Effect of External Electrical Power on Speed of Hydration of Oil Well Cement

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Abstract

In this study a series of experiment had been performed to investigate the effect of external current on hydration of cement through calorimetric analysis. After mixing eelectrical current was applied to cement and temperature development was recorded. The study showed that when electrical power was applied to cement the peak temperature was increased by 12.5% and the temperature-time curve from the calorimetric analysis was shifted to the left.

1. Introduction

One of the most challenging stages in the oil and gas well construction is the efficient placement of the well cement. Once the cement is placed properly in the well, the rapid setting of cement is important to avoid the delays in the drilling operations. The calorimetric tests have been used by many researches to quantify the speed of chemical reactions and the rate of cement hydration (Pane et al., 2005). It was shown that the speed of hydration is proportional to the heat generated by the hydration products and could be used as a measure to quantify the hydration of cement. However, no studies have been done to evaluate the effect of the external electrical current on the hydration of oil well cement.

2. Objective

The main objective of this study was to investigate the effect applying external electrical current on the temperature development and the speed of hydration of cement.

3. Materials and Methods

Class H cement with water-to-cement ratio of 0.38 was used in this experiment. A direct current (DC) power supply was used to apply current to the cement samples. The current was applied through the electrical wires that were embedded in the cement. The amplitude of the voltage of the signal applied was 10 volts. The specimens were placed inside the calorimeter and the change in temperature was monitored at 1 minute intervals during 7 days. In order to investigate the effect of the applied power on cement hydration, another calorimetric test was done on control cement sample without any external power. The weight changes were also monitored to assure the changes were due to the external current.

4. Result and Analysis

Fig. 1 presents the calorimetry of two cement samples with and without external power. It was observed that applying power to the cement accelerated the hydration. The time to reach the peak temperature for the sample with applied current was 11.5 hours after mixing the slurry. The sample without applied current reached the peak in 22 hours (Table 1). It was also found that the peak temperature for cement with and without external power were 152 °F and 171°F, respectively. This can be explained by the Joule's law for a resistive material as follows:

$$Q = I^2 Rt \quad \text{(Eq. 1)}$$

Where Q is the heat generated, I is the current, R is the electrical resistance and t is the time. According to Eq. 1 when the current is applied to a resistor such as cement, a portion of the electrical energy will be

converted to the heat and flow out to the material. As shown in Fig. 1, applying electrical current increased the temperature development of the cement. It is reported in many studies that at higher temperatures the degree of hydration of cement develops faster (Pane et al., 2005). In this test, the peak temperature was shifted to the left when the power was applied to cement which verifies the acceleration in the hydration.

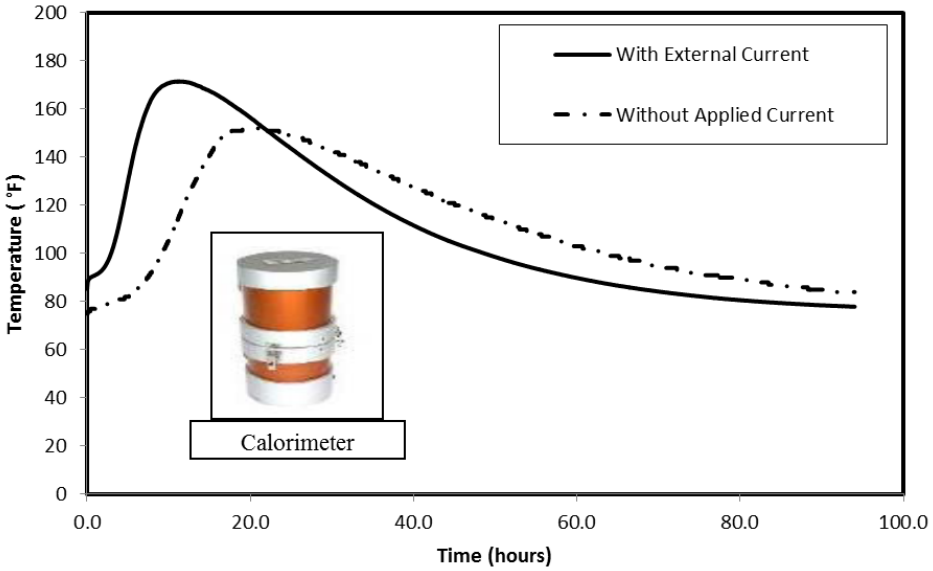

Figure 1. Calorimetry of cement with and without the presence of external power

Table 1. Summary of the calorimetric test for the cement with and without applied current

Condition	Peak temperature (°F)	Time to reach the peak (hrs)	Area under the curve up to peak
Without Applied power	152	22	112,412
10 V DC power applied	171	11.5	103,568

5. Conclusions

Based on the experimental and analytical study following conclusion is advanced:

The calorimetric analysis showed that compared to the control cement sample, the peak temperature increased with applying current to the cement and time to reach the peak temperature was reduced by 47%.

6. Acknowledgement

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7. References

Pane, I., & Hansen, W. (2005) Investigation of blended cement hydration by isothermal calorimetry and thermal analysis. Cement and Concrete Research, 35(6), 1155–1164. doi:10.1016/j.cemconres.2004.10.027