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ESTIMATION OF MATERIAL REQUIREMENTS AND COATING COSTS IN FIBERGLASS PILOT BOAT HULL REPAIRATION

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Abstract

The purpose of painting the ship is to improve the quality of the ship's hull. Superior painting techniques and materials result in a hull that is resistant to seawater and air corrosion, the painting process and procedures related to painting, since almost all of the ship's building materials are metallic finishes. In order for the paint to meet the specified requirements, it must comply with the specified painting process, one of which is the painting process according to Utomo (2019) pre-inspection, surface preparation, paint preparation, and paint application. For that, you need to know the various types of painting techniques that must be prepared before carrying out the hull painting process. Metal is very sensitive to corrosion, because the working area of the ship is near the sea. Repairs to ships are important things that need to be done routinely and need regular planning to ensure that at any time they can sail and operate safely. one of the maintenance of the ship is painting the purpose of painting is to improve the quality of the hull. One good technique with several stages, namely pre-inspection, surface preparation, paint preparation, and paint application can produce a hull that is resistant to damage from seawater and air. the repair process that is needed is coating. To find material requirements and coating costs, use a comparison of 2 local A paint products and international B paint products. Then it can be seen that the total coating requirement for the most economical 12 meter pilot boat is Cat B with a total of 453.15 liters and a cost of 36,692,619.

Keywords: Coating, and Material Requirements

1.Introduction

Indonesia is the largest archipelagic country in the world and has the potential for the world's maritime axis. Indonesia's marine activities are very active so that a ship is needed to function as a work tool. One of them is a scout or pilot boat. Pilot boats are classified as fast boats that function as directions or guide ships out or in from the pier to sail from the danger zone for their safety (Arifin et al., 2019).

Transportation in the era of globalization is a very important need for society to support all activities and daily life. Public transportation usually includes trains and cars, but also air services, ferry ports, and more. The presence of good public transport has a significant impact on the economy of a region or region. The success of a country's economic growth is inseparable from government intervention to provide comfortable, safe, clean, and well-organized public transportation. The development of the world of shipping and the world of sea must be balanced with an increase in the quality of means of transportation, namely ships as the main means of transportation. Ship maintenance is very necessary so that the ship is declared in good condition. It is marine resistant.

When coating, working on the coating process, the initial stage of the repair process is to determine the size of the hull surface area that will carry out the coating process from the pilot boat. The second stage after determining the size of the hull surface area is calculating the estimated material requirements and the price of the material to be used. The next stage is determining the type of paint and estimating the needs and costs for the coating process.

The purpose of estimating the needs and costs of coatings is to estimate the needs and costs so that the repair process is not too costly. Calculation of material requirements and costs in the coating process to find economic needs and avoid large losses and wastage of material became the basis for researchers to conduct a case study on "ESTIMATION OF MATERIAL REQUIREMENTS AND COATING COSTS IN FIBERGLASS PILOT BOAT HULL REPAIRATION" will be coated, only the main hull size data is used in this study.

repair

Fishing vessels are used for fishing/fishing activities which include the use or repair or improvement is a condition that is carried out to make something more beautiful and good in its use. According to KBBI, repair is an action taken to return something to a better condition or close to new by changing, repairing, or replacing certain parts.

The ship repair stage includes preparation, boarding process (dock), and ship loading and unloading process. The types of maintenance and repair work carried out while the ship is anchored during the investigation are cleaning / scraping the ship's hull, cleaning with fresh water, repairing damaged parts of the hull. The keel is covered with armor plate, the hull is covered with fiberglass, and painted with antifouling (AF) (Subawa et al., 2016).

According to (Sasongko, 1978) there are four types of docking methods for ships:

1.Graving dock is a column/pool with concrete construction, which is located on the beach/sea. The column door is directly related to the sea. where the pool / pond with the sea is limited by a watertight door.

2.*Slipway*is the simplest way to raise and lower ships. The slipway structure consists of rails mounted on a concrete foundation such as a berth building and a train (Klendel) above it. The crane can move the rail up and down with the help of a steel cable pulled by the winch. There are two types of longitudinal slipways and transverse slipways.

