



Potato Starch for Enhancing the Properties of the Drilling Fluids

Amel Habeeb Assi

University of Baghdad / College of Engineering

Abstract

Different additives are used in drilling fluids when the demanded properties cannot be gotten with clays. Drilling muds need several additives and materials to give good characteristics. There are local alternatives more suitable for enhancing the rheology and filtration of drilling fluids. An experimental work had been conducted to assess the suitability of using potato starch to enhance rheological properties and filtration in drilling mud. This study investigated the potato starch as a viscosifier and fluid losses agent in drilling fluid. Results from this study proved that rheological properties of potato starch mud increased when pH of drilling fluid is increased. Potato starch could be used to enhance gel strength at low pH (approximately 8.6) and viscosifier at high pH mud (approximately 10.8). The experimental work shows that the optimum NaOH concentration was between (2-6) lb./bbl and if more than that concentration was used, the relation between pH and plastic viscosity would be inverted. Comparative analysis of mud properties obtained from the potato starch and starch at low pH showed good rheological properties of the starch than for potato starch, while at high pH, both of them nearly showed good rheological properties. In conclusion, potato starch reduced filtration rate of fluid and improved the characteristics and consistency of mud cake as a primary function and showed an effect on the fluid rheology as a second function.

Keywords: starch, mud, filtration, rheology, potato starch.

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1- Introduction

A few years ago, used fluid was dumped in an open pit, polluting the natural environment and towns. Really, this is no longer acceptable, and the drilling fluid must be disposed of in a manner where there is no pollution of the environment or towns. Chemicals used in drilling mud may be polluting the environment as well, generating a wide of environmental problems. Natural additives or native drilled solid are incorporated into the drilling fluid for viscosity, weight, and fluid losses control. They are often used with bentonite to enhance stability and fluid losses control [1]. The drilling mud additives are responsible of enhancing optimizing and drilling efficiency and stability. Keeping the proper viscosity and pH is very important step during the drilling process [2].

In oil and gas processes, sodium hydroxide is an important material to maintain the integrity of water – based drilling mud. In oil well drilling NaOH neutralizes gasses in rock formations, increases the viscosity of drilling mud, and is a good source of hydroxyl ions which leads to control pH. That increase in viscosity would prevent heavy materials from settling down in bore hole [3]. Various materials, chemicals and polymers are used in mud formulation to convene different practical mud requirements such as density, rheology and fluid losses control.

One of such starch materials, starch (polymers) used for fluid loss control or as viscosifier, forms the basis of many studies [4].

Several corn based starch additives using local resources to study their suitability to use as drilling fluid additives have been developed [5].

Starch was considered as the first of the organic polymer which was used in substantial quantities in drilling mud. Beginning in 1939 with salt water drilling fluid in West Texas, '09 starch was used for controlling of filtration spread rapid rather than the other areas and applications wherever drilling fluid problems related to filtration were experienced [6]. The use of starch typically causes temperature stability at (225°F), a minimal increase in viscosity while effectively controlling fluid loss [7].

Experimental results indicate that some of newly developed starch products have similar or better filtration control properties than the filtration control properties of the widely used imported starch [8].

Thus, it is imperative to source locally available drilling fluid materials and evaluate their various characteristics, then determine fluid that can be used in drilling process.

This study tends to investigate the determination of drilling fluid used as locally sourced material and in turn reduce the overdependence of some imported very expensive viscosifiers.

2- Experimental Work

2.1. Materials

a. Potato Starch

A potato starch is a substance which extracted from potatoes. A cell of root tubers of potato plant contains starch grains. To get the starch, the potatoes are crushed and the starch grain is released from the destroyed cells. Starch is then washed out and after that dried to powder to use it [9]. Fig. 1 illustrates molecular structure of the potato starch.

