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Nanotechnology For Gas Wells Cement: Innovative Material

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Abstract: *The cement industry faces the challenge of obtaining an economic cement type that has high strength and low permeability, especially at high economical. This research introduces preparing nanolime (NL) mechanically and measuring the size distribution using a dynamic light scattering device (DLS). Followed by, formulating and testing geopolymer (GP) mixed with NL as an economic well cement type that results in higher strength (CS).*

Keywords: Nanocement; Cement; Geopolymer

1-Introduction

Nanotechnology is the most up-to-date technique that leads to formulating a homogeneous and strong cement and mud products for oil and gas wells. Gas channels through cement faster than oil because it is compressible and it has a faster ability to escape through cement. Consequently, nanoparticles (NPs) are utilized in cementing gas wells in order to solve the gas channeling problem by the homogeneous and strong nanocement. The research target is to study the previous work done on different types of nanoparticles and their enhancements in well operations. Then, it introduces a planned experimental work to test the effect of nanolime (NL) on geopolymers GP as a replacement of cement used in gas wells.

1.1 Nanoparticles (NPs)

The previous works indicated the importance of NPs in various fields of applications. First, NPs provide a crystalline structure for the cement that is able to partially block capillary pores. This makes the final cement more flexible and prevents micro cracking. In another scenario, Nano-Graphite was used in order to get more reduction in cement viscosity with increasing shear rate, which makes this additive an attractive solution for squeeze cementing operations. For controlling cement loss, Nanobarite was used in various concentrations of NPs (from 1% to 5%). The results proved that the highest Nanobarite concentration led to the minimum cement losses]. According to Nanolime, it was used to prevent cement contamination by oil-based mud. Density, rhyological properties and electrical resistivity were measured before and after adding NPs, which showed the positive effect of adding them.

1.2 Geopolymer (GP)

In China, Fly ash waste proved to have the highest value of radiation rates. Consequently, GP industry was developed to solve this environmental problem by using fly ash waste as the main component of GP (75%). The resulting GP proved to have a very high value of compressive strength (CS).

2- Materials and Methods

2.1 NL

The process starts with preparing the NL using a mechanical method. Limestone (purity = 99.3 % for $CaCO_3$)was heated to 800 degrees Celsius, which resulted in calcium oxide and carbon di-oxide. Then, the calcium hydroxide is obtained by adding 50 cubic centimeters of water to 100 grams of the calcium oxide. After that, the calcium hydroxide was dried and ground in a mill (applying the same speed and duration to get 30 microns is size). Most of the accurate preparation methods of NL are chemical (expensive). The process of formulating nanolime mechanically, is an innovative and cheap technique with long operational steps. Consequently, the mentioned steps in the methodology for manufacturing NL are the simplest way to describe the scientific principles on which the operations were designed. This scientific principle is that heating and quenching limestone leads to breaking the strong bonds between particles which can't be broken by normal grinding operation. This technique facilitates obtaining the nanosize of limestone by the successive grinding process in a mill. $Ca(OH)_2$ can't be used directly because it is expensive but $CaCO_3$ is available and cheap

The following equations show the sequence of reactions:

$$CaCO_3 \xrightarrow{Heat} CaO + CO_2$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$Ca(OH)_2 \xrightarrow{Heat} CaO + H_2O$$

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$CaO + CO_2 \rightarrow \underline{CaO} + CO_2$

The resulting size distribution was measured by a dynamic light scattering machine (DLS) in order to check if the particle size is on the nanoscale [25]. NL is different than CaO because NL has other negligible amounts of impurities.

2.2 Formulating and Testing NLGP

The fly ash and the dry calcium oxide were mixed dry (2-3 min). Then, they were ground in a mill (300 rpm for 5 minutes) to help in obtaining a smaller size of NL. After that, NaOH and NaSi were mixed with them for 6 minutes. Followed by mixing water with them (3-4 min). The mixtures were poured in 50X50X50 mm cubes and the compressive stength is measured.

3- Results

3.1 Results of DLS:

The results of the size distribution using DLS devise are indicated. The average particle size is 40.27 nm.

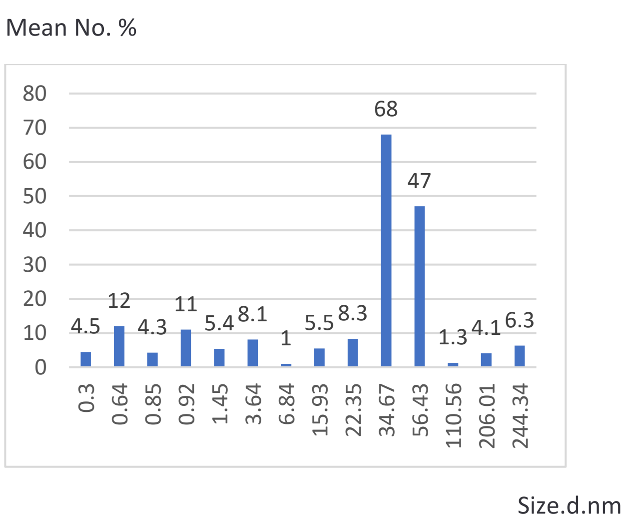

Figure 1: NL size distribution

3.2 CS Results.

The mixing processes for NLGP components were repeated with different concentrations of NL (C0, C1, C3, C6 and C12) which are (0%, 1%, 3%, 6%, and 12%) successively. The results of the CS after twelve hours, three, seven and twenty-eight days are shown as follows:

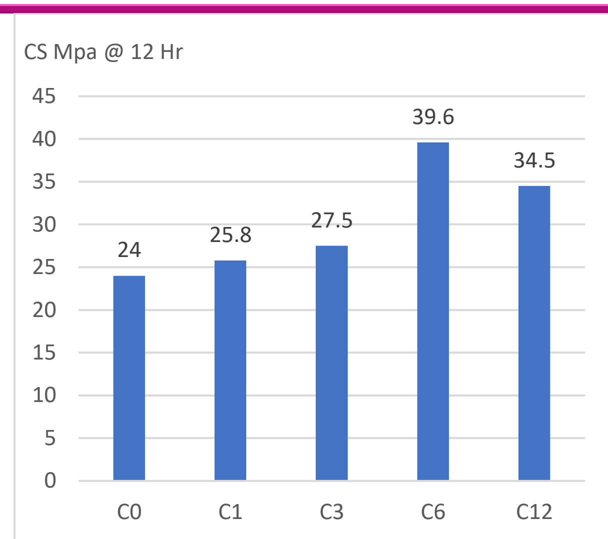

Figure-2: CS (at 12 hours) using (0%, 1%, 3%, 6% and 12%) of NLGP

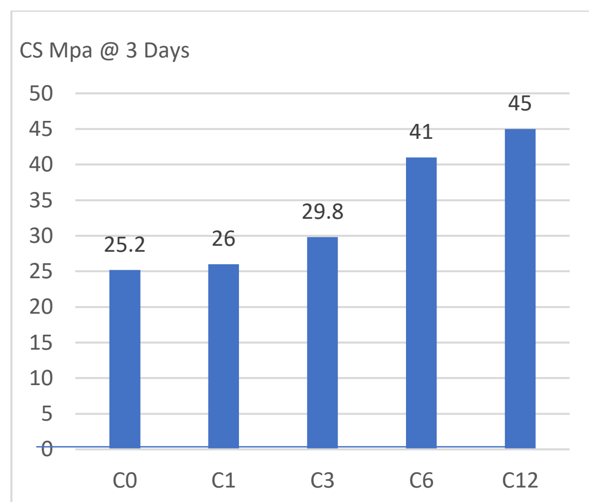

Figure-3: CS (at three days) using (0%, 1%, 3%, 6% and 12%) of NLGP

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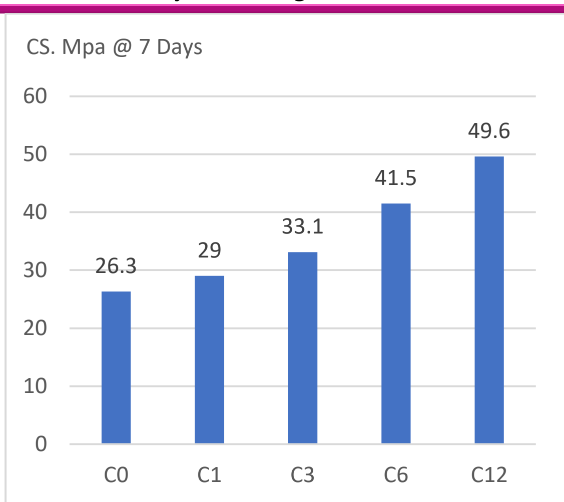

Figure-4: CS (at seven days) using (0%, 1%, 3%, 6% and 12%) of NLGP

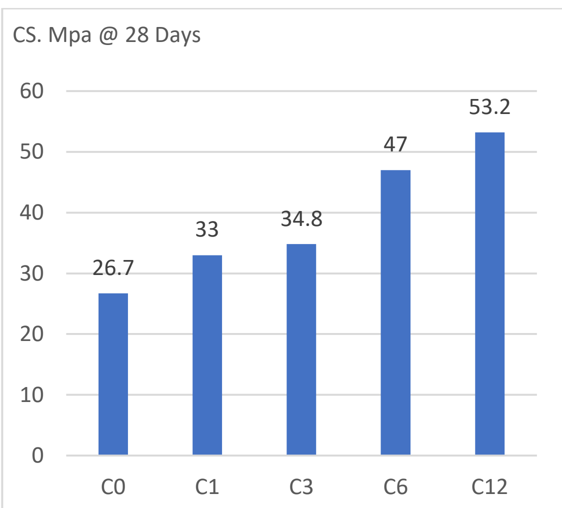

Figure-5: CS (at twenty eight days) using (0%, 1%, 3%, 6% and 12%) NLGP.

4- Conclusions

NL is prepared experimentally by an innovative mechanical method starting with heating and ending with quenching. The average particle size of NL was measured by DLS and was found to be 40.27 nm. The NLGP product is cheap because its two main components (fly ash and CC) are very cheap. The CS increases with the increase of NL concentration. The resulting values of CS after twelve hours and on the third day are closer to each other. Also, the CS on the seventh and twenty-eighth days are closer to each other. But, there is a gap between the CS on the third and the twenty-eighth days.

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