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DETERMINING THE OPTIMUM CONCENTRATION OF PUMPKIN SEED SHELLS AS FILTRATION CONTROL ADDITIVE TO WATER-BASED MUD SYSTEM

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Abstract: Filtrate loss within formations is one of the biggest problems during drilling operations. Therefore, many commercial chemical additives have been used to reduce fluid loss, such as carboxymethylcellulose (CMC) and polyanionic cellulose (PAC), which are expensive and are not environment-friendly substances. This study evaluates the usage of pumpkin seed shells (PSS), which is agricultural waste and at the same time an environment-friendly material, as an additive to the drilling fluid to reduce fluid loss. Six drilling fluid samples were formulated, adding PSS of 250 μm in size at different concentrations (1 wt%, 2 wt%, 3 wt%, 4 wt%, and 5 wt%). The effect of adding PSS on rheological properties and density was recorded and analyzed. Filtration was also studied by using an API LT LP press. The results of the study indicated that the addition of PSS to the drilling fluid has a clear effect on reducing fluid loss. The optimum concentration of PSS was 5 wt%.

Keywords: *Water-based mud, Drilling fluid, Lost circulation material, environmentally friendly additives, Filtrate loss*

1. INTRODUCTION

Oil is one of the most important economic resources for most countries in the world. Therefore, wells are frequently drilled to explore for new reservoirs of oil. Drilling operations are extremely complex and expensive operations. The drilling fluid used in drilling operations carries out many functions, which include the removal of cuttings from the well bottom to the surface, cooling and lubrication of the drilling bit, and stabilizing the wellbore by means of hydrostatic pressure exerted by the fluid column [1–3]. Drilling fluid is composed of liquid and solid phases, and certain additives are added to achieve the desirable properties. The additives affect important properties such as rheology, fluid loss, cake thickness, and density. The type and concentration of additives used in the drilling fluid are chosen on the basis of the properties that need to be modified. Depending on the type and concentration of the additives, some of the additives may increase the viscosity when added to the drilling fluid, while others might reduce the viscosity [4]. Hence, the success of drilling process relies on the selection of suitable material used in the drilling fluid with respect to the prevailing conditions. During drilling it is certain that problems like pipe sticking, lost circulation, borehole stability, mud contamination, formation damage and hole cleaning will take place due to different geological conditions. Therefore, it is important to understand and anticipate the drilling problems, find the cause and plan the solution to reduce the cost of drilling and reach the target zone safely and successfully [5, 6]. Fluid loss is one of the most common problems that increases the cost and the total drilling time. Significant fluid loss into the formation can result in irreversible changes in the properties of the drilling fluid such as density, viscosity, and borehole instability [5, 7].

Fluid loss occurs as a result of the pressure difference between the drilling fluid column and the formations, which leads to the penetration of the liquid phase of the drilling fluid into the formations and the solid phase making a mud cake on the walls of the wellbore [8]. Thus, the properties of the drilling fluid must be modified to reduce the amount of fluid loss as well as to reduce the thickness of the mud cake forming on the wellbore [9].

Water-based drilling fluids are the most common type of drilling fluid used in well drilling due to their relatively low cost and environment friendly nature. Many materials have been used to control fluid loss and the rheological properties of drilling fluid, such as carboxymethylcellulose (CMC), starch, and xanthan gum (XC) [10–13]. These chemical materials are costly, harmful to the environment, and disintegrate at the high temperatures present in the well. Some of the additives are highly toxic and can harm health when used improperly during drilling operations. For these reasons, new additives are being tested which would be safe and comparatively affordable.

Researchers are focusing on finding low-cost, environment-friendly materials that reduce fluid loss and enhance the rheological properties of the drilling fluid. In the past various types of environment-friendly waste have been tested to reduce fluid loss, such as corn cobs, walnut shells, banana peels, rice husks, sawdust, and potato husks [17–21]. Pumpkin seed shells are an environmentally friendly waste material, and to date, no previous studies have been made on the evaluation of pumpkin seed shells as an additive in drilling fluid.

This study presents experimental work on pumpkin seed shells (PSS) as an additive to water-based bentonite drilling fluid and a measurement of its impact on many properties of drilling fluid, including rheology, density, fluid loss, and cake thickness.

2. Experimental procedure

All experimental measurements were done based on API-RP-13B-1 standards. The workflow of the experimental process is shown in *Figure 1*. The measurements included the rheological properties (plastic viscosity, apparent viscosity, production point, gel strength for 10 seconds, 1 minute, and 10 minutes), filtration properties (fluid loss for 30 minutes, cake thickening), and the density. The density was recorded with different concentrations of pumpkin seed shell powder added to a water-based drilling fluid.