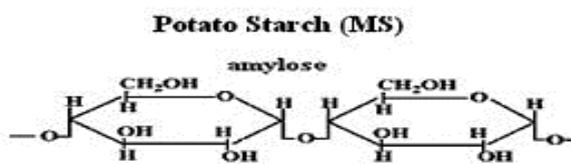


Fig. 1. Molecular structure of potato starch [6].

b. Sodium Hydroxide NaOH

The used name is caustic soda, its color is white; deliquescent; beads, pellets, flakes, very strong irritant to tissues. This material is used in water base muds for increasing pH; to solubilize lignite, lignosulphonate and tannin substances; to prevent corrosion, on the other hands to neutralize the hydrogen sulfide. Caustic soda is experimentally added in concentration between 0.2-4 lb. /bbl. NaOH is hazardous substance to handle because it is so caustic and generate off heat when dissolved in water. Caustic soda should be added carefully and slowly. The amount that required increasing the pH range depends upon the type and concentration of drilling mud components [6] The used Sodium hydroxide was purchased from India.

c. Starch

Starch purchased from china is considered as a natural polymer which is primarily used for drilling purposes in brine fluids at relatively low temperature. Starch is considered as one of a few materials unaffected by water salinity.

The thermal degradation of starch begins at about 180°F and increases to be a prohibitive rate at a temperature of 250°F. The Starch should be used in concentrations between of 2 to 6 lb. /bbl. Because of its viscosity building ability; it is always used as a good source for regulating both viscosity and fluid-loss.

Starch is subjected to bacterial degradation and should be used with a preservative saturated salt fluid or at pH value equal to 11.5, and in fresh water where the chloride concentration is below 10,000 ppm [10], [11].

Fig. 2 shows the molecular structure of starch. The used starch is manufactured in India.

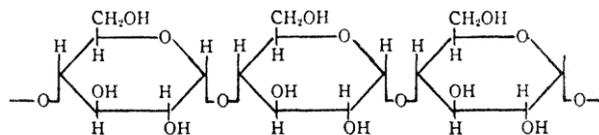


Fig. 2. Molecular structure of starch [6]

2.2. Devices

a. PH Meter

The control on drilling mud properties is dependent on the pH value. In other words, the detection and treatment of contaminants like cements during cementation and the soluble carbonates. pH also affects the solubility of a wide thinners types and divalent metal ions like calcium and magnesium, and influences the dispersion and flocculation of the clays types. pH meter(Model 603 SE) manufacturing in America is an electric device, consists of utilizing glass electrodes for measuring the potential difference which indicated directly as digital signal of pH of the drilling fluid. The pH meter is considered as the most accurate device for measuring pH of drilling muds [6], as shown in Fig. 3.



Fig. 3. pH meter

b. Mud Balance

Density is used for controlling the hydrostatic pressure. Mud density is measured by using mud balance. The mud balance is always calibrated with fresh water and it must give the reading of 1 gm. /cc. Mud density test is conducted by using the mud balance tools. The mud balance consists of base and a balance arm with cup, lid, knife edge, rider, level glass, and counterweight. The cup is attached to one end of the balance arm and the counterweight is at the other end of the mud balance [6].

The mud balance was manufactured by fann (model 140) manufacturing in America, as shown in Fig. 4.



Fig. 4. Mud balance

c. Viscometer

The Rheological property is measured by using viscometer 8 speed (model 800) manufacturing in America. This device is commonly used for indicating solids buildup, flocculation or deflocculation of drilling fluid, and it helps for calculating the hydraulics of drilling muds [12], as shown in Fig. 5.

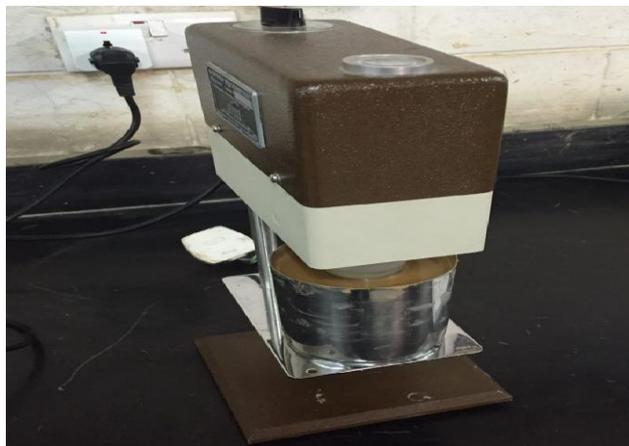


Fig. 5. Viscometer

d. The Dead Weight and Hydraulic Filter Press

Is one of Series 300 Filter Press equipped with a Dead-Weight Hydraulic tool [6] as shown in Fig. 6.



