

## Investigation of Effect on Prefabricated Light Steel Structure Non-coating and Coating Using Transogard Zinc Chromate Paint after Exposed to Seawater

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### Abstract

The main objective of this research is to determine corrosion rate and weight loss for the coated and non-coated with several layer of mild steel AISI 1020. This research discussed and focusing on prefabricated material coating and non-coating of light steel structure effect on seawater and study on the research have been done before by others researcher for better understanding on this research. Basically, most of the researches conducted before are only focusing on the type of prefabricated materials. However, in this research the coating will be used in other to improve the properties of materials.

**Keywords:** AISI 1020; Coating; Optical microscope; Zinc chromate;  $ZnCrO_4$

### Introduction

This research is conducted due to the problems faced by the marine area. Firstly, there is no specific coating can be used to coat the light steel for the application in sea water, the right selection for light steel material should be done properly for better outcome of experimental result without neglecting the cost [1-3].

The following objective need to achieve:

- To investigate the profile of prefabricated material light steel coated and non-coated structure after exposed to sea water.
- To determine weight loss of the coated and non-coated light steel material due to sea water.

The coatings based in chromium (VI) already used since a long time ago and now prohibited because of the toxic content especially chromium (VI) [4-6]. A solution came out, which is trivalent chromate coating, but this coat does not produce the yellow color like the hexavalent chrome coating does. But the function is quite same as the hexavalent chrome coating, so it is used to replace hexavalent chrome in coating, since trivalent chromate coating is more environmental friendly [7-10].

“Many factors in surface preparation affect the integrity of coating which includes residues of oil grease, rust on the surface and mill scale which can decrease adhesion or mechanical bonding of coating to the surface” [11]. Coating is mostly used in Steel piling and other maritime structures because coating constitute the most commonly used and most effective method of corrosion control of marine structures.

The coating used in this experiment will be transogard zinc chromate Paint. The chromate type used is trivalent chromate coating which is a non-toxic paint. The paint Chemical formula is  $ZnCrO_4$  and the appearance of the coating is yellow-green crystals (Figure 1).

This shows that before applying any kind of coatings the penetration playing an important role in order to make sure the coating fully covered the specimen surface. Besides that, the surface finishing also important to make sure the coating fully used as the protective surface to minimize the corrosion occurs. In seawater, the reduction of dissolved oxygen molecules is the primary cathode reaction on the

specimen surface, and such a steady current is due to the limitation of oxygen diffusion. Based on the result also shows, the corrosion rate of the coating depended on its porosity.

The weight loss is converted to a corrosion rate (CR) or a metal loss (ML), as follows:

$$\text{Corrosion (CR)} = \frac{\text{Weight loss (g)} \times K}{\text{Density (g/cm}^3\text{)} \times \text{Exposed Area (A)}}$$

The constant used, k coefficient is  $3.45 \times 10^6$ , the desired corrosion rate unit used is Mils/year (mpy) and the area units used is in  $\text{cm}^2$ . The density used is  $7.87 \text{ g/cc @ g/cm}^3$ .

$$\text{Percentage of Weight loss (\%)} = \frac{\text{Weight loss (g)} \times 100\%}{\text{Initial Weight (g)}}$$

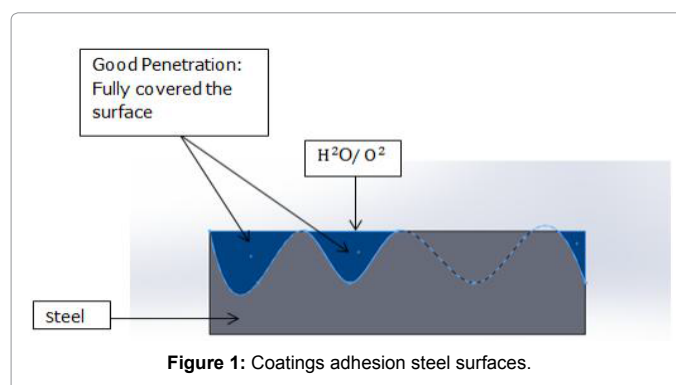


Figure 1: Coatings adhesion steel surfaces.

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## Methodology

The specimen used will be in rectangular design, before the experiment conducted, preparation of the specimen is the complex system (Figure 2).

Surface finishing methods vary across a broad range for better result. Type of steel used is AISI 1020 in the experiment. Firstly, cut the material into rectangular design with size 3 mm × 30 mm × 80 mm. Clean of specimens before weighing to remove any contaminants that could affect test results. The specimens clean by using grinding and polished using sand paper (Figure 3). Before coat the specimen, the samples will be degreased with ethanol and labeling to easier to identify the specimens (Figure 4).

After the cleaning process, 12 pieces of mild steel rectangular design will be coated with one layer of Zinc chromate,  $\text{ZnCrO}_4$  paint with the thickness of 0.09692 mm. 12 pieces of mild steel rectangular design will be coated with two layer using the same paint which are Zinc chromate,  $\text{ZnCrO}_4$  with the thickness of 0.14792 mm. the second layer applied when the first layer is completely dry. The other 12 pieces will be in non-coated condition.

The digital scale weigh will be used in order to weigh the specimen, before and after the experiment or test conducted (Figure 5).



**Figure 2:** AISI 1020 mild steel.



**Figure 3:** Cleaning the specimens by grinding using sand paper.



**Figure 4:** Samples after degreased with ethanol and labeling.

A closer picture of the corrosion products formed after progressive corrosion for long-term atmospheric exposure and compared to neutral salt fog and ASST accelerated methods is shown in Figure 5. The progressive corrosion product formation follows the same pattern as during initial corrosion, as described in the preceding paragraph for each corrosion exposure type [12]. From the figure above it is showed that how we can examine the corrosion happened effect of exposed to seawater (Figure 6).

## Result

### Optical microscopy without coating

The reddish colour covered most of the surface and the red participate more thick than 10<sup>th</sup> day, 20<sup>th</sup> day and 30<sup>th</sup> day. The based with silver and white colour show the area of the metal without any coating (Figure 7) [13-15].

### Optical microscopy with one layer of coating

The size of water bubble on the paint layer is decreases compare to the 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> days. Besides that, the number of the bubble produce after submerged into the water is decreases covered the surrounding of the specimen surface but some of reddish colour is form on the surface (Figure 8).

### Optical microscopy with two layer of coating

“Many factors in surface preparation affect the integrity of coating which includes residues of oil grease, rust on the surface and mill scale which can decrease adhesion or mechanical bonding of coating to the surface”. This shows; the coating cannot be function fully as protective to the surface because of surface preparation (Figure 9). The mechanical bonding of coating to the surface also plays an important role, to avoid



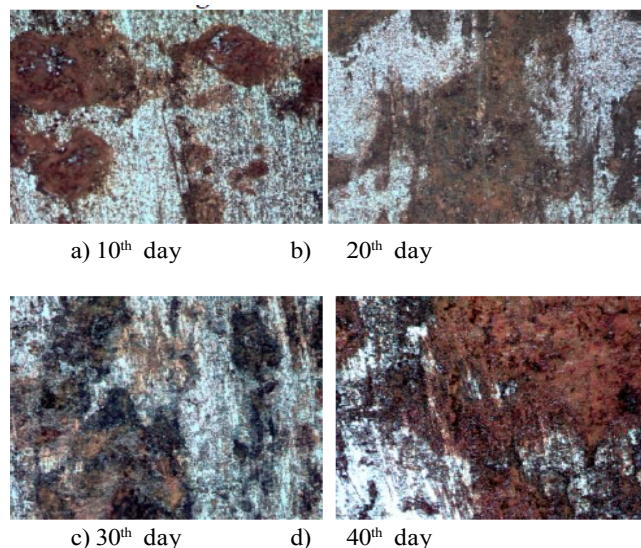
**Figure 5:** Specimens weighed using digital scale weigh.



