Technical Report

Effect of Sacrificial Anode Power Dissipation on Its Anode Life

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Abstract: Studies have been carried out to investigate the effect of sacrificial anode power dissipation on its anode life. The results of the investigation show that decrease in the power dissipated by the sacrificial anode during the discharge of current, increases the anode life. This resulted from the fact that decrease in the power dissipation implies increased resident energy of the sacrificial anode hence, the greater the length of time the sacrificial anode can perform its protective function. It was also found that increase in the electrical resistance of the sacrificial anode increases the anode life. This results from reduction in the discharged current and minimization of power dissipation.
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1. Introduction

Anodic protection implies that the object to be protected is coupled as an anode in an electrochemical cell (Ijomah, 1991). The potential of the metal is then displaced in the positive direction towards the passive region, where the oxide of the metal is thermodynamically stable. Anodic protection is therefore only applicable to metals that show chemical passivity, such as iron, chromium, aluminum, titanium etc. (Ijomah, 1991).

Conversely, cathodic protection means that the corroding object is coupled as a cathode of an electrochemical cell (Ijomah, 1991). The electrode potential of the metal is then displaced in the negative direction to a value below its equilibrium or reversible potential in the environment in question. Its dissolution is therefore totally prevented. Instead, there occurs hydrogen evolution as shown (Ijomah,1991) ;

$$2H^+ + 2e = H_2 \qquad (1)$$

or oxygen reduction at a rate corresponding to the applied current [1].

$$O_2 + 2H_2O + 4e = 4OH^- \qquad (2)$$

Cathodic protection is divided into galvanic or sacrificial cathodic protection and electrolytic or impress current cathodic protection. In galvanic cathodic protection, (Fig. 1) the corroding object is made the cathode of a galvanic cell, the anode of which is a more reactive metal such as magnesium, aluminum or zinc and which by being sacrificed, protects a valuable construction, e.g a steel tank, from corrosion. The galvanic anode may be applied as a coating on the protected structure, most important example being galvanized steel, or it may be a separate anode plate welded or electrically connected to the structure.

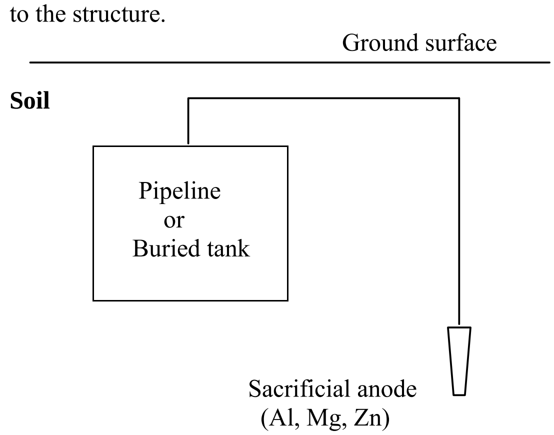

Figure 1 Galvanic cathodic protection

In electrolytic cathodic protection, (Fig.2) the protected structure (cathode) is supplied with direct current from an outer current source or rectifier, the auxiliary electrode being insoluble platinum, carbon, silicone or lead. The process is controlled by either regulating the current via the applied cell voltage or regulating the cathode potential by means of a potentiostat.

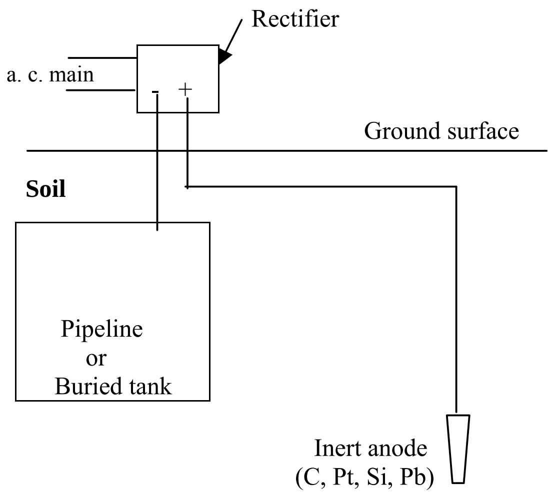

Figure 2 Electrolytic cathodic protection

Equation (2) implies that alkali is produced at the surface of the metal unless the water around is deaerated.