3. Floating dock is a building used to dock ships by floating the building and sinking it to a certain weight. Floating dock system is done by pumping and adding water to the internal tank.

4. Lift dock Ship docking facility with a platform that can be lifted vertically (up and down) with a hoist.

Ship painting

The definition of paint in the ISO 4618-1 standard:

Based on (Kurniawan & Periyanto, 2019). Paint is a pigmented coating material in liquid, paste or powder properties which, when applied to a substrate, forms an opaque film with technical properties of protection, decoration or specifications.

Varnish is a coating material that can be applied to a substrate to form a hard and transparent film with technical protective properties. The paint parts include:

1. Resin

This product sticks to the surface and provides a long-lasting coating. Wood protective varnishes are made of resins, resins provide most of the properties of paints which are:

a. resilience
b. Stickiness
c. Resistant to UV rays

2. Pigment

Pigments don't dissolve, soft like powder. Mixed into the paint to give the effect:

a. Corrosion resistant properties
b. Color
c. Shut power
d. Save costs

3. Solvent

Solvent is a solvent that can evaporate when a chemical reaction occurs between the solvent and oxygen. Air moving around the paint that has been applied to the product accelerates evaporation and reduces drying time.

4. Additive

Used in small quantities to change properties such as:

a. Anti-fungal
b. Prevents paint quality from fading quickly.
c. Increase the spread of pigment.
d. applied to the surface
e. speed up dry time.

Process and Method of Painting

Based on(Utomo et al., 2019)There are several painting methods and processes that need to be known, including:

a. Surface Preparation

Pre Inspection is the start of the surface of the material to be painted with the objective being to obtain maximum adhesion for the painting process.

b. Pre Inspection

Pre Inspection is the start of the surface of the material to be painted with the objective being to obtain maximum adhesion for the painting process.

c. *Paint Preparation*
Paint Preparation Mixing paint is the preparatory stage Before painting, it is necessary to prepare paint and paint tools, the mixing process is mixing paint.

d. *Paint Application*
After the painting process, the paint results should be checked.

Coating

Coating is a process for coating a base material or plate which aims to protect the material from corrosion and provide protection for the material. In addition, the coating also provides negative buoyancy, provides an anti-slip function on the substrate surface and several other functions.

Coating is the process of adding or stacking one material on another surface (or the same material). Generally, coatings are applied to surfaces with the aim of:

1. Protects surfaces and environments that can cause corrosion and deterioration (damage).
2. To improve surface appearance
3. To improve the surface or shape of a particular component and others .

The coating system is used to comprehensively protect the material from corrosive attack. There are several factors to consider when choosing the type of material and coating process.

The ideal coating material used for coating is:

1. The coated metal must be more resistant to the environment than the protected metal.
2. After plating the protected metal, the plated metal must not corrode.
3. Mechanical and physical properties such as strength and wear resistance. Corrosion resistance and thermal properties must be matchedwith the operating conditions of each component.
4. The coating process must match the component manufacturing process.
5. The thickness of the layer must be uniform and must not tarnish*contains pores (Pawlowski, 2008).*

Calculation of coating needs

In calculating the material requirements for the coating process, it is necessary to have a theoretical spreading rate. The theoretical spreading rate of paint is one of the main data to determine the need for paint to be used. The following is an example of the theoretical spreading rate listed on International paint products.

To get the theoretical spreading rate according to the planned DFT thickness, it can be done with the following equation.

$$\frac{DFT_0}{DFT_1} = \frac{TSR_1}{TSR_0}$$

DFT0 = Thickness of DFT data sheet paint (µm)
DFT1 = Thickness of planned DFT (µm)
TSR0 = Spreadability of data sheet paint (m²/l)
TSR1 = Planned spreadability (m²/l)

By knowing the area of the ship's hull and the theoretical spreading rate of paint, it can determine the needs with the following equation

$$TC = \frac{A}{TSR}$$

$$CF = 100 + Lf$$

$$PC = \frac{A}{TSR} \times Cf$$

TC = Theoretical Coating, the need for paint to coat the area (liters).
PC = Practical Coating, needs paint after taking into account the loss factor that occurs.
TSR = Theoretical Spreading rate, paint spreadability in 1 liter (m²/liter)
with a certain DFT thickness.
Cf = Coating factor, the factor used to estimate
the need for paint due to the loss factor.
Lf = Loss factor, a factor used to represent paint loss
due to the painting process.