**Figure 6:** Pitting and corrosion in a crude oil tank (International Marine Coating, 2011).



the bubble to form between the coating paint and the mild steel. Hence, effect of the bonding between the coating paint and the mild steel is not strong to prevent the corrosion process of mild steel during exposed

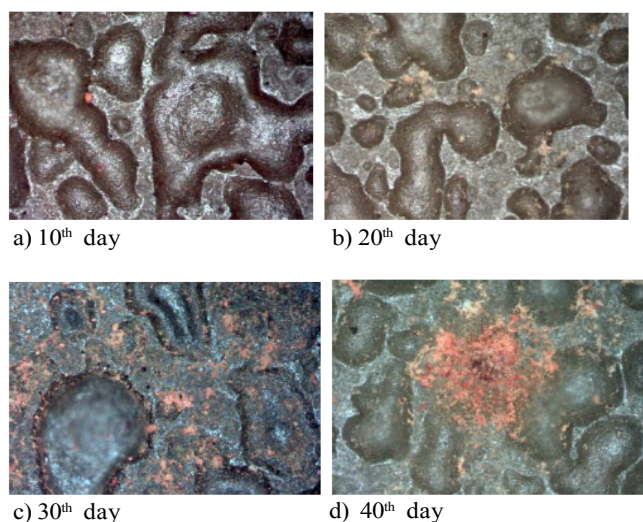


**Figure 7:** Showing optical microscopy without coating.

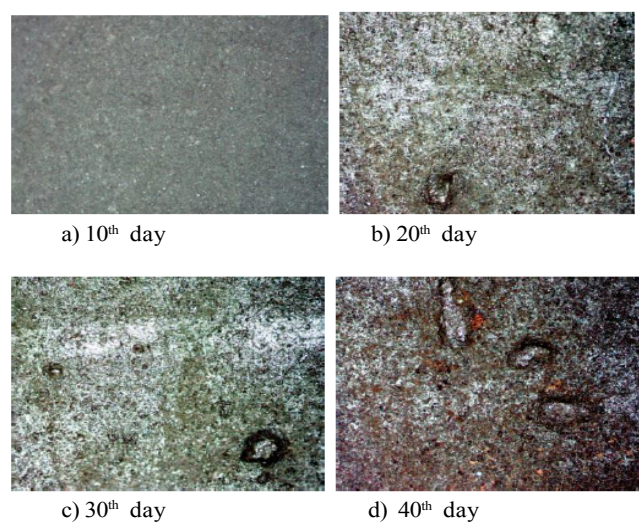
to sea water [16,17]. Thus, the water bubble is form, the corrosive sea water inside the bubbles do the corrosion process (Tables 1 and 2).

The samples without coating showed increment in percentage of weight loss as the time increases. The percentage of weight loss increase directly proportional with time when the specimens exposed to sea water without any protective layer to reduced corrosion process (Figure 10). The specimens applied with one layer of coating, the percentage weight loss during the 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> day is negative. This means when the percentage of weight loss is negative there is no weight loss occur, the specimens gain weight due to the layer of the coating produce bubble and stored water inside the specimens surface through bubbles. On the 40<sup>th</sup> day, the percentage of weight loss is 0.0006%. This shows the corrosion start to take place at the 40<sup>th</sup> day. For the two layer of coating the percentage weight loss is negative along the period [18-21].

While the rate of corrosion, of the samples without coating showed decrement in corrosion rate as the time increases. The Corrosion rate decreases as the time increases, but start to increases on the 40<sup>th</sup> day. The specimens applied with one layer of coating, the percentage weight loss is negative on the 10<sup>th</sup>, 20<sup>th</sup> and 30<sup>th</sup> day. This means when the percentage of weight loss is negative there is no weight loss occur, the specimens gain weight due to the layer of the coating produce bubble and stored water inside the specimens surface through bubbles [22,23]. On the 40<sup>th</sup> day, the corrosion rate is increases to 0.07mmY. This shows the corrosion start to take place at the 40<sup>th</sup> day. The corrosion rate