Fig. 6. The Dead Weight and Hydraulic Filter Press

2.3. Method

This study involves two major experimental work, namely the preparation of the used drilling raw material "potato starch" and the rheological and filtration tests of the drilling muds.

a. Preparation of drilling raw material "potato starch"

The procedure of preparing potato starch:

- 1- Potatoes were washed by water to clean them from muds and other things.
- 2- Potato were cut in to small pieces and put in the mixer with amount of fresh water

- 3- A piece of clean cloth was used as a filtration paper, and then the potatoes were put and squeezed it in a bowl.
- 4- After the potato starch has been squeezed, wait 40 min to make starch settle in the bottom of the bowl.
- 5- Potato starch was dried carefully by using a dryer (model SYH-1307) which was manufactured in India to prevent any loss with air because of the fine particles of potato starch. After following the above steps, the result is as shown in Fig. 7.



Fig. 7. The Potato starch preparation

3- Results and Discussion

3.1. The Rheological and Filtration Tests of the Drilling Mud

a. Potato Starch Effect In Bentonite Mud

The compositions of drilling fluid samples were prepared in standard 350 ml laboratory barrel. In other words, each 1 gm. of material was added to 350 ml. of fluid and this was equivalent to add 1 pound of material to 1 barrel of fluid. This mixture consists of 350ml water, 22.5gm red bentonite, and 1, 2, 3 gm. of potato starch and then we add NaOH to show the effect of pH value on the potato starch as shown in Table 1 and Table 2.

Table 1. Potato starch mud properties

ϕ	Shear Rate	Blank Mix	Potato starch 1gm	Potato starch 2gm	Potato starch 3gm
RPM	Sec ⁻¹	lb./100Ft ²	lb./100Ft ²	lb./100Ft ²	lb./100Ft ²
600	1021.8	28	30	31	38
300	510.9	23	24	25	31
200	340.6	21	22	25	30
100	170.3	20	20	23	28
60	102.18	17	19	22	28
30	51.09	16	18	22	27
6	10.218	14	18	22	27
3	5.109	12	18	22	27
PV		5	6	6	7
Yp		18	18	19	24
pH		8.6	8.64	8.67	8.67
ρ (gm./cc)		1.05	1.05	1.051	1.052
7.5min Filter size cc		12	11	10	10
mud cake		2mm	1.5mm	1.5mm	1.35mm
Gel 10 sec		13	18	21	23
Gel 10 min		16	23	26	29

Table 2. Potato starch mud properties with 4 gm. NaOH

Φ	ShearRate	Potato starch +4gm NaOH	Potato starch 1gm +4gm NaOH	Potato starch 2gm +4gm NaOH	Potato starch 3gm +4gm NaOH	Potato starch +4gm
RPM	Sec ⁻¹	lb./100Ft ²	lb./100Ft ²	lb./100Ft ²	lb./100Ft ²	
600	1021.8	54	74	81		
300	510.9	44	61	66		
200	340.6	40	56	59		
100	170.3	37	50	50		
60	102.18	34	47	49		
30	51.09	27	44	44		
6	10.218	17	38	41		
3	5.109	11	18	21		
	PV	10	13	15		
	Yp	34	48	51		
	pH	10.82	10.82	10.85		
	ρ (gm/cc)	1.06	1.061	1.063		
	7.5min					
	Filter size	8.75	6.9	6		
	cc					
	mud cake	1.25 mm	1.25mm	1mm		
	Gel 10 sec	18	16	15		
	Gel 10 min	16	17	18.5		

b. The Effect of Adding Potato Starch on Density Of Drilling Fluid

As shown in Table 1 there is no significant effect of adding potato starch on density of drilling fluid because of the low specific gravity of potato starch.

