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The Effect of Soybeans Hull (*Glycine Max*), Beans Pod (*Phaseolus Vulgaris*) and Dry Willow Leaf (*Salix Spp*) on the Properties of a Simple Water -Based Mud

Sarah A Akintola*, Abosede David Anuoluwapo and Lagbayi Ayorinde Moses

University of Ibadan, Nigeria

ABSTRACT

This study is aimed at investigating the effects of varying concentration temperature and aging time on the property of a water-based mud treated with agro-waste materials, (soybean hull, beans pod and dry willow leaf with CMC used as control. From the result, it was observed that the mud samples containing soybeans have the highest plastic viscosity with those with dry willow leaf the highest yield point. The effect of aging on the mud sample shows the plastic viscosity of each of the mud sample decreased with soybeans having the highest plastic viscosity. While the yield point and gel strength at 10 minutes and 10 seconds increased respectively with dry willow leaf having the highest yield point. The result of the fluid loss shows the mud samples treated with dry willow exhibiting the closet linear relationship with sample treated with CMC at room temperature, but as temperature increased samples with beans pod exhibited the closet linear relationship with that of the control.

***Corresponding author**
Sarah A Akintola, University of Ibadan, Nigeria.

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Keywords: CMC, Soya Beans Peel, Dry Willow Leaves, Beans Pod, Water-Based Mud, Fluid Loss, Rheological Properties

Introduction

Drilling fluid is an important component in any drilling process, often referred to as the "lifeblood" of any drilling operation. Drilling fluid must have properties that facilitate safe, efficient, economical and satisfactory completion of the well. It must be carefully designed and fine-tuned to meet the wide variety of conditions found in modern wells. Drilling fluid additives play a crucial role in enhancing drilling operations, but their environmental impact and effectiveness in maintaining filtration properties remain critical concerns. Water-based mud (WBM) has emerged as a popular drilling fluid due to its environmental friendliness and versatility. However, the optimization of its rheological properties remains a critical challenge in the pursuit of efficient drilling. The rheology properties of drilling fluid include viscosity, yield point, plastic viscosity, gel strength and apparent viscosity.

Apparent Viscosity: Viscosity is a measure of the internal friction that exists between the layers of a fluid in motion. the viscosity of a drilling fluid can be obtained by using the Rotational Viscometer. The apparent viscosity can be calculated using the equation 1.0.

Apparent Viscosity = (300x dial reading in degrees) / (rotor speed in revolutions per minute) - (1.0)

Plastic Viscosity: Plastic viscosity is that part of resistance to flow caused by mechanical friction, and calculated using the equation 2.0.

PV = 600 rpm reading- 300 rpm reading (2.0)

Yield Point: The yield point (YP), is a measure of the electro-chemical attractive forces within the mud under flowing conditions. The yield point is the shear stress at zero shear rate, and is measured in the field by using equation 3.0;

YP- 300 rpm- PV -------------------------- (3.0)

Gel Strength: Gel strength is obtained by noting the maximum dial deflection when the rotational viscometer is turned at a low rotor speed (usually 3 rpm) after the mud has remained static for some period of time. 10 seconds, the maximum dial deflection obtained when the viscometer is turned on is reported as the initial gel.

Lately, the use of agro-materials as cost effective and environmentally friendly additive in improving the rheological and filtration properties of a drilling mud have been investigated. Adebowale et al. (2019) reported that the addition of plantain peel powder to water-based drilling mud resulted in improved viscosity and gel strength and reduced fluid loss but had no significant impact on the mud density. Adeboye et al. (2019) also evaluated the performance of burnt palm head sponge ash powder as an additive in the drilling mud and found that it improved the rheological properties of the mud, including viscosity and gel strength. Their study showed that the addition of burnt palm head sponge ash powder in a water-based mud reduced the filtration properties. Humairah et al (2020) investigated the effects of temperature and concentration of graphene retrieved from unwanted industrial waste on the rheological and filtration properties of the water-based drilling mud. Their result showed that the addition of small concentration of graphene nanoparticles increased the plastic viscosity, yield point and improved the API and HPHT filtrate volume.

Mamukuyomi (2021) examined the potential of using plantain peel-snail shell biocomposite powder as an enhancer of pH and rheological parameters in water-base muds. The study reveals that the inclusion of the biocomposite powder led to an increase in drilling fluid weight and pH value, enhancing the rheological properties of WBDFs with higher concentrations of the additive. Mohammed Kebir et al (2023) compared the effect of the addition of eggshell powder (ESP) as a native and local additive and Calcium Carbonate (CC) as a traditional and conventional additive on the rheological and filtration properties of the drilling fluid system. The findings showed that the CC with various concentrations (10g, 20g and 30g) increases the rheological properties and mud density while it reduces the filter cake and the fluid loss values which are desirable, calcium carbonate had a slightly higher effect on the pH. The result show that the addition of ESP with different ratios revealed he later has a considerable impact on the plastic viscosity, yield point, gel strength and the cake thickness.

Asma Nour et al (2022) investigated the performance of starch extracted from potatoes and corn. A comparative study of the rheological properties was carried out. The measurements were performed in the presence of caustic soda and potassium chloride while varying the concentration for both starches. The results showed that both potato and corn starches enhanced the rheological properties meanwhile reduced the fluid loss and the filter thickness in basic/saline media drilling fluid formulations. Ali Raza et al (2023) evaluated the performance of rice husk ash (RHA) as an alternative to chemical additives to enhance the rheological properties of drilling fluids. This work explores the rheological properties of drilling fluid with RHA as a filter control medium. The results showed that increasing concentrations of RHA in the drilling mud significantly improved its plastic viscosity, yield point, density, gel strength, and thixotropy.

In this study, a simple water based drilling mud treated with pulverised agro waste (soybeans Hull, beans pod and dry willow leaf) was investigated at varying temperatures and aged conditions as a potential suitable additive which can enhanced the drilling fluid rheological and filtration properties.

Materials and Methodology

The materials and equipment used during the experimental study are soybean hull (Glycine max), beans pod (Phaseolus vulgaris) and willow leaf (Salix spp), Bariod Mud Balance, Fann 35A, Aging cell, Hamilton Beach Multimixer, Digital weighing balance, Measuring cylinder. Distil water, API Filter Press.

Sample Collection and Preparation

Dry Willow Leaf (*Salix spp*)

The dry willow leaves (Figure 1.0a) a local bio-degradable material, was sourced from the department of petroleum engineering premises. They are rich in cellulose, with complex carbohydrate known for its ability to form a network structure. The willow leaves was sun- dried for 2 weeks, crushed and pulverized, sieved using a 120 micro sieve size into a finely powder texture (Figure 1.0 b) stored in labelled air tight container.

Figure 1.0a: Dry Willow Leaf

Figure 1.0b: Powdered Dry Willow Leaf

Soya Bean Peel (*Glycine Max*)

The Figure 1.1a, presents the byproduct of processed soybean. obtained from a local market (Bodija) in Ibadan. They offer a range of components, including proteins, fibers, and lipids, these constituents suggest multiple potential benefits for drilling fluids, the proteins could enhance viscosity and gel strength, fibers could contribute to structural integrity, and lipids may act as lubricants. The soybean hull was proficiently sun dried for 8 days, crushed, pulverized, sieved using a 120 micro sieve size into a finely powder texture (Figure 1.1b) and stored in labelled air tight containers.

Figure 1.1a: Soyabean Peel

Figure 1.1b: Powdered Soyabean Peel

Beans Pod (*Phaseolus Vulgaris*)

The Beans pod (Figure 1.2a), another agricultural residue, was obtained from a local market, Bodija, in Ibadan. Beans pod offers a different set of characteristics that may impact WBM rheology, as it is rich in fibers and potentially containing natural polymers that can contribute to both the rheological enhancement of the mud. The Beans pod was sun dried for 6 days, crushed, pulverized and sieved using a 120 micro sieve size in to a finely powder texture (Figures 1.2b) and stored in labelled air tight container.

Figure 1.2a: Beans Pod

Figure 1.2b: Powdered Beans Pod

Samples Characterization

The samples characterization was done before experimentation to determine the physicochemical (proximate) properties and was evaluated using the American Standard for Testing and Material (ASTM E872-82) standard. Also Fourier Transform Infrared Spectroscopy (FTIR) using the Shimadzu 1240 FTIR spectrometer was carried out. The characterization was carried out at the Multidisciplinary Central Research Laboratory, University of Ibadan.

Formulation of Mud Samples

Water-based drilling mud was prepared and tested according to the API RP 13A-1. All formulations and tests were carried out in the University of Ibadan Petroleum Drilling Fluid Laboratory. Basically, twenty drilling mud samples formulated with 350 ml distil water and 21.5g bentonite, the mixture was allowed to stay for 17 hours before thorough agitation while treating with varying concentration of the additives.

Determination of Mud Sample Weight and pH

At various concentrations of the formulations mixed, the mud weight and pH were determined using the Bariod four-scale mud balance and pH meter, respectively.

Mud Sample Rheological Properties

To test for the rheological properties of the mud samples, a Fann35 A was used.

Mud Sample Filtration Properties

The mud sample fluid loss was measured using the API filter Press.

Results and Discussions

Characterization of Sample

Sample Proximate Analysis

The results of the proximate analysis of the samples are shown in Table 1

Table 1.0: Proximate Analysis of the Samples

Sample	Ash Content, %	Silica Content, %	Total Sugar Content, %	Moisture Content, %	Total Lignin, %
Soybean Hull	5.2 +0.1	0.83 +0.1	26 +0.2	12 +0.3	18 +0.2
Beans Pod	4.3 +0.1	0.79+0.2	18 +0.1	10 +0.2	15+0.1
Willow leaf	2.4 +0.1	0.52+0.2	5 +0.3	18 +0.1	24+0.1

The Sample FTIR

The FTIR Spectra results are presented in the Figures 2.0 – 4.0

Soybeans Peel (*Glycine Max*)

The FTIR spectrum, Figure 2.0., show peaks corresponding to cellulose, hemicellulose, lignin, and possibly protein content. Cellulose and hemicellulose are the main components of plant cell walls, so their characteristic peaks are prominent. Lignin, another component of cell walls, would also contribute to the spectrum. Additionally, peaks related to any remaining proteins or amino acids.

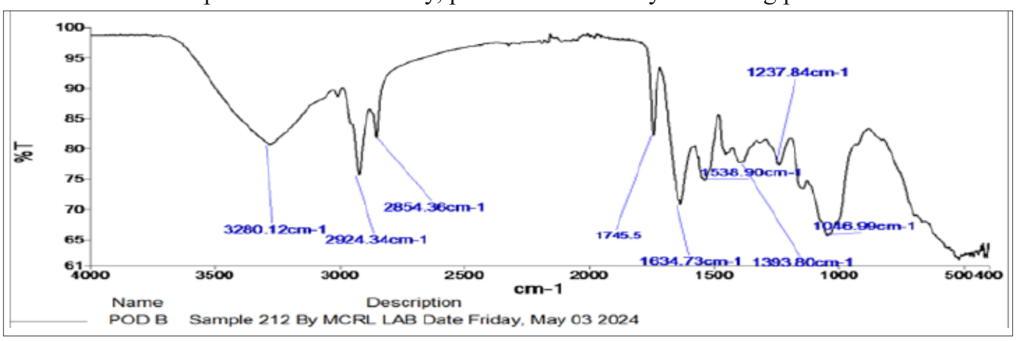

Figure 2.0: FITR result for Soyabean Hull

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Beans Pod (*Phaseolus Vulgaris*): The FTIR spectrum of beans pod, Figure 3.0, exhibit peaks indicative of cellulose, hemicellulose, and possibly some protein content. Cellulose and hemicellulose are common constituents of plant cell walls, so their characteristic peaks are present. Since beans are also a source of protein, peaks associated with protein structures is visible.

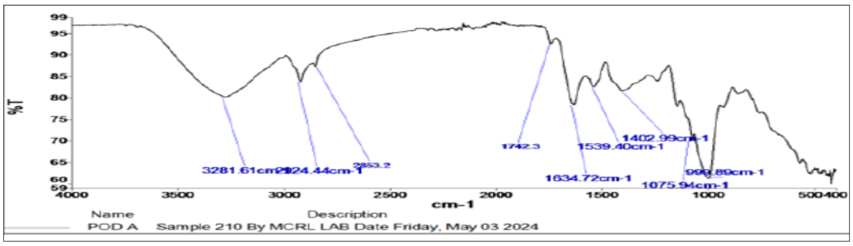

Figure 3.0: FITR for Beans Pod

Dry Willow Leaf (*Salix spp*)

The FTIR spectrum of dry willow leaves, Figure 4.0, display peaks representing cellulose, hemicellulose, and possibly lignin. Cellulose and hemicellulose are major components of plant cell walls, so their characteristic peaks would be prominent. Lignin, which provides structural support to plants, would also contribute to the spectrum. Additionally, there are peaks indicative of other organic compounds commonly found in leaves.

