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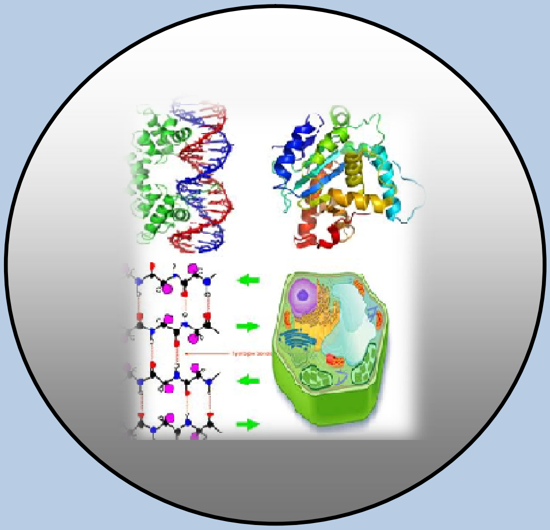

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RESEARCH PAPER

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Cathodic Protection Tests against Corrosion

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ABSTRACT

The cathodic corrosion were measured and tested by forming corrosive cells with different metals; Fe, Zn and Mg. Then cathode protection method has been used in this work for treating the corrosion in cells, The tests includes formation corrosion cells (test 1,2) in addition of applied the cathodic protection (CP) by using sacrificial anode method test (3,4), and impressed current method test (5).

Keywords: Cathode Protection, Corrosion, Sacrificial Anode Method and Electro Chemical Reduction.

INTRODUCTION

Cathode protection is widely used to prevent corrosion and rust on the outer surfaces of the equipment-ferrous metal that buried or submerged in water making them negative poles of an electrical circuit. The use of cathode protection to protect steel structures for various tasks by making anti-corrosion metal body (Morgan, 1987). The reaction that occurs during the process of corrosion is called electrochemical reaction whether it happens in a humid or a dry atmosphere. The electrochemical reaction is defined as reduction-oxidation reactions. The former represent a reduction reaction whilst the later representing the oxidation reaction cathode protection is one of the effective methods used widely to protect oil pipelines buried in the ground as well as the buried mineral reservoirs. It used also to protect the ports and docks for many others purposes. None of these previous investigations have established link between the arrangements of galvanic or voltaic cell to convert the chemical energy to the electrical one contrary to what happens in the analysis electrical cell. It is consists of two different electrodes in terms of electrochemical activity. One pole consider as anode and the other one as cathode so that the anode pole is more active and more likely to ionization.

The electrons in the outer circle flown from the anode to the cathode as shown in figure (1).

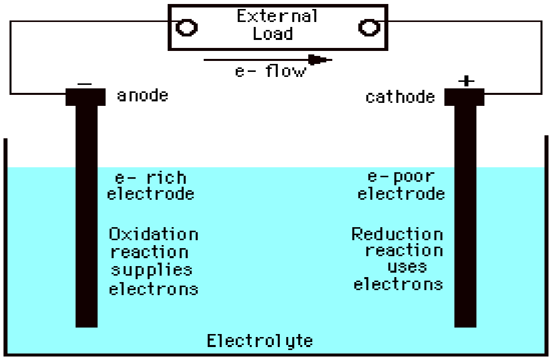

Figure 1. Electrochemical cell

Practical Part

MATERIAL AND METHODS

In this part a group of scientific tests we used

1- Different poles (Fe, Zn, Mg) in various sizes

2-Container from polyethylene contains dry soil also wet soil with sea water.

3-Ammeter to measure the amount of current flowing in the circuit

4-Cables and wires to connect with accessories

RESULTS AND DISCUSSION

The first test:

This test was conducted using the poles of zinc metal with different surface areas (4cm2……1cm2), copper Pole with fixed surface area (5cm2) When the poles are connected by wire and ammeter the electric cycle is completed and reading electrical current 2mA (Mateer, 1994). When zinc pole replaced with another pole have surface area less than the first noticed increase in the value of the current to 15, 38 till reach 52m A. Table (1) below.

Table 1. Surface area of the poles and the values of the current generated and medium of cell.

Number of test	The poles	The medium	Cathode (surface area) Cm^2	Anode (surface area) Cm^2	current mA
1	Zinc Copper	Soil wetting by use sea water	5	4	2
			5	3.5	3
			5	3	15
			5	2.5	29
			5	2	38
			5	1.5	45
			5	1	52

In this experiment galvanic cell is formed, consisting of zinc pole as anode lose electrons and gives to the other pole acting as cathode can be observed that through the ammeter which it refers to the flow electric current, and when replacing the zinc pole with another pole has smaller surface area note the increase in the value of electricity and this was due to the influence of the surface area on the corrosion, the smaller surface area of the anode Proportion to the cathode increase the value of the current generated between the poles table (1) that meaning increase of the corrosion (BS EN 12473).

Second test

This test was performed using two poles of iron and magnesium. The reaction medium is dry soil and the moist soil with sea water, we used the mediums individual in a containers and then we put iron and magnesium poles in each container, the poles are connected by wire and ammeter, the electric cycle is completed (ASTM B843 - 07).

Table2.Effect of medium and current values generated with time

Number of test	The poles	Time Min	Current In wet soil mA	Current in dry soil mA
2	Iron-magnesium	0	0	0
		5	100	10
		10	85	0
		15	79	0
		20	70	0
		50	45	0
		80	15	0
		120	0(corrosion fully)	0

Stream erosion depends on the medium or solution conductivity ,Dry sandy soil have high electrical resistance as can be seen from the table above ,while The wet soil with Seawater be irresistible less and accelerate corrosion Shortly .

Reading electrical current equal to 100 mille Amps at the five minute, and then decreased the intensity of the current with the passage of time until Erosion of magnesium swivel fully (in wet soil).The current is high at first because the voltage difference between the anode and the cathode great, but with decreasing voltage difference as a result of the impact of the current flow in the cathode, the current gradually decreasing due to polarization of the cathode. The magnesium in this experiment active anode and it is a metal which has the most negative voltage which gives the highest rate of electricity supply at a short time.

The magnesium pole will be eventually consumed by the reaction

Mg(s) -> + Mg2+(aq) + 2e-

while the steel pipe as the cathode will be protected by the reaction

O2(g) + 2H2O(l) + 4e- -> 4OH-(aq).

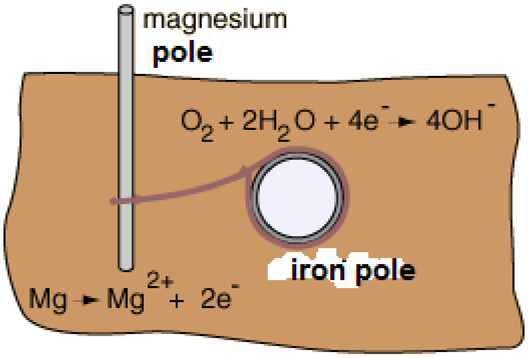

Figure 2. Corrosion cell.

Connecting the iron pole to a more active metal like Mg makes an (Fe-Mg) voltaic cell which oxidizes the magnesium in preference to the iron.

Test three

CP can be accomplished by two widely used methods:

By coupling a given structure (like Fe) with a more active metal such as zinc or magnesium. This produces a galvanic cell in which the active metal works as an anode and provides a flux of electrons to the structure, which then becomes the cathode. The cathode is protected and the anode progressively gets destroyed, and is hence, called a sacrificial anode .this is the principle of tests three and four.

In this test we used the poles of iron 50cm2, zinc50cm2 and magnesium20cm2, using wet soil as a medium of reaction

When the poles of iron and zinc are connected by wire and ammeter the electrons moving from the anode (zinc) to the cathode (iron) in this case corrosion occur on the zinc pole. When the stream of electrons enters to zinc pole from another pole such as magnesium that is connected with zinc pole the corrosion converted from zinc pole to the magnesium pole (as shown in Figure (3).

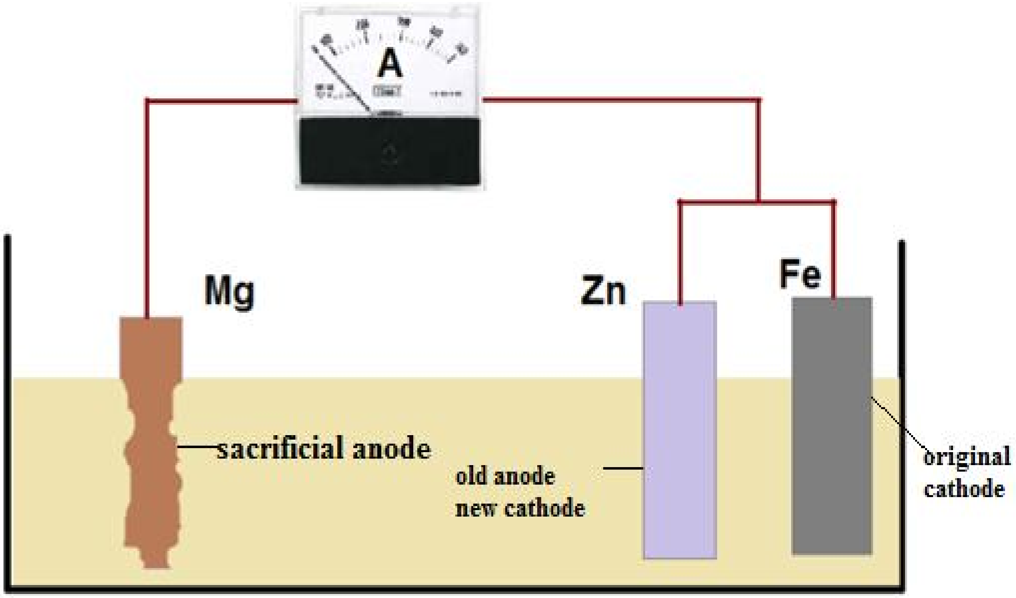

Figure 3. Application of cathodic protection by using sacrificial anode (Mg).

Table 3. Relationship between times with the current generated by anode sacrifice (Mg).

Number of test	The poles	The medium	Time Min.	Current mA
3	Iron zinc Magnesium	Soil wetting by use sea water	0	0
			5	6
			20	13
			50	15
			80	17
			100	15
			140	10
			180	5
			220	0 (corrosion fully)

The test is designed corrosion cell (Figure 3) where the corrosion occurs on the magnesium pole instead of zinc pole.

The corrosion of magnesium can be seen through passing the corrosion current through the ammeter traffic and decreases the current value to be eroded pole magnesium completely after 3.40 hours and ended current flow, meaning that pole magnesium sacrificed himself in order to protect the pole zinc, where the magnesium pole worked as positive pole and zinc and iron two negative poles.

Fourth Test

When the poles of irons connected by wire and ammeter the electrons moving from the anode (Fe1) to the cathode (Fe2) in this case corrosion occur on the anode. When a third pole (zinc) is immersed to the same cell and linked with iron poles applies a stream of electrons from zinc pole to the anode (Fe1) in this case corrosion occur on the zinc pole (as shown in Figure 4).

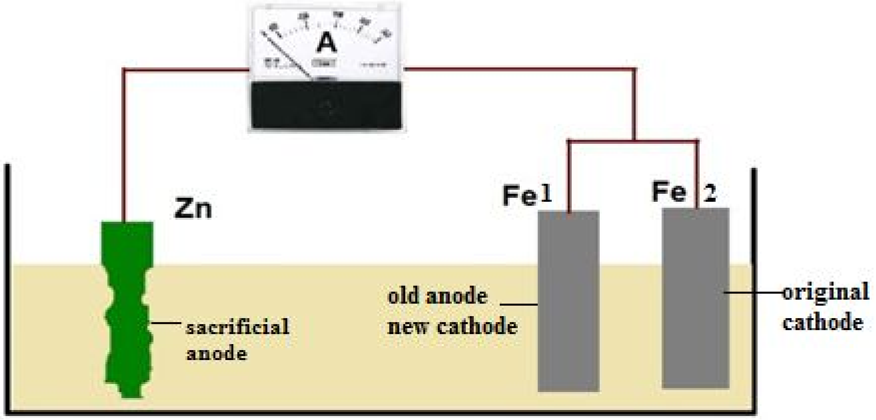

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Figure 4. Application of cathodic protection by using sacrificial anode (Zn).

Table4.Relationship between time with the current generated by anode sacrifice (Zn)

Number of test	The poles	The medium	Time Min.	Current mA
4	Iron (1) Iron (2) Zinc	Soil wetting by use sea water	0	0
			10	13
			40	14
			80	15
			120	14
			200	12
			400	10
			500	5
			600	0

In this experiment two iron poles have been immersed in the wet soil wetly with seawater as corrosion medium, one iron poles act as positive pole and the other negative pole and in this case the corrosion occur on the anode pole in order to protect the cathode pole. But when the iron poles are linked with each other then with zinc pole by wires (Figure 4) the zinc pole will act as positive pole and corrosion converted from one of them to the zinc pole that is acting as positive pole for the cell, where this experiment is considered an example of using cathode protection during the sacrifice (Gummow, 2000).

To understand the action of sacrificial anodes for cathodic protection it is necessary to know the galvanic series of metals Anodes can lose their activity and become passivized, developing a non-conducting film on their surfaces.

So that they no longer are able to supply current. This can be avoided by careful control of the concentrations of trace impurities in the anode materials, and by alloying. For zinc anodes the level of iron, for example, must be kept below 0.005% for satisfactory long-term operation of the anodes.

This has been observed in this test by reading the corrosion current which ended after the loss of a small amount of zinc weight and for long time table(4). Unlike magnesium pole in the previous test where corrosion completely and shortly.

Fifth Test

Impressed current cathodic protection (ICCP) systems are commonly used where there are increased current requirements for corrosion protection, where the driving voltage is greater than what can be obtained with galvanic systems and where there may be a need for enhanced control of the system (National Association of Corrosion Engineers, 1983).

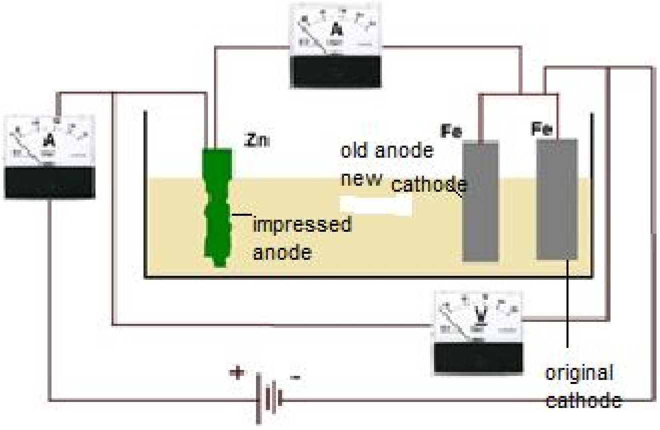

Figure 5. Application of cathodic protection by using impressed current.

When the iron poles are immersed with zinc pole inside the electrolyte medium, connect the iron poles with each other and with the zinc pole, ammeter and linking the cell with a source of electrical current (Figure 5). Happens one of the reactions either Absorption of oxygen or releasing hydrogen, this test considered example for cathode protection that is using to control the corrosion or reduced it by shining an electric current into the metal with rate equal or greater than the rate of release from the metal when eroded, and determine the corrosion by tests for shortage in weight of the poles. The iron pole which is wanted to be protected must connect the negative pole of the voltage source and zinc pole that dissolved, in this case the iron pole which is wanted to protect was cathode (figure 5). One reaction is happened either absorption of oxygen or releasing hydrogen. When electrical current shed with several readings and notice their impact on the weight of the protected iron poles (table 5).

The best reading was(55---65) mA, and from this table the readings shows that least causing of continuing corrosion and reading which shows the largest cause of cracks or loss of current.

Table 5. Values current with time with the accompanying notes.

Number of test	The poles	The medium	Time Min	Impressed current	Note
5	Iron (1) Iron (2) Zinc	Soil wetting by use sea water	2---5	150---130	Cracks and great loss in the current
			10----20	125---110	Cracks and great loss in the current
			30----50	100---90	Few cracks simple loss in the current
			60----70	80---70	Without cracks simple loss in the current
			90---110	65---55	Without cracks of metal current is ideal
			120---150	50---30	No protection of poles

CONCLUSIONS

At the end of this research we refer to a set of important things in the application of cathodic protection including

1. The surface area of the component to be protected.
2. Current requirements for protection.
3. Number of anodes required to protect the structure.
4. Lifetime of anodes.
5. Cost requirements for the system.

The impressed current cathodic system is much cheaper than the galvanic anode protection system. Also it has been found that by considering a rectifier of lower potential the lifetime of the anodes considerably increased and hence the cost/year is also reduced in the case of impressed current cathode system .The number of anodes involved in the case of impressed current is also very less in comparison to the number of anodes involved in the galvanic anode system for the same structure.

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