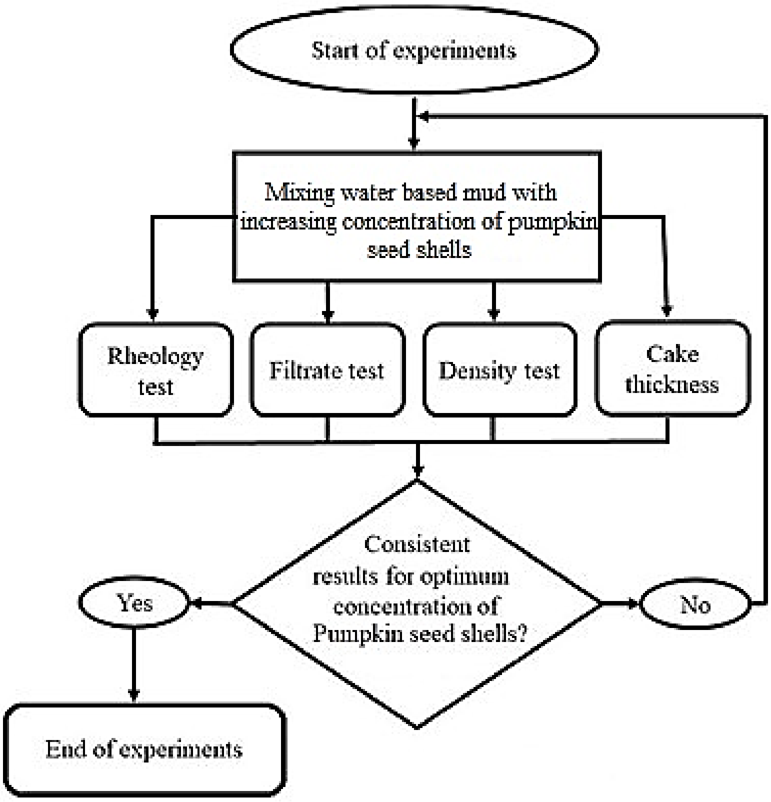


Figure 1. *Workflow of the experimental process*

2.1. Materials

In this article, the pumpkin seed shells (PSS) were the main materials used as an additive to water-based drilling fluid. After drying these peels for a week under the sun shines and then placing them in the oven at a 60 ºC temperature were grinded by an electric food grinder *Figure 2*. Then sieve them by mesh to the size less than 250 µm.

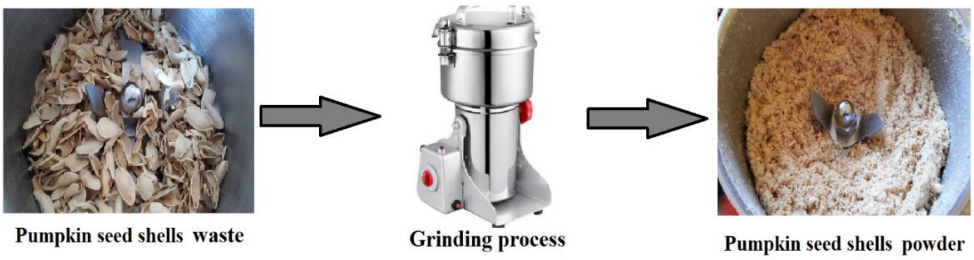


Figure 2. *Preparing pumpkin seed shell powder*

2.2. Preparation of the drilling fluid samples

Water-based drilling fluid was prepared with pumpkin seed shells as an additive in different concentrations by the weight of mud sample (1 wt%, 2 wt%, 3 wt%, 4 wt%, and 5 wt%). A single system of water-based drilling fluid consisting of water (base fluid) and bentonite (viscosifier agent) was used keeping in mind that this is strictly an index test for determining the effects of PSS in a base bentonite suspension. *Table 1* shows the formulation of the samples used in this study. Preparation was done by pouring 350 ml of water into a Hamilton Beach mixer, then adding 22.5 grams of bentonite and mixing for 20 minutes until the mixture was completely homogeneous. The drilling fluid was left to age for 24 hours to ensure the bentonite was hydrated in the water. Tests were conducted on six samples using different concentrations of PSS to determine their effect on the different properties of the drilling fluid and to determine the optimum concentration of the pumpkin seed shells.

