounting of the stern seal to the stern tube is to be applied[8].

3.3.3. Minimum Thickness 0,25 Propeller Radius.

Standard values for the thickness 0,25 of propeller radius can be determined as equation (3):

\[
t_{0,25R} = K \sqrt{\frac{C \cdot P \cdot 10^2}{B \cdot z \cdot n_2}} \quad [\text{mm}]
\]  

\[P\] = propulsive power [kW]  
\[n_2\] = propeller revs. [min-1]  
\[B\] = width of blade at 0,25 R [mm]  
\[z\] = number of blades  
\[K\] = 60 for propellers of cast brass  
= 75 for propellers of an alluminium alloy (cast in chill mould)  
= 100 - 120 for propellers of synthetic material  
\[C\] = 1,2 for vessel in operating category III  
= 0,8 for vessel in operating categories IV and V

4. Results and Discussion

4.1. Minimum Shaft Diameter (Ds)

On this bellow an example of minimum diameter shaft calculate with two (2) engines

1. KM Kebudablak

\[
d_s = k \cdot \sqrt{C \cdot \frac{P}{n_2}} \quad [\text{mm}]
\]

\[
d_s = 90 \cdot \sqrt{1,0 \cdot \frac{17,90}{(2200/5,06)}}
\]

\[
d_s = 90 \cdot \sqrt{0,04117}
\]

\[
d_s = 90 \cdot 0,345
\]

\[
d_s = 31 \text{ mm}
\]

With the same formula and method, it can be applied to other vessels. Following below is a comparison of survey results with the minimum shaft diameter calculation according to BKI guidance.

- Panceng Subdistrict

The measure of the shaft diameter (Ds) in Panceng District (vessels with 2 engines) is quite varied ranging from 32 to 45 mm. These results approach with the minimum value of the shaft diameter according to BKI which is 30 to 33 mm. However, there are 2 (two) vessels that hasn’t fulfill the
minimum shaft diameter \((Ds)\) calculation from BKI guidance, namely Nabila Vessel and Hasil Laut Vessel where shaft diameter value is 32 mm while the value according to BKI is 33 mm. On Panceng Subdistrict vessels first shaft diameter can mentioned actual shaft diameter 1, and for second shaft diameter can mentioned actual shaft diameter 2.

![Figure 9. Minimum Shaft Diameter \((Ds)\) Comparassion in Panceng Subdistrict](image)

- **Ujung Pangkah Subdistrict**
The shaft diameter \((Ds)\) in Ujung Pangkah Subdistrict ranges from 19 to 24 mm. These results approach with minimum value of the shaft diameter according to BKI which is 12 to 15 mm. Based on these data it can be seen that the 10 vessel data has a value above the calculation interval according to BKI so it can be stated that all vessels is fulfill the standard of minimum shaft diameter \((Ds)\) that has been regulated by BKI.

![Figure 10. Minimum Shaft Diameter \((Ds)\) Comparassion in Ujung Pangkah Subdistrict](image)
Gresik Subdistrict
The shaft diameter (Ds) in Gresik Subdistrict ranges from 19 to 24 mm. These results approach with minimum value of the shaft diameter according to BKI which is 14 to 15 mm. Based on these data it can be seen that the 10 vessels data has a value above the calculation interval according to BKI so it can be stated that all vessels is fulfill the standard of minimum shaft diameter (Ds) that has been regulated by BKI.

![Minimum Shaft Diameter Comparison in Gresik Subdistrict](image)

**Figure 11.** Minimum Shaft Diameter (Ds) Comparassion in Gresik Subdistrict

4.2. Maximum Distance Between bearings (Imax)
On this bellow an example of maximum distance between bearings calculate.

1. KM Kebudablak

\[
I_{\text{max}} = K_2 \cdot \sqrt{\frac{d}{n}}
\]

\[
I_{\text{max}} = 6000 \cdot \sqrt{\frac{32}{434.78}}
\]

\[
I_{\text{max}} = 6000 \cdot \sqrt{0.0736}
\]

\[
I_{\text{max}} = 6000 \cdot 0.271
\]

\[
I_{\text{max}} = 1628 \text{ mm}
\]

With the same formula and method, it can be applied to other vessels. Following below is a comparison of survey results with the maximum distance between bearings calculation according to BKI guidance.
Panceng Subdistrict
The value of the distance between the bearings in the Panceng District (vessels with 2 engines), quite varied ranging from 1333 to 1967 mm. These results approach with the minimum value according to BKI it is 1628 to 1930 mm. However, there are 4 (four) vessels that hasn’t fulfill the maximum distance between bearings from BKI, namely KM Aimeelele, KM 7 Lungan, KM BGS and KM Mayang where each bearings distance is 1817 & 1850 mm, 1800 & 1800 mm, 1900 & 1800 mm and 1967 & 1833 mm while the maximum values according to BKI are 1750 & 1797 mm, 1797 & 1774 mm, 1774 & 1726 mm and 1797 & 1702 mm.