**Figure 8:** Showing optical microscopy with one layer of coating.



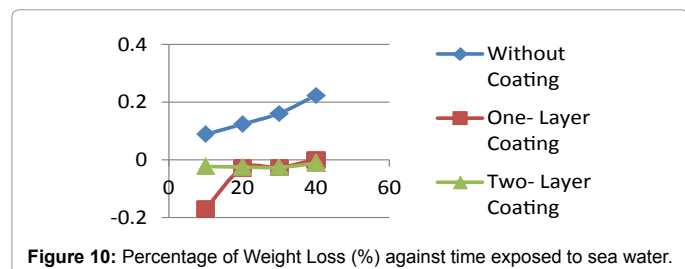
**Figure 9:** Showing optical microscopy with two layer of coating.

Days	Condition	Initial Weight (g)	Final Weight (g)	Weight loss (g)	Surface Area (cm <sup>2</sup> )	Corrosion rate (mmY)	Percentage of weight loss (%)
10	Without coating	135.0286	134.9.95	0.1191	5.418313	4.015	0.0882
	One -layer coating	134.9469	135.1761	-0.2292	5.43548	-77.02	-0.1698
	Two-layer coating	137.6914	137.7231	-0.0317	5.468987	-10.59	-0.023
20	Without coating	140.4065	140.2331	0.1734	5.46264	28.99	0.1235
	One -layer coating	136.0834	136.1232	-0.0397	5.44794	-6.655	-0.0292
	Two-layer coating	138.4652	138.4998	-0.0347	5.47076	-5.79	-0.0251
30	Without coating	139.5726	139.3480	0.2246	5.463780	25.03	0.1609
	One -layer coating	134.4546	134.4814	-0.0267	5.429353	-2.99	-0.0199
	Two-layer coating	139.9052	139.9421	-0.0370	5.479760	-4.11	-0.0264
40	Without coating	139.3340	139.0227	0.3112	5.461087	26.00	0.2233
	One -layer coating	143.9855	143.9846	0.0009	5.511080	0.07	0.0006
	Two-layer coating	145.3728	145.3904	-0.0176	5.528207	-1.45	-0.0121

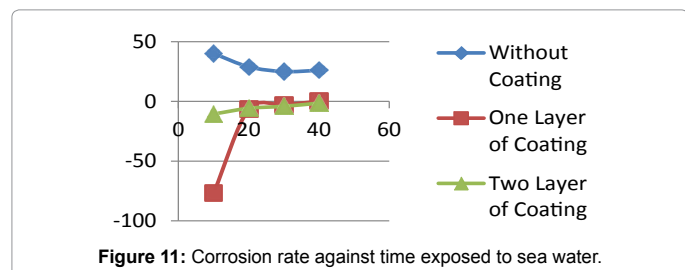
**Table 1:** Corrosion rate.

Symbol	Quantity	Unit
CR	Corrosion Rate	1Mils/year (mpy)
$\rho$	Density	7.87 g/cc@g/cm <sup>3</sup>
A	Area	cm <sup>2</sup>
k	coefficient	$3.45 \times 10^6$

**Table 2:** Units properties.



**Figure 10:** Percentage of Weight Loss (%) against time exposed to sea water.



**Figure 11:** Corrosion rate against time exposed to sea water.

is slowly increases after undergoes the highest increment in corrosion rate due to the corrosion rate approaching the positive corrosion rate. For the two layer of coating, the corrosion rate is negative along the experiment period of time. The specimens start to undergo the corrosion rate after approaching the positive corrosion rate (Figure 11).

The corrosion take place after the water bubbles is formed. This is because the corrosion occurs between mild steel and sea water and the increases the weight loss of the samples. The surface finishing is also some of causes to the water bubbles to forms [24,25].

## Conclusion

The data that was recorded show that there are different outcome from different condition of specimens surface. It is showed that with some protection of the mild steel surface can reduce the weight loss and also reduce corrosion rate. In addition, the water bubbles produce is due to the bonding attraction between the water and the mild still is high compare to the bonding attraction between the paint coatings and the mild steel. This is because the corrosion processes occur due to the presence of some ion presence on the mild steel and sea water. The coating only acts as to reduce the corrosion rate.

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