

Design and Application of Unsinkable Tuna Longboat for Local Fishermen

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Abstract

The activities of fishermen in archipelago regions (Eastern Indonesia and Pacific) mostly relate to the efforts in catching fishes and other marine resources. One of the most valuable fish is Tuna which is caught by simple up to modern big vessels and fishing gears. Most Moluccas fishermen are using small “tuna longboats” for this purpose. Those small boats operate in open seas where most of the time the sea conditions are rough. In many cases, those small boats could not resist in such conditions which will end-up with flooding, capsizing or sinking. Some records showed the fishermen and boats are lost at sea. A study was executed to solve this problem. Three new tuna long boats, with the size of 1.5 GT each, were designed. Those boats were provided with solid boxes inside to provide reserve buoyancy. The boats were constructed with the material of composite (Fibre Glass Reinforced Plastic). Then, the boats were tested at sea. The results of test showed that for a maximum flooding of boats, they still float (unsinkable) with a minimum trim level. In addition, for a capsize condition, they were still afloat and easily were returned to upright position. The results of boat design and evaluating were recommended to be applied to the users. A training program was conducted for the local boat builders during the study. Nowadays, the local boat builders have developed this unsinkable concept to their new boats into the market.

Keywords: Fibre Glass Reinforced Plastic (FRP), reserve buoyancy, solid boxes, training program

Introduction

Eastern Indonesian waters as well as some Pacific regions have great potential of marine products, particularly tuna fish. This kind of fish has a valuable selling price in the international markets. Tuna fishes are caught in some fishing grounds in Eastern Indonesian and Pacific waters. They are caught by using some simple up to modern vessels with fishing gears. Local fishermen, especially in Moluccas, are using small boat, called “tuna longboat” with the capacity of 1.5 GT. The boat is operated by two fishermen where they use the fishing gears of hand or trolling lines. The fishing grounds are in open waters with some rough sea conditions. At certain periods, there are strong winds with big waves. The operation of those small boats in such rough waters is not possible. Some accidents occurred where the boats were flooded, capsized and sunk. The fishermen lost their life at sea. The boats were

designed and constructed by local boat builders without paying any attentions of boat design concept. The design process were only based on traditional experiences where this issue lasts for long time. Such small boats were constructed with the material of wood or Fibre Glass Reinforced Plastic (FRP).

A study was conducted to find the solutions. New boat configuration was introduced in this study. A team of design and construction of small fishing boat, Faculty of Engineering, Pattimura University was responsible for this work. Three boats (hull material of FRP), with the size of 1.5 GT each, were designed and constructed based on proper ship design concept. Those boats were provided with some solid boxes inside. The configuration and dimensions of solid boxes were calculated and distributed properly along the boats. Furthermore, the boats were tested at sea for floating purpose. At the test, the boats were filled with sea water into all compartments inside. It was found that the boats were still afloat at certain draft. In addition, the boats were capsized at an upside-down position. It was found also that the boats were still afloat at certain condition and easily to be turned into their initial upright position.

Boat Design and Construction

Design of a boat should be based on some requirements, design considerations and following the whole design process (TAGGART 1983). In this case, design consideration is the boat ability to afloat on upright or even in capcized positions. In addition, a consideration of boat operation and environmental conditions would end up with a boat configuration. Other considerations are based on the requirements of small fishing boat with a certain cathing target. The boat was also designed to fulfill the requirements as a fishing boat (FYSON 1985). Some input design parameters should be determined to be included in the design process. Fishing gears were choosen properly to be fixed in this small fishing boat (HETHARIA *et al.* 2001, HETHARIA *et al.* 2003). The design process ended up with boat dimensions, geometrical hull forms, structures, general arrangements and other design parameters. In addition, blue prints are included for construction phase.

To keep a boat afloats on its upright position at designed waterline, a certain reserve buoyancy is required. A relationship of total boat weight should be the same as boat weight displacement and is presented as (LEWIS 1988, RAWSON and TUPPER 1984):

$$\text{Total weight} = \Delta, (t) \quad \text{and} \quad \Delta = V \times \gamma \quad (1)$$

$$\text{Total weight} = \text{lightweight (LWT)} + \text{deadweight (DWT)} \quad (2)$$

where: Δ = weight displacement (t)

V = volume displacement (m^3)

γ = specific weight of sea water (t/m^3)

LWT = lightweight = boat hull+engine+ equipments.

DWT = deadweight = cargo (fish and ice) + crews + fuel + lugages + fishing gears + live bait fishes.

