Growth Prevention System for Inhibiting Corrosion Rate in Ship Operation

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Abstract: Marine Growth Prevention System (MGPS) is a system applied on ships to inhibit marine growth or biofouling, namely colonies of marine animals and plants that grow and cover the surface of structures or piping systems on ships that can cause corrosion. The reduced flow as a result of the appearance of impurities on the inner wall of the cooling system pipe causes a failure in cooling the ship's engine, which results in overheating. Another impact of reducing the inside diameter of the pipe, the pressure received by the pipe on the discharge side becomes larger, and cavitation occurs in the suction side due to excessive pressure drop. The purpose of this study was to determine the impact of the use of the Marine Growth Prevention System which was applied to the MT ship. Savvy in inhibiting the corrosion rate on the JIS F0507 type seawater pipe by using copper (Cu) electrode type RRY17 based on the ship speed variability value. From the research, it was found that protection using the Marine Growth Prevention System carbon anode (copper electrode) is very effective for protecting the pipes in the engine cooling system and ship hull from marine animals and plants.

1 INTRODUCTION

The operation of a large ship is always equipped with an engine cooling system and a ship balancing system with fluid using seawater, so a piping system is needed for the circulation of the cooling fluid. This causes the growth of various marine biota plants such as coral, barnacles, and marine algae that trigger corrosion. The Motor Tanker (MT) Savvy ship uses seawater as engine cooling medium and also as ballast water. The pipe installation used is JIS-F0507. The use of sea water causes the growth of marine growth which triggers corrosion which will affect engine performance and decrease usability, especially engine effectiveness and cause a lot of detrimental damage.

To protect against corrosion in the piping system, MT. Savvy uses a type-SC MGPS mounted on a Sea Chest (SC) which is equipped with an RRY17 type copper (Cu) electrode each and an aluminum electrode placed in strategic locations, as close as possible to the area to be protected. The anode is connected to a control panel that regulates the current flowing to the anode. Ions produced by the anode will be dispersed by seawater and create an environment that is not conducive to marine growth in the area. Another advantage is that the aluminum hydroxide formed will create a protective layer on the surface of the channel so as to prevent corrosion.

The use of a stable current on the copper electrodes and aluminum electrodes on the hull will produce copper and aluminum hydroxide ions to protect the pipe from marine biota plants that can be corrosive and form rust. This method of preventing the development of corrosion is known as the Marine Growth Prevention System (MGPS).

MGPS works with an electrolyte method or principle that works to provide continuous protection without the use of chemicals. The trick is to combine two systems, namely the installation of anti-fouling pipes and corrosion suppression. With control from a low-voltage power supply panel that is channeled to an anode which is connected directly to the liquid in the pipeline to minimize the influence of acidity of the liquid content on the corrosion process along the pipeline installation. The specialty of using this system is that it is environmentally friendly, does not use chemicals to neutralize the liquid condition, in accordance with

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the rules that apply to the classification of international rules.

This system consists of a pair of copper and aluminum called anodes which are attached to the inlet filter of the liquid to be neutralized. The copper anode produces ions that flow through a liquid medium that is in direct contact with it. These ions have the potential to inhibit the growth of shellfish and barnacles along the anode current flow range. Without anti-fouling protection, pipes can be full of organisms which over time can cause blockages, reducing system efficiency in pipe installations, with the help of aluminum hydroxide as flocculation released by copper. This is the so-called double protection, where the system can benefit from being protected from bio-fouling and corrosion processes. In new installations the anodes are attached to the sea chests using special retainers or a mounting flange. Or if the system is installed before the drydocking vessel, the anode can be installed in the seawater filter. Another advantage is that it is easy to replace a new anode.

Another study related to this problem was carried out by Seung Jun Lee and Jun Lee Seong (2011) which was about the effect of flow velocity on marine growth using electrochemical alloy Al 5083-H116 on the suction pipe. The results showed that the corrosion rate increased linearly with flow velocity compared to static conditions. Meanwhile, other studies have shown that the installation of aluminum alloy carbon anodes on the hull plate of KM ADRI XLIV technically has good performance and is very influential in slowing the corrosion rate of ship steel plates (Nur Aziz, 2012).