Coating costs

The calculation of coating costs can be done as follows: (Total hull surface area : Area per liter) : Liters per pack x Price.

2. Method

Before analyzing the needs and coatings, it is necessary to collect data. The required data collection is data on a pilot boat image which contains information on the area of the ship's hull that will be carried out by the painting repair process. The next data is collecting material type data. Collection of sandblasting and coating material needs is carried out in the form of interviews with painters in the field so that effective and efficient results are obtained for the amount of coating material needed.

3. Findings and Discussion

Main data on the size of the pilot boat.

In this chapter, the analysis and discussion phase will be carried out regarding the calculation of material requirements and coating costs. In addition to material and cost calculations, an area on the hull surface is also required. For the initial stage of calculating the area of the ship's hull, data regarding the Pilot Boat cargo ship is needed. The data obtained as follows.

Ship Name: pilot boat 12 meters
LOA : 12.00 meters
LBP : 10.50 meters
B : 3.00 meter
H : 2.00 meter
T : 1.50 meter

The results of the calculation of coating needs and costs

In calculating the need for a second coating for painting the pilot boat hull using paint, the calculation for the need for each layer of paint can be applied as follows:

- The primary paint or coat (anti-corrosion) uses paint with a red Penguard Primer type which has a paint thickness of 100 µm and a solid volume of 51. This paint has a Theoretical Spreading Rate of 12.8 m²/l which is obtained from the Technical Data Sheet Paint. To get paint with a thickness of 40 µm DFT.

  $\frac{DFT0}{TSR1} = \frac{DFT1}{TSR0}$

  For bottom primer paint:

  $\frac{40}{TSR1} = \frac{100}{12,8}$

  TSR1=$\frac{40x12,8}{100}$

  TSR1= 5.12 m²/l for 100 µm DFT.

  For top side primer paint:

  $\frac{40}{TSR1} = \frac{70}{12,8}$

  TSR1=$\frac{40X12,8}{100}$

  = 6.82 m²/l for 75 µm DFT.

- The sealer coat or coat (epoxy coat) uses Jotun with the gray Jotamastic 80 type which has a paint thickness of 100 µm and a solid volume of 80. This paint has a Theoretical Spreading Rate of 10.7 m²/l obtained from Technical Data Sheet Paint. To get paint with a thickness of 175 µm DFT. Then the calculation can be done as follows.

  For primer paint on the bottom and top side:

  $\frac{175}{TSR1} = \frac{100}{10,7}$

  TSR1=$\frac{17,5X10,7}{TSR1}$

TSR1= 18.7 m²/l for 100 µm DFT

c. The finish coat or coat (anti-fouling) uses Jotun with a red SeaForce 30 type which has a paint thickness of 100 µm and a solid volume of 58. This paint has a Theoretical Spreading Rate of 7.7 m²/l. Meanwhile, the top side uses Jotun with a Universal Penguard type in blue with a paint thickness of 150 µm DFT. And this paint has a Theoretical Spreading Rate of 10.3 m²/l which has a solid volume of 72. To get paint with a thickness of 75 µm DFT. Then the calculation can be done as follows.

   For the bottom finish coat:

   75/TSR1=100/7,7
   TSR1=75X7,7/100
   TSR1= 5.77 m²/l for 100 µm DFT.
   For top side primer paint:
   175/TSR1=100/10,3
   TSR1=175,10,3/150
   TSR1= 12.01 m²/l for 150 µm DFT.

