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Investigating the Effect of Brachystegia Eurycoma (Achi) on the Thickening Time of Cement Slurry

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A B S T R A C T

Development of adequate thickening time cement is a critical task in cementing operations today. Achievement of suitable thickening time oil well cement ensures both prevention of lost circulation and a long wait on cement time. With a vast increase in reservoir discoveries in recent years, the oil and gas industry is expanding and maturing in the offshore West Africa area and also due to importation barriers it has been the need that local cement produced in our country should be used for oil well cementing. With this in mind, this project work shows the comparative study of the thickening time of oil well cement with Achi contamination and oil well cement without Achi contamination.

Keywords: Oil Well Cement, Thickening Time, Achi, Cement Slurry

Introduction

The thickening time is the amount of time a cement slurry may be pumped while still being in a fluid state (Guo et al., 2016). To stimulate conditions for a specific well depth, thickening time is simply a setting period under regulated temperature and pressure ramps. Additionally, it can be thought of as the amount of time needed for a cement slurry with a specified composition to reach a consistency of 100 Bearden units (Be), as determined by the techniques described in API specification 10A. Using a pressurized consistometer that traces a slurry's viscosity over time under the anticipated temperature and pressure conditions, thickening time is evaluated downhole. The thickening time, which limits how long cement can be worked with after mixing with water, is a crucial consideration when creating cement slurry (Umeokafor et al., 2010). The setting reaction causes the viscosity to rise over time after this, and when it becomes too high, the cement loses its pumpability. In order to avoid major damage to the well, the cement must be placed as soon as it has finished mixing. While excessive thickening can result in financial losses due to increased Wait-On-Cement (WOC) delays during drilling periods, premature thickening might have disastrous effects due to loss of circulation in the well (Nauman et al., 2012). It is crucial to know the temperature conditions in the well because thickening time often decreases with temperature. Retarders and accelerators, cement additives, are commonly used to reduce the thickening time (Collins, 2008). Without ignoring the fact that water and cement are being mixed, there must be contaminants in the water and any tiny additives applied during the production of cement. In oil fields, salt can occasionally be found in relatively high proportions, especially in offshore regions where fresh water is scarce or when the wellbore passes through a salt dome, and if salt water is used in cementing instead of fresh water systems, thickening time and other cement factors will be affected (Bourgoyne, 2008). Impurities like salt present in the water would increase the viscosity causing a premature thickening time, and will in turn yield to problems in the oil well.

Oil Well Cement

Oil well cement is a type of cement specifically designed and formulated to be used in the construction and sealing of oil and gas wells. It is typically composed of a blend of Portland cement, powdered limestone, and other additives that provide the required strength and durability to withstand the high pressures and temperatures found in oil and gas wells. Additionally, oil well cement must also be able to resist corrosion from the well fluids and gases, and must be able to set and harden quickly in order to maintain the integrity of the well.

A good oil well cement should be able to withstand high temperature and pressure encountered in oil wells and should set quickly and uniformly to provide a secure bond between the casing and the wellbore. Oil well cement is used to secure the steel casing that lines the borehole of an oil or gas well. It is a critical component in the construction and operation of an oil or gas well, as it helps to prevent the movement of fluids between different zones, and to protect the well from collapse. Cementing also helps to bond the steel casing to the surrounding rock, making the well more stable. Additionally, it plays a role in sealing off lost circulation zones, which are areas where fluids are lost into the surrounding formation. Overall, oil well cement is important for the safety, integrity and longevity of an oil or gas well.

Oil well cement is utilized for cementing works in the boring of wells where they are liable to high temperatures and pressure. Oil well cement is important because it acts as a barrier between the borehole, the formation and the outside environment. It helps to ensure the structural integrity and isolation of the well, preventing the movement of fluid and gas between different zones. This helps to prevent blowouts, leaks and other problems that could result in environmental damage or loss of production. Additionally, oil well cement provides zonal isolation, allowing for proper formation pressure control and efficient hydrocarbon recovery. It helps to prevent the mixing of different fluids and gases within the well, ensuring that oil and gas are only produced from the intended zones.

Thickening Time

Thickening time, also known as initial set time, is the amount of time it takes for cement slurry to change from a liquid state to a semi-solid state. It is the time it takes for the slurry to transition from a liquid state to a more solid, gel-like consistency. This transition is indicated by the slurry losing its plasticity and becoming stiff enough to support its own weight without collapsing. The time it takes for cement slurry to thicken is affected by a number of factors, including the type and amount of cement used, the water-to-cement ratio, the temperature and pressure of the well, and the chemical composition of the slurry. In general, a shorter thickening time is desirable, as it allows the cement to set and harden more quickly, reducing the overall time required to complete a well.