c. The Effect of Adding Potato Starch on Gel Strength of Drilling Fluid

The gel strength is a measure of the thixotropic behavior of mud. Thixotropy is the ability of the mud to form a gel structure when it is at rest and then it becomes fluid again once agitated. The gel strength is a measure of the stress required to break a gel structure under static conditions. It is also a measure of the same particle-to-particle forces that is determined by the yield point except that the gel strength is measured under static conditions and the yield point is measured under dynamic conditions. Potato starch can be used to enhance gel strength at low pH, while after adding NaOH the gel structure build up slowly not like that in the sample without NAOH. The reason behind that is after adding NaOH some bubbles or foam has been created and that will lead to weaken the ability of drilling fluid to form gel structure. As shown in Fig. 8.

d. The Effect of Adding Potato Starch on Plastic Viscosity of Drilling Fluid

Before adding NaOH, the effect of potato starch on plastic viscosity was small. In contrast, after adding NaOH, the effect of potato starch on plastic viscosity was significant as shown in Fig. 9. In other words, the potato starch affected the drilling fluid properties at high PH.

e. The Effect of Adding Potato Starch on Yield Point of Drilling Fluid

The value of yield point is low before adding NaOH, whereas the value of yield point is improved after adding NaOH, as shown in Fig. 10.

The reason behind that is the increase in the yield point is dependent on the type of solids present and their respective surface charges, the concentration of these solids, and the type and concentration of other ions or salts that maybe present.

f. The Effect of Adding Potato Starch on Filtration

Potato starch control on filtration by viscosifying the water phase to restrict fluid flow through the filter cake is by hydrating, swelling and plugging pores in the filter cake. In other word, it builds viscosity in order to control fluid loss. Fig. 11 and Fig. 12 clarify that adding potato starch led to good filtration control.

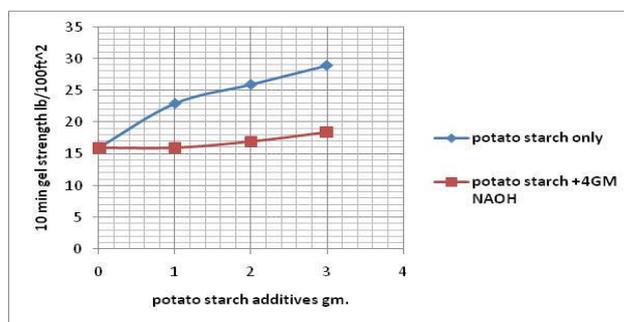


Fig. 8. The effect of potato starch on 10 min gel strength.

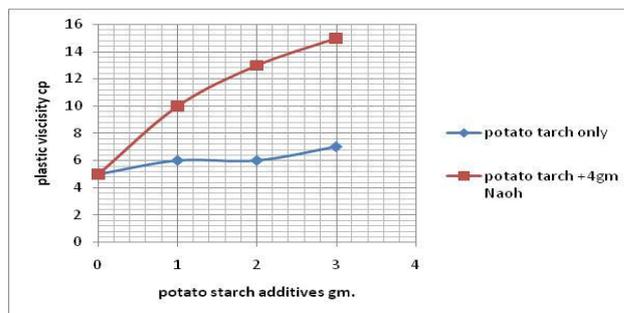


Fig. 9. The effect of potato starch on plastic viscosity.