An interesting recent development has been the use of sacrificial anodes to solve limescale problems (Metal Mart). The zinc is sacrificed for limescale protection. This works by tiny amounts of zinc dissolving in water are attracted to the calcium. They react to form aragonite (Metal Mart) and in this form it doesn't react with plumbing system.

Cathodic protection anodes have specific parameters relating to their rates of consumption and utilization. These determine the useful life that can be obtained from an anode operating at or below its calculated current output (Ijomah, 1991).

Past reports (Ijomah, 1991) have shown that galvanic anodes do not operate at maximum efficiency. Hence only a fraction of the electrical energy content of the anode is available for useful cathodic protection while the remainder is consumed in the self-corrosion of the anode itself.

Studies (Ijomah, 1991) have shown that utilization factor is determined by the amount of anode material consumed when the anode can no longer deliver the required current. This factor should take account of both the reduced size of the anode and/or disbondment of the sacrificial anode material from the core at the end of life.

The anode capacity of a galvanic anode is calculated from the equation. (Ijomah, 1991);

$$A_C = \left(\frac{A_L \text{ x } I \text{ x } 8760}{A_W \text{ x } U_F} \right) \qquad (3)$$

Where

A_C = Anode capacity (Ahrs/Kg)
A_L = Anode Life (hrs)
I = Discharged current (A)
A_W = Anode Life (Kg)
U_F = Utilization factor
8760 = Total hours in a year

The present work is aimed at investigating the effect of sacrificial anode power dissipation on its anode life.

2. Materials and methods

In this study, work was carried out on the major oil pipeline; PPL 1 at offshore platforms in South Southern State of Nigeria, having been certified corrosion infested. Varied quantities of current discharged in each case for 480 hrs (as result of varied resistance of zinc metals used) were measured and the corresponding power dissipation and utilization factors determined by calculation. Values from these parameters were used to calculate the associated varied anode life and anode capacity of the anode. Details of the experiment are as stated in the report (Nwoye, 2008).

Table 1: Parameters used

Parameters used	Values
Anode Capacity (Ahrs/Kg)	780
Utilization factor	0.9
Anode weight (Kg)	3.5
Time elapse for current discharge (hrs)	480

As current is discharged by the sacrificial anode power is dissipated.

$$P_W = I^2Rt \quad \text{(Okeke, 1987)} \qquad (4)$$

$$I^2 = \left(\frac{P_W}{Rt} \right) \qquad (5)$$

$$I = \left(\frac{P_W}{Rt} \right)^{1/2} \qquad (6)$$

Substituting equation (6) into equation (3) reduces it to;

$$A_C = \left(\frac{A_L \text{ x } (P_W/Rt)^{1/2} \text{ x } 8760}{A_W \text{ x } U_F} \right) \qquad (7)$$

Rearranging equation (7) for anode life;

$$A_L = \left(\frac{A_C \text{ x } A_W \text{ x } (Rt)^{1/2} \text{ x } U_F}{8760 \text{ x } (Pw)^{1/2}} \right) \qquad (8)$$

Where
P_W = Power dissipated by the sacrificial anode (W)
R = Resistance of galvanic anode (Ω)
t = Time elapse during which current was discharged (hrs)

3. Results and discussion

Analysis of Figures 3 and 4 shows that increase in the resistance of the sacrificial anode decreases the current discharged from the anode (equation (5)). This in turn decreases the power dissipated as shown in equation (4).

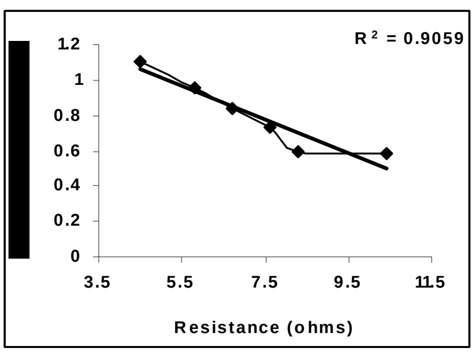

Figure 3 Effect of sacrificial anode resistance on the discharged current

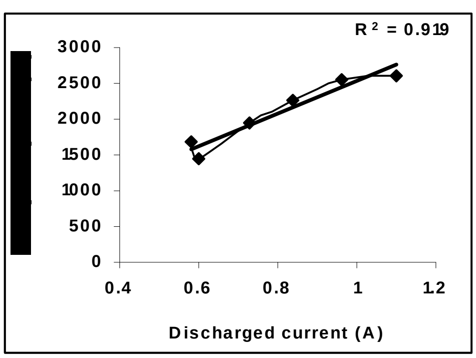

Figure 4 Effect of discharged current on power dissipation

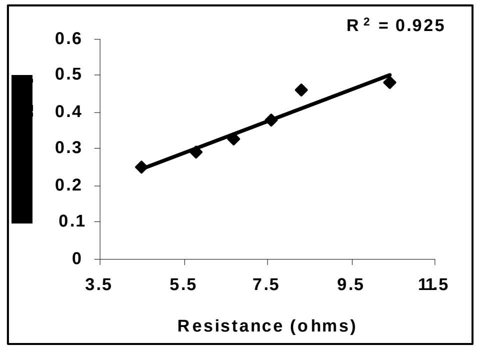

Figure 5 Effect of sacrificial anode resistance on the anode life

Figure 5 shows that increase in the electrical resistance of the sacrificial anode results to increase in the anode life of the sacrificial anode. This result from the fact that increases in electrical resistance decreases the current flow. Therefore when current flowing or discharging through the anode is reduced, the life of the anode is enhanced.

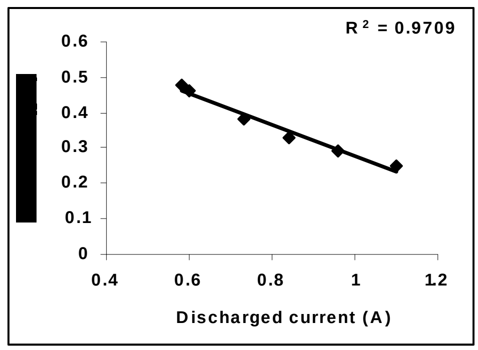

Figure 6 Effect of discharged current by sacrificial anode on the anode life

Figure 6 indicates that increase in the discharged current decreases the anode life since lesser time elapse would be required for the sacrificial anode to be completely consumed.

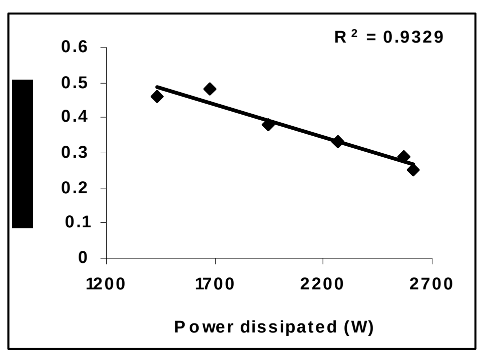

Figure 7 Effect of power dissipated by sacrificial anode on the anode life

Critical analysis of Figure 7 and equation (8) show that decrease in the power dissipated by the sacrificial anode during the discharge of current, increases the anode life. This is attributed to the fact that the discharged electrical energy (as power) called into play is converted to heat energy and is lost. Therefore the lesser the heat energy lost; the greater the length of time the sacrificial anode can perform its protective function. And this invariably means increased anode life.

4. Conclusion

Studies carried out to investigate the effect of sacrificial anode power dissipation on its anode life shows that decrease in the power dissipated by the sacrificial anode during the discharge of current, increases the anode life. This resulted from the fact that the discharged electrical energy (as power) called into play is converted to heat energy and is lost. Therefore the lesser the heat energy lost; the greater the length of time the sacrificial anode can perform its protective function.

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