Thickening time is assessed under down-hole conditions using a pressurized consistometer that plots the viscosity of a slurry overtime under the anticipated temperature and pressure conditions. This is a test machine that has a rotating cylindrical slurry container, equipped with a stationary paddle assembly and enclosed in a pressure chamber. The thickening time of cement slurry is an important parameter for construction industry, as it affects the workability of the slurry and the time in which the slurry can be used before it becomes too thick to work with. The consistometer provides an accurate and consistent way to measure thickening time. This time can vary depending on the type of cement used, the mixing process, and the conditions under which the slurry is stored. Generally, the thickening time of cement slurry is between 30 minutes and several hours.

Brachystegia Eurycoma (Achi)

Brachystegia Eurycoma is a leguminuous plant that is popular amongst the people of the southern part of Nigeria for its ethno medicinal and nutritional values. The seeds are rich in protein and fat, and are often used in West African cuisine to make a traditional fermented condiment called "dawadawa" or "iru" which is used as a flavoring or seasoning in soups and stews. However, this legume has been grossly underutilized despite the promise that it holds for oil well cement development. In West Africa, dietary pattern varies and is influenced by the vegetation belt (Park and Oh 2016). Among the legumes used in soups (mainly for emulsification and stabilization of soups) are Brachystegia Eurycoma (Achi), Detraiummicropam (Ofor), Mucuna Pruriens (Ukpo) and Irvingiagabonensis (Ogbono). Brachystegia eurycoma is considered to exhibit the greatest thickening properties and thus could be considered a local viscosifier.

Effect of Temperature on the thickening time of cement slurry

The thickening time of cement slurry, also known as the initial set time, is affected by a number of factors, including temperature. In general, an increase in temperature will accelerate the chemical reactions that occur during the setting process, leading to a shorter thickening time. Conversely, a decrease in temperature will slow down the reactions, resulting in a longer thickening time. It's important to note that the optimal temperature range for cement hydration is between 50-90°F. Temperatures outside of this range can negatively impact the setting time and the overall strength of the cement. The thickening time of cement slurry is affected by temperature. As temperature increases, the thickening time decreases, meaning the cement sets faster. Conversely, as temperature decreases, the thickening time increases, meaning the cement sets slower. This relationship is due to the fact that the rate of chemical reactions involved in the setting process of cement is temperature-dependent. It is important to maintain a proper temperature range during the setting of cement to ensure optimal setting characteristics.

Effect of Viscosifier on the thickening time of cement slurry

A viscosifier is a substance that is added to a liquid to increase its viscosity, or resistance to flow. In the context of cement slurry, viscosifiers are often used to control the thickening time, or initial set time, of the slurry.

When viscosifiers are added to cement slurry, they can slow down the rate at which the cement particles settle and interact with each other, thus slowing down the setting process and resulting in a longer thickening time. This can be beneficial in situations where a longer working time is needed to place the cement in the wellbore or to ensure that the cement is in contact with the formation for a sufficient amount of time. The amount of viscosifier added to the slurry will also impact the thickening time. A higher concentration of viscosifier will generally result in a faster thickening time. Overall, the effect of a viscosifier on the thickening time of cement slurry can be significant and can have a significant impact on the pumping and placement of the cement in the well. It is important to carefully consider the type and concentration of viscosifier used, as well as the mixing conditions, in order to achieve the desired thickening time and pumping properties.

Methodology

This section of the research comprises of the research methodology utilized for the study. It covers the materials used for the study including the data type and data set, the sampling procedures, including the method of analyzing the data.

Materials/Apparatuses

- Achi
- Distilled Water
- Consistometer
- Retort Stand
- Weighing Balance
- Volumetric Flask

a

b

c

Fig. 1 - (a) Granulated Achi seed; (b) Chandler Atmospheric Consistometer; (c) Electric Motor Stirrer

Sample Collection

Achi plants are typically harvested when the pods have turned brown and dry. The pods are then collected by hand or with the use of a cutting tool. In this research, the "Achi" seeds are commercial ones purchased from Tombia market in Bayelsa State, Nigeria. The chemical and equipments were obtained from the laboratory in Niger Delta University.