For a critical condition, cargo is considered as water that fills all compartments in boat.

$$\text{Cargo} = W_{\text{total water}} \quad (3)$$

In this study, some solid-closed boxes (with foam inside) were provided inside the boat in order to reduce total water weight or to keep the boat still afloat. On the other hand, the inside solid boxes provide the buoyancy forces when the boat is in the capsized condition. This will make the boat afloat at capsized condition.

In addition, a distribution of closed boxes along the boat were arranged in order to obtain a proper longitudinal centre of gravity (LCG) which approaches the position of longitudinal centre of buoyancy (LCB).

$$\text{LCG} = \text{LCB} \quad (4)$$

When the boat is in capsized condition, the relationship of volume below should be met:

$$V_{\text{boat}} = V_{\text{hull shell + structures}} + V_{\text{solid boxes}} \quad (5)$$

In the case where the boat still afloat at the upright or capsized positions then the quantity of inside solid boxes should be provided to meet Archimedes' principle of floating subject. Besides, the location of LCG should be as close as LCB to ensure the boat would not be in excessive trim condition.

The hull material of FRP was applied for the boats. The construction of boats were based on the procedure of using FRP (referred to "Marine Design Manual for Fiberglass Reinforced Plastic"). The boats were constructed at the Faculty of Engineering, Pattimura University, Ambon, Moluccas. The boats were constructed as prototype for evaluating their performance at sea (HETHARIA 2008). Three boats (similar configurations) were constructed based on the parameters of output design. All boats have the same size which was 1.5 GT. They were Fatek 08, Barracuda and Yellow Fin, as seen in Fig. 1. The boat dimensions and output design parameters are presented in Table 1.



Fig. 1. Tuna longboats 1.5 GT.

Table 1. Dimensions of tuna longboat.

No	Items	Symbol	Dim	Unit	No	Items	Dim	Unit
1	Length Overall	L _{OA}	8.050	M	Condition: Full Load at Designed Waterline			
2	Length of Waterline	L _{WL}	7.600	M	Flooding to Upper Line, Upright Position			
3	Length Bet. Perpend.	L _{BP}	7.600	M	19	Reserve weight	0.509	Ton
4	Beam	B	1.076	M	20	Reserve volume	0.497	M ³
5	Maximum Beam	B _{max}	1.165	M	21	Reserve freeboard	0.067	M
6	Draft	D	0.390	M	22	After draft	0.518	M
7	Height	H	0.640	M	23	Fore draft	0.713	M
8	Block Coef.	C _B	0.641		24	Reserve freeboard aft to U.L	0.224	M
9	Midship Coef.	C _M	0.795		25	Reserve freeboard fore toU.L	0.037	M
10	Prismatic Coef.	CP	0.807		Condition: Capsized, Upside Down			
11	Waterplane Coef.	CW	0.773		26	Volume displacement	0.807	M ³
12	Gross Tonnage	GT	1.500	Tons	27	Weight displacement	0.827	Ton
13	Vol. displacement	V	2.045	M ³	28	Long. Centre of Buoyancy	-1.360	M
14	Wt. displacement,	Δ	2.096	Ton	29	Total boat weight	0.548	Ton
15	Length C. Buoyancy	LCB	-0.200	M	30	Long. Centre of Gravity	-4.540	M
16	Total boat weight	W	2.088	Ton	31	Trim: by stern		
17	Length C. Gravity	LCG	-0.202	M	32	Reserve weight	0.279	Ton
18	Trim : even keel				33	Reserve volume	0.272	M ³

Other output design parameters are:

- Payload: 0.7 t fish and 0.35 t ice
 - Volume of solid boxes: 0.623 m³ (14.3 %)
 - Prime mover: outboard engine 25 or 40 HP
 - Fishing gears: hand line and trolling line
 - Fishing grounds: Banda Sea, Seram Sea and other Moluccas waters
- Ratio ice/fish: 0.5
Total volume: 4.37 m³
Crew: 2 persons
Autonomy: 50 nautical miles

Sea Trial

The boats sea trial tests were executed in order to confirm the output design. The tests included speed and floating conditions. The test of speed was executed based on a procedure of speed testing. The tests were executed in Ambon bay for three boats (Fig. 2). The results of the tests met the design requirements. At the floating test, all components such as engine and equipments were still attached on boats (Fig. 3, 4). The boats reached the speed of 12 or 15 knots for the engine power of 25 HP or 40 HP, respectively.

