The Effect of Paint Thickness Coating on Power Radiated in Above Ground Carbon Steel Pipe for Fire Hydrant System

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Abstract: Corrosion is a primary cause of material failure, especially in the fire hydrant system that uses carbon steel placed above ground. Corrosion protection is performed on the pipeline to prevent or reduce the occurrence of corrosion. The most common method for corrosion protection is coating with a layer protective. Corrosion is applied to the entire panel with a primer coat of red epoxy resin before assembling to pipes. In this research, the variable coating thickness of the paint used was 150, 200, 250, 300, 350, and 400 µm. The result showed that the highest radiation occurred at the 200 µm of coating thickness and the lowest radiation was 350 µm. It can be concluded that 350 µm coating thickness was the lowest absorbed by the material. Therefore, it was better to be applied to protect the carbon steel pipe for fire hydrants system from corrosion.

1 INTRODUCTION

Coating is one of the methods to resist the materials from corrosion. Coating is also applied as a decorative, protective, and some others specific purposes (Wicks, 2007). The first attempt to control corrosion in pipelines is to use coating materials. Corrosion can be prevented as the pipeline metal can be isolated from the contact with the natural environment. Moreover, the coating can be as an effective protection against corrosion because it is an effective electrical insulator and it can be applied without any damage and will be easily to repair. (Peabody, 2001).

For the protection of a fire hydrant system that uses Carbon Steel Pipe on the ground surface which may daily exposed to sunlight and other environmental factors, protection in the form of a coating is needed (Maulana, 2020). However, the optimum thickness that can be applied to reach the best performance and without incurring the excessive costs for coatings are required.

In this study, the thickness using FDTD (Finite Difference Time Domain) method of the pipe coating was varied. The optimum thickness with low power radiated was also obtained to increase the protection of carbon steel pipes that were used for the fire hydrants which placed above ground.

2 MATERIALS AND METHODS

2.1 Materials

In this study, corrosion-resistant metals such as Carbon Steel ASTM A53 gr A with NPS 4" Sch 40 for fire hydrants were used to reduce the corrosion rate. Figure 1 below shows the simulation of carbon steel pipe with 4 m length.

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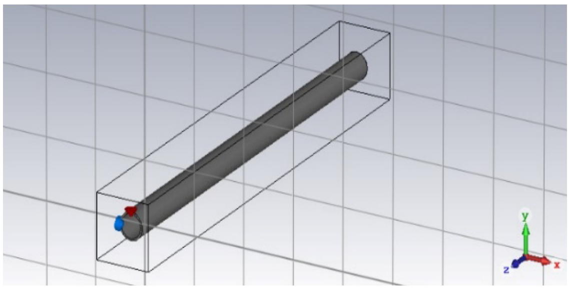

Figure 1: Carbon steel pipe simulation.

While the material specifications of carbon steel pipe used in the simulation are shown in the Table 1.

Table 1: Carbon steel material specifications.

Specification	Value
Electric cond.	6.993e+06 [S/m]
Density	7870 [kg/m^3]
Thermal cond.	65.2 [W/K/m]
Heat capacity	0.45 [kJ/K/kg]
Diffusivity	1.84103e-05 [m^2/s]
Young's modulus	205 [kN/mm^2]
Poisson's ratio	0.29
Thermal expand	13.5 [1e-6/K]

On the other side, a red epoxy resin material was used as the protective layer of coating paint. The epoxy resin specifications are shown in the Tabel 2.

Table 2: Epoxy resin material specifications.

Specification	Value
Density	1500 [kg/m^3]
Thermal cond.	0.2 [W/K/m]
Young's modulus	13 [kN/mm^2]
Poisson's ratio	0.45

2.2 Methods

FDTD (Finite Difference Time Domain) is a differential numerical method that is often used in simulation of electromagnetic waves (Siregar, 2021). The FDTD method uses a differential approach in the spatial domain explicitly and a differential approach in the time domain implicitly. First introduced by Yee, the FDTD method has been used in a variety of application problems (Gregory, 1999). The algorithm used is quite simple in numerical approximation of Maxwell's equations of differential form.

Then, an electric field grid (E) and magnetic field (H) intermittent in space and time were used, so that computation can be done by calculating the field equation as a function of the previous field. The basis of the Yee algorithm is approximation with a second-order Taylor expansion in space and time. Numerical dispersion and lattice-induced errors Irregularity can be minimized by giving the number of lattice spaces per unit length appropriate wave (Pozar, 2005).

3 RESULTS

The energy of sunlight received by a surface on the earth is about 1000W/m^2. It means that each location of 1 m^2 has the potential to generate 160-200W of solar electricity. Therefore, this study used 200 W for solar electricity lighting in simulation. The result of simulation showed that the addition of a paint coating could affect to the power of sunlight reflected on the pipe.

Table 3: Irradiation simulation results on carbon steel pipe.

Thickness (µm)	Power Radiated (10^{-5}W)	Frequency (GHz)
150	0.27	1
200	0.46	1
250	0.33	1
300	0.31	0.921
350	0.22	1
400	0.35	1

Based on Table 3 above, the reflected power of sunlight was affected by coated pipe (the thickness). Most coated pipe received normal energy absorption (1 GHz) although they were varied in value of power radiated. The greatest energy absorption happened at the 300 µm paint coating. It occurred at a frequency of 0.921 GHz which was in the same phase with the wave of sunlight on the carbon steel pipe affected. Here, the thickness of the coated was able emit electromagnetic waves at the UHF (Ultra High Frequency). Means here, the 300 µm has fast responses for sunlight irradiated compared to others.

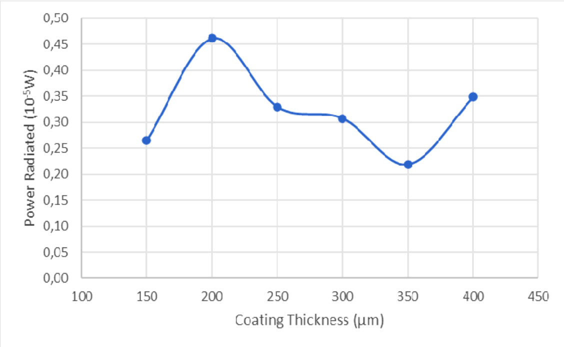

Figure 2: Graph between thickness of coating pipe and power radiation.

While in the Figure 2, it can be shown that the highest radiation occured at the 200 µm coating thickness and the lowest radiation was at 350 µm. The higher power radiated value indicated that there was more sunlight absorption into the material. In other hand, the lower power radiated value indicated less sunlight absorption into the material.

From the Figure 2, it also can be indicated that 350 µm coating thickness was the lowest sunlight absorption by the materials. Less sunlight absorption also indicated low of corrosion rate. Therefore, the 350 µm was better applied to protect the carbon steel pipe for fire hydrants system from corrosion.

4 CONCLUSIONS

Based on the research result, the best coating thickness to protect carbon steel pipe for fire hydrants was the coating thickness which had the minimum power radiated value. Furthermore, with the appropriate coating thickness applied to the materials, it could minimize the corrosion rate which later it also could affect to the lifetime of the materials.

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