Table 1

Mud formulation of water-based mud

Sample	1	2	3	4	5	6
Tap water (ml)	350	350	350	350	350	350
Bentonite (gr)	22.5	22.5	22.5	22.5	22.5	22.5
PSS (%wt)	–	1	2	3	4	5

2.3. Rheological testing

Figure 3 shows a multi-speed Fann 35 viscometer which was used to perform rheological tests that included measuring plastic viscosity (PV), apparent viscosity (AV), yield point (YP) and gel strength at 10 seconds, 1 minute and 10 minutes respectively. The device cup was filled with a designed volume of drilling fluid and then installed on the device after making sure that the clean and dry rotor was installed in the correct place. The viscometer was operated, and the readings were recorded at six different rotational speeds (600, 300, 200, 100, 6, and 3) [rpm], and this reading is it is the angular position of the torsion spring, and its unit is the degree of angular rotation. The plastic viscosity (PV) was calculated from the difference between reading at 600 [rpm] and reading at 300 [rpm] measured in [cp] unit. The apparent viscosity (AV) calculated by dividing the reading at 600 [rpm] by the number 2 measured in [cp] unit. As for the calculation of the yield point, it is the difference between the reading at 300 [rpm] and the plastic viscosity measured in [lb/100ft^2] unit. To measure the gel strength, the viscometer was turned on at 600 [rpm] for 10 seconds, then the viscometer was turned off for ten seconds. After that, the viscometer was restarted at 3 [rpm] and the maximum value that the viscometer index reached was recorded. This value indicates the gel strength, measured in [ml]. The process was repeated when the viscometer was stopped for 1 minute and for 10 minutes, each measured in [lb/100ft^2] unit.

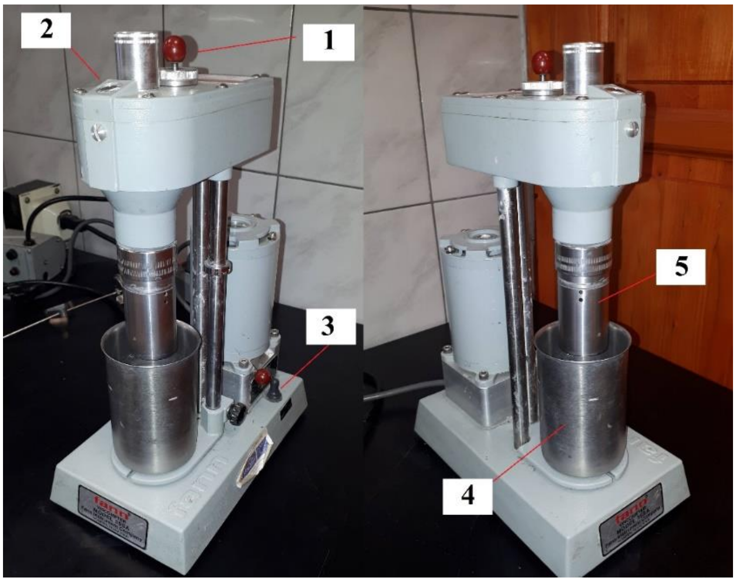


Figure 3. *Fann 35 Viscometer, Parts: 1. Gear shift knob, 2. Dial, 3. Motor speed switch, Sample cup, 5. Rotor*

2.4. Density testing

The density of the drilling fluid is measured using a mud balance *(Figure 4)*. The cup was filled with the drilling fluid to be measured, and a cup cover was placed which passes the drilling fluid from a hole in the middle of the cup cover to expel the excess amount of drilling fluid out of the cup. Once a balance was achieved between the cup of the device and the moving weight on the arm of the device, the density value was recorded from the ruler of the arm in ppg.

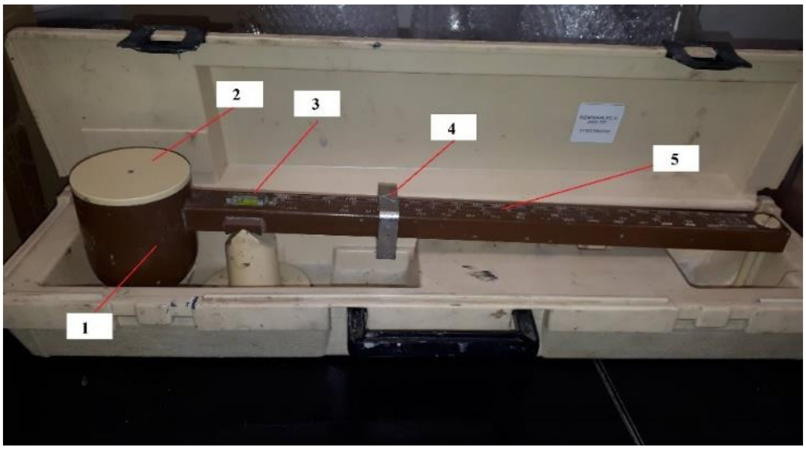


Figure 4. *Mud balance, Parts: 1. Cup, 2.cup cover, 3. bubble levelling, 4. moving weight, 5. Device arm*

