Characterizing of Steel-Smart Cement Interface for Corrosion Detection

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Abstract: Study of electrical properties at the interface level could determine the difference in the electrical resistance and capacitance of interfaces between smart cement and corroded rebar, and that of smart cement and non-corroded rebar. In this research, detecting and quantifying interface corrosion was investigated. The laboratory test also indicated the interface corrosion change with respect to time.

1. Introduction

Corrosion is the primary factor affecting the longevity and reliability of pipelines that transport crucial energy sources throughout the nation. For the past two decades, there has been a tremendous amount of research focused on smart coatings for structural applications; coatings the can sense certain conditions and then respond (Harovel G. Wheat, 2012). These are coatings that typically contain one or more indicators that can sense condition such as corrosion and respond by means of changes in pH, color, fluorescence or a combination thereof (Harovel G. Wheat, 2012). In the industry of gas and oil, corrosion of steel casing is of concern because it requires almost immediate repairs and rehabilitation to extend the service life of the structures. The applicability of such coatings for the steel casing in oil wellbore is difficult and impractical to monitor the changes that the coatings may exhibit through time due to the inaccessible nature of wellbore.

2. Objective

The objective of this study was to develop a non-destructive electrical test method to determine and monitor the presence of interface corrosion for steel embedded in smart oil well cement.

3. Materials and Methods

Oil well cement specimens embedding two kinds of rebar have been prepared for laboratory tests. The specimens have cylindrical shape with diameter of 2 inches and height of 4 inches. To improve the electrical properties, conductive filler was also added into the composite. The rebars used had size of #3 and length of 6 inches. The specimens were instrumented with 2 silver-paint wires connected to the oil well cement (illustrated in Figure 2). The electrical resistances and capacitance of the oil well cement, rebar, and transitional surface (interface zone) between the oil well cement and rebar were measured with impedance analyzer precision LCR meter.

4. Discussion

The equivalent circuit adopted based on expected behavior of the material under this study is shown in Figure 1. The total impedance of the equivalent circuit is given as follows:

$$Z = R_b + \frac{R_c}{1 + \omega^2 R_c{}^2 C_c{}^2} + \frac{R_i}{1 + \omega^2 R_i{}^2 C_i{}^2} - j\left(\frac{\omega R_c{}^2 C_c}{1 + \omega^2 R_c{}^2 C_c{}^2} + \frac{\omega R_i{}^2 C_i}{1 + \omega^2 R_i{}^2 C_i{}^2}\right)$$

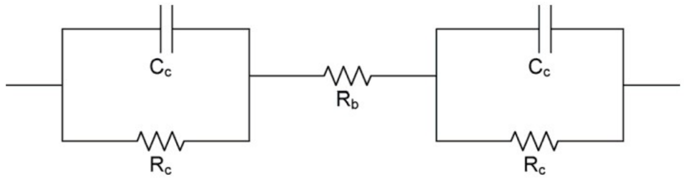

Figure 1. Equivalent circuit

In the equation, ω is the angular frequency of the applied signal. Applied signal was carried out with frequency range of 20Hz to 300 kHz. Figure 2 shows the product of resistance and capacitance (R*C) at the interface between the rebar (both corroded and non-corroded types) and oil well cement. From the plot, it can be seen that the R*C for the corroded rebar is greater than that of non-corroded rebar with respect to time.

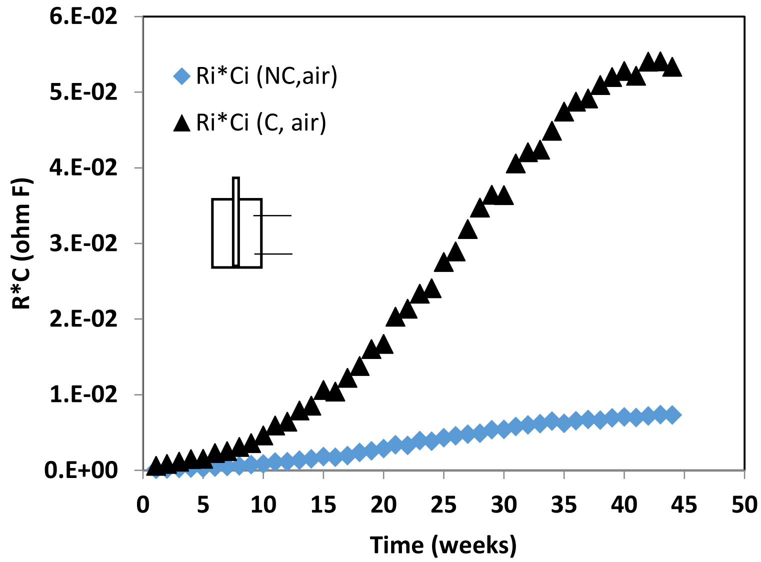

Figure 2. R*C vs Frequency

5. Conclusion

In conclusion, the analysis of electrical properties at the interface level in determined the difference in the electrical resistance and capacitance of interfaces between oil well cement and corroded rebar, and oil well cement and non-corroded rebar. Also, the test results showed the change in the interface corrosion with respect to time. This non-destructive electrical test method could be highly effective in determining the presence of interface corrosion in between steel and oil well cement interface.

6. Acknowledgement

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7. References

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