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# Feasibility of Water Hyacinth Ash as an Accelerator in Cement Slurry Formulation

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**ABSTRACT**

**Cement is primarily used in drilling operations to protect the casing against the corrosive tendency of formation fluid and to support the casing with the external load on and around it. Cement slurry is formed by mixing water with Portland cement or with cement containing various essential additives as the case may be and pumping it down through to critical points in the annulus around the casing using various techniques. Class G cement is widely used in cementing jobs because it allows the use of accelerators and retarders for wide range of well depths and temperatures. Due to wait-on-cement time before commencement of drilling of the next section of the well, it is necessary to reduce the waiting time and it ripple effects on cost of drilling by introducing accelerator to the cement slurry. The chlorides of calcium, potassium and sodium are the commonly used accelerators. Water hyacinth ash have been known to contain high percentage of calcium, potassium and chlorine, these elements readily combine with water to form potassium chloride and calcium chloride of which both are used as accelerator additives in cement slurry formulation. The utilization of these compounds in water hyacinth ash as accelerator additives would be a major breakthrough in cementing jobs especially in shallow section of the wells. Locally sourced water hyacinth plants were dried and combusted in air, the ash was then activated with water and filtered. The filtrate was used to determine the thickening time of class G cement slurry and the results obtained was compared with that of inorganic calcium chloride. The thickening times at the various set temperatures for this experiment were close to the inorganic calcium chloride used. Though, the thickening time of cement slurry is dependent on temperature, the concentration of the accelerator in the slurry also affect it.. It was found out that water hyacinth ash reduces the thickening time of class G cement slurry comparatively and therefore, should be considered as accelerator additive in the formulation of oil well cement slurry for accelerating the cement setting time.**

***Keywords--*** Cement Slurry, Portland Cement, Water Hyacinth, Thickening Time, Accelerator Additives

## I. INTRODUCTION

Cement is primarily used in drilling operations especially in the oil and gas industry to protect and support the casing. Other uses of cement are to prevent the movement of fluid through the annular space outside the casing, to stop the movement of fluid into porous or fractured formations and to sealed off an abandoned portion of the well. Cement slurry is formed by mixing water with Portland cement or with cement containing various essential additives as the case may be and pumping it down through to critical points in the annulus around the casing using various techniques.

The success of a drilled well often depends on primary cementing operations. Failure to achieve this objective, the well may have future problems which may increase the cost of drilling or remedial operations as the case may be.

***Physiochemical Properties of Water Hyacinth Ash (WHA)***

Water hyacinth plant (*Eichhornia crassipes*) grows in tropical and sub-tropical regions. The pH, ash, 1% alkali solubility and some extractives compounds together with their calorific value were determined in a study conducted by Lara-Serrano et al. The soluble compounds easily dissolved in alkaline or organic solvents due to the medium acidity of the solution's pH. The main components of the ash from this plant include potassium, calcium, and chlorine.

**Table 1:** Microanalysis of the elements in the Ashes of WH (Atomic %), as determined by EDS

| Elements | Plant Section (Water Hyacinth, El Tunal River, Durango, Mexico | | |
|---|---|---|---|
| | Root (wt %) | Stems (wt %) | Leaves (wt %) |
| Sodium | 0.67 | 4.43 | 1.51 |
| Magnesium | 0.46 | 5.33 | 3.76 |
| Aluminum | 8.84 | 0.82 | 0.03 |
| Silicon | 62.8 | 8.06 | 2.21 |
| Phosphorus | 1.81 | 5.12 | 8.61 |
| Sulfur | 1.07 | 2.44 | 2.75 |
| Chlorine | 0.71 | 19.4 | 17.4 |
| Potassium | 10.9 | 38.4 | 47.3 |
| Calcium | 5.30 | 15.1 | 16.1 |
| Manganese | 1.96 | 0.73 | 0.28 |
| Iron | 5.45 | 0.26 | Not detected |

[Physicochemical characterization of water hyacinth plant **(***Eichhornia crassipes* (Mart.) Solms)," *BioResources.* 11(3), 7214-7223.]

**Table 2:** Elemental Volumetric Analysis of the Water Hyacinth Ashes.

| Elements | Na | Mg | Al | P | S | Cl | K | Ca |
|---|---|---|---|---|---|---|---|---|
| Stem & Leaves (vol %) | 2.3 | 4.6 | - | 9.2 | 3.1 | 20.4 | 43.9 | 16.5 |

(Elemental analysis of water hyacinth ash, Chemistry and EMT laboratories, FUPRE, 2019)

***Accelerators***

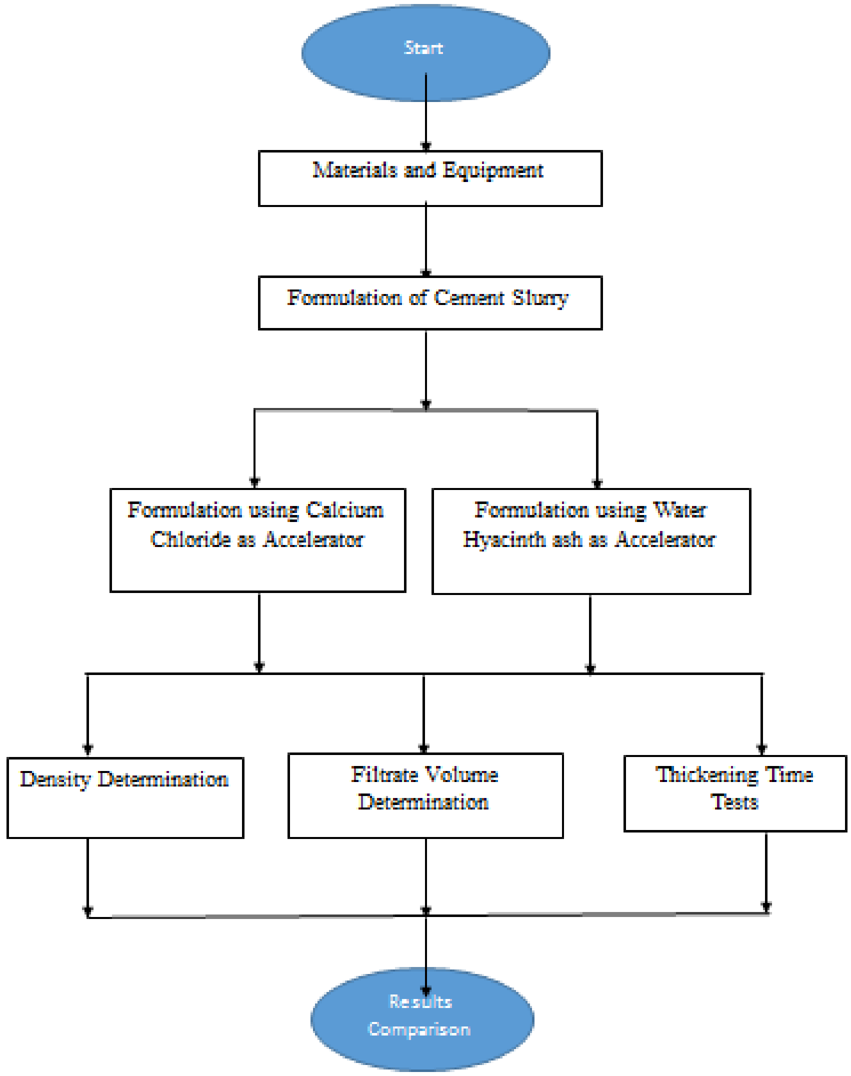
These are chemical additives that are mostly used to increase the normal rate of chemical reaction between cement and water with the objective of shortening the thickening time of the cement, speed up the early compressive strength of cement, and saves valuable rig time. Cement slurries for most shallow wells needs accelerators to speed up the process for "Waiting-On-Cement (WOC)" because temperatures are usually low, before the drilling process can be continued Accelerators might not be strictly necessary in deeper wells because of how the greater temperatures affect the setting process. Although they don't necessarily boost the cement's ultimate compressive strength, accelerators do ensure quick strength development. It is important to keep in mind that larger accelerator concentrations act as retarders, therefore typically 2-4% by weight of cement (bwoc) are recommended. In order to counteract the delaying effects of other cement additives in the slurry, such as dispersants and fluid loss control agents, accelerators are also needed.