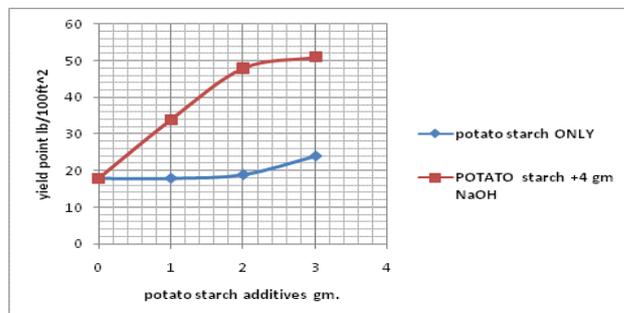


Fig. 10. The effect of adding NaOH to the potato starch on the value of YP

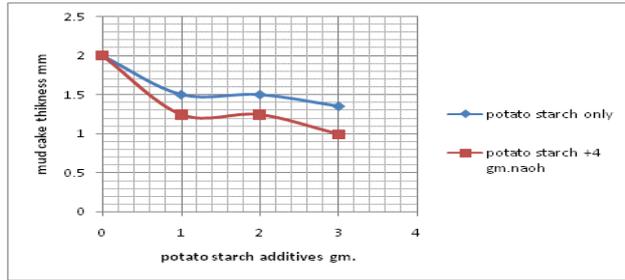


Fig. 11. The effect of potato starch on mud cake thickness

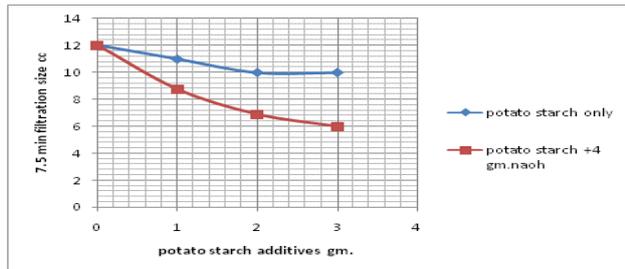


Fig. 12. The effect of potato starch on mud cake filters size.

3.2 Comparison Between the Potato Starch and Starch

The Potato starch contains typical large oval spherical granules; its size ranges between 5 and 100 μ m. Potato starch has very refined starch, containing minimal protein or fat. This gives the powder a very clear white color, and the cooked starch has typical characteristics of the neutral taste, good clarity, high binding strength, and the minimal tendency to make foaming. Thomas had been developed method, based on the reaction rate kinetics, to determine the rate of decomposition at various values of temperatures. By this means he proved that the temperature of decomposition of the starch was till about 225 °F (107°C). In other words, he founded that the thermal stability of starch is about 225 °F (107°C) [13].

From the other hand the thermal stability of potato starch is 250°F [14]. Four samples of drilling fluid were prepared the first :22.5 gm. red bentonite +350 cc water+ potato starch additives, the second sample 22.5 gm. red bentonite +350 cc water+ potato starch additives+4gm NaOH, the third sample was 22.5gm red bentonite +350 cc water+ starch additives, the last sample was 22.5gm red bentonite +350 cc water+ starch additives+4gm NaOH. Experimental work was proved that starch appeared better rheological properties than potato starch without NaOH. After adding NaOH the potato starch showed nearly the same rheological properties of starch as the following:

a. Plastic Viscosities

Before adding caustic soda to starch, it showed values of plastic viscosity greater than potato starch and as shown in Fig. 13. After adding caustic soda the pH reached approximately to 11 and the potato starch showed good values of plastic viscosity, but the starch still better than potato starch as shown in Fig. 14.

b. Yield Point

The values of yield point of starch were higher than those of potato starch, but after adding NAOH both starch and potato starch showed nearly the same values of yield point, as illustrated in Fig. 15 and Fig. 16

c. 10 min Gel Strength

At low pH (approximately 8.5) potato starch samples were better than starch samples. In contrast, at high pH starch samples were better than potato starch samples, as shown in Fig. 17 and Fig. 18.

d. Filtration Size and Mud Cake

Both of starch and potato starch reduced filtration losses at low and high pH .The reason behind that was reduced filtration which was the primary function of those materials as shown in Fig. 19 and Fig. 20.

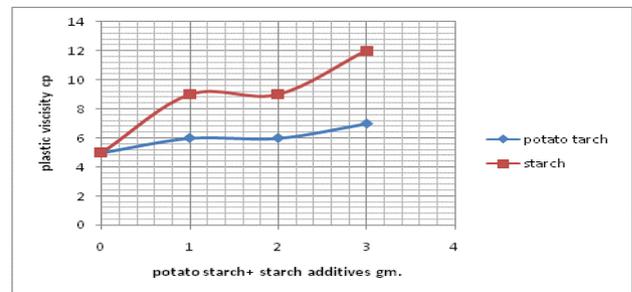


Fig. 13. The effect of potato starch and starch on plastic viscosity without NaOH