2.5. Filtration properties measurement

API LT-LP press device was used to measure filtration properties *(Figure 5)*. The stainless-steel cell was filled with a sample of drilling fluid and the cover was tightly closed after making sure that the seal ring and filter paper are installed correctly. A pressure of 100 [psi] was applied on the cell and the filtrate was collected by a graduated cylinder placed below the cell and the amount of the filtrate was recorded at different times (1, 3, 5, 7.5, 10, 15, 20, 25, and 30 min) in ml. After that, the pressure was released, the cell was opened, the filter paper was taken out, and the thickness of the mud cake was measured on filter paper in three different areas, then the average value of the thickness was calculated in mm.

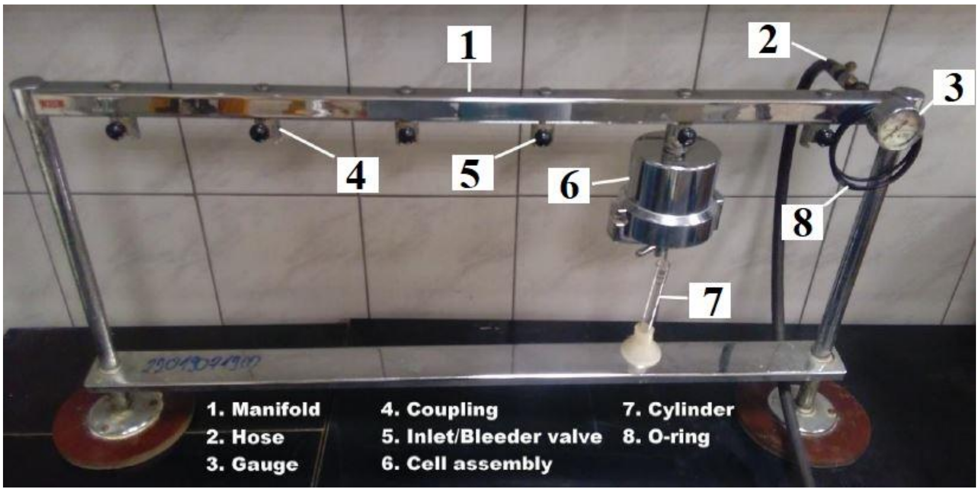


Figure 5
Multiple-unit filter press

3. Results and discussion

3.1. The effects of different concentrations of PSS on the rheology

To analyze the rheological properties of the drilling fluid, the samples were prepared by adding PSS. The concentrations which were used here are 1 wt%, 2 wt%, 3 wt%, 4 wt%, and 5 wt%. *Figure 6* represents the shear stress with shear rate. From *Figure 6* it is clear to say that the rheological model which best describes flow characteristics of tested muds is Bingham plastic fluids. An increase in PSS concentration led to increasing shear stress required to circulate the drilling fluid in the annulus. From analysing the results of the rheological test, it was found that increasing the concentration of PSS in the drilling fluid greatly improved the viscosity. *Figure 7* represents the plastic viscosity (PV) of drilling fluid with varying concentrations of PSS. It can be noticed that plastic viscosity increases with the concentration of PSS in the drilling fluid system until 4 wt% then decreases at 5 wt%, which means that using small proportions of PSS can improve the viscosity significantly, thus increasing the effectiveness of cleaning the well and suspend cuttings and weighting additives. In case if the viscosity is undesirably high viscosity thinners can be added to the mud to compensate. *Figure 8* shows that the apparent viscosity increases with increased concentration of PSS in the drilling fluid system. The same is true for the yield point: its value increases with the increase in the concentration of PSS, as shown in *Figure 9*. The gel strength also shows a gradual increase with the increase in the concentration of PSS as shown in *Figure 10*. This increases the ability of the drilling fluid to suspend the cutting when the circulation is stopped.