Pre Treatment Operations

Pretreatment operations are those operations carried out on the Achi seed before its usage as an additive. These treatments are necessary in order to get seeds ready and to obtain good quality and quantity. These pretreatment operations comprise three stages. The stages are discussed below:

Cleaning

The seeds are then cleaned to remove any remaining debris or foreign materials. This can be done by sieving or winnowing. The sorting steps preceeds this and then debris, such as dirt, broken seeds or other impurities are removed. The seeds are then washed in clean water to remove any remaining dirt or impurities.

Drying

The drying process for achi seeds typically involves spreading the seeds out in a single layer on a clean surface, such as a tray or a tarp, and exposing them to direct sunlight for several days. The seeds should be turned regularly to ensure that all sides are exposed to the sun and to prevent mold or mildew from forming. Once the seeds are dry and brittle, they can be stored in a sealed container in a cool, dry place.

Milling

The seeds are then milled to produce flour. This was done using a pestle and mortar. Finally, the powder is sifted to remove any larger pieces or impurities, resulting in a smooth, fine flour.

Experimental Procedure

- A micro sieve was used to sieve enough quantity of cement and transferred into a plastic bag and sealed properly to avoid exposure to air which could have effect on the cement properties.
- 230ml of portable water was measured using a measuring cylinder and transferred into one of the plastic containers
- 2g of Achi was measured out using an electrical weighing balance and poured into the already measured portable water and allowed to dissolve completely

- The plastic container with the solution was now placed under the cement mixer
- 500g of cement was measured out from the sieved cement using a triple beam balance
- The cement mixer was powered on and adjusted to a speed of 4000 RPM
- The cement was then poured gradually into the plastic container containing 2g of Achi solution while simultaneously stirring the slurry with the cement mixer for about 10 secs.
- The prepared slurry was then poured into the consistometer slurry container and installed on the consistometer
- The consistometer calibration settings is being adjusted to match the desired parameters for the test such as temperature and pressure.
- The consistometer will display the results of the test, typically in the form of a graph that shows how the consistency of the slurry changes over time. The data can then be analyzed to determine the slurry's final consistency
- Steps 2-10 were repeated to prepare the cement slurry for 4g, 6g, 8g, 10g and 12g of Achi respectively.

Laboratory Method of Thickening Time Measurement

Thickening time testing measures the length of time the slurry will remain in a fluid state under simulated under downhole conditions without any shutdown periods. A consistometer is used to carry out this test. The consistometer consists of a rotating cylinder slurry container that envelops a stationary paddle. This slurry container is in turn encased within a vessel and is surrounded in a ’’chilled” fluid that can manipulate the operating temperature. In this experimental work at the cement and drilling fluid laboratory, Niger Delta University, a chandler atmospheric consistometer model 1200 (Figure b) was used and it has a chiller built within to maintain its temperature. As the consistometer maintains the slurry at a desired temperature, the torque on the stationary paddle is measured and converted into a slurry consistency, in BC (Bearden units). According to API standard 10, the thickening time is the time at which the viscosity becomes 70Bc.

The thickening time test was carried out for slurries for both Achi contamination and without Achi contamination and the thickening time for each slurry sample was measured at 30Bc, 50Bc and 70Bc respectively.

Results

The consistometer reading were being obtained at various achi concentrations tested at varying temperatures & pressures and tabulated below;

Table Results of thickening time test for each Achi concentration tested at 200F and pressure 3,000 psi

Achi Concentration(g)	**Thickening Time**			**Design Temperature(F)**
	@30Bc	@50Bc	@70Bc	
0	160	180	205	200
2	65	120	129	200
4	64	118	127	200
6	57	66	73	200
8	53	64	71	200
10	43	55	61	200
12	41	53	60	200

Table Results of thickening time test for each Achi concentration tested at 250F and pressure 3,000 psi