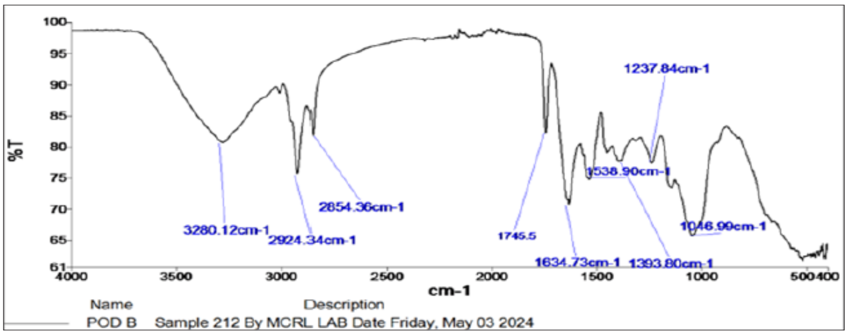

Figure 4.0: FITR Result for Dry Willow Leaf

The Mud Samples pH and Mud Weight

Maintaining the appropriate mud weight of a drilling fluid is essential for a successful drilling operation The Figure 5.0 and Table 2.0 show the result of the effect of aging on the varying concentration of the drilling fluid mud samples for the mud samples density and pH, respectively.

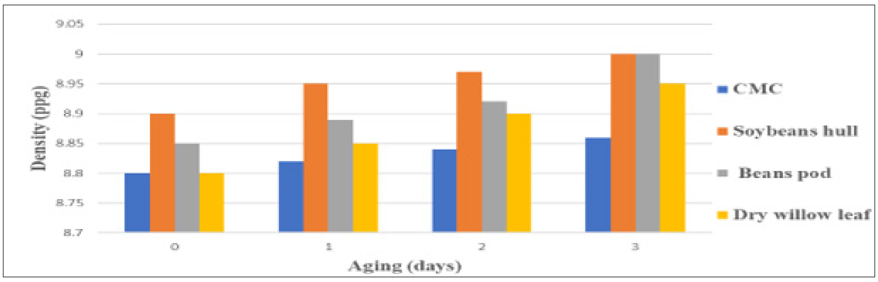

Figure 5.0: Effect of Aging on the Density of Each of the Mud Sample

Table 2.0: The Mud Samples pH

pH					
	2g	**4g**	**6g**	**8g**	**10g**
Dry Willow Leaf	8.38	8.41	8.35	8.24	8.07
Beans Pod	8.35	8.64	8.55	8.60	8.65
Soyabeans Hull	8.80	8.85	8.92	8.90	8.94
CMC	8.69	8.72	8.70	8.80	8.85

Effect Temperature on the Rheology of Mud Sample

The Figures 6.0 and 7.0 shows the effect of temperature on the plastic viscosity and apparent viscosity, respectively, for each of the mud samples. CMC has the highest value followed by soybeans hull and beans pod as the temperature increases, with dry willow leaf having least.

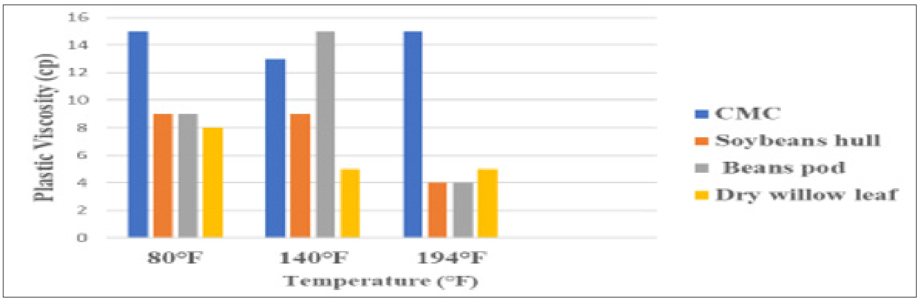

Figure 6.0: Effect of Temperature on the Plastic Viscosity of the Mud Samples

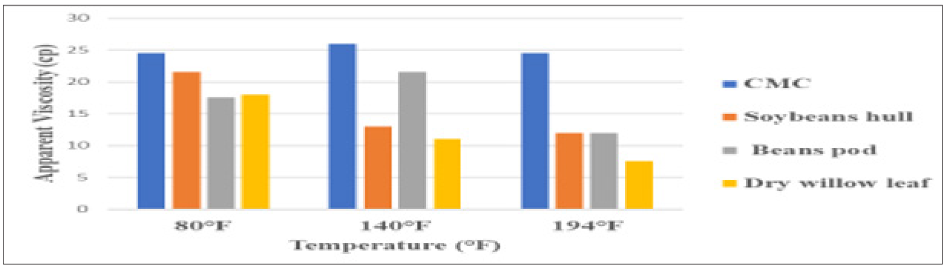

Figure 7.0: Effect of Temperature on the Apparent Viscosity of the Mud Samples

The Figure 8.0 shows the effect of temperature on the yield point of each of the mud sample. Soybeans hull has the highest yield point from the trend followed by dry willow leaf, CMC and beans pod at 80°F. At a temperature of 140°F, CMC has the highest yield point followed by beans pod, dry willow leaf while soybeans hull has the lowest yield point. At a temperature of 194°F, CMC has the highest yield point followed both beans pod and soybeans hull, with dry willow leaf exhibiting the lowest yield point.

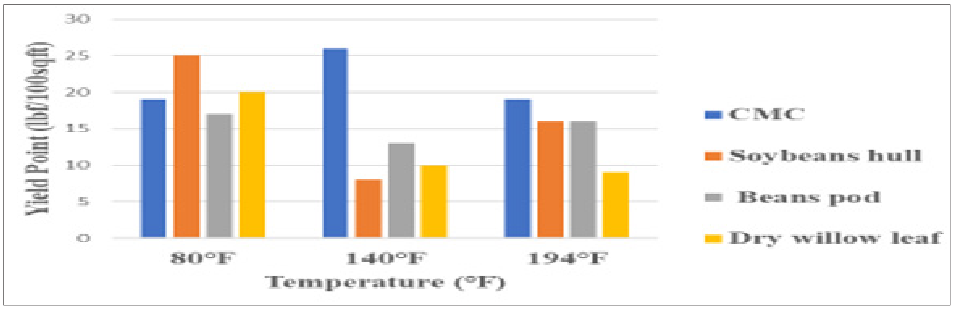

Figure 8.0: Effect of Temperature on the Yield Point of the Mud Samples

The Figures 9.0 and 10.0 shows the effect of temperature on the gel strength at 10 minutes and 10 seconds of each of the mud sample respectively. Gel strengths, 10 seconds and 10 minutes indicate the strength of attractive forces (gelation) in a drilling fluid under static conditions.