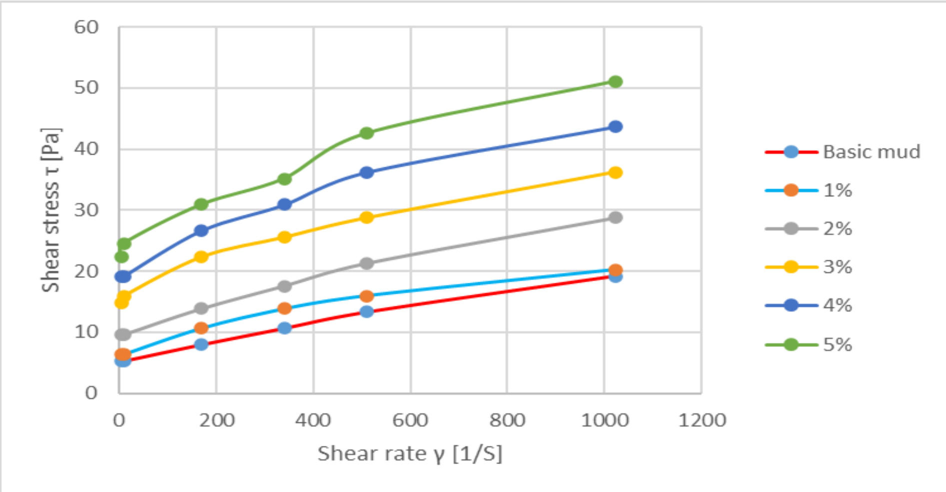


Figure 6. *Shear stress via. shear rate*

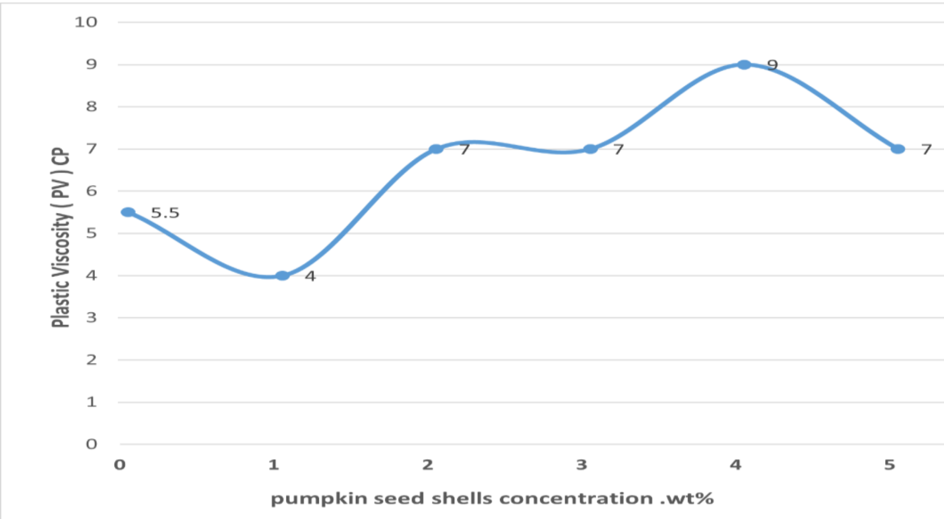


Figure 7. *Influence of PSS additive on plastic viscosity*

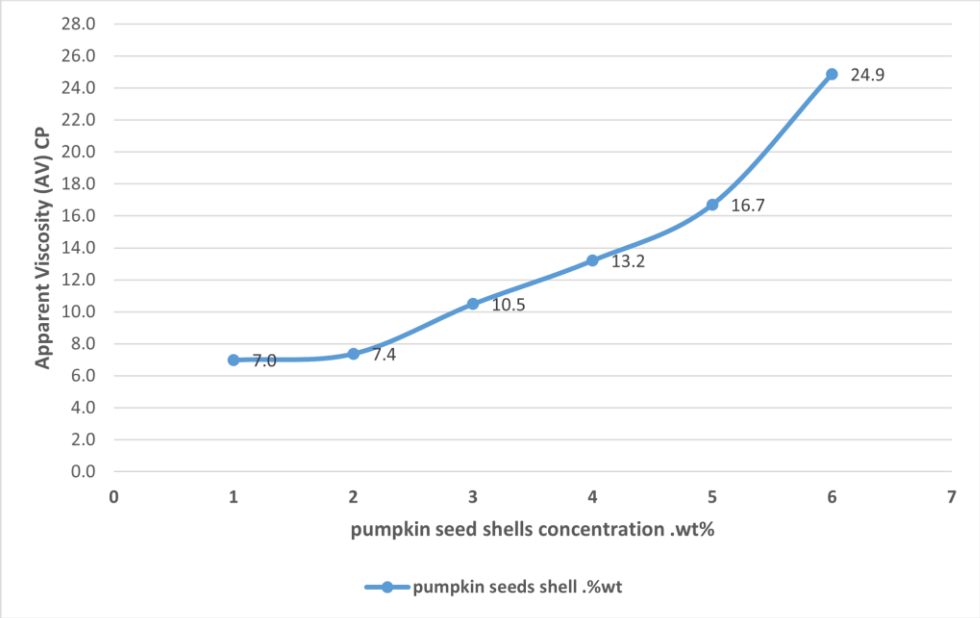


Figure 8. *Influence of PSS additive on apparent viscosity*

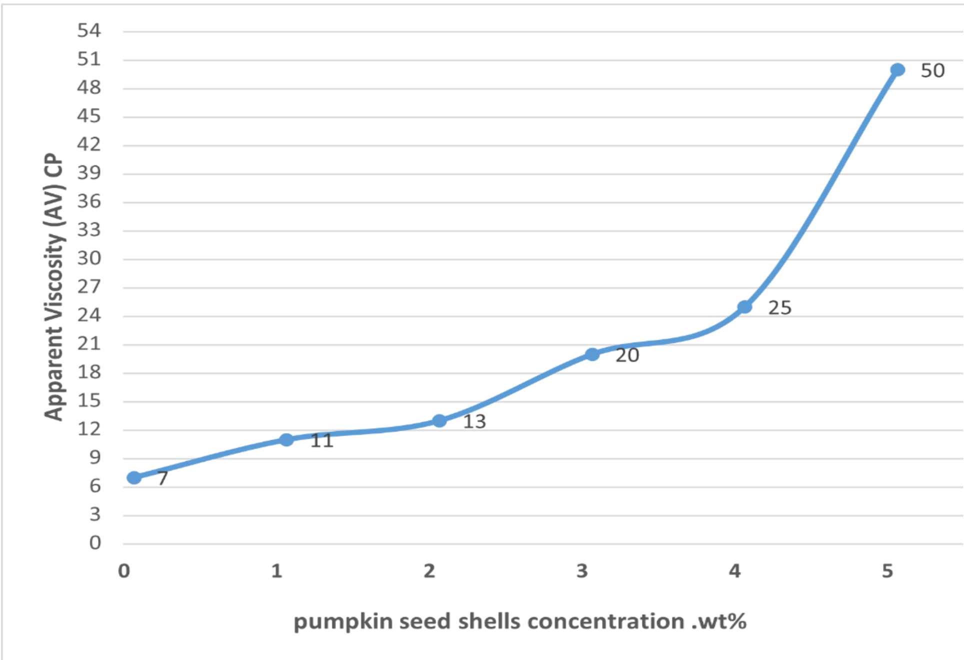


Figure 9. *Influence of PSS additive on yield point*

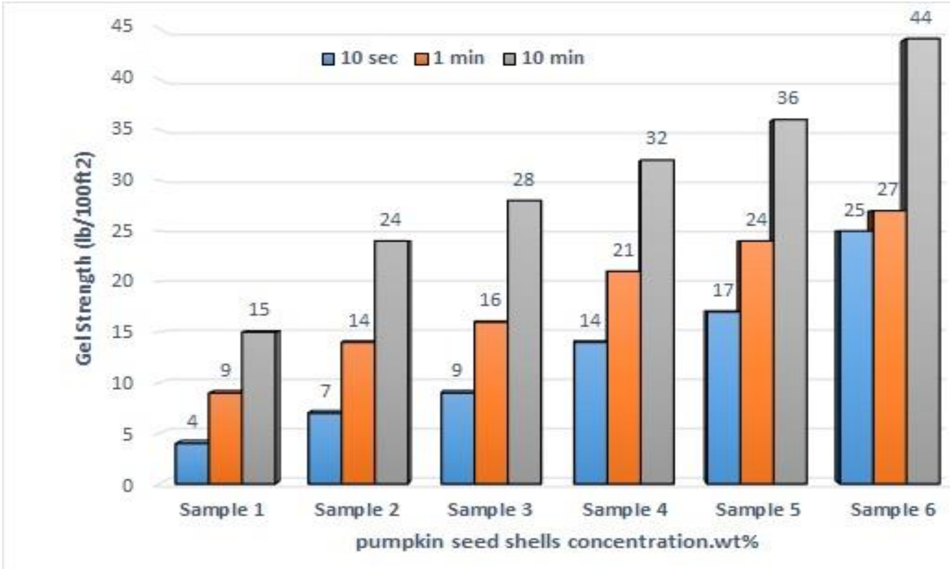


Figure 10. *Influence of PSS additive on gel strength*

3.2. The effects of different concentrations of PSS on the density

From *Figure 11*, it can be seen that there is no noticeable change in the density value after adding the PSS to the drilling fluid at different concentrations, which means that using the PSS as lost circulation material is a good option without exposing the well to the risk of breaking the formations by the extra weight of the drilling fluid.