This study aims to analyze the use of MGPS on MT. Savvy at inhibiting the corrosion rate on the ship engine cooling pipe due to Marine growth. The method used is to calculate the corrosion rate in the JISF0507 seawater pipe and weigh the decrease in weight of the RRY17 type copper electrode based on the value of ship speed variability.Be advised that papers in a technically unsuitable form will be returned for retyping. After returned the manuscript must be appropriately modified.

2 RESEARCH METHODS

The research was conducted on the MT Savvy Ship, which uses the MGPS system using a combination of Aluminum (Al) and Copper (Cu) electrodes.

2.1 Equipment Used Tup

- Megger insulation tester, 1 set
- Multimeter, 1 set
- Toll set, 1 box
- Vernier calipers, 1pc

2.2 Mgps Materials

- Prevent corrosion resistance electrode, type RRY17, 1 pc
- Pipe, JIS F 0507 standard pipe (the level of UNS G10200 Carbon steel) with a diameter of 20 cm, a length of 150 cm as the sample metal (seawater pipe).

2.3 Data Collection Techniques

Data collection through observation techniques and field note documentation. This research instrument emphasizes the observation technique because it is considered in accordance with the characteristics of action research.

2.4 Implementation of Corrosion Test

In the corrosion test, the normal concentration level or the average pH of the seawater environment is 8.0 and the electrode sample (Cu) is immersed in a sea chest box for 3 days or 72 hours non-stop with several treatments for variations in seawater speed based on the speed of ship movement, including:

- Ship totally stop, moving water, 0.0m/s
- Full speed ship, 12.9knots, or moving water 6.6363m/s.
- Medium speed ship, 9.7knots, or water moving 4.9901m/s.
- Slow speed ship, 6.5knots, or water moving 3.3438m/s.
- Dead speed ship, 3.3knots, or water moving at 1.6976m/s.

The condition in the case of sea chest intake is not protected with MGPS as shown in Figure 1.

Figure 1. Marine growth and its effects, (a) intake hole, (b) pipe interior, (c) filter, (d) pole base plate

Ship particulars of MT. Savvy:

Specifications:

Tonnage, gross (6,694tons), nett (3,785tons), displacement (13,263tons), dead weight (10,327 tons), lightship (2,935tons), length over all (120m), length between perpendicular (114m), breadth molded (20.50m), depth molded (10m), summer draft (7.61 m), height from keel (29.16m).

Machineries:

Main engine, Hanshin, LH46LG, power: 3,960hp, speed: 220rpm (1 unit), Auxiliary engine,Yanmar, 6LAAL-DTN, power: 250kW, speed: 1,200 rpm (3 units), Harbor generator, Yanmar, 6CHL-TN 80 kAV, power: 75kW, speed: 1,800rpm (1unit), Emergency generator, Mitsui Deutz, F4910, power: 40 kW, speed: 1,800 rpm (1 unit)), Bow thruster engine, Yanmar, 6KY-ET1 4CyC, power: 370kW, speed: 2,040rpm (2 units), Cargo pump, screw type, CSL- 1000P, speed: 600 rpm, pressure: 0.98MPa, capacity 1,000m3/h (2 units), Stripping pump, screw type, CSL-300, speed: 600rpm, pressure: 0.98MPa, capacity: 300 m3/h (1 unit), air conditioner (Daikin Ind US20H, power: 75kW (2 units), Fan, power: 2.5kW (1 unit).

Tanks:

Cargo tank, capacity: 13,307m3, slop tank, capacity: 1,476m3, MFO tank, capacity: 8,300liter + 343.22m3, MDO tank, capacity: 6,000 liter + 76m3, ballast tank, capacity: 4,264m3.