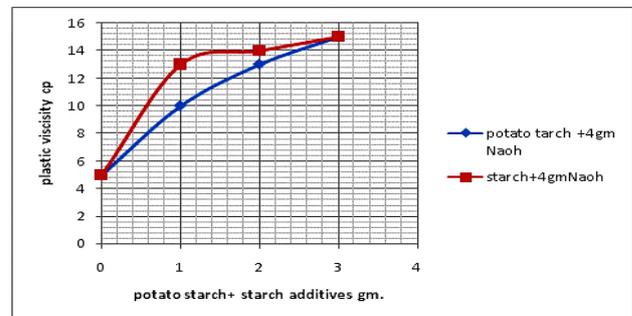


Fig. 14. The effect of potato starch and starch on plastic viscosity with NaOH

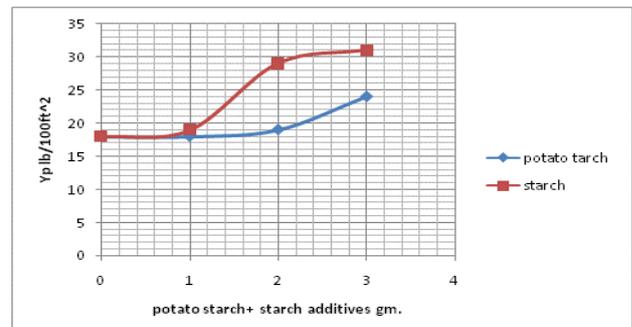


Fig. 15. The effect of potato starch and starch on yield point without NaOH

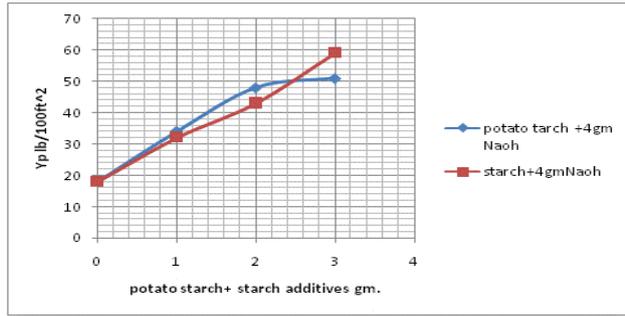


Fig. 16. The effect of potato starch and starch on yield point with NaOH

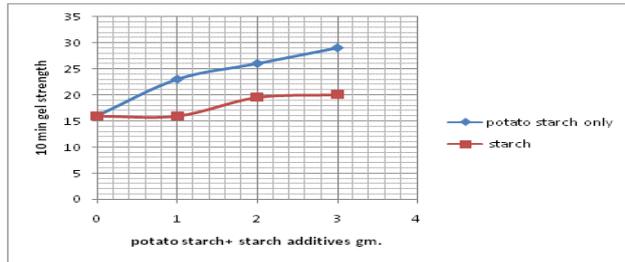


Fig. 17. The effect of potato starch and starch on 10 min gel without NaOH

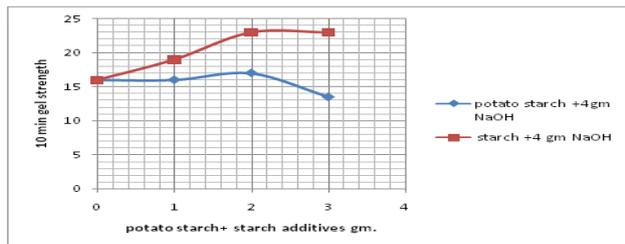


Fig. 18. The effect of potato starch and starch on 10 min gel with NaOH

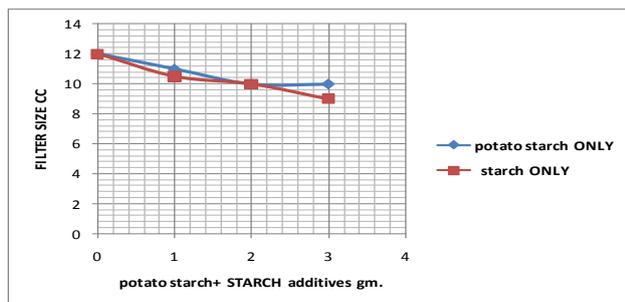


Fig. 19. The effect of potato starch and starch on filter size without NaOH

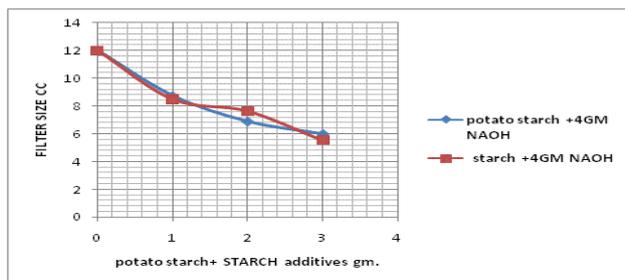


Fig. 20. The effect of potato starch and starch on filter size with NaOH

After reviewing the prices of materials that can act as additives, it was found that potato starch was the cheapest in Iraqi market, as shown in Fig. 21.



