

# Resistance Test of Fast Patrol Ships in The Islands of Indonesia

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## ABSTRACT

This paper is researching about the results of the resistance test from fast patrol ships in Indonesia. The test itself describes a series of-resistance test of the Fast Patrol Ship model in a Towing Tank. The test has a purpose to predict the resistance and effective horsepower (EHP) of a ship at a certain speed on various knots. Resistance test is done at full load condition, and by making model of ship with scale which is adjusted with Towing Tank capacity at Indonesia Hydrodynamics Laboratory (IHL) - BPPT. The testing itself will use various equipment and instruments such as Trim Meter and Data acquisition tools. The shape and dimension of the model are based on the client's lines plan and are made of fiberglass / laminated wood. The results are presented in curve form describing the relationship between the velocity of the vessel to the total ship resistance and the ship effective power (EHP) in knots and Kilowatts unit.

**KEY WORDS:** *Fast Patrol Boat, Resistance, Effective Horse Power (EHP)*

## NOMENCLATURE

$LOA$	Length Over All
$Lwl$	Length on the waterline
$LPP$	Length Between Perpendiculars
$B$	Breadth
$D$	Depth/Height
$T$	Draft/Draught

$V_m$	Model Current Velocity In Tensile Pool (m/s)
$V_s$	Actual Scale Vessel Speed (knots)
$\lambda$	Scale Model
$Fn$	Froude number
$Vo$	Speed
$g$	Gravity
$L$	Length Between Perpendiculars

## 1.0 PRELIMINARY

Indonesia needs more fast patrol boats to keep an eye on inter-island waters, where more strict monitoring is necessary because Indonesia's extensive and strategic location, it can actually lead to the risk of smuggling, illegal fishing and breaches of maritime boundaries. This is where the role of marine patrols becomes very important in securing Indonesia's territorial from the entry of unauthorized parties or illegal immigrants.

The security of the territory, required a fast patrol ship, this type of ship is a fast reaction speed ship in the implementation of its duties priority element, carrying the mission to attack quickly, destroy the target once and avoid the opponent's attack in a short time as well.



Figure 1: Borders of Continental Continental

With limited weight and capacity, these fast patrol boats it only operates in shallow seas instead of waters that have large waves. That Fast Patrol, in its operation, will quickly interact with the currents, waves, and winds in the surrounding waters. At that time the Fast Patrol ship will

have a good motion on manoeuvring, seakeeping and having a good resistance in Sea

In order for the Fast Patrol Ships to operate and sail can be safe to the destination, prior to being constructed the resistance testing is required, this resistance test is conducted in Towing tank at Indonesia Hydrodynamics Laboratory (IHL) - BPPT.

Laboratory experiment (towing tank) is a representation of sea trials. The physical model experiment was performed in a tank known as the Towing Tank.

In determining the scale of the model depends on the actual size of the actual ship, the size of the test tank, and the tensile velocity. The approximate magnitude of ship resistance is based on the function of the ship's geometry size, ship speed, fluid type mass, and others. The data of the ship resistance indicates that 's the load to be borne by the driving force and the whole propulsion system. Thus, the availability of ship resistance data is an important aspect of the shipbuilding process.

The resistance test is the oldest experiment in the ship model testing period where the basic principle is simple and consists of measurements of the force required to draw a structure that passes over the water at a given speed.

The test resistance shall be carried out under full load condition and shall be measured by a variation of speed between 17 (seventeen) knots to 33 (thirty-three) knots on a full scale (actual ship). The measurement/test results on the scale of the model were extrapolated according to ITTC 1957 method to obtain the total ship resistance value and the effective power of the ship (Effective Horse Power). The test process is to be equipped with a report by making photos and video for each condition.