***Class G Cement***

Class G Cement, being one of the basic oil and gas well cements, is a special hydraulic binding material. Portland cement clinker makes up the majority of its ingredients. It also goes by the term Block Cement. Oil or gas wells are specifically cemented with Class G Cement. It is basically intended for used from surface to about 8,000ft (2400m), meaning it is suitable for surface and intermediate casing operations and can be use with either accelerators or retarders to meet a wide range of well conditions such as depth and temperature. Class G is available in both sorts, i.e., moderate and high sulfate resistant types, in contrast to Class H, which is only available in the moderate sulfate resistant type. hence it was chosen for this work.

## II. MATERIALS AND METHODOLOGY

The block diagram for this research is depicted in figure below:




***Materials Used***

The materials used for this research work are: Water Hyacinth, Class G Cement, Calcium Chloride, Bentonite, Antifoaming Agent (AFA) D206, Lomar D, Diacel-Fl, Marabond 21 and fresh water. The choice of the additives and the fresh water in the preparation of the cement slurry were based on certain parameters, such as formation fluids conditions and the section of the well to be cemented. Table 3.1 below shows the additives and the amount used for this work.

**Table 3:** Cement additives and the amount used in this work

| Materials/Additives | Mass (g) | Concentration | Function |
|---|---|---|---|
| Class G Cement | 270 | - | Cement |
| Calcium Chloride | 5.4 | 2% bwoc | Accelerator |
| Bentonite | 40.5 | 12% bwoc | Density reducing Additive |
| AFA D206 | 0.75 | 0.012gal/sk | Defoamer |
| Sodium Chloride | 6.50 | 2.4% bwoc | Deflocculant (viscosity) |
| Diacel-Fl | 24.5 | 0.35gal/sk | Fluid Loss Additive |
| Marabond 21 | 0.25 | 0.025% bwoc | Retarder |
| Fresh Water | 118.5 | 1.6gal/sk | Base fluid |
| Water Hyacinth Ash | | | Possible Accelerator |

***Preparation of Molar Concentration Solution from the Ashes of the Burnt Water Hyacinth***

The ash was smoothly grinded into powdery form using mortar and pestle and the resulting material was weighed using an electronic weighing balance. 10g, 20g, 30g and 40g of the ashes were dissolved in separate beakers of 100ml of distilled water each, stirred thoroughly for five (5) minutes and were allowed to dissolve for thirty (30) minutes each. The dissolved mixtures were sieved using a filter paper to obtain the filtrates of the solution while the residue were disposed appropriately.

***Determination of Optimum Filtrate Volume of WHA***

In order to determine the filtrate volume of water hyacinth ash to serve as a possible accelerator additive, filtrate volumes of 10g of WHA in 100ml and 20g of WHA in 100ml of fresh water at ambient temperature were used in the multiples of 5 to determine it effect on the weight of the cement slurry and the results are shown in table 4.2 and figures 4.2 below.

