Piezoresistive Ultrafine Cement for Repairing Damaged Oil Well Cement

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Abstract: Modified ultrafine cement was used to repair damaged oil well cement to regain strength and piezoresistivity. Results showed that the repaired sample recovered piezoresistive behavior and regained more than 95% of the initial strength.

1. Introduction

When an oil well gets damaged, a proper repair method for cement is required to ensure the integrity of the wellbore. No or improper repair may result in well abandonment. For successful repair, cracks may require a repair material which is either liquid or slurry with small particles to allow deep penetration into the fracture. Though injection of epoxy resins, chemical gels, and silicate materials can be suggested as repair material, considering cost and regaining the strength at high pressure - high temperature conditions in the well, cementitious material can be a better repair material. Minimizing particle size of the repair material maximize its penetrating capabilities. Hence, small-particle-size cement can be used as repair material.

Since ultrafine cement contains very fine particles, it is capable of invading narrow openings that other standard cement cannot access. In the literature ultrafine cement is defined as $d_{95} < 10$ microns which is very smaller compared to Type I Portland cement of 70 microns and Blaine fineness of at least 900 m^2/kg.

While regaining of strength is a matter of importance, it is very challenging to regain the piezoresistivity of the material, if the well had self-sensing ability before the occurrence of the damage. Unfortunately there are no or very limited number of studies available in the literature on this topic.

2. Objective

The objective was to investigate the effectiveness of modified ultrafine cement in repairing oil well cement to regain piezoresistivity while retrieving the strength.

3. Materials and Methodology

Modified class H oil well cement was used to prepare cylindrical hollow specimens of 2x4” (outer diameter 2” and inner diameter 0.75”) with a water:cement ratio 0.4 by weight as shown in Figure 1(a). After hardening 3mm crack was made in between the sensing points as shown in Figure 1(b). The crack was deep enough to access through the hollow. The repair material was pressurized through the hollow and allowed to squeeze out through the crack so that it fills the crack. Figure 1(c) shows repaired sample. To find out the strength and piezoresistivity of the specimen before damage, initial specimen was tested for compressive strength using displacement controlled destructive method as shown in Figure 2 after 7 days of curing. Two probe method with 300 kHz AC device was used. The same test was conducted on similar ultrafine cement hollow specimen and repaired specimen after 5 days of curing.

(a) **(b)** **(c)**

Figure 1. (a) Initial specimen (b) Damaged specimen (c) Repaired specimen

4. Results and Discussion: Immediately after the crack formation, relative resistivity increased by 65%. It showed the formation of the crack was sensed by the resistivity change. Figure 2 shows strength and piezoresistive behavior of initial oil well cement, ultrafine cement and repaired sample.

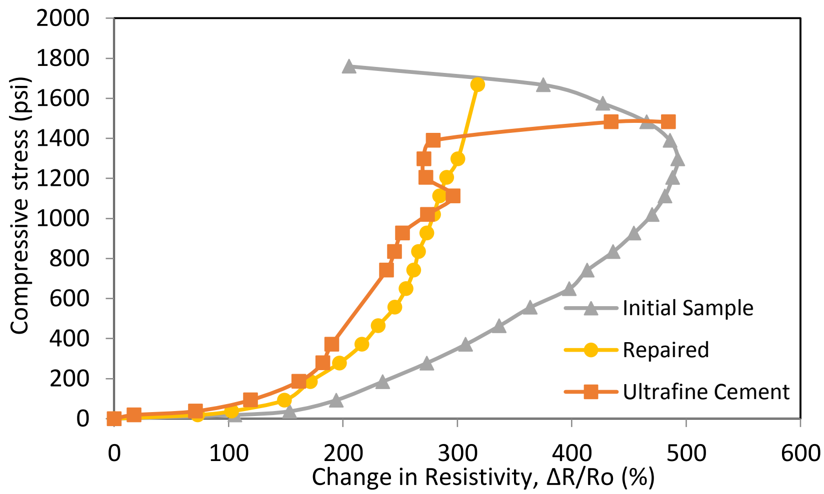

Figure 2. Piezoresistivity of Tested Specimens

5. Conclusion

While initial specimen showed about 500% of change in resistivity, repaired specimen showed about 300% of it. Also above 95% of the strength was regained through this method of repair.

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7. Reference

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