In this test, the Carriage is run over two rails mounted on the sides of the pool tank. The Carriage can be slowed or accelerated according to the desired speed. The vessel model is positioned so that at the time it is pulled along the tank, it can freely hold a nodding or vertical upward and other movements. The control and data recording space is located above at carriage so that the running test can move together and facilitate control of test results and models under test

As we know that the ship model is pulled at a certainty speed corresponding to the actual ship, is meant the actual ship model and ship have the same Froude Number, if the gravity's force is considered constant or has the same rate of speed and root ratio.

$$\text{Froude Numbers: } F_n = \frac{V_o}{\sqrt{g \cdot L}} \quad (1)$$

A model of the ship is drawn, so the water flow across the ship's body can be one of the three kinds of water flow as follows:

1. The laminar stream, in which the friction forces have a great effect, while the motion of the water particles is parallel to the side of the object.
2. The turbulent flow, in which the forces of inertia which play the role and movement of the water particles have local arches and there are water repressions.

3. A mixed stream, in which laminar and turbulent flows may be interpreted to have the same parts.

From the experimental results show that the resistance of laminar flow is smaller than the resistance in turbulent flow. Thus, in some cases, the mixed flow may have less resistance than the turbulent flow.

The point at which the laminar flow turns into a turbulent stream is determined by a constant value called the Reynold Number. The type of current flow for the actual vessel is turbulent, while the ship model will produce laminar and mixed flows. So to equate to the type of flow between the ship and the same model, installed what is called Turbulent Stimulator which serves to generate turbulent flow. This tool can be made of small thin wire or rows of small stones mounted on the front near the model bow.

Generally, there are 2 kinds of resistance testing that can be done in Towing Tank depending on the ship Owner request that is:

1. Testing of bare hull body resistance (bare hull), and
2. Testing of prisoners with limbs such as bilge keel (appendages hull)

## 2.0 FACILITIES AND TESTING EQUIPMENT.

In testing, the ship model determined the size of the ship resistance required by the test pool, ship model, and equipment for testing includes:

### 2.1 Towing Tank

Towing Tank at the Indonesian Hydrodynamics Laboratory (IHL) - BPPT, which is the place to test ship model, has the following size and facilities:

- Building is: 7520 m<sup>2</sup>
- Length : 234.5 m (including harbor)
- Width : 11 m
- Pond depth : 6.0 m
- Water depth : 5.5 m

At the ends of the Towing Tank is also equipped with an harbour, wave generator and wave absorbers used for Seakeeping Test, but in the Resistance Test, the equipment is not used.

### 2.2 Ship Model

Generally, ship models used for testing, made hollow in addition to material savings as well so that draft arrangements can be easily implemented. The arrangement of the draft is done by using iron scales as Ballast. The ship model is made in a model workshop with main material of wood with a gluing system

**Table 1:** The Main Dimension of The Ship

No.	Items	Symbol	Ship (mm)	Model (mm)
1	Length Over All	LOA	33.140	3.882,2
2	Length on waterline	Lwl	27.110	3.012,2
3	Length between perpendiculars	LPP	27.110	3.012,2
4	Breadth	B	6.200	688,88
5	Depth	D	3.250	481,32
6	Draught	T	1.350	150
Scala			1:9	

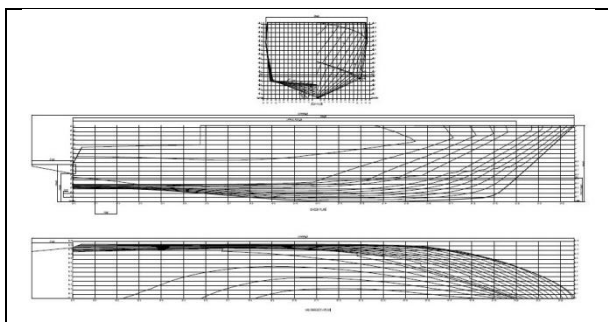


Figure 2: Lines plan



Figure 3: Model of Ship Patrol

### 2.3 Testing Equipment

In the test of ship model resistance, the equipment used is:

#### A. Towing Train Model (Towing Carriage)

Towing Carriage is a towing rig mounted on a Towing Tank that is used to pull the model and is designed to draw a model with lengths ranging from 4 meters to 9 meters, which has:

- Maximum speed: 9 m/s
- Maximum acceleration: 1 m/s

#### B. Clamp Model

The Clamp Model is an apparatus mounted on a trolley and serves as a holder of the ship model as the tug-train is accelerated to achieve the speed specified shortly before / after the measurement process is carried out



Figure 4: Clamp Models With Resistance Dynamometer

#### C. Resistance Dinamometer

Resistance Dinamometer is a tensile measurement apparatus or an opposing force arising from the movement of the ship model to water that occurs when the model is pulled by a carriage at a certain speed. In Indonesia Hydrodynamics Laboratory (IHL) - BPPT this equipment is installed in one unit with Clamp Model. For more details can be seen in the picture below

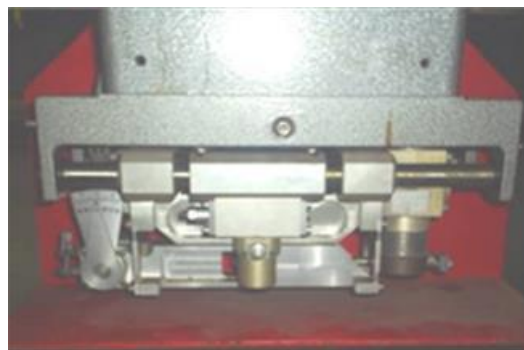


Figure 5: Resistance Dinamometer

#### D. Towing Guide

Towing Guide is a device mounted at the front and rear of the ship model that serves as the holder and guide for the model of the ship can be free to perform movement nod or up and down without sideways movement (yawing or swaying).

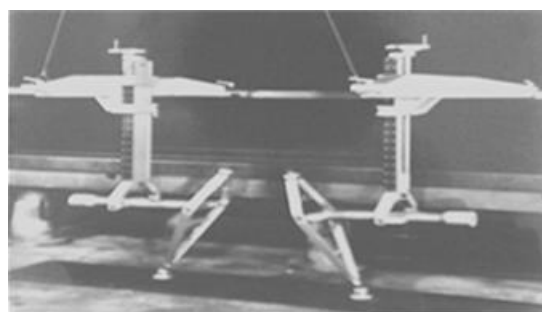


Figure 6: Towing Guide

#### E. Trim Meter

Trim Meter is the equipment used to measure the change of trim of the ship during the measuring process



Figure 7: Trim Meter

#### F. Data Acquisition & Analysis System (DAAS) Towing Tank

For data collection and analysis of ship model experiments in Towing tanks used VAX 3400 computer with up to 16 channel measurement and maximum 100Hz sample frequency.



Figure 8: DAAS Towing Tank

### 3.0 TESTING PROCEDURES

This paper aims to evaluate the characteristics of ship resistance. Test results are expected to be utilized to support efforts to improve the hull characteristics of the ship and assist the design process propulsion system.

Experiments at Indonesian Hydrodynamics Laboratory (IHL) - BPPT (towing tank) is a sea trial representation. Physical model experiments were performed in a tank known as Towing Tank. In determining the scale of the model depends on the actual size of the actual ship, the size of the test tank, and the tensile velocity. The approximate magnitude of ship resistance is based on the function of the ship's geometry size, the speed of the vessel, the mass of fluid type, and others. The data of the ship resistance indicates the load to be borne by the driving motor and the whole propulsion system.

The data of the ship resistance indicates the load to be borne by the driving motor and the whole propulsion system. In cases where such data are not available, the selection of driving motors is based on empirical estimates. Of course, the possible negative impact is the waste of power usage that directly affects the installation price and vessel operating costs. Thus, the availability of ship resistance data is an important aspect of the shipbuilding process.