   After calculating the Theoritical Spreading Rate (TSR) of each paint layer, the next step is calculating the needs of the 2 parts of the painting area, namely the underwater and top side. What can be done with equation 2.9 as follows.

PC = A/TSRx Cf .... (2.9)

Bottom section

The hull area from below the waterline of the pilot boat is 327.75 m². The area can be coated with paint with a certain thickness. The arrangement of the bottom paint layer is as follows.

Primer paint layer (anti corrosion) with a thickness of 100 µm DFT.

PC = 327,75/5,12x 1,5
PC = 96,02 liter
The need for paint per liter/m² = 96.02 liters / 327.75 m²
= 0,292 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,292 liter/m²
= 0,0146 liter/m²
= 0,0146 x 327,75
= 4,78 liter
The need for paint brand B Penguard Primer and thinner No. 17
= Need for paint per m² - Need for thinner
= 0.292 – 0.0146
= 0,2774 x 327,75
= 90.917 liter

Layer of sealer coat (epoxy coat) with a thickness of 100 µm DFT.

PC = 327,75/18,7x 1,5
PC = 26,29 liter
The need for paint per liter/m² = 26.29 liters / 327.75 m²
= 0,080 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,080 liter/m²
= 0,004 liter/m²
= 0,004 x 327,75
= 1,31 liter
The need for paint brand B Jotamastic 80 and thinner No. 17
= Need for paint per m² - Need for thinner
= 0.080 – 0.004
= 0,076 x 327,75
= 24,90 liter

A layer of finish coat (anti-fouling) with a thickness of 100 µm DFT.

PC = 327,75/5,77x 1,5
PC = 85,20 liter
The need for paint per liter/m² = 85.20 liters / 327.75 m²
= 0,259 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,259 liter/m²
= 0,01295 liter/m²
= 0,01295 x 327,75
= 4,244 liter
The need for paint brand B SeaForce 30 and thinner Jotun No. 7
= Need for paint per m² - Need for thinner
= 0.259 – 0.01295
= 0,24605 x 327,75
= 80.64 liters

The top side

The area of the hull above the waterline of the Pilot Boat is 54 m². The area can be coated with paint with a certain thickness. The arrangement of the top side paint layers is as follows.

Primer paint layer (anti corrosion) with a thickness of 75 µm DFT.

PC =54/6,82 x 1,5
PC = 11,87 liter
The need for paint per liter/m² = 11.87 liters / 54 m²

= 0,219 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,219 liter/m²
= 0,01095 liter/m²
= 0,01095 x 54
= 0,59 liter
The need for paint brand B Penguard Primer and thinner No. 17
= Need for paint per m² - Need for thinner
= 0.219 – 0.01095
= 0,20805 x 54
= 11,23 liter
Layer of sealer coat (epoxy coat) with a thickness of 100 μm DFT.
PC = 54/18,7 x 1,5
PC = 4,33 liter
The need for paint per liter/m² = 4.33 liters / 54 m²
= 0,080 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,080 liter/m²
= 0,004 liter/m²
= 0,004 x 54
= 0,21 liter
The need for brand B paint and thinner No. 17
= Need for paint per m² - Need for thinner
= 0.080 – 0.004
= 0,076 x 54
= 4,104 liter
A layer of finish coat (anti-fouling) with a thickness of 150 μm DFT.
PC = 54/12,01x 1,5
PC = 6,74 liter
The need for paint per liter/m² = 6.74 liters / 54 m²
= 0,124 liter/m²
Thinner requirement = 5% x the amount of paint needed each liter/ m²
= 5% x 0,124 liter/m²
= 0,0062 liter/m²
= 0,0062 x 54
= 0,33 liter
The need for brand B paint and thinner No. 17
= Need for paint per m² - Need for thinner
= 0.124 – 0.0062
= 0,1178 x 54
= 6,36 liter

Total Coating Needs

Table 1 Table of Total Coating Needs

No	Painting Coating	Total number
1.	Primer Coat	121,02 Liter
2.	Sealer Coat	110,29 Liter
3.	Finish Coat	221,84 Liter
	Total number	453,15 Liter