***Thickening Time Determination***

The following procedures shows how slurry thickening time was determined:

i. To get the time of thickening of the cement slurry at different temperature conditions a high pressure, high temperature consistometer was employed.
ii. The slurry cup assembly contained the cement slurry.
iii. The slurry cup was put into the test vessel and the pressure was raised via an air-driven hydraulic pump.
iv. A temperature controller regulated the internal heater which maintained the required temperature profile, while the magnetic drive mechanism turned the slurry cup assembly at 150 rpm.
v. A potentiometer controlled the output voltage.
vi. The dual channel strip chart recorder registered and displayed the reading of the slurry's consistency and temperature as a function of time. and the readings were recorded

## III. RESULTS ANALYSIS AND DISCUSSION

***Analysis of Effect of Bentonite on Slurry's Density of Class G Cement***

The density of oil well cement slurry for a given fracture gradient depends on the water-cement ratio and the composite additives. For an intermediate casing string to be cemented in place with class G cement at a depth not greater than 8,000ft with a determined equivalent cement slurry density of 12.4ppg high-strength cement, a mixing ratio of 0.44 as per API standard would give 15.8ppg. Because of bentonite's lower specific gravity and capacity to hydrate, which allowed for the use of considerably higher amount of water, the introduction of bentonite (12% BWOC) lowers the slurry density to 12.4ppg as shown in the table below.

**Table 4:** Effect of addition of bentonite on mixing ratio and slurry density

| Cement Slurry Composition | Mixing Ratio | Slurry Density in ppg |
|---|---|---|
| Water + Class G Cement | 0.44 | 15.8 |
| Water + Class G Cement + Bentonite | 1.076 | 12.4 |

***Analysis of Optimum Filtrate Volume of WHA on Slurry Density***

The results of the various filtrate volumes in fixed volume (400ml) of the slurry were tabulated as shown in table 4.2. There were no changes on the slurry density as the filtrate volume of WHA were arithmetically added from 5.0ml to 20.0ml. However, there was noticeable effect on the slurry density as the filtrate volume increases from 20.0ml to 25.0ml, hence a filtrate volume of 20.0ml in 400ml of cement slurry was taken as the optimum volume in this experiment.

**Table 5:** Effect of filtrate volume on slurry density

| Concentrations | 10g of WHA in 100ml of water | | | | | 20g of WHA in 100ml of water | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Filtrate Vol. (ml) | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 |
| Percent by Vol. (%) | 1.25 | 2.50 | 3.75 | 5.00 | 6.25 | 1.25 | 2.50 | 3.75 | 5.00 | 6.25 |
| Slurry Density (ppg) | 12.4 | 12.4 | 12.4 | 12.4 | 12.1 | 12.4 | 12.4 | 12.4 | 12.4 | 12.1 |