![Maximum Distance Between Bearings (lmax) Comparassion in Panceng Subdistrict](image1.png)

Figure 12. Maximum Distance Between bearings (lmax) comparassion in Panceng Subdistrict

Ujung Pangkah Subdistrict
The value of the distance between the bearings in Ujung Pangkah Subdistrict ranges from 443 to 593 mm. These results approach with the maximum value of the distance between the bearings according to BKI which is 558 to 627 mm. Based on these data it can be seen that the 10 vessel has a value below the calculation interval according to BKI guidance, hence it can be stated that in all Ujung Pangkah Subdistrict vessels has fulfill with standard of the maximum distance between bearings by BKI.

![Maximum Distance Between Bearings (lmax) in Ujung Pangkah Subdistrict](image2.png)

Figure 13. Maximum Distance Between bearings (lmax) Comparassion in Ujung Pangkah Subdistrict
Gresik Subdistrict
The value of the distance between the bearings in Gresik Subdistrict ranges from 357 to 550 mm. These results approach with the maximum value of the distance between the bearings according to BKI which is 548 to 613 mm. Based on these data it can be seen that the 10 vessel has a value below the calculation interval according to BKI guidance, hence it can be stated that in all Gresik Subdistrict vessels has fulfill with standard of the maximum distance between bearings by BKI.

![Figure 14. Maximum Distance Between bearings (lmax) Comparison in Gresik Subdistrict](image)

4.3. Minimum Thickness 0.25 Propeller Radius ($t_{0.25R}$)
On this bellow an example of minimum thickness 0.25 propeller radius calculate

1. KM Kebudablak

\[
t_{0.25} = K \cdot \sqrt{\frac{C \cdot P \cdot 10^2}{B \cdot z \cdot n_2}} [mm]
\]

\[
t_{0.25} = 60 \cdot \sqrt{\frac{1,2 \cdot 17,90 \cdot 10^2}{75.3.434,78}}
\]

\[
t_{0.25} = 60 \cdot \sqrt{\frac{1790}{97825,5}}
\]

\[
t_{0.25} = 60 \cdot \sqrt{1,2.0.0183}
\]

\[
t_{0.25} = 60 \cdot 0,0219
\]

\[
t_{0.25} = 60 \cdot 0,1481
\]

\[
t_{0.25} = 8,9 \text{ mm}
\]

With the same formula and method, it can be applied to other vessels. Following below is a comparison of survey results with the minimum thickness 0.25 propeller radius calculation according to BKI guidance.
- Panceng Subdistrict

The value of the minimum $t_{0.25R}$ in Panceng Subdistrict ranges from 10 to 15 mm. These results far different with the minimum thickness 0.25 propeller radius according to BKI which is 8.9 to 9.6 mm. Based on these data it can be seen that the 10 vessel has a value above the calculation interval according to BKI guidance, hence it can be stated that in all Panceng Subdistrict vessels has fulfill with standard of the minimum thickness 0.25 propeller radius by BKI.

**Figure 15.** Minimum Thickness 0.25 Propeller Radius ($t_{0.25R}$) Comparasion in Panceng Subdistrict

- Ujung Pangkah Subdistrict

The value of the minimum $t_{0.25R}$ in Ujung Pangkah Subdistrict ranges from 8.8 to 9 mm. These results far different with the minimum thickness 0.25 propeller radius according to BKI which is 2.9 to 3.8 mm. Based on these data it can be seen that the 10 vessel has a value above the calculation interval according to BKI guidance, hence it can be stated that in all Ujung Pangkah Subdistrict vessels has fulfill with standard of the minimum thickness 0.25 propeller radius by BKI.

**Figure 16.** Minimum Thickness 0.25 Propeller Radius ($t_{0.25R}$) Comparasion in Ujung Pangkah Subdistrict
Gresik Subdistrict

The value of the minimum $t_{0.25R}$ in Gresik Subdistrict ranges from 7.9 to 9.2 mm. These results far different with the minimum thickness 0.25 propeller radius according to BKI which is 3.3 to 3.7 mm. Based on these data it can be seen that the 10 vessel has a value above the calculation interval according to BKI guidance, hence it can be stated that in all Gresik Subdistrict vessels has fulfill with standard of the minimum thickness 0.25 propeller radius by BKI.