Calculation of coating costs

Coating Cost
= (Total surface area of the hull : Area per liter : Liters per pack x Price

Bottom section

The area of the hull from below the waterline of the pilot boat is 327.75

For the cost of the underwater primer coat:

Area cover cat = 7.5 m²

- Packaging per liter of paint = 5 liters
- Type paint = Jotun Penguard Primer
- Material unit price = Rp. 997,000
- Packaging per liter thinner = 5 liters
- Type thinner = Thinner Jotun No.17
- Material unit price = Rp. 160,000

(Total surface area of hull : Area per liter : Liters per pack x Price

= ((327.75 m² : 7.5 m²) : 5) x Rp. 997,000

= (43.7 : 5) x Rp. 322,000

= 8.74 x Rp. 322,000

= Rp. 8,713,780,-

For thinner Jotun No.17

- The amount of primer paint needed = 320.65 liters
- The amount of thinner needed = 96.02 liters : 5

= 19.20

Total cost of thinner = 19.20 x Rp. 160,000

= Rp. 3,072,000,-

The total price of Primer coat sealer and thinner No.17 is

= Rp. 8,713,780 + Rp. . 3,072,000

= IDR 11,785,780,-

For the cost of the bottom sealer coat:

- Area cover cat = 4 m²
- Packaging per liter of paint = 5 liters
- Type cat = Jotun Jotamastic 80
- Material unit price = Rp. 710,000
- Packaging per liter thinner = 5 liters
- Type thinner = Thinner Jotun No.17
- Material unit price = Rp. 544,500

(Total surface area of hull : Area per liter : Liters per pack x Price

= ((327.75 m² : 4 m²) : 16) x Rp. 2,010,000

= (81.93 : 5) x Rp. 710,000

= 16.38 x Rp. 710,000

= Rp. 11.629.800,-

For thinner Jotun No.17

- The required amount of sealer coat = 26.29 liters
- The amount of thinner needed = 11.31 liters : 5

= 2.262

Total cost of thinner = 2,262x Rp. 544,500

= Rp. 1,231,659,-

The total price for sealer coat and thinner No.17 is

= Rp. 11,629,800 + Rp. 1,231,659

= Rp. 12,861,459,-

For the cost of the bottom finish coat:

- Area cover cat = 4,3 m²
- Packaging per liter of paint = 5 liters
- Type cat = Jotun majestik
- Material unit price = Rp. 350,000
- Packaging per liter thinner = 5 liters

- Type thinner = Thinner Jotun No.7
- Material unit price = Rp. 300,000

(Total surface area of hull : Area per liter : Liters per pack x Price
= ((327.75 m² : 4.3 m²) : 5) x Rp. 350,000
= (76.2 : 5) x Rp. 3,000,000
= 15.2 x Rp. 350,000
= Rp. 5,530,000,-

For thinner Jotun No.7
- Number of finish coats needed = 85.20 liters
- The amount of thinner needed = 14.24 liters : 5

=2.84
Total cost of thinner = 2.84 x Rp. 300,000
= Rp. 953.000,-
The total price of finish coat and thinner is
= Rp.5,530,000 + Rp. 953,000
= Rp. 6,483,000,-

The top side

The hull area from below the waterline of the Pilot Boat is 54 m².
For the cost of the top side primary coat:
- Area cover cat = 5.5 m²
- Packaging per liter of paint = 5 liters
- Type paint = Jotun Penguard Primer
- Material unit price = Rp. 645,000
- Packaging per liter thinner = 5 liters
- Type thinner = Thinner Jotun No.17
- Material unit price = Rp. 265,000

(Total surface area of hull : Area per liter : Liters per pack x Price
= ((54 m² : 5.5 m²) : 5) x Rp. 645,000
= (9.81: 5) x Rp. 645,000
= 1.962 x Rp. 645,000
= Rp. 1.265.490,-