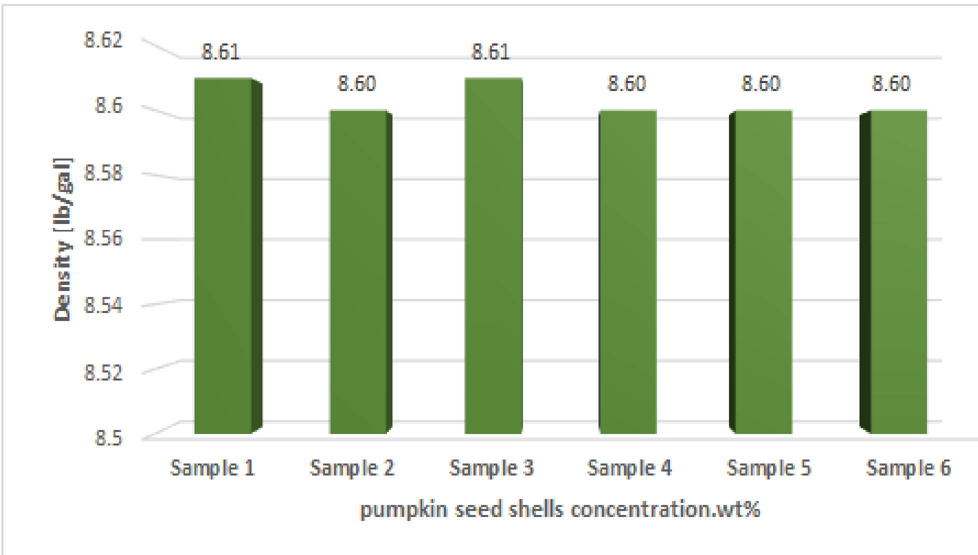


Figure 11. *Influence of PSS additive on density*

3.3. The effects of different concentrations of PSS on the filtration

Figure 11 presents the result of the filtration experiment using the API LT-LP press. The fluid loss test on all six samples was performed at room temperature. From the *Figure 12*, the effect of pumpkin seed shells on fluid loss property when added in different concentrations can be seen. As the concentration of the (PSS) increases, fluid loss continues to decrease. The volume of fluid loss with no added PSS (Sample 1-base mud) was 23.1 ml. From sample 2 it is shown that with the addition of 1 wt% of PSS the fluid loss was reduced to 19.6 ml. The lowest value of the fluid loss was for Sample 6, where the fluid loss decreased to 18.1 ml, which means that it decreased about ~22% from the original fluid loss value. Consequently, the addition of PSS reduces the contamination of the formations with the drilling fluid due to the low permeability of the mud cake, thus preserving the productivity of the production zones.

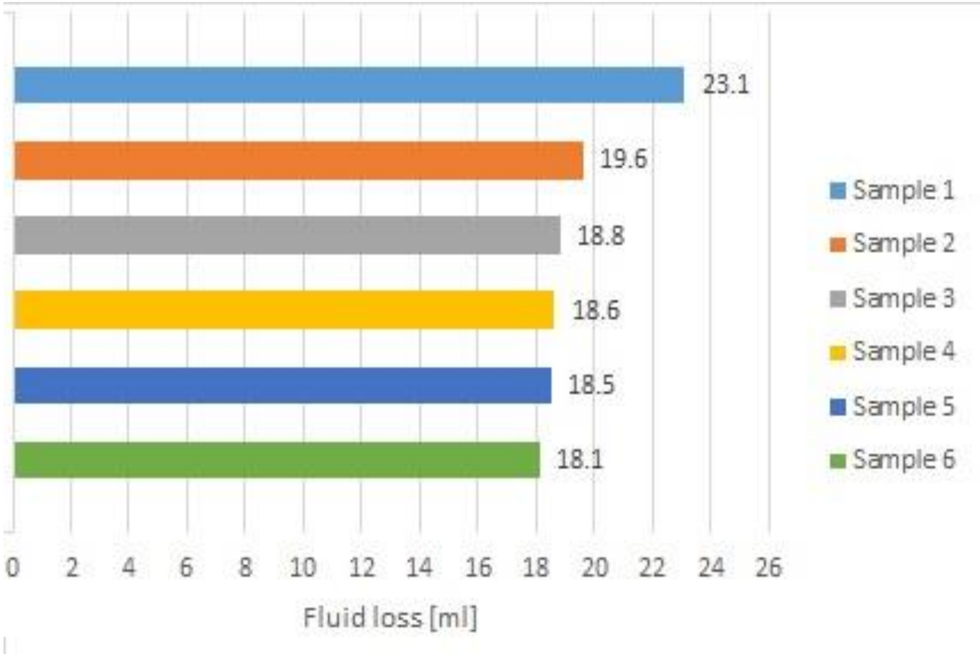


Figure 12
Effect of PSS additives on the filtration characteristics

Figure 13 shows that the cake thickness at 1 wt% remains the same as the sample with no PSS, at 1.9 mm. The thickness of the cake increases with further increase in concentration, reaching 2.3 mm. However, the cake thickness keeps growing with increasing PSS concentration, but the overall thickness grow is only 0,4 mm = 400 µm. The inserts in *Figure 14a* & *14b* shows the cake thickness of the original drilling fluid and after adding 5 wt% PSS.