![Figure 17. Minimum Thickness 0.25 Propeller Radius ($t_{0.25R}$) Comparison in Gresik Subdistrict](image)

| Vessels Name | Actual $t_{0.25R}$ (mm) | Minimum $t_{0.25R}$ by BKI (mm) |
|--------------|--------------------------|----------------------------------|
| Cahaya Hatni | 9.0                      | 3.3                              |
| Sari Nylia   | 9.0                      | 3.3                              |
| Setus Meerah | 9.0                      | 3.3                              |
| Kamelia     | 9.0                      | 3.3                              |
| Zafhran     | 9.0                      | 3.3                              |
| Samudira    | 9.0                      | 3.3                              |
| Maulud      | 9.0                      | 3.3                              |
| Sentosa     | 9.0                      | 3.3                              |
| Sanuber Rejeki | 9.0              | 3.3                              |
| Ademayem    | 9.0                      | 3.3                              |

4.4 Result comparison

Lastly, we compare the results from Panceng Subdistrict, Ujung Pangkah Subdistrict and Gresik Subdistrict as summarized in Table 2, 3 and 4.

### Table 2. Minimum shaft diameter (Ds) comparison

| Subdistrict Name     | Survey Result (mm) | BKI Calculate (mm) | Caption                  |
|----------------------|--------------------|--------------------|--------------------------|
| Panceng Subdistrict  | 32 - 45            | 30 - 33            | 20% hasn’t fulfill       |
| Ujung Pangkah Subdistrict | 19 - 24        | 12 - 15            | 100% has fulfill         |
| Gresik Subdistrict   | 19 - 24            | 14 - 15            | 100% has fulfill         |

### Table 3. Maximum distance between bearings (lmax) comparison

| Subdistrict Name     | Survey Result (mm) | BKI Calculate (mm) | Caption                  |
|----------------------|--------------------|--------------------|--------------------------|
| Panceng Subdistrict  | 1333 - 1967        | 1628 - 1930        | 40% hasn’t fulfill       |
| Ujung Pangkah Subdistrict | 443 - 593       | 558 - 627          | 100% has fulfill         |
| Gresik Subdistrict   | 357 - 550          | 548 - 613          | 100% has fulfill         |
Table 4. Minimum Thickness 0.25 Propeller Radius ($t_{0.25R}$)

| Subdistrict Name          | Survey Result (mm) | BKI Calculate (mm) | Caption               |
|---------------------------|--------------------|--------------------|-----------------------|
| Panceng Subdistrict       | 10 - 15            | 8.9 - 9.6          | 100% has fulfill      |
| Ujung Pangkah Subdistrict | 8.8 - 9            | 2.9 - 3.8          | 100% has fulfill      |
| Gresik Subdistrict        | 7.2 - 9.2          | 3.3 - 3.7          | 100% has fulfill      |

5. Conclusion

Based on survey results and a series of calculation processes that have been carried out. There are conclusions that can answer the problem formulation. The results of adjustments or standardization that refer to the regulations of the Indonesian Classification Bureau (Biro Klasifikasi Indonesia or BKI) is minimum shaft diameter ($D_s$) which weren’t fulfill BKI guidance is Panceng Sub-district with 20% of 10 vessels. Second results is maximum bearings distance which weren’t fulfill BKI guidance is Panceng Sub-district with 40% of 10 vessels. And the last is all sub-district has fulfill minimum thickness 0.25 propeller radius ($t_{0.25R}$). Therefore socialization about BKI guidance is very important so that fishing vessels fulfill the standards and can sail safely and optimally.

References

[1] East Java Central Bureau of Statistic. 2015. Fishing Vessels Accord Type and Subdistrict Locate Vessels.

[2] Muhammad AH, Rauf AM, Lage FF, and Renaldy A. 2010. Bulbous Bow Impact on Traditional Vessel Resistance Reduce. Prosiding Marine Technology Research 2010.

[3] Saudi A, Rauf FA, and Lumintang R. 2016. Review Propeller Shaft Cracked with Non Destructive Testing Method. Machine Shaft Journal. vol 5, no 2.

[4] Indonesia Classification Bureau. 2018. Part 1 Seagoing Ships: Volume I Rules For Classification and surveys. Jakarta: Indonesia Classification Bureau. IDN.

[5] Kondo Y, Siahaya Y, and Leonard J. 2012. Investation Analysis on Vessel Propeller Moulding Industry (Study Case: CV. Antero Jaya Sakti) Mechanical Journal. vol 3, no 1, pp. 231-239.

[6] Carlton J.S. 2007. Marine Propellers and Propulsion. Global Head of Marine Technology and Investigation, Lloyd’s Register: John Carlton. USA.

[7] Indonesia Classification Bureau. 2015. Part 3 Special Ships: Volume A Guidance For FRP and Wooden Fishing Vessel Up to 24m. Jakarta: Indonesia Classification Bureau.IDN.