Generally known two components are namely friction resistance component, and a residual resistance component. The first component is single (no subcomponents) while the residual resistance which is the main component the wave-resistant component, by the wave making resistance occurring at a high speed, consists of many subcomponents. Knowing the resistance component of a ship's designer can design, particularly related to fuel savings, vessels with relatively low resistance. The important thing in achieving the goal is to understand the viscous flow

related to friction and non-viscous flow related to residual resistance, especially related to wave carry resistance.

Before testing the ship model begins, the first preparations have steps include the following:

- Calibration of measurement tools ie Resistance Dynamometer before use.
- Determination of the position of the accessories of connecting measuring equipment in the ship model and its installation.
- The weight of ship model and measurement equipment accessories weighed.
- The model is lifted with a crane and inserted into a pool at the Towing Tank harbor.
- Weights as ballasts are incorporated into the model of the vessel until it reaches the specified water level.
- Waterpas are placed on top of the model.
- To adjust the equilibrium or flattening of the ship model, according to the draft then the weights are shifted left or right and forward or backward.
- Once a balanced model is launched under the carriage frame test.
- The model is then connected to the Towing Guide and Resistance Dynamometer.
- With a carriage, the model is pulled from the harbor into the test pool.
- Testing of resistance is ready to begin

#### 3.1 Testing Conditions

The condition of the test of the ship resistance (resistance test) and the test results are referred to as shown in the following table

Table 2: Test Conditions

Type of Testing	Draft (m)	Speed
	FP/AP	(Knots)
Resistance	1.350 / 1.350	17 – 33

- To reduce the effect of the scale factor, then at the front of the model (approximately 5% Lpp from the front end of the model) mounted carborundum strip (0.5 mm diameter sand) with a circular 10 mm width along the hull section of the model.
- Towing point is installed in line with the center line of the towing tank and at the position of the center of the ship's floatation model.
- Tests are conducted at the towing tank of the Indonesian Hydrodynamics Laboratory (IHL) and in accordance with the Standard Operational Procedure of resistance testing.

#### 3.2 Testing

Measuring the magnitude of ship model resistance is made based on General Arrangement and Lines plan Fast Patrol Ship with a certain scale with a variation of speed 2.915 m/s representing speed 17 knot on the actual ship.

In the test process, the speed interval to be tested is at 5 knots range around the standard speed (velocity of service) on the ship is actually a draft full condition. The speed interval is 3 knots below the service speed and 2 knots above it. Generally, the test

at this speed interval is done in 8 to 10-speed measurement points. In the model testing process, the velocity interval is converted first in units of m / s on the model scale. (1 knot = 0.514477 m/s).

$$V_m = \frac{V_s \cdot 0.514477}{\sqrt{\lambda}} \quad (2)$$

Where:

$V_m$  = model current velocity in tensile pool (m/s)  
 $V_s$  = actual scale vessel speed (knots)  
 $\lambda$  = scale model

Testing the next resistance is done with the following steps:

- The first Test Run is performed at a chosen speed in the middle of the speed interval to be tested.
- At the time of the test, the model is withdrawn with a carriage carrier whereby during acceleration of speed to the specified speed, the model is held by the clamp model. After reaching the specified speed, the clamp model is stretched (released) and at the same time, the connecting shaft between the dynamometer resistance and the working ship model. At that time the speed of the ship model is equal to the speed of the train pull and then the recording of data begins.
- The next test run is performed at a higher interval from the first test run until the top speed of the interval is reached.
- Then the next test run starts from the lowest speed of the interval and continues to increase up to the same speed as the first test run speed.
- The data of the model test results at each further speed is plotted in the speed graph by the technician in Towing Carriage.
- Some additional test runs may be provided at some speed after the specified speed interval has been completed. It aims to control the test results and determine whether or not a test run is repeated if the test results are found to be unsatisfactory