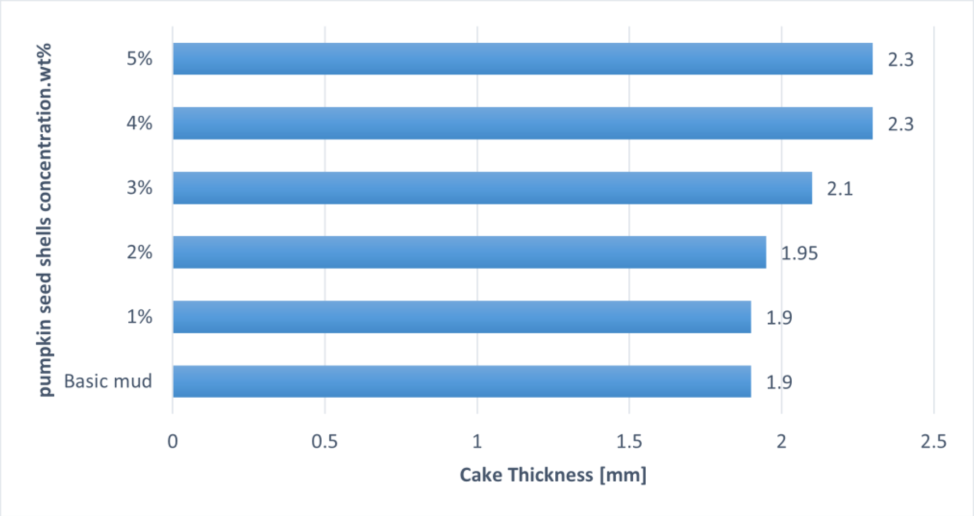
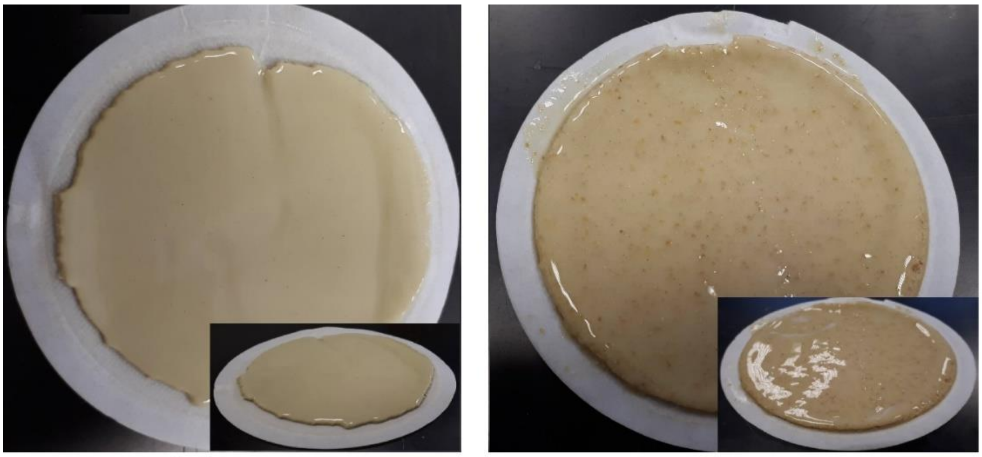


Figure 13. *The effect of PSS additive on the cake thickness*



(a) **(b)**

Figure 14. *The cake thickness of: (a) The original drilling fluid and (b) After adding 5 wt% of PSS*

4. Conclusion

A successful drilling operation requires minimizing fluid loss inside the formations. For this reason, many commercial materials such as carboxymethylcellulose (CMC) and polyanionic cellulose (PAC) have been used, which are very expensive and negatively affects the total cost of drilling in addition to their harmful environmental effects. In index study, pumpkin seed shells were used as an additive to control fluid loss in the water-based drilling fluid. Through experiments, the following conclusions were drawn:

- Increasing concentration of the pumpkin seed shells (PSS) will positively affect the reduction of fluid loss, which means that in this study 5% was the optimum concentration of the PSS.
- Adding PSS gives a mud cake with acceptable thickness and low permeability.
- The addition of PSS has no significant effect on density and increases the plastic viscosity, apparent viscosity, yield point and gel strength. Thus, compared to the original fluid, adding PSS may has a good ability to increase the effectiveness of cleaning the well, reduce many drilling problems such as high torque, and increase the ability of the drilling fluid to carry the cuttings when circulation of the drilling fluid in the well is stopped.

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