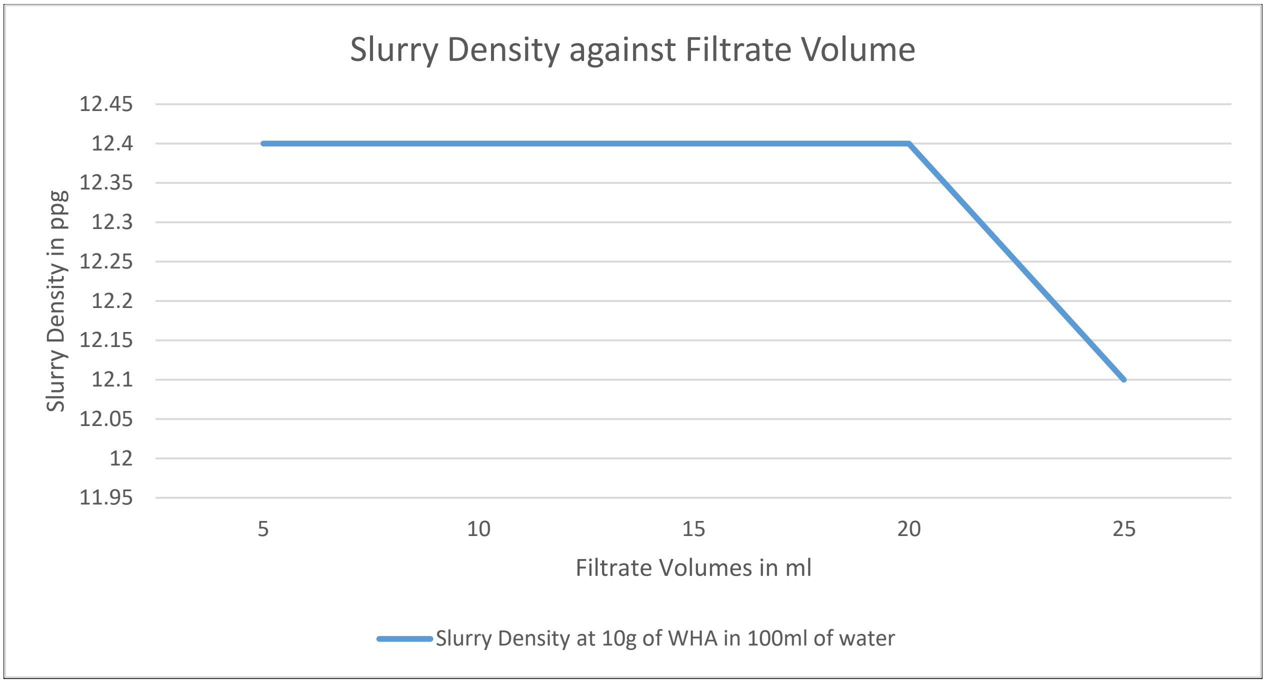



**Figure 1:** Chart of Slurry Density versus Filtrate Volume.

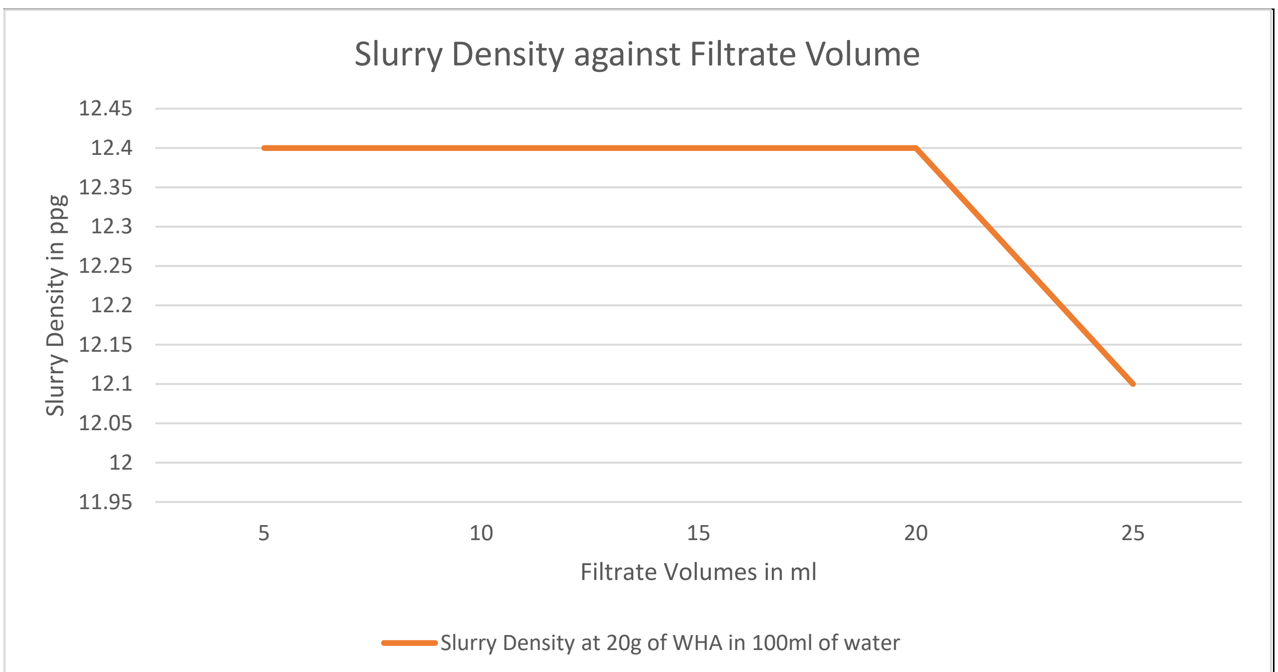



**Figure 2:** Chart of Slurry Density versus Filtrate Volume

***Analysis of Effect Calcium Chloride as Accelerator Additive on Thickening Time of Class G Cement Slurry***

Thickening time is considered as the length of time it takes cement slurry to harden. Calcium chloride as an accelerator additive is frequently employed in wells with bottom-hole temperatures of less than $125^0$F. In table 3.3 below, 2% of calcium chloride by weight of cement was used as accelerator additive at various set temperatures to determine the slurry thickening time and then compared with the control experiment. The control experiment was without calcium chloride (0%) as accelerator additive. The results obtained at 100Bc consistencies showed a gradual decrease in thickening time with increase in temperature in both experiments at an interval difference of almost two (2) hours at each set temperature.

**Table 6:** Thickening Times Comparison at Various Concentrations of Calcium Chloride, Water Hyacinth Ash and Set Temperatures

| Accelerators | Thickening Time at 100Bc in Hr:Min | | | |
|---|---|---|---|---|
| | Sample A @ $90^0$F | Sample B @ $100^0$F | Sample C @ $110^0$F | Sample D @ $120^0$F |
| Control Experiment | 5:44 | 5:35 | 5:23 | 5:11 |
| 2% of $CaCl_2$ | 3:35 | 3:27 | 3:21 | 3:15 |
| 40g of WHA in 100ml | 3:53 | 3:42 | 3:33 | 3:25 |
| 50g of WHA in 100ml | 4:25 | 4:13 | 4:04 | 3:56 |

