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Studying the Effects of Different Polymers on Rheological Properties of Water Base Muds

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ABSTRACT

This research is focusing on finding more effective polymers that leads to enhance the rheological properties of Water Base Muds. The experiments are done for different types of mud for all substances which are Polyacrylamide, Xanthan gum, CMC (Carboxyl Methyl Cellulose). This study shows the effect of add polymer to red bentonite mud, effect of add polymer to Iraqi bentonite mud, the effect of add bentonite to polymer mud. The mud properties of Iraqi bentonite blank are enhanced after adding the polymers to the blank mix, CMC gives the highest value of plastic viscosity and Gel strength than others; X-anthan gives the highest value of yield point and gel strength than others. For the red bentonite mud, Polyacrylamide has the highest shear stress and yield point than the others polymers, but Xanthan has the highest effect on plastic viscosity than other polymers. All polymers reduce filtration loss. The polymer solution mud failed to suspend the barite so we cannot use it as drilling fluid even so this mud has good Rheological properties (PV and YP). The maximum amount of each polymer is founded for the studied clay types.

Key words: polymer, rheological properties, bentonite, drilling fluid.

دراسة تاثير مختلف البوليمرات على الخواص الريولوجية لسوائل الحفرالمائية القاعدة

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يوجد العديد من البوليمرات التي تستخدم لتحسين الخواص الريولوجية لسوائل الحفر المائية القاعدة وهدف هذا البحث هو ايجاد المواد الاكثر تاثيرا على تلك الخواص.تمت التجارب باستخدام ثلاثة بوليمرات وهي كاربوكسي مثيل سيليلوز،الزنثان،البولي اكريلمايد .كل تلك المواد لها تاثير على الخواص الريولوجية بنسب مختلفه ومفعول مختلف ويرجع السبب في ذلك لاختلاف تلك المواد في خواصها الفيزيائيه والكيميائية. بداية استخدمنا بوليمر +ماء بحيث كانت نسبة المادة الصلبة قليلة جدا لكن هذا النوع فشل في تعليق البارايت لهذا التجئنا الى اضافة البنتونايت الى البوليمر والعكس صحيح.النتائج اظهرت بان كل من الزنثان و البولي اكريلمايد هما الاكثر تاثيرا على الخواص الريولوجيه لسوائل الحفر وكان الكاربوكسي مثيل سيليلوز هو الاقل تاثيرا .كذلك تم دراسة الخواص الريولوجية للبنتونايت العراقي حيث انه بعد اضافة تلك البوليمرات للبنتونايت العراقي لاحظنا تحسن كبير في خواصه الريولوجيه والترشيح .كذلك تم دراسة تاثير اضافة البنتونايت الى البوليمر (طين الحفر ذا المحتوى القليل من المواد الصلبة)،وكذلك تم دراسة الخواص الريولوجية لسائل حفر مكون من بوليمر وماء فقط ومدى امكانية استخدام هكذا نوع من سوائل الحفر.اقصى كمية لكل بوليمر تم ايجادها من خلال التجارب لكل نوع من انواع البنتونايت المدروسة.

الكلمات الرئيسية : بوليمر،خواص ريولوجية،بنتونايت،سائل حفر.

1. INTRODUCTION

Rheology is the learning of the twist and movement issues. Revision of rheology is significant because it permits the drilling fluid to be explicitly analyzed in expressions of fluid current profile, viscosity, pressure losses, hole cleaning capability, equivalent circulating density and the well bore hydraulics. Rheological properties of a mud are those properties which define the flow features of a mud under several flow circumstances. In a mud circulating structure, flow happens at a variation of amounts in conduits of dissimilar sizes and forms**, Ogbeide, and Igbinere, 2016**. In order to recognize or guess the effects of that flow, we need to distinguish the flow performance of the mud at the numerous topics of interest in the circulating system. To shorten the measurement way, we create only a restricted number of measurements. When a mud flows, it employs a frictional drag – termed shear stress on the surface of the channel. The amount of the shear stress is governed by the frictional drag between neighