Characterizing Initial Steel Corrosion In Polymer Modified Smart Cement

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Abstract:
In this study ,polymer modified smart cement was used to investigate the initial corrosion of steel embedded in cement. Three different types of polymer was used to make polymer modified smart cement and steel is embedded inside. The specimen was kept in 3.5%NaCl aqueous solution and corrosion is measured as per ASTM standard. Also .Electrochemical Impedance Method was used to monitor the corrosion development in the system.

1. Introduction

Steel Casings have failed in many areas as a result of either internal or external corrosion. Although internal corrosion of the casing surfaces can be caused by carbon dioxide, hydrogen sulfide and organic acids are responsible for casing corrosion .In general, the main cause of internal attack is hydrogen sulfide. External Corrosion is caused by bacterial action, electrolytic effects and chemical action by acidic subsurface(Goodnight & Barret, 1956).

In polymer modified cement based material polymer particles are positioned between inside of hydrates and surface of anhydrous cement grains. The presence of polymers results in improved pore structure and thus has reduced porosity. Polymer addition is effective enchanting vibration damping capacity, frost resistance and resistance to biogenic sulfuric acid corrosion. Polymer modified cement forms a barrier and prevents steel corrosion(Chung, 2004).

Around, 25% of failure in oil and gas industry is corrosion related. Corrosion related failure impose significant penalties on the operation(Kermani & Harrop, 1996).In this paper, smart oil well cement have been modified with polymers to prevent steel corrosion.

2. **Objective**. The objective was to study the corrosion inhibiting efficiency of polymer modified cement by monitoring change real time using a nondestructive electrical method

3. Materials and Methods-

Four different set of cement specimen with w/c ratio of 0.4 were prepared with 0.02% conductive filler was prepared. Styrene Butadiene rubber, Butadiene and Acrylonitrile copolymer and carboxylate SBR were used as polymer.

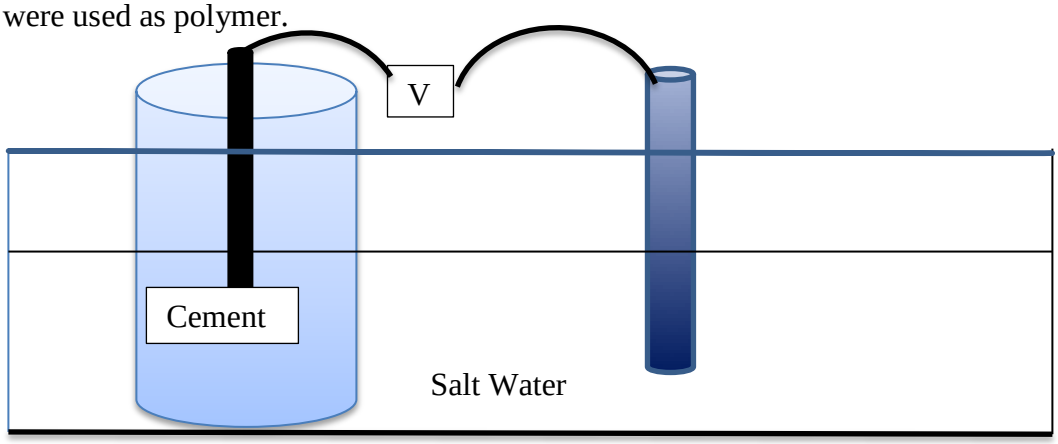

Figure 1 Specimen for measuring corrosion Activity

Initially resistivity of the cement slurry was measured for all the 4 different types of cement and steel bars was embedded inside the cement specimens. The prepared samples were put inside aqueous solution 3.5% NaCl solution. Using standard calomel electrode the potential difference was measured. LCR meter was used to measure Electrochemical Impedance spectrum.

Table 1 Composition of samples

	Cement(gm)	Water(ml)	Polymer type	Polymer (%)
Sample 1	350	140	None	
Sample 2	350	140	Butadiene and Acrylonitrile Copolymer	1%
Sample 3	350	140	Carboxylated SBR	1%
Sample 4	350	140	SBR	1%

Four wires were inserted into the sample to measure vertical, horizontal and diagonal resistance by using LCR meter. After 2 days of curing, the sample were put in NaCl solution. Using standard calomel electrode the potential difference was measured. LCR meter was used to measure Electrochemical Impedance spectrum.