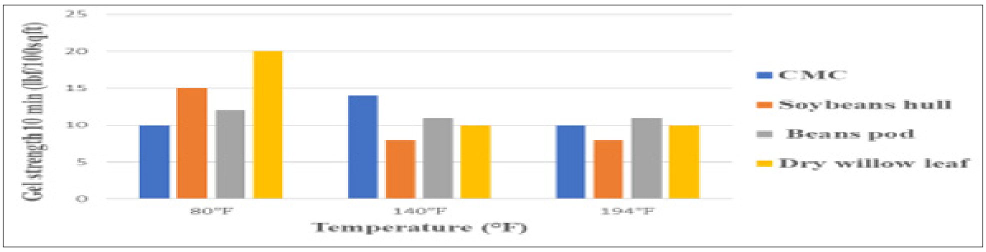

Figure 9.0: Effect of Temperature on the Gel Strength at 10 Minutes of the Mud Samples

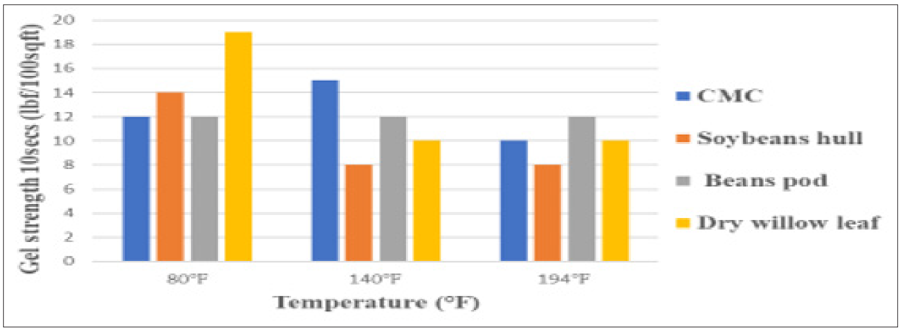

Figure 10.0: Effect of Temperature on the Gel Strength at 10 Seconds of the Mud Samples

Effect of Aging on Rheology of Mud Sample

The effect of aging on the properties of the mud samples are presented in Figures 11.0 – 15.0. from the result it was observed that the viscosity of the mud samples decreases due to increase in aging time while the yield point, gel strength at 10 minutes and 10 seconds of the mud sample increases due to increase in aging time.

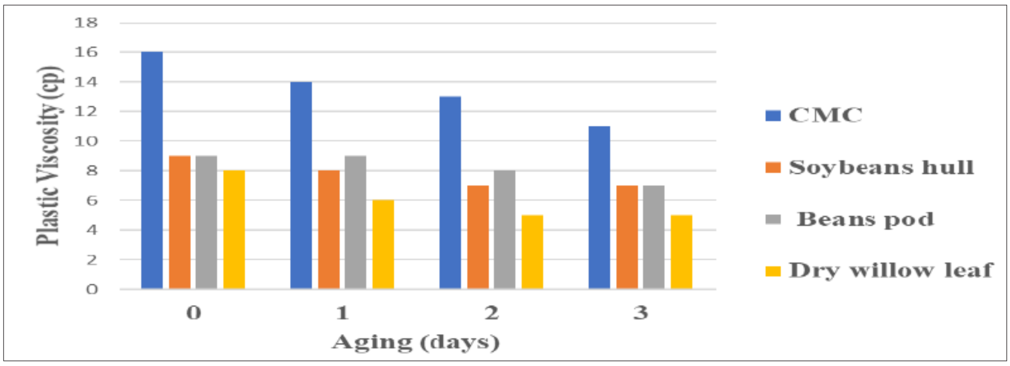

Figure 11.0: Effect of Aging on the Plastic Viscosity of the Mud Samples

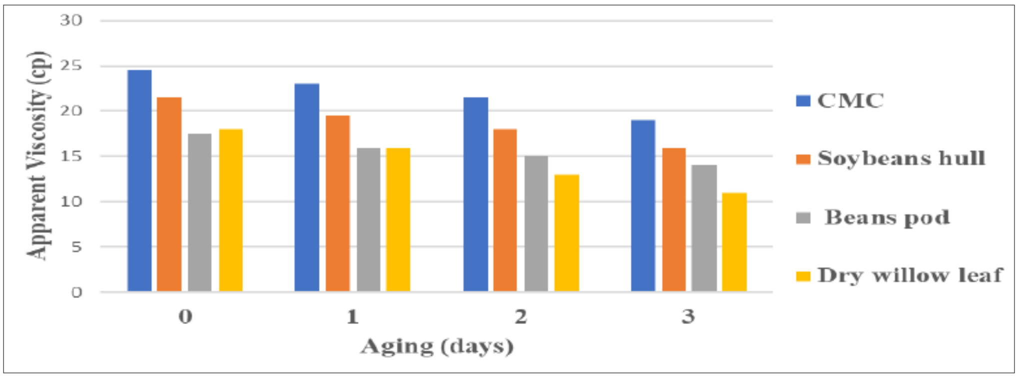

Figure 12.0: Effect of Aging on the Apparent Viscosity of the Mud Samples

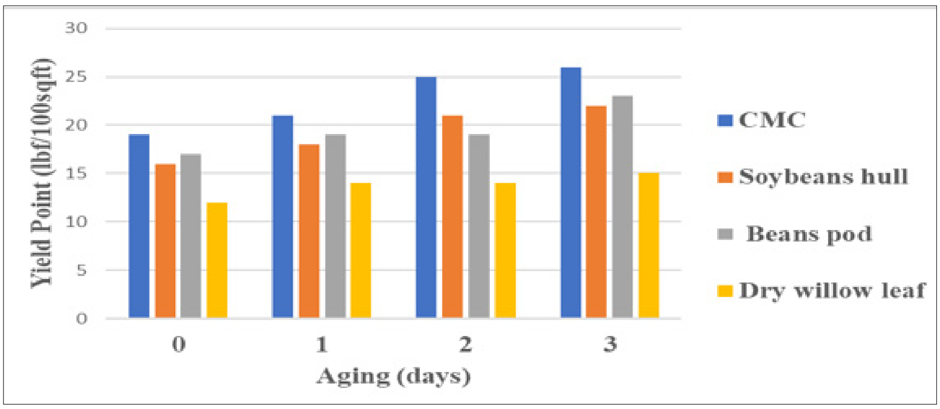

Figure 13.0: Effect of Aging on the Yield Point of the Mud Samples

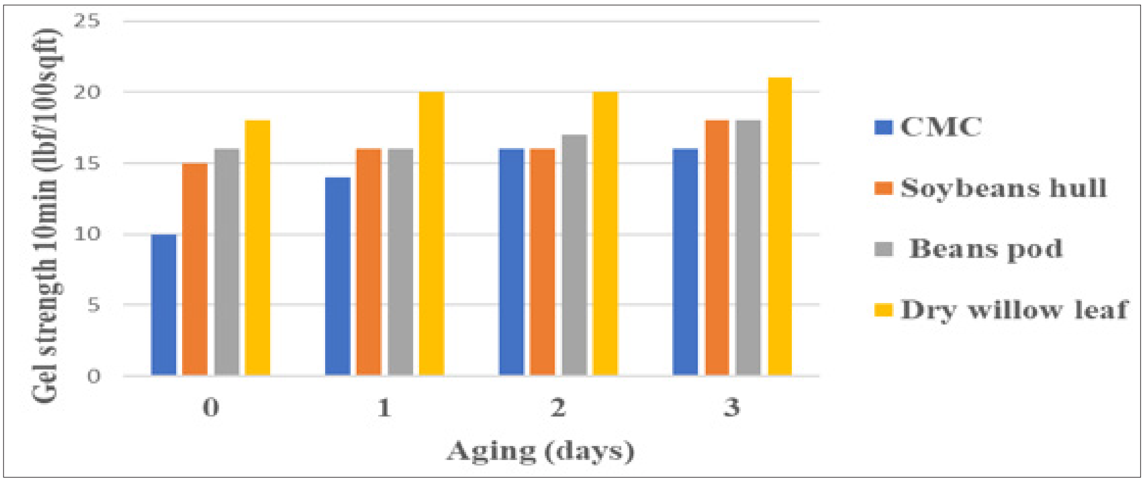

Figure 14.0: Effect of Aging on the Gel Strength at 10 Minutes of the Mud Samples