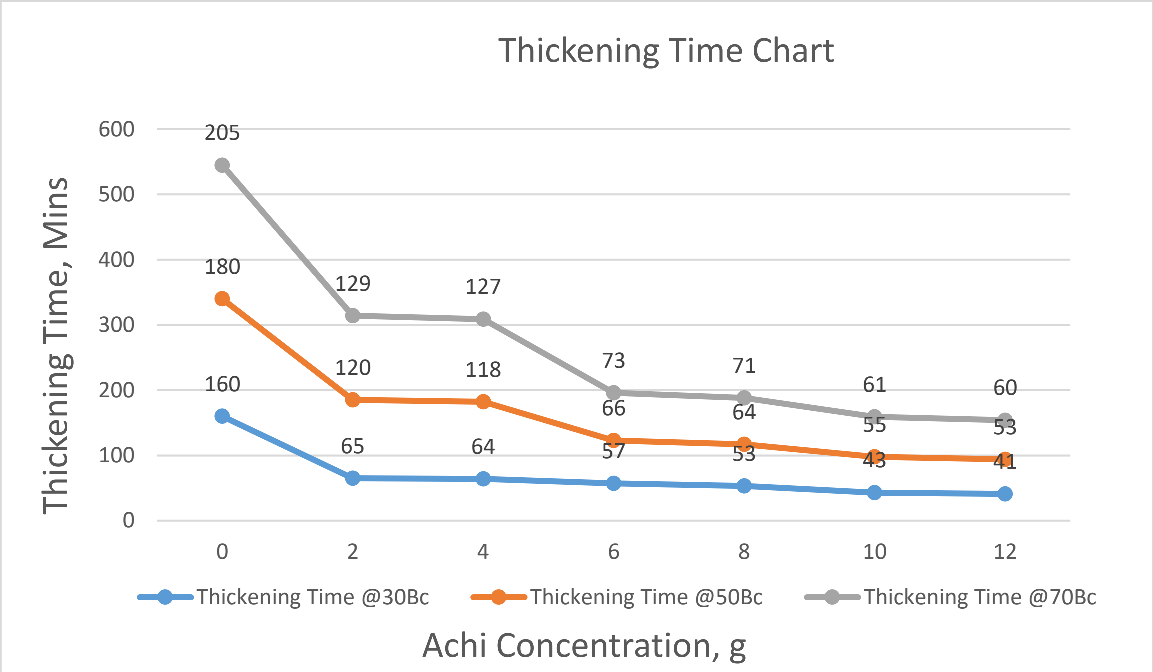
Achi Concentration(g)	**Thickening Time**			**Design Temperature(F)**
	@30Bc	@50Bc	@70Bc	
0	160	180	212	250
2	74	128	135	250
4	72	126	131	250
6	70	80	83	250
8	62	73	77	250
10	60	69	68	250
12	58	60	66	250

Table Results of thickening time test for each Achi concentration tested at 250F and pressure 2,500 psi

Achi Concentration(g)	**Thickening Time**			**Design Temperature(F)**
	@30Bc	@50Bc	@70Bc	
0	154	174	205	250
2	68	120	129	250
4	66	118	127	250
6	61	74	75	250
8	56	67	70	250
10	55	61	62	250
12	50	56	60	250

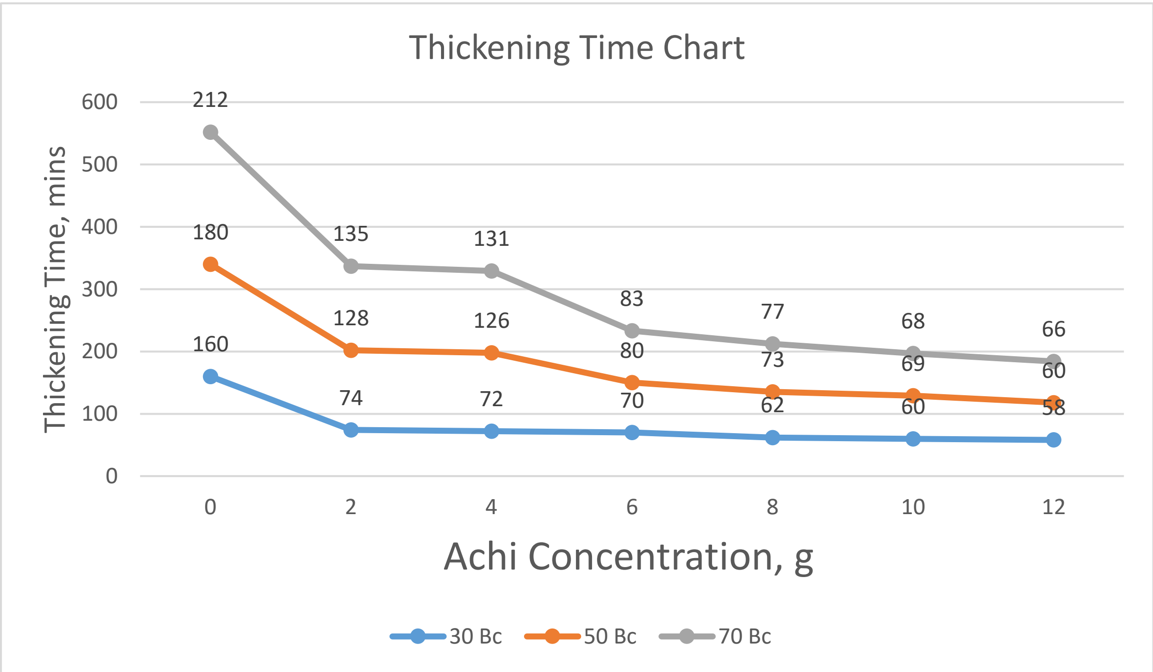
Table Results of thickening time test for each Achi concentration tested at 200F and pressure 2,500 psi