Figure 9: Testing of fast patrol ship resistance model in Towing Tank IHL-BPPT

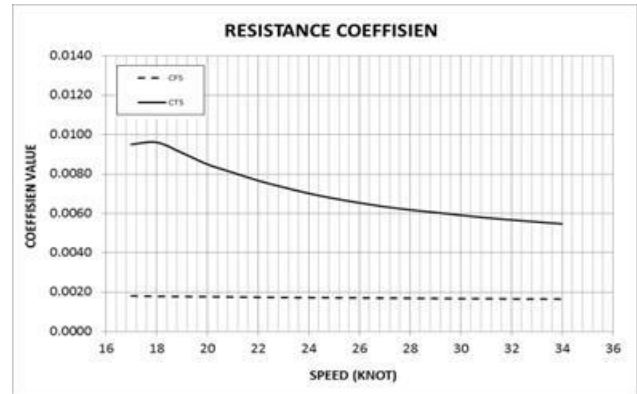


Figure 10: The diagram of the coefficient of ship resistance at the laden condition of 1,350 m

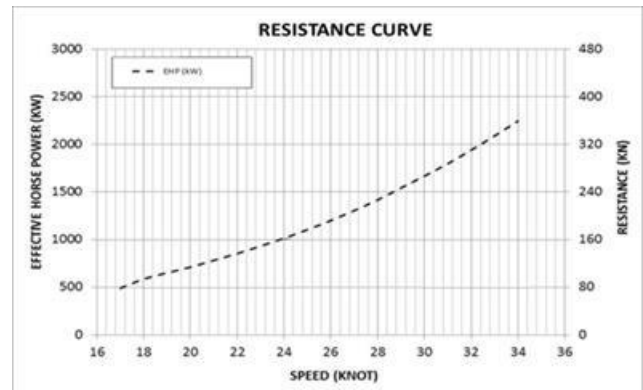


Figure 11: Ship resistance curve at each ship speed at 1,350 m

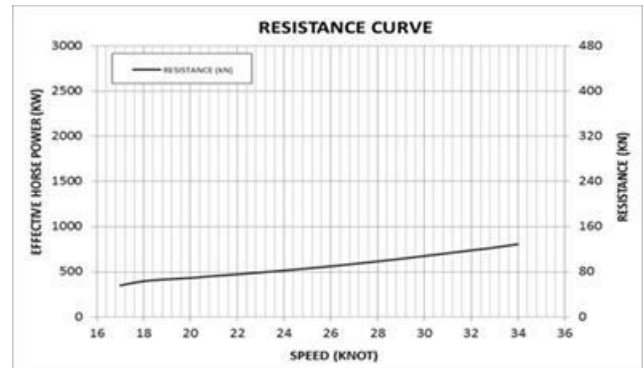


Figure 12: Ship effective power (EHP) at each ship speed at 1,350 m

#### 4. 0 CONCLUSION

Based on the test results of resistance to the model Patrol Fast Ships, then analyzed several things as follows:

- By comparing the statistical data of the test results of detainees from similar vessels of hull form, this ship's resistance is considered normal in terms of resistance of the ship.

- The wave profile observed along the hull side of the vessel model during resistance testing is considered normal for this type of vessel.
- From the extrapolation data of the Fast Patrol Model resistance test at speed of 18 knots, value of resistance at 1.350 m of 63.3 kN and. Then for the value of Power Effective (EHP) at 1,350 m of 586 kW. While at a speed of 33 knots, laden 1350 m by 123 kN. Then for the value of Power Effective (EHP) at 1,350 m of 2091 kW.
- To search for power from the installed Power Effective (EHP) powered ship engine should be shared with Propulsive Coefficient (PC). In addition, the results of testing this model are for the ideal trial condition (no currents, wind, and waves). For that, we need to add Allowance Sea Margin to overcome the loss of speed due to waves during the sea trial.

In testing of ship model resistance at Indonesia Hydrodynamics Laboratory (IHL) - BPPT must be considered things that affect the accuracy and performance of measuring instruments used. It is necessary to know and understand the things that are required before or during the running test process is done so that the accuracy of the required data in accordance with the expectation

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