For thinner Jotun No.17
- The amount of primer paint needed = 10.219 liters
- The amount of thinner needed = 10.59 liters : 5

= 2.118
Total cost of thinner = 2.118 x Rp. 265,000
= Rp. 561.270,-
The total price for sealer coat and thinner No.17 is
= Rp.1,265,490 + Rp. 561,270
= Rp. 1.826.760,-

For the cost of the top side sealer coat:
- Area cover cat = 4 m²
- Packaging per liter of paint = 16 liters
- Type cat = Jotun Jotamastic 80
- Material unit price = Rp. 2,010,000
- Packaging per liter thinner = 5 liters
- Type thinner = Thinner Jotun No.17
- Material unit price = Rp. 265,000

(Total surface area of hull : Area per liter : Liters per pack x Price
= ((54 m² : 4 m²) : 5) x Rp. 610,000
= (13.5 : 5) x Rp. 610,000
= 2.7 x Rp. 610,000
= Rp. 1.647.000,-

For thinner Jotun No.17
- The required amount of sealer coat = 10.80 liters

- The amount of thinner needed = 10.21 liters : 5
= 2.042
Total cost of thinner = 2.042 x Rp. 265,000
= Rp. 541.130,-
The total price for sealer coat and thinner No.17 is
= Rp. 1,647,000 + Rp. 541,130
= IDR 2,188,130,-

1. For the cost of the top side finish coat:

- Area cover cat = 4,4 m²
- Packaging per liter of paint = 5 liters
- Type paint = Jotun Penguard Universal
- Material unit price = Rp. 605..000
- Packaging per liter thinner = 5 liters
- Type thinner = Thinner Jotun No.17
- Material unit price = Rp. 265,000

(Total surface area of hull : Area per liter : Liters per pack x Price
= ((54 m² : 4.4 m²) : 5) x Rp. 605,000
= (12.2 : 5) x Rp. 605,000
= 2.44 x Rp. 605,000
= Rp. 1.476.200,-
For thinner Jotun No.17
- Number of finish coats needed = 10.124 liters
- The amount of thinner needed = 10.33 liters : 5
= 2.066
Total cost of thinner = 2.066 x Rp. 265,000
= Rp. 547.490,-
The total price of finish coat and thinner No.17 is
= Rp. 1,476,200 + Rp. 547,490
= Rp. 2,023,690,-

Total coating cost calculation

Table 2*Total Coating Cost Calculation*

No	Painting Coating	Total number
1.	Primer Coat	13,612,540
2.	Sealer Coat	15,049,589
3.	Finish Coat	8,030,490
Total number		36,692,619

4. Conclusion

From the results of calculating the needs and costs of coatings that have been carried out based on the problem formulation of this Final Project, the following conclusions can be obtained:

- **Coating Needs**

In the coating process on the hull, 2 brands of paint are used, namely Brands A and B, where each part of the ship is coated with 3 parts of the need. Get the difference needed between brands A and B below:

1. Primer Coat

For brand A, the results obtained from the 2 parts of the ship's hull, the sum of the primary paint was 121.02 liters, while the results obtained from the primer paint for brand B, from the 2 parts of the bottom and topside were 192.57 liters.

2. Sealer Coat

In this second layer on brand A, the result of the sum of 2 parts of the paint requirement is 110.29 liters.
For brand B, the results of 2 parts, namely the bottom and topside, are 588.73 Liters.

3. Finish Coat

The finish coat is the third layer on 2 parts of the ship's hull that uses brand A paint, with a total requirement of 221.84 Liters, from the bottom and top side.
And for the results from brand B, the amount is 240.93 liters from the 2 parts added together.

- **Cost Requirement**

Based on the calculation of the cost of painting, paint brand A and paint brand B will be charged the total cost of the painting process from the 2 brands of paint used. Based on the total cost of paint brands, the most competitive coating cost is brand B paint. This is because the demand for paint issued is less than that of brand A paint. The cost of paint brand B is more economical than paint A with the total comparison of brand A being Rp. 48,628,881 and brand B Rp. 36,692,619

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