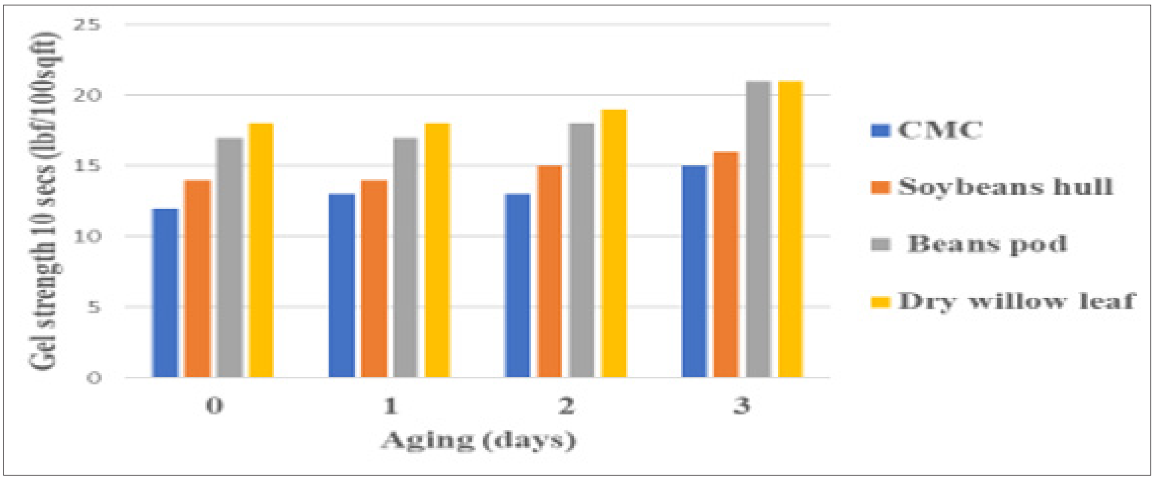

Figure 15.0: Effect of Aging on the Gel strength at 10 seconds of the Mud Samples

Filtration Properties

The results of the fluid loss of the different concentration the fluid additives are shown in the Figures 16.0- 20.0 at room temperature, Figures 21.0- 25.0 and 26.0 -30.0 presents results of fluid loss at 60 o and 90o F, respectively. The Table 3.0

Table 3.0: The Mud Filter Cake $hickness

Sample Concentration	2g	4g	6g	8g	10g
Cake thickness 32nds-inch.	0.4	0.3	0.5	0.3	0.6

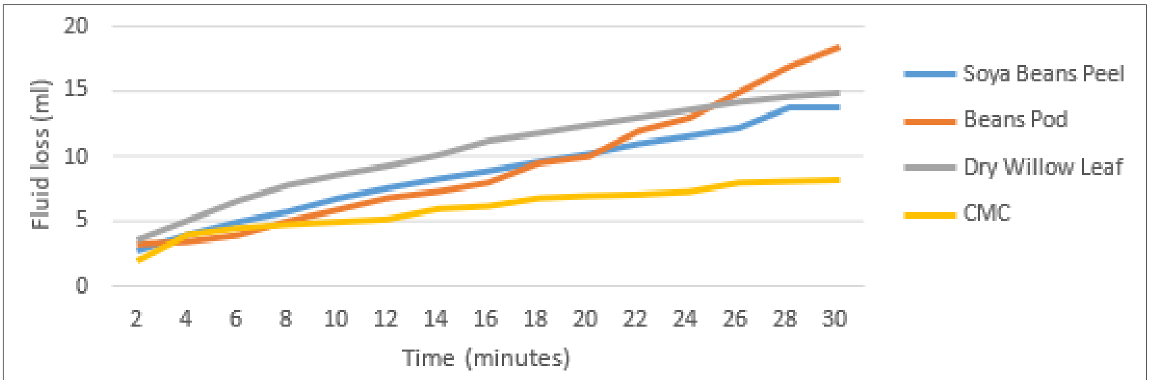

Figure 16.0: Fluid Loss of 2.0g of the Mud Samples at Room Temperature

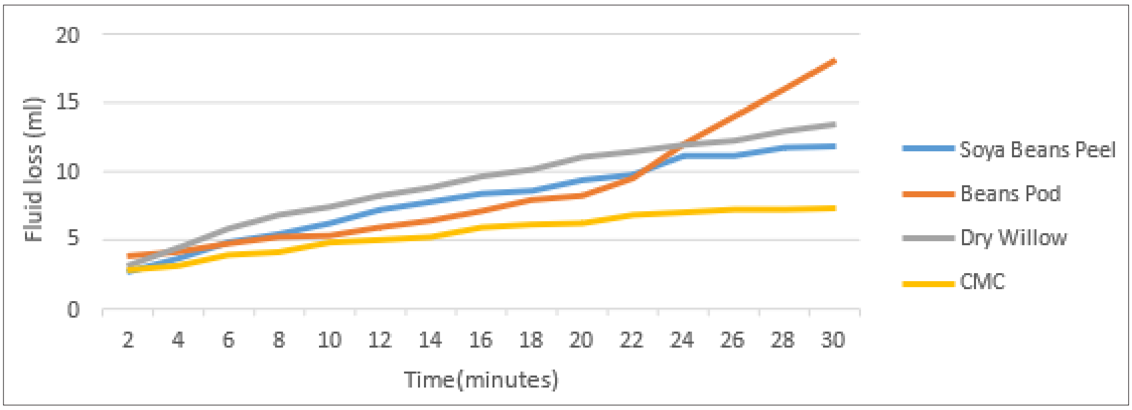

Figure 17.0: Fluid Loss of 4.0g of the Mud Samples at Room Temperature

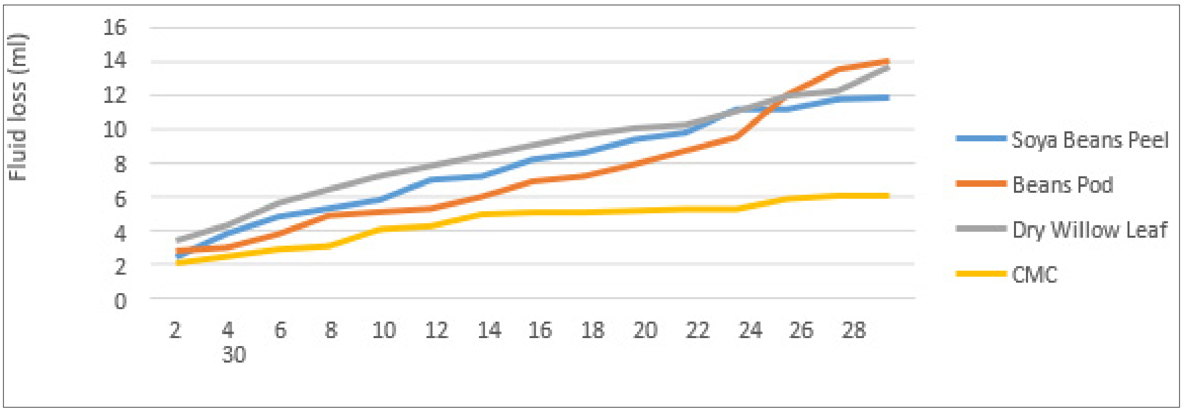

Figure 18.0: Fluid Loss of 6.0g of the Mud Samples at Room Temperature

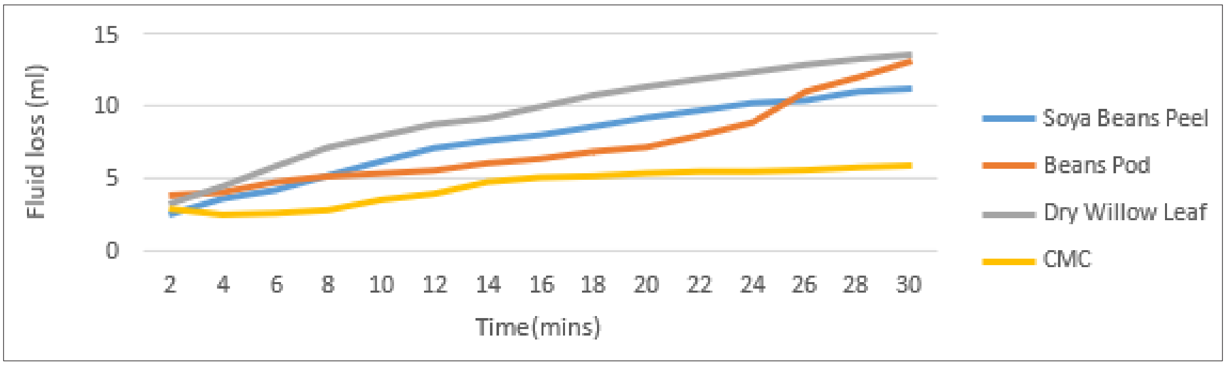

Figure 19.0: Fluid Loss of 8.0g of the Mud Samples at Room Temperature

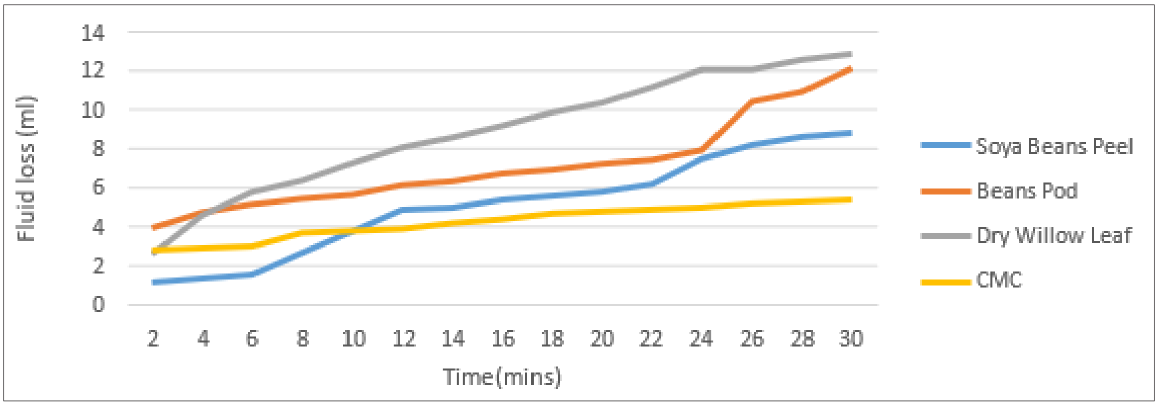

Figure 20.0: Fluid Loss of 10.0g of the Mud Samples at Room Temperature

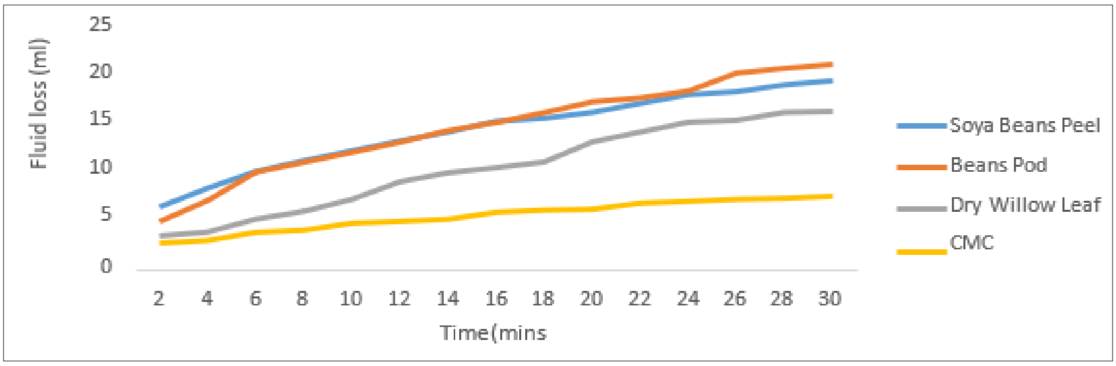

Figure 21.0: Fluid Loss of 2.0g of the Mud Samples at 60°F

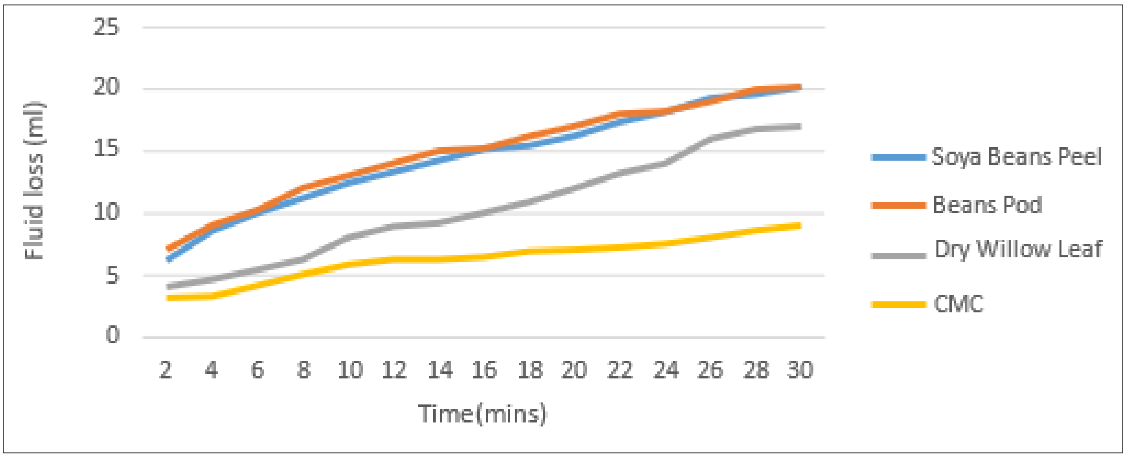

Figure 22.0: Fluid Loss of 4.0g of the Mud Samples at 60°F

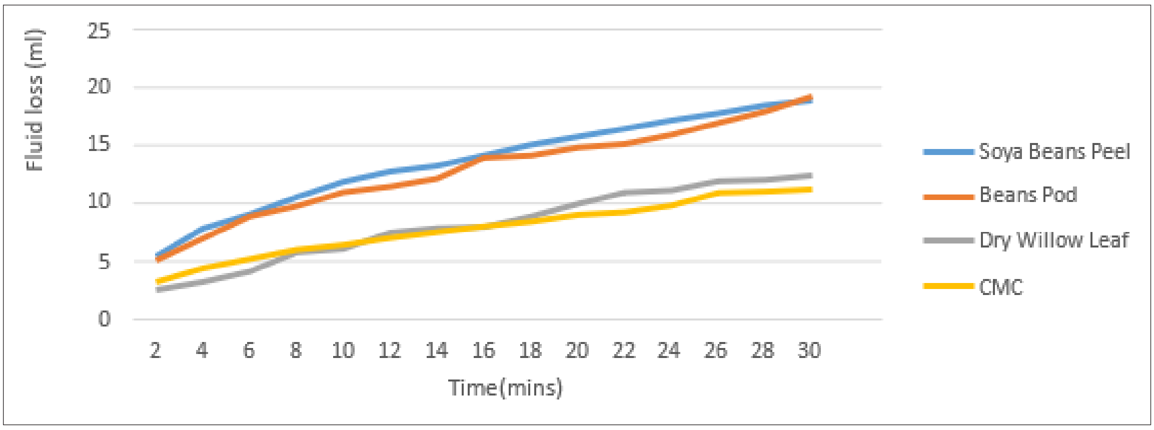

Figure 23.0: Fluid Loss of 6.0g of the Mud Samples at 60°F

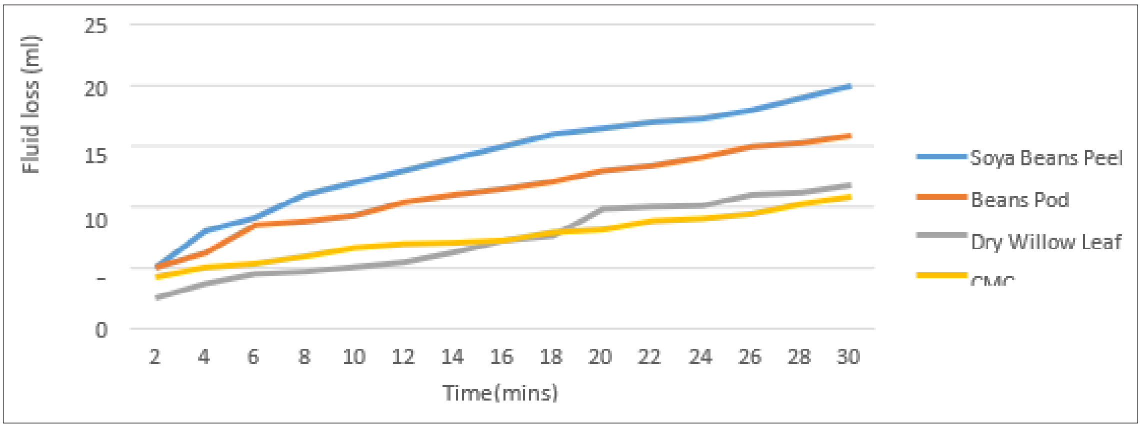

Figure 24.0: Fluid Loss of 8.0g of the Mud Samples at 60°F

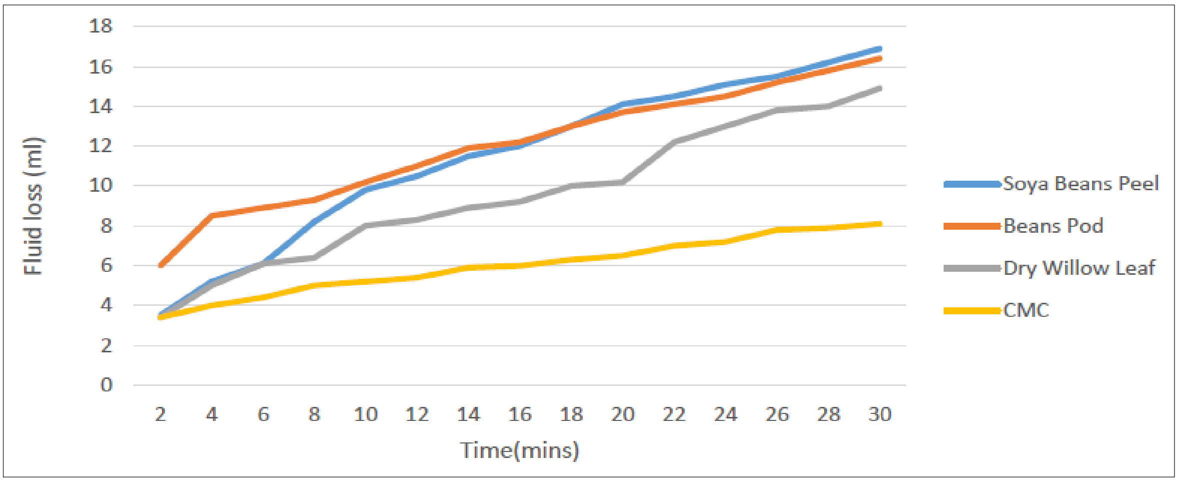

Figure 25.0: Fluid Loss of 10.0g of the Mud Samples at 60°F

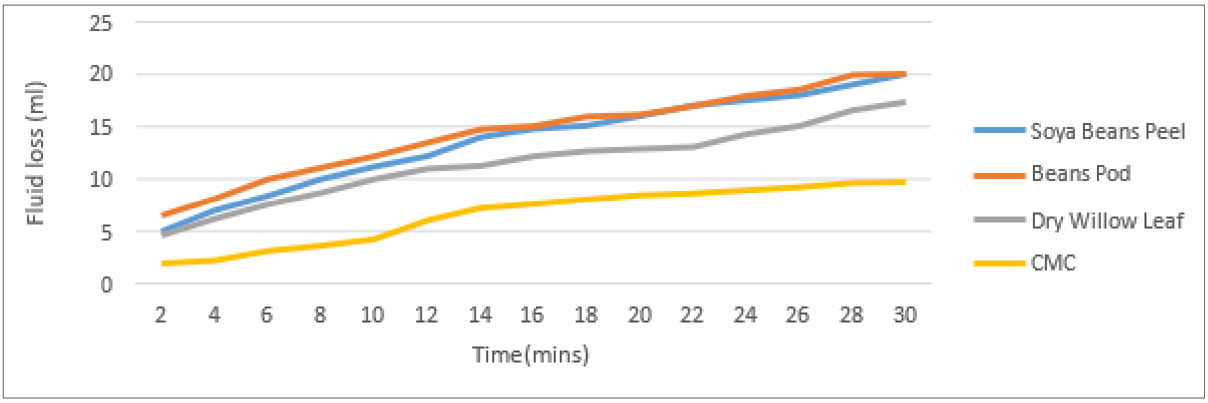

Figure 26.0: Fluid Loss of 2.0g of the Mud Samples at 90°F

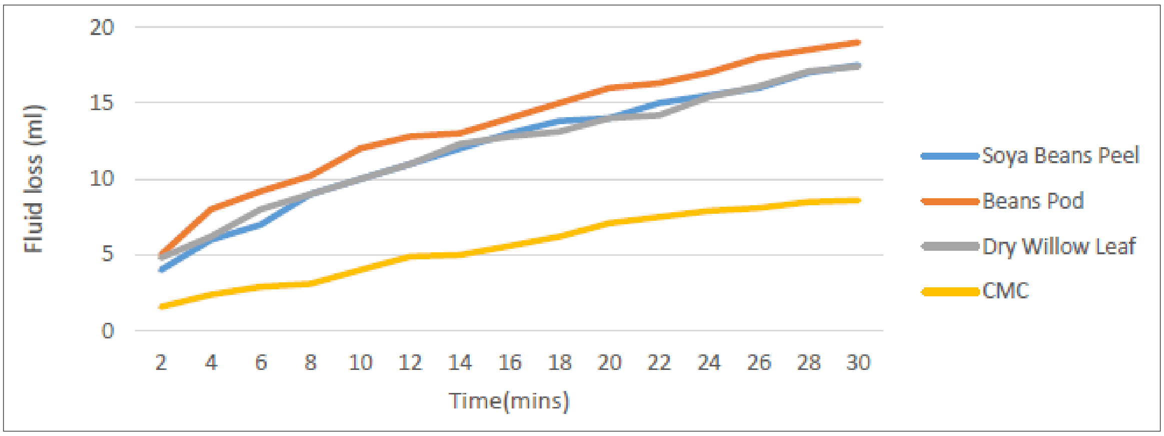

Figure 27.0: Fluid Loss of 4.0g of the Mud Samples at 90°F

Figure 28.0: Fluid Loss of 6.0g of the Additives at 90°F

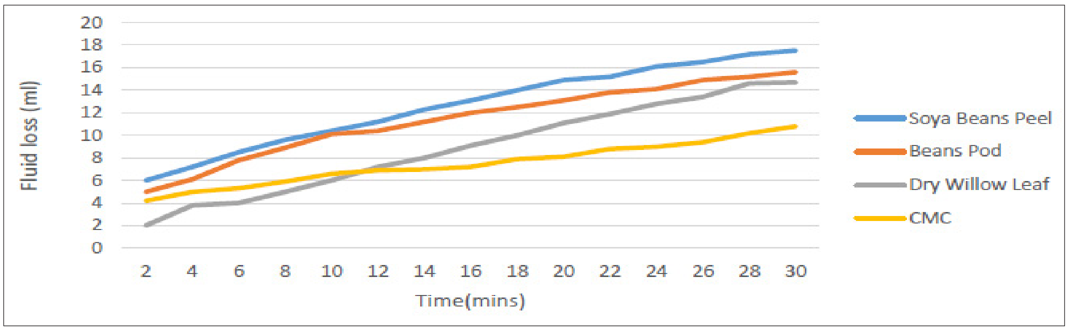

Figure 29.0: Fluid Loss of 8.0g of the Mud Samples at 90°F

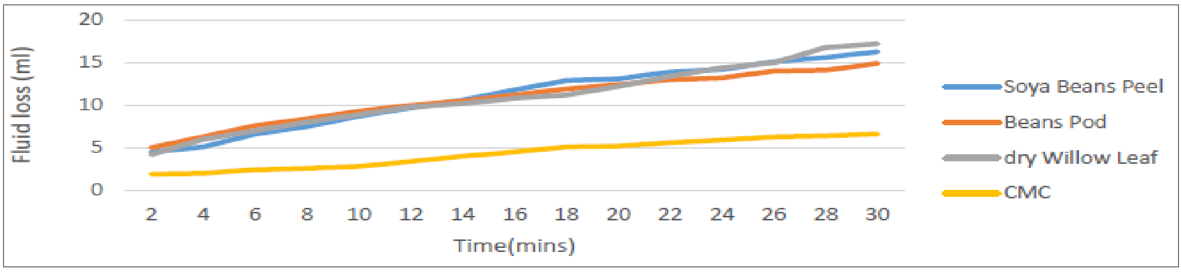

Figure 30.0: Fluid Loss of 10.0g of the Mud Samples at 90oF

Conclusion

The plastic viscosity, apparent viscosity and yield point for the mud samples decreases as the concentration increases from 2g to 10g at room temperature. Indicating that soybean hull has the highest plastic viscosity, apparent viscosity, yield point and gel strength at 10 minutes and 10 seconds respectively.

The effect of varying temperature shows a decrease in the plastic viscosity and apparent viscosity indicating that soybean hull has the highest plastic viscosity and apparent viscosity but an increase in the yield point and gel strength at 10 minutes and 10 seconds for each of the mud samples is observed as the temperature increases indicating that dry willow leaf has the highest yield point and gel strength [1-20].

The effect of aging on the mud samples indicates that the density of the mud samples increases as the aging time increases. The plastic viscosity and apparent viscosity of the mud samples decreases due to aging time indicating that soybeans have the highest plastic viscosity and apparent viscosity. While the yield point and gel strength at 10 minutes and 10 seconds increases due to increase in aging time indicating that dry willow leaf has the highest yield point and gel strength.

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