Effect of foam on the Electrical Resistivity and Impedance Characteristics of Smart Cement

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Abstract: In this study, the effect of foam on the electrical resistivity and impedance of smart cement were investigated. The results of electrical resistivity for cement samples with different foam content are presented. Foam contents of 0%, 5% and 20% are investigated. Addition of 20% foam increased the electrical resistivity of smart cement from 1.05Ωm to 2.03Ωm, a 93% increase. The k value of the smart cement increased from 32.38m-1 to 39.7m-1, a 22% increase with the addition of 20% foam. Bulk resistance showed an increase of 137% with 20% foam.

1. Introduction

Impedance spectroscopy is a method of characterizing the electrical properties of materials and their interface with electronically conducting electrodes. [1]This method is used for determining the bulk resistances of the materials. Electrical resistivity is the property that defines how material opposes the flow of current through it.

2. Objective

The main objective was to investigate the effect of foam on the electrical resistivity and impedance of smart cement modified with foam.

3. Materials and Method

Oil well cement of Class H was used for the formulation of the foam cement. A water to cement ratio of 0.38 was employed. Conductive Fillers of about 0.075% of weight of cement and water were added for the mix to enhance the sensing properties. Preformed foam was used in percentage of total weight of the slurry. LCR device has been used for recording the resistance values at various frequencies. API resistivity meter was used for computing the resistivity of the cement with time for 4 hour duration.

4. Results and Discussion

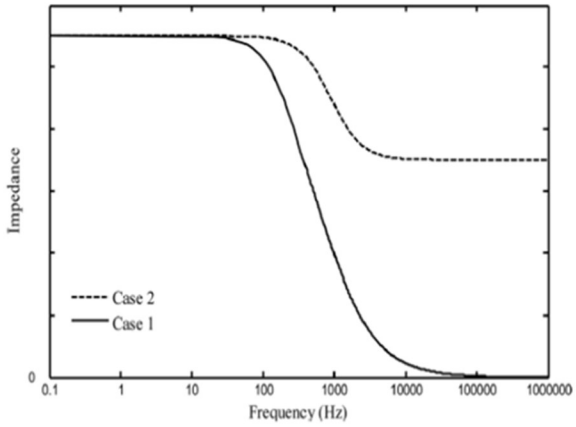

Fig 1. Comparison of typical responses of equivalent circuits for case 1 and case 2 (Vipulanandan & Prashanth, 2013)

The impedance of the conventional smart cement along with addition of 20% foam displayed case 2 behaviour (Fig. 1) as explained by (Vipulanandan & Prashanth, 2013). Thus the equivalent circuit of bulk material is represented only by resistance. From (Fig. 2) it is evident that the impedance for frequencies above 1000Hz remains constant as depicted in case 2. Thus, the bulk resistance of smart cement was around 34Ω and increased to 80.6Ω with the addition of the foam (Fig. 1).the electrical resistivity of smart cement increased from 1.05 to 2.03 and displayed decrease in the t_{min} (time required to achieve minimum resistivity) from 80min to 35min.

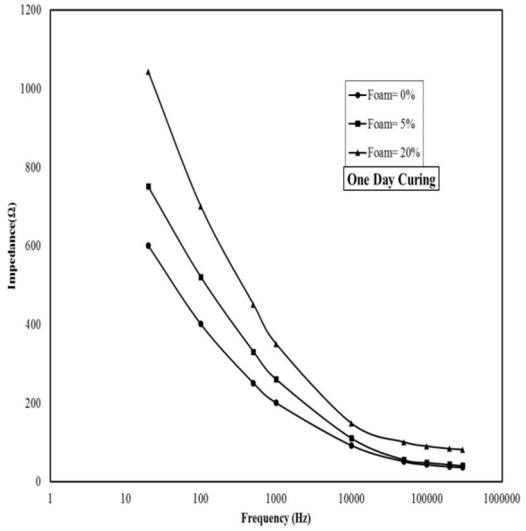

Fig 2. Impedance Vs Frequency for various foam contents

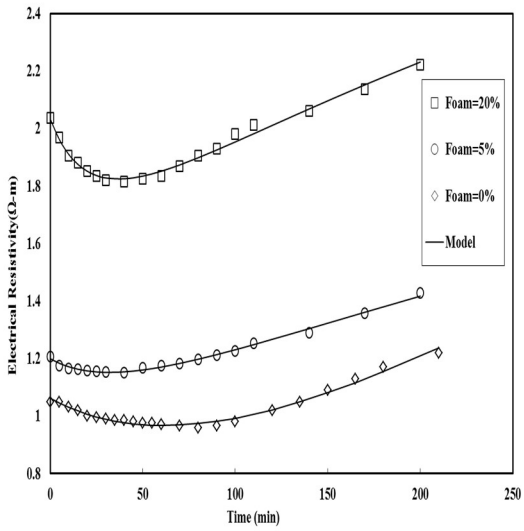

Fig 3. Variation of Electrical resistivity with curing time

5. Conclusion

The equivalent circuit for smart cement with foam continues to follow case 2 behavior. Addition of 20% foam increased the initial electrical resistivity of smart cement from 1.05Ωm to 2.03Ωm, a 93% increase. The k value of the smart cement increased from 32.38m-1 to 39.7m-1, a 22% increase with the addition of 20% foam. Bulk resistance showed an increase of 137% with 20% foam.

6. Acknowledgement

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7. References

1. Campo, M. A., Woo, L. Y., Mason, T. O., Garboczi, E. J., "Frequency-Dependant Electrical MixingLaw Behavior in Spherical Particle Composites", Journal of Electroceramics, 2002, Vol. 9, pp. 49–56.
2. Vipulanandan, C., & Prashanth, P. (2013). Impedance Spectroscopy Characterization of a Piezoresistive Structural Polymer Composite Bulk Sensor. Journal of Testing and Evaluation, 41(6), 20120249.