Achi Concentration(g)	**Thickening Time**			**Design Temperature(F)**
	@30Bc	@50Bc	@70Bc	
0	159	180	210	200
2	73	125	135	200
4	71	123	131	200
6	66	79	81	200
8	61	71	75	200
10	60	67	67	200
12	57	60	65	200



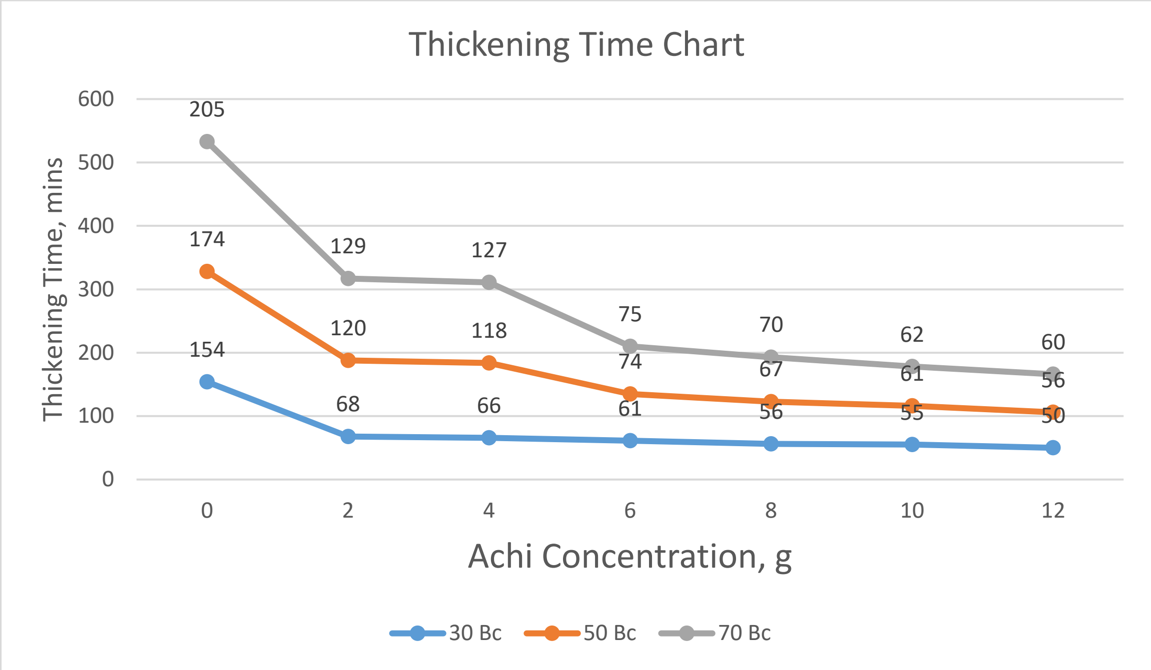
Thickening Time recorded at 200F and 2500psi

The results of the thickening time experiment conducted under experimental condition of temperature at 200F and pressure at 3000psi is presented in the figure above. This results clearly illustrates that, thickening time at the consistency of 30 Bc, 50 Bc and 70 Bc, respectively decreases at the rate of about -4.1, -3.8 and -3.1 minutes; It was also observed from these results that at 70Bc the accelerating rates were the fastest