Fig. 21. The price of potato starch and other polymers in Iraqi market until 2017

3.3. Effect of Ph on Potato Starch Mud

It was found that High concentrations of caustic soda led to make high-pH mud which has some desirable features in drilling that are, low value gel strength and high plastic viscosity. As shown in Fig. 22, the relation between concentrations of caustic and plastic viscosity showed good increment when the caustic concentrations were between (0.5-6) lb. /bbl. After that, the concentration relation would be inversed. The interpretation is flocculated mud, increase in viscosity .Flocculation means a thickening of mud due to edge to edge or edge to face association of the clay particle. Flocculation was also caused by high concentration of active solids or by high electrolyte concentration and high temperature. When an electrolyte is added to the drilling fluid, the double layers of clay are compressed, then the particles can approach to each other very closely that attractive forces predominates.

This phenomenon is named as flocculation. High degree of flocculation means high particle attractive force. The structure of drilling mud become stronger if the flocculation is accompanied by aggregation. Conversely, the deflocculating of mud causes a decrease in plastic viscosity, as illustrated in Fig. 18 the deflocculated starts when the concentration of caustic soda was between (6-10) lb. /bbl. [6].

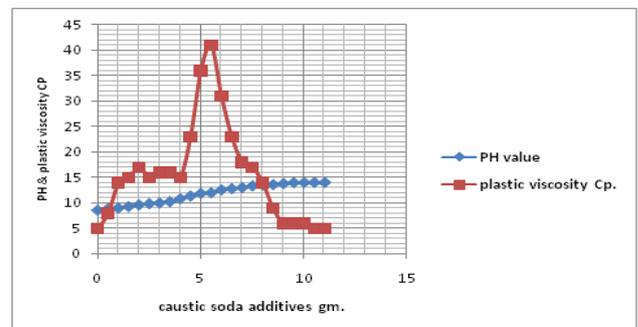


Fig. 22. The effect of adding NaOH on the value of plastic viscosity and PH

4- Conclusions

- 1- Addition of potato starch to bentonite mud led to little increase in PV, YP but after adding NaOH to increase pH, the effect of potato starch appeared clearly by high increase in PV, YP. As result the potato starch was effective at high pH media.
- 2- Adding potato starch led to decrease filtration at low and high pH. Potato starch could be used to enhance gel strength at low pH and viscosifir at high pH value and filter loss additives in all cases.
- 3- Potato starch retained fluid better than other starches due to the large size of its molecules.
- 4- According to reviewing the prices of polymers and starches in Iraqi markets until 2017, potato starch was the cheapest.
- 5- The experimental work clarified that, at low pH the starch showed good rheological properties than potato starch, while at high pH, both of them nearly showed good rheological properties.
- 6- Results from this study have shown that high concentrations of caustic soda led to make high-pH mud which has some desirable features in drilling that are, low value gel strength and high plastic viscosity. The relation between concentrations of caustic soda and plastic viscosity showed good increment when the caustic concentrations were between (0.5-6) lb. / bbl. After that, the concentration relation would be inversed. The interpretation of this behavior is flocculated mud.