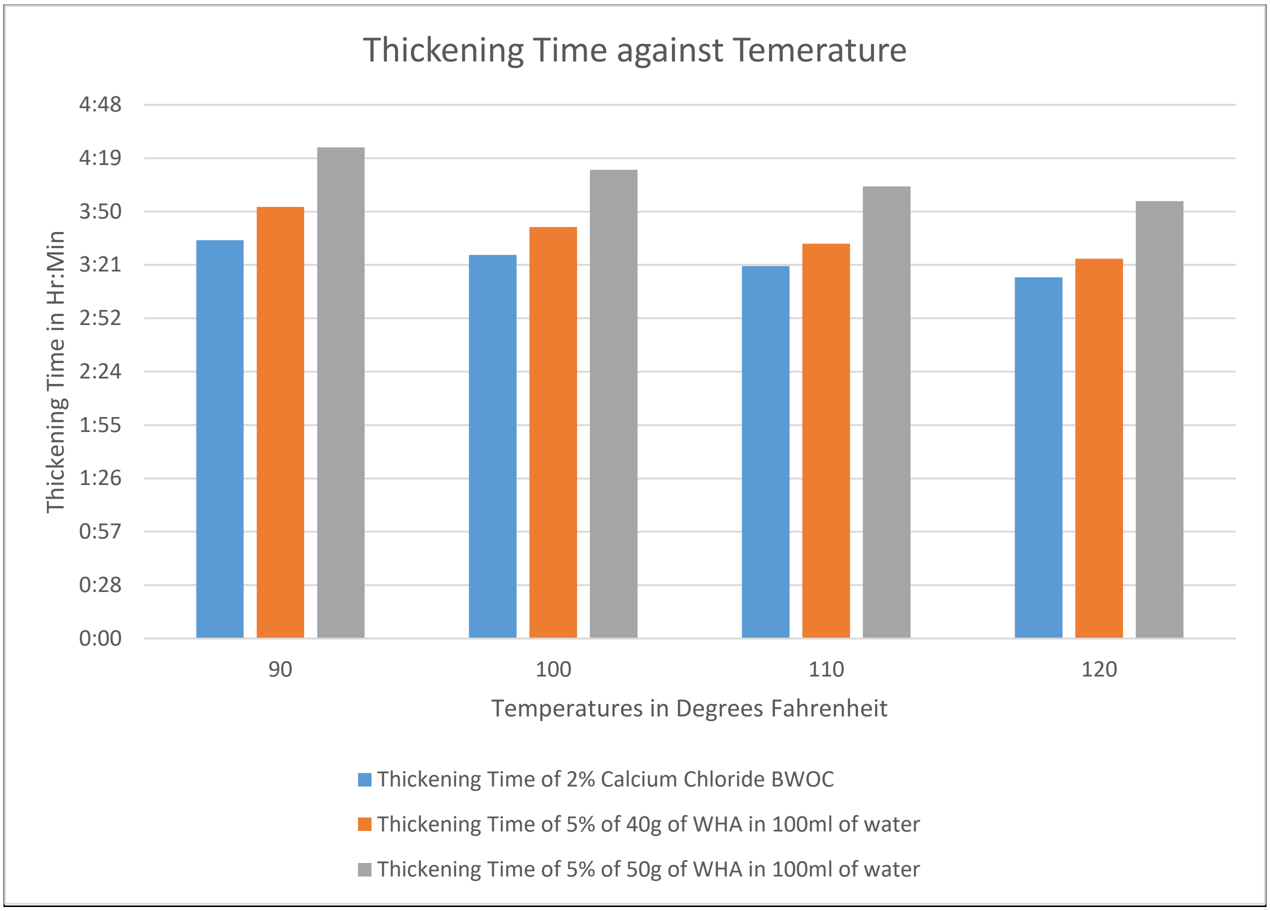



**Figure 3:** Chart of Thickening Time at 100Bc consistency versus Set Temperatures.

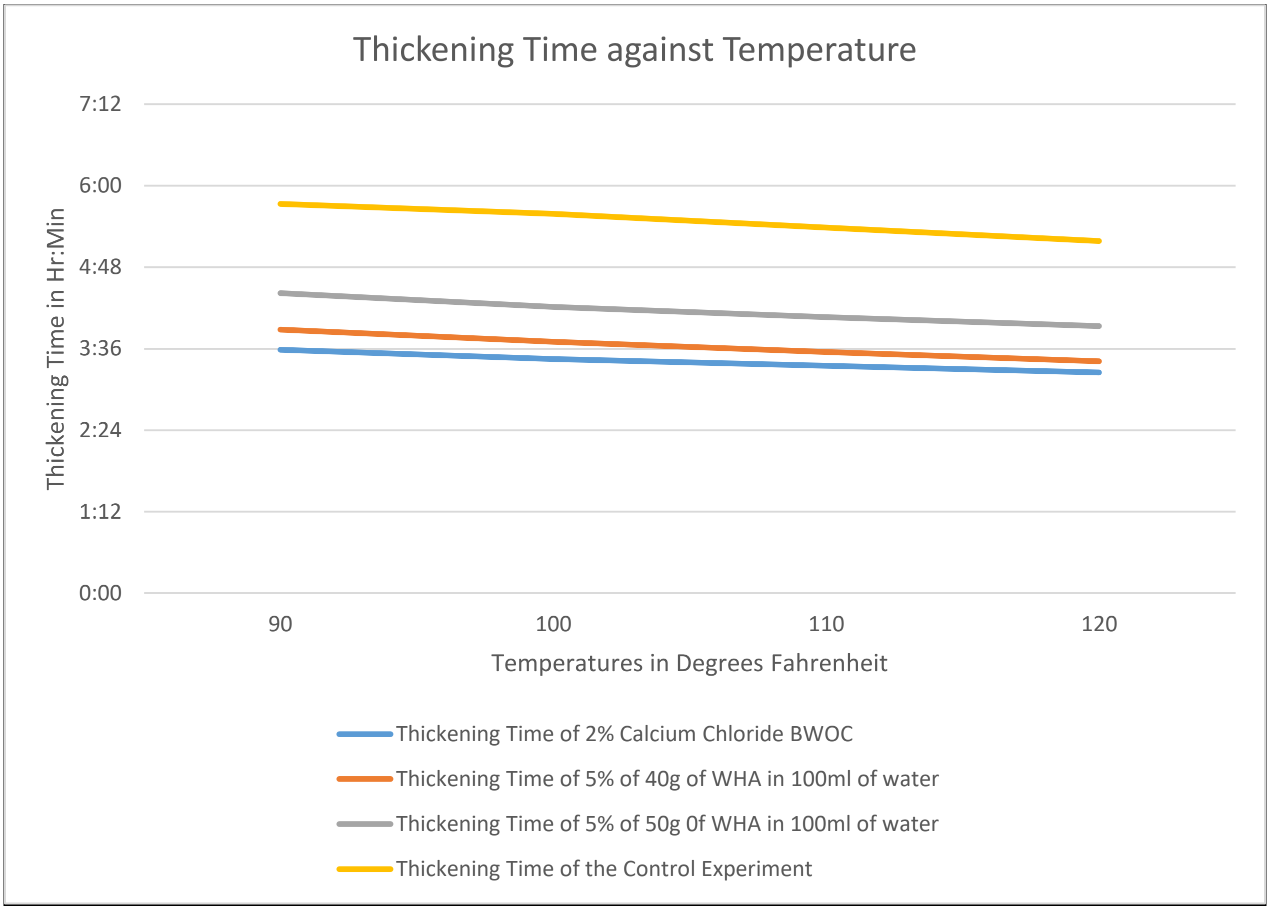



**Figure 4:** Chart of Thickening Time at 100Bc consistency versus Set Temperatures.

## IV. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

***Summary***

It was deduced from Table 3.1, that addition of bentonite to oil well cement (class G) would lead to increase in water-cement ratio and thereby decreasing the slurry density. Also, in Figures 3.1 and 3.2, while determining the filtrate volume of water hyacinth ash to be used in a constant volume of the cement slurry, a finding was made that the filtrate volumes of 10ml, 20ml, 30ml and 40ml did not cause a change in the given slurry density, but as the filtrate volume was increased beyond 20ml or 5% in the fixed volume (400ml), the slurry density decreased from 12.4ppg to 12.1ppg.

While determining the thickening time at 100Bc consistency, 40g of WHA in 100ml of water at the various set temperatures was similar to that of 2% of $CaCl_2$ for each set temperature as shown in Tables 3.3, but at 50g of WHA in 100ml of water, the thickening time began to increase above that of 40g of WHA in 100ml of water and that of 2% of $CaCl_2$ as shown in Figure 3.3. This therefore shows that the slurry's time-to-thicken is dependent on temperature and the percentage concentration of the accelerator in the slurry.

***Conclusion***

From the experimental findings and analysis above, it can be deduced that the thickening time of class G cement slurry is dependent on temperature and the concentration of the additives used. The following conclusions are drawn from this investigation:

i. Addition of extenders, like bentonite will cause a corresponding increase in thickening time of the cement slurry.
ii. A 40g concentration of water hyacinth ash in 100ml of water as accelerator additive will cause a corresponding decrease in thickening time at constant filtrate volume.
iii. An increase in temperature will cause a corresponding decrease in thickening time the cement slurry.

It should be noted that this study and its findings are valid for the oil well cement and the additives used. Other classes of cement/additives combinations can exhibit different characteristics. Even additives from the same category, but different source, could behave differently, and thus need to be investigated separately.

***Recommendations***

From the above analysis, it is recommended that water hyacinth ash should be considered as accelerator additive in the formulation of oil well cement slurry, since it has the tendency of reducing the cement slurry system's thickening period, thereby accelerating the cement setting time. Also, it is recommended that, further investigation of its suitability as an accelerator be carry out to establish its impact on the cement's compressive strength.

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