The tests for floating purpose were executed in three conditions, which are:

1. Loading condition up to designed waterline to check full capacity of cargo loads.
2. Loading condition up to upper line to check the ability to afloat in flooding condition.
3. Capsized condition to check the ability of boat to afloat in such condition.

The test of full cargo load was set-up for boat draft up to the designed waterline. This was adjusted for a payload of 0.70 t and bulk ice of 0.35 t. It was found that the boats were in even keel position. The test of flooding condition was executed by filling sea water to all compartments inside the boat. All compartments were filled with water meanwhile some boat equipments were fixed. From theoretical computation, the total weight of displacement was 4.08 t and total boat weight was 3.576 t.



Fig. 2. A sea trial test for the speed.



Fig. 3. A floating test for upright position.



Fig. 4. A floating test for capsized condition.

This means that there was still a reserve weight of 0.50 t or reserve volume of 0.50 m³ was provided. It was found also from the test measurement that the boats were trim by bow. A reserve freeboard was measured for three boats as follows:

After freeboard to upper line:

Fatek 08: 0.20 m Barracuda: 0.22 m Yellow Fin: 0.215 m

Fore freeboard to upper line:

Fatek 08: 0.041 m Barracuda: 0.045 m Yellow Fin: 0.042 m

The tests of capcized were executed by turning the boats to upside-down position. From theoretical computation, total weight displacement was 0.827 t and total boat weight was 0.548 t. This means that reserve weight of 0.279 t or reserve volume of 0.272 m³ were provided for the boats. It was found also from the test that the boats were trim by stern. Vertical dimensions of freeboard height were found from measuring floating conditions. They are:

After freeboard measured from DWL (immersed):

Fatek 08: -0.010 m Barracuda: -0.011 m Yellow Fin: -0.010 m

Fore freeboard measured from DWL (emerged):

Fatek 08: 0.018 m Barracuda: 0.019 m Yellow Fin: 0.017 m

It was seen from the results of sea trial tests that the designed boats were afloat to their upright as well as capcized positions. Those results were closed to the theoretical computations. For a loading condition to designed waterline, it was found that the boats were in even keel condition. A cargo capacity of fish 1.0 t and ice 0.50 t was designed in this work. A critical conditon where the boats were fully flooded was obtained by filling water into all boats' compartments. The results were all three boats still afloat with a little trim by bow. According to theoretical computations, a reserve of after and fore free board to upper line were 0.224 m and 0.037 m, respectively. Where from the results of sea trial tests, they were 0.21 m and 0.043 m. The differences were came from the difference of LCG position in this loading condition.

When the boats were capcized, they were still aflot as seen from the results of the tests. The boats were trimmed by stern. An indication of measurement for this condition was freeboard measured from designed waterline. On the average, after freeboard measured from DWL for the three boats are -0.11 m. The negative sign means that the boats were immersed at after perpendicular. Meanwhile, fore freeboard measured from DWL for the three boats are +0.018 m. The positive sign means that the boats were emmerged at fore perpendicular.

Training Program for Local Boat Builders

During the project of boats construction in 2008, the local boat builders were participated. The training project was organized by Department of Naval Architecture, Faculty of Engineering, Pattimura University, Ambon, Moluccas. The total of 55 participants from private and government sectors in Moluccas are involved. They were trained for theoretical and practical approaches of boat design and construction (Fig. 5). By the knowledge achieved during the training period, they continue to develop this concept to their new product of boats.

Conclusion and Future Work

From the results of theoretical computation and sea trial tests, it was concluded that when a boat is provided with some solid boxes inside it is still afloat even in full of water or capsized conditions. Those solid boxes reduce the quantity of water coming into the boat. Besides, the solid boxes create the buoyancy of the boat in the capsized position. A proper distribution of solid boxes give a condition where the boats were not trimmed excessively. This condition makes easy operation of turning back the boat from the capsized condition to its initial upright condition.

The boats were designed, constructed and tested for their capability to afloat. It was recommended to be applied to the users. The local boat builders have developed this concept for their new products and this help the local fishermen for preventing the sink of boat in the rough seas. This concept of boat design is recommended to be used for the fishermen in Eastern Indonesia as well as the users in the Pacific regions.

The application of this concept for the larger fishing boats is still in the question mark but it will be some solutions for the future. However, this concept will be applied soon for the small fast passenger boats operated in the archipelago regions.



Fig. 5. A training session for local boat builders.

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