Nomenclature

- PV: plastic viscosity
 Yp: yield point
 Rpm: revolution per minute
 lb.: pound
 Gal: gallon
 bbl.: barrel

References

- [1] Rabia H."Oil well drilling engineering principles and practice" , Graham and Trotman publishing Co.,1985 PP.197
- [2] Gallus, J. P., "Method for Drilling with water base mud," U.S. Patent No. 3,040,820,June 26, 1962.
- [3] Continual chemical, "Sodium Hydroxide in the oil and gas industry" , report, USA,2018.
- [4] [Hudson ,T.&Coffey,M."Fluid Losses Control Through the use of a liquid thickened completion and work over brine",journal of petroleum technology,1983,vol35,no.10,pp1776-1782](#)
- [5] [Amanullah ,M.,Marsden J."An experimental study of swelling behavior mud rocks in the precence of drilling mud system" , 1997,Canadian Journal of petroleum tech. vol36,no.3,pp45](#)
- [6] Darley H.CH. and George R.Gray "Drilling Fluid Composition", 5th edition, golf professional publishing ,1988.PP.165-170
- [7] [Ademiluyi, T., Joel, O. "Investigation of local polymer as a suitable for imported sample in viscosity and fluid loss control of water based drilling mud",2001,ARNP Journal of engineering and applied science. Vol.6, no.12.](#)
- [8] [Egun,I.& Achandu,M. "Comparative performance of Cassava starch to PAC as fluid loss control agent in water base drilling mud",2013,Discovery.vol.3,no.9,pp1-4](#)
- [9] EBIC. Oil Field Equipment"fluid losses control aid for water based drilling fluids",2015
- [10] Amoco Production Company, "Drilling Fluids Manual" (PDF), 1990.
- [11] Grey and Darley "handbook of oil based mud technology" 1992,pp.152
- [12] Baroid drilling handbook. Houston, TX 77251, 1998 Baroid Drilling Fluids, Inc.pp.22
- [13] [Thomas, D. C., "Thermal Stability of Starch and Carboxymethyl Cellulose-Based Polymer." Soc. Petrol. TechnoL J. April, 1982. pp. 171-180.](#)
- [14] [Ewa rudnik ,et all "Thermal stability and degradation of starch derivatives", journal of thermal analysis and calorimetry.,2006.](#)

نشا البطاطة لتحسين خواص سوائل الحفر

الخلاصة

يتم اضافة بعض المواد الى سائل الحفر وذلك للحصول على الخواص المرغوبة لسائل الحفر والتي لا يمكن الحصول عليها باستخدام طين الحفر العادي بنتونايت وماء. بمعنى اخر يتم اضافة تلك المواد للحصول على خصائص جيدة لسائل الحفر. توجد العديد من البدائل المحلية و التي تستخدم لتحسين خواص سائل الحفر الريولوجية والترشيح. سلسلة من التجارب العملية تم اجراؤها لبيان مدى امكانية استخدام نشا البطاطة لتحسين الخواص الريولوجية والترشيح لسائل الحفر. اظهرت النتائج بانه يمكن استخدام نشا البطاطا لتحسين الخواص الريولوجية والترشيح لسائل الحفر ولكن عندما تكون قيمة القاعدية لسائل الحفر عالية تقريبا 10.8 فان فعالية وعمل نشا البطاطا في التأثير على اللزوجة والترشيح يكون اكثر. والعكس صحيح في حالة التأثير على مقاومة الجل حيث عندما يكون مقدار القاعدية لسائل الحفر قليلة تقريبا 8.6 فان مقاومة الجل تكون جيدة اما عند القاعدية العالية فان المقاومة تقل. اثبتت التجارب المختبرية بان التركيز المثالي لهيدروكسيد الصوديوم هو من (2-6) باوند لكل برميل لانه اذا استخدمنا اكثر من هذا التركيز فان العلاقة بين اللزوجة وتركيز هيدروكسيد الصوديوم تكون عكسية. تم عمل دراسة تحليلية وتجريبية للمقارنة بين ادائية البطاطا ونشا البطاطا وكانت النتائج كالتالي: عندما يكون قيمة القاعدية قليلة فان النشا هو افضل من نشا البطاطا في التأثير على خواص سائل الحفر. اما في حالة القاعدية العالية كلا النشا ونشا البطاطا كان لهما نفس الادائية. نتيجة لذلك يمكن القول بان نشا البطاطا يمكن استخدامه كاحد الاضافات في سائل الحفر حيث يعمل كمقلل ترشيح وتحسين تماسكية كيكة الطين كوظيفة اولية ويحسن بعض الخواص الريولوجية لسائل الحفر كوظيفة ثانوية.