4. Results and Discussion.

4.1**)** Initial resistivity of smart cement with different polymer content is provided.

Table 2 Sample Vs Resistivity

	Resistivity
Sample 1	1
Sample 2	1.05
Sample 3	1.05
Sample 4	1.06

Initial resistivity of the samples was measured using API resistivity meter. Polymer modified cement shows increased resistivity compared to normal smart cement.

4.2) Resistivity Plot .The resistivity of the all the specimen were measured. The resistivity plot indicates the changes occurring in the system.

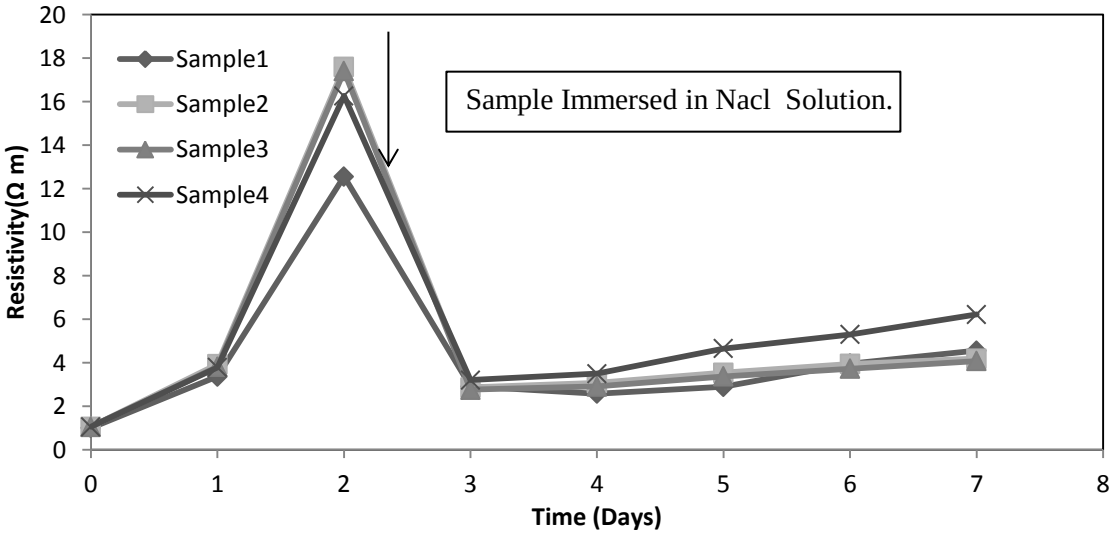

Figure 2: Resistivity Vs Time

The resistivity of the specimen with time is plotted. After samples are immersed in NaCl solution, sudden drop in resistivity is observed. Similar trends are observed in all the specimens. The decline in resistivity is due to the absorption of NaCl into the sample. As the cement hydrates, the resistivity of all specimens immersed in solution starts to increase.

4.2) Corrosion Potential-

The samples were dried for 2 days and then immersed in NaCl solution to simulate the actual condition. The corrosion potential was measured using ASTM standard. As per ASTM C876 -15,if potentials over an area are in the range of -0.2 to -0.35V ,corrosion activity of the reinforcing steel in the area is uncertain and when the potential are more negative then -0.35vcse ,there is 90% probability that reinforcing steel corrosion is occurring that area.

The corrosion potential of all the samples were measured and compared with ASTM standards. The potential difference of all sample with the reference electrode were measured after being immersed in NaCl Solution for 1 day.

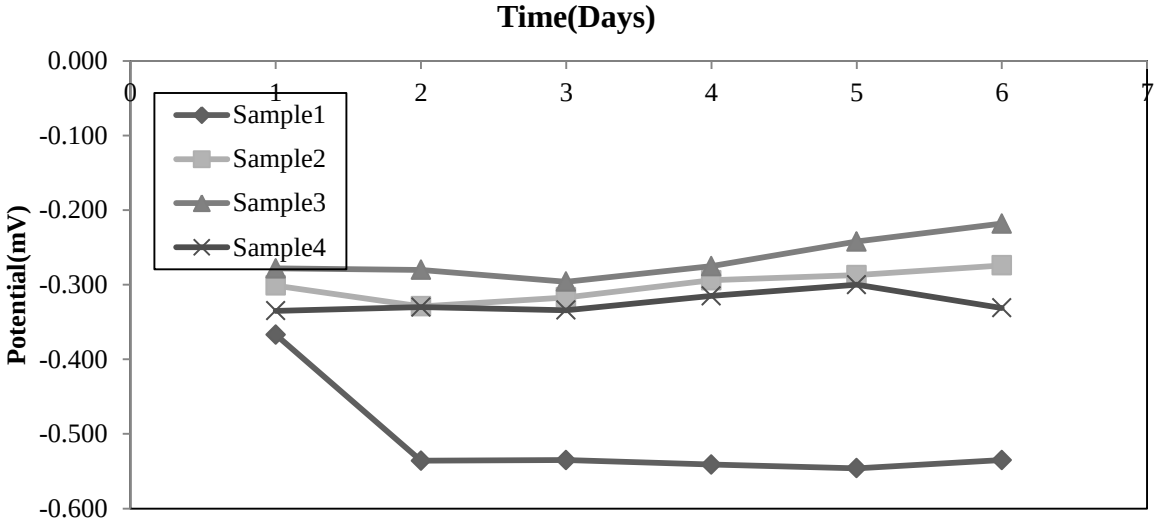

Figure 3.Potential Vs Time

From the tests, it was found that Sample 1 was more prone to corrosion as showed higher negative potential and sample 3 was found to be more resistant to corrosion. Addition of 1% polymer into sample showed significant corrosion resistance potential.

4.4) Electrochemical Impedance Curves-The impedance curves of the specimen were plotted and all of them showed case 2 results.

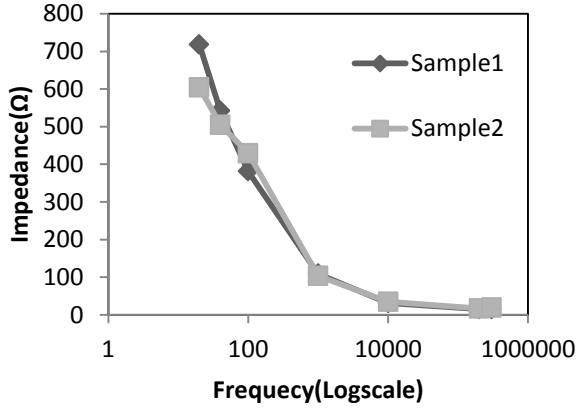

Figure4.(Impedance Vs Frequency, when prepared)

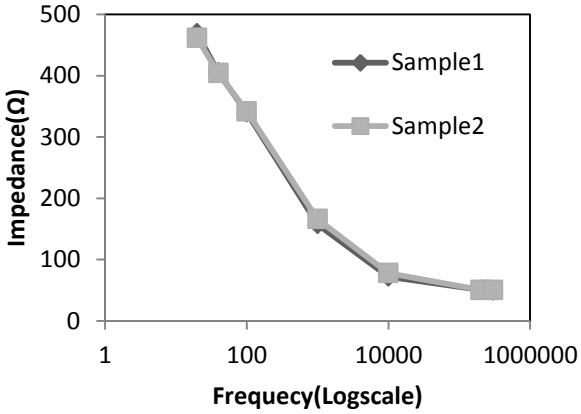

Figure 5.(Impedance Vs Frequency after immersed 2 days)

The impedance curve of sample 1 and sample 3 were compared. Reading after preparation of sample and after they were immersed in the solution were compared. In both the cases, Case 2 impedance curve is observed. From the impedance curve, contact and bulk resistance can be calculated by using the equation $Z_A = R_b + \frac{2R_c}{1+\omega^2 R_c^2 C_c^2} + \left(\frac{\omega R_c^2 C_c}{1+\omega^2 R_c^2 C_c^2}\right)$, where Rb is bulk resistant is contact resistant and w is the angular frequency.

5. Conclusion: To prevent external corrosion of casing, smart cement can be modified by polymer. Polymer modified smart cement showed lower negative potential compared to smart cement alone. Thus polymer modified cement can be additionally be used to control corrosion.

6. Acknowledgements:
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7. References.

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