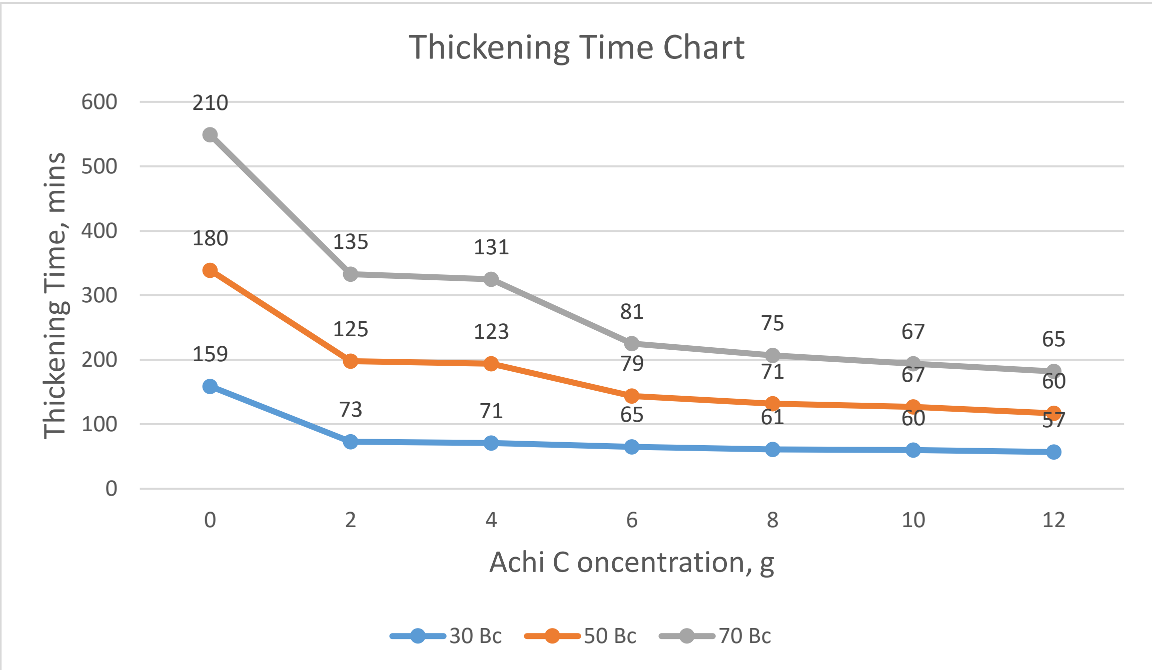
Thickening Time recorded at 250F and 3000psi

The results are quite similar to that of the results obtained in the figure above. This illustrates the outcome of the thickening time test investigated under experimental conditions of 250F and 3000psi. An increased temperature accelerated the thickening time and there was a rate decrease of about -3.8,-3.5 and -2.9 respectively at 30 Bc, 50 Bc and 70 Bc.



Thickening Time recorded at 250F and 2500psi

The decreasing trend still follows from the result being illustrated in the figure above for thickening time test investigated at a temperature of 250F and 2500ps. There was a rate decrease of about -3.9, -3.7 and -3.0 respectively across all tested bearden consistencies.



Thickening Time recorded at 200F and 2500psi

The results are quite similar to that of the results obtained in the figure above. This illustrates the outcome of the thickening time test investigated under experimental conditions of 200F and 2500psi. An increased temperature accelerated the thickening time and there was a rate decrease of about -4.1,-3.5 and -3.2 respectively at 30 Bc, 50 Bc and 70 Bc

4. Conclusion

When High pressure and high temperature (HPHT) environments are being considered, it is generally believed that when exactly same cement slurries are replicated under increased temperature and pressure it accelerates more as were clearly more conspicuous at 70 Bc. This depicts the fact that Mofunlewi et al. (2019) stated that at increasing high-pressure of any high-temperature accelerates.

The API standard specifies that an oil field cement should exhibit a pumping time ranging from 3-5 hours. As the results obtained above, there are significant effects when Achi was added to the cement slurry mixture. In the first case, which had no Achi in the cement slurry mixture, the thickening time measured at 30Bc was 2.40 hrs which is slightly below the required standard by API. Then the thickening time was measured at 50Bc was 3 hours which meets the API standard. At 70Bc the thickening time measured was 3.25 hrs which falls within the range by API standard.

In the second case, Achi was introduced to the cement slurry mixture. This affected the thickening time of the cement slurry as the time reduced significantly compared to when no Achi was involved in the slurry mixture. This only indicates that Achi present in a cement slurry mixture serves as an accelerator thereby enhancing the thickening time of the cement.

The major aim of investigating the impact of Achi on the thickening time of cement was achieved whereby a detailed explanation presenting facts, figures and graphical analysis was derived for the process as well. Further, relevant results were obtained in form of graphs and also in addition tables were generated having a comparative analysis of the various cases.

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