Application of MGPS on MT. Savvy

Application of the MGPS pipe guard system on MT. Savvy uses Hikari production Sangyo Co., Ltd. Japan with two combination types of installation, namely:

a. Typical seachest anode arrangement

Copper anodes and aluminium anodes are installed in the sea chest if the tanker is planned for drydocking for less than 5 years, assuming there is sufficient space available.

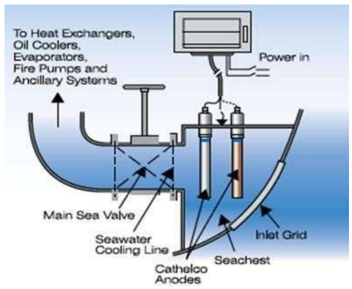

Figure 2. Type of anode installation on sea chest

Typical strainer anode arrangement

The advantage of the filter mount system is that the anode can be changed at any time without the need for drydocking. In this case, the sea water coming from the sea chest must still be ensured free from dirt and contamination.

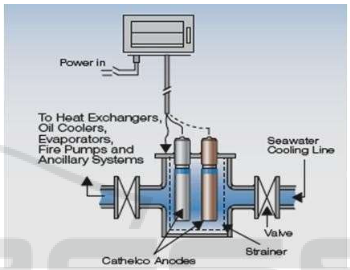

Figure 3. Type of anode installation on filter strainer

Figure 4. MGPS copper electrode and aluminum electrode

Measurement/identification

The dimensions and mass of the electrodes are measured before carrying out the test. Dimensions are measured using a vernier caliper and steel ruler.

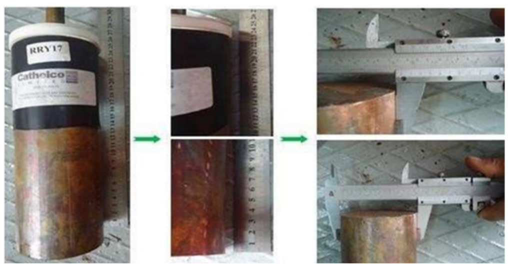

Figure 5. Dimensional measurement of copper electrode RRY17

3 RESULT AND DISCUSSION

The chemical composition of the electrodes used is obtained from the delivery order sheet, as follows:

Table 1. Chemical composition of copper electrode RRY17.

No.	Nama unsur	Komposisi (%)
1	Tembaga (*Cu*)	96.66
2	Argentum (*Ag*)	2.439
3	Zirkonium (*Zr*)	0.701
4	Besi (*Fe*)	0.18
5	Silikon (*Si*)	0.002
6	Seng (*Zn*)	0.002
7	Nikel (*Ni*)	0.013
8	Mangan (*Mn*)	0.001
9	Timbal (*Pb*)	0.001
10	Aluminium (*Al*)	0.001

The form should be completed and signed by one author on behalf of all the other authors.

The electrodes (samples) were immersed in a sea chest box with variations in seawater discharge based on the speed of the ship for 72 hours. After observing the data obtained in the form of reduction of the anode mass as shown in table 2 below:

Table 2. Mass reduction in seawater pipes (JIS F-0507)

Ship movement category	Sea water speed, m/s	Mass reduction, W, mg	Cd, mA/mm
Stop	0.000	46.1	157.89
Dead speed	1.698	105.8	333.17
Slow speed	3.344	179.0	1,591.51
Medium speed	4.99	214.0	2,122.01
Full speed	6.636	267.0	2,652.52

Table 3. Corrosion rate in seawater pipes (JIS F 0507)

Ship movement category	Sea water speed, m/s	corrosion rate, Cr, mm/y
Stop	0.000	0.075710
Dead speed	1.698	0.173760
Slow speed	3.344	0.293890
Medium speed	4.99	0.351460
Full speed	6.636	0.438510

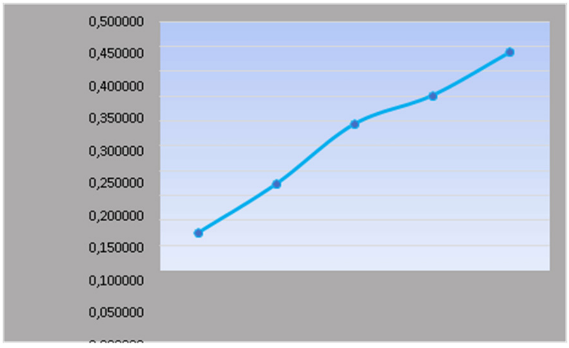

Figure 6. Effect of ship speed on corrosion rate in seawater pipes

Steel pipe in seawater (NaCl) environment will corrode due to the presence of Cl ions. These ions will break down the passive layer on the seawater pipe steel (JIS F 0507). When in contact with metal surfaces, Cl- ions will dissolve metal ions and make it easier to enter the solution. From Figure 6, it can be seen that the corrosion rate of the seawater pipe (JIS F 0507) will increase along with the increase in the value of the seawater speed, as a modeling of ship movement

Other research conducted by Seung-Jun Lee et al also showed that the corrosion rate that occurred in the sea chest of the ship increased with increasing flow velocity compared to the static state. When the ship is traveling at full speed away, the propulsion engine burns more fuel, thus requiring a cooling fluid, which in this case is seawater, with a larger flow capacity, and causes the velocity of the water flow in the pipe to increase.

2. Weight Reduction on RRY1 Copper Electrode

The total weight of the anode, Wtot required for protection can be calculated by the equation:

Wtot = I p □Y □ C
□

Explanation:

dimana Ip = A □ □Cd □
1000

Ip, the current strength needed for protection Y, test time = 3days or 0.008year

C, anode reduction number = 3.6kg/Amp.y

Cd, electric current density (console panel), mA/m2

A, seawater pipe area = 0.09425m2

μ, utilization factor = 90%

The following is the current density data (Cd) from various ship speeds as shown in Table 4 below.

Table 4. Test results for copper (Cu) RRY17 electrodes

Ship movement category	Sea water speed, *m/s*	Cd, mA/m^2
Stop	0.000	157.89
Dead speed	1.698	333.16
Slow speed	3.344	1,591.51
Medium speed	4.990	2,122.01
Full speed	6.636	2,652.52

Then the value of Wtot for various ship speeds:

a. Water is still or when the ship stops (0m/s)
Cd = 157.89mA/mm

So:
Ip = 0.09425□ □157,89□ = 0.015 Amp
1000
Wtot = 0.015□ 0.008□ 3.6 = 0.48 mg
0.90

b. Dead slow ship, 3.3knots (1.698m/s)
Cd = 333.156mA/m2,

so :
Ip = 0.031Amp
Wtot = 0.99mg

c. Ship slow ahead, 6.5 knots (3,344 m/s)
Cd = 1591.51mA/m2,
so :
Ip = = = 0.15 Amp
Wtot = = 4.8mg

d. Half ahead, 9.7 knots (4.99 m/s),
Cd = 2122.01mA/m2,
so:
Ip = = 0.20Amp
Wtot = 6.4mg

e. Full away ship, 12.9knots (6,636m/s),
Cd = 2652.52mA/m2,
so:
Ip = 0.25Amp Wtot = 8.0mg

Table 5. mass reduction of RRY17 copper (Cu) anode at various vessel speeds

Ship movement category	Sea water speed, m/s	Currents, Ip, Amp	Mass reduction, Wm, mg
Stop	0.000	0.015	0.48
Dead speed	1.698	0.031	0.99
Slow speed	3.344	0.15	4.80
Medium speed	4.99	0.20	6.40
Full speed	6.636	0.25	8.00

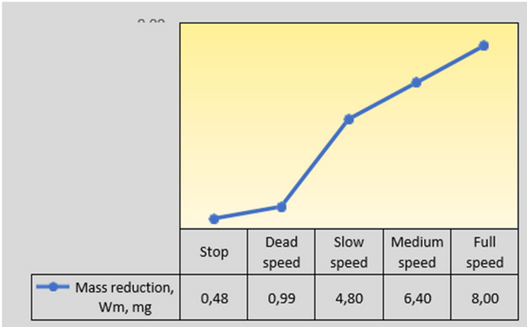

Figure 7. The effect of ship speed on the reduction of the anode mass of copper (Cu) RRY17

Figure 8. Weight reduction on the copper electrode RRY17, (A). Initial conditions, (B). Condition after 72 hours, (C). Image magnification B

From the calculation results of the relationship between the corrosion rate of seawater pipes (JIS F-0507) compared to the reduction in mass of the copper anode (Cu) RRY17 as shown in Table 6 and Figure 9 below.

Table 6. Reduction of mass of copper anode (Cu) RRY17 and corrosion rate of seawater pipe (JIS F-0507) at various ship speeds

Ship movement category	Pipe corrosion rate, Cr, *mm/y*	Anode mass reduction, Wtot, *mg*
Stop	0.07571	0.48
Dead speed	0.17376	0.99
Slow speed	0.29389	4.80
Medium speed	0.35146	6.40
Full speed	0.43851	8.00

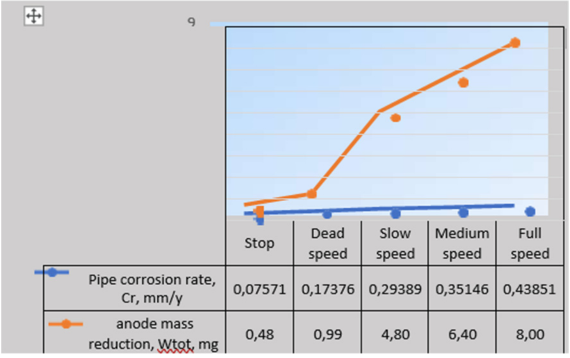

Figure 9. Reduction of mass of RRY17 copper anode (Cu) and corrosion rate of seawater pipe (JIS F-0507)

If you look at the mass reduction value at the JIS F-0507 seawater pipe cathode in Table 6, it is clear that the reduction that occurs is very large when compared to the mass reduction that occurs at the copper (Cu) RRY17 anode. Steel pipe for seawater pipe JIS F 0507 is at the top of the table and has the most negative electrode potential value when compared to copper (Cu) RRY17. Thus, (Fe) is the most reactive when compared to (Cu). This causes the cathode weight reduction (JIS F-0507) to be greater when compared to the RRY17 copper anode weight reduction. Likewise with (Al), aluminum has a more negative electrode potential than copper which is more positive when compared to (Fe). When comparing the anode weight reduction value obtained in the field and the anode weight reduction value obtained from the formula calculation, it is seen that there is a difference in the anode weight requirement value. This happens because the formula does not take into account the speed of the sea water (ship speed), while the data in the field shows that the speed of the sea water greatly affects the weight requirements of the anode. The higher the speed of the water (vessel speed), the higher the anode weight requirement which is used to prevent the growth of marine growth that causes corrosion.

4 CONCLUSIONS

Corrosion rate of seawater pipe (JIS F 0507) on MT. Savvy increases with increasing sea speed (ship speed). At the stop speed (0.0m/s) corrosion rate is 0.07571mm/y, at full speed (6636m/s) corrosion rate is 0.43851mm/y.

The reduction in the mass of the copper (Cu) RRY17 electrode is higher or faster in proportion to the speed of sea water (ship speed). At the stop position (0.0 m/s) the reduction in the mass of the electrode (Cu) RRY17 is 0.48 mg and the current at the electrode is 0.015 Ampere. Meanwhile, at full speed (6.636 m/s) the reduction in the mass of the electrode (Cu) RRY17 is 8.0 mg and the current at the electrode is 0.25 Ampere.

The amount of current density (Cd) depends on the effect of the environment, maintenance and coating, in this case the speed of the ship is very influential because when the ship stops the Cd value is 157.89 mA/m2 while at full speed Cd is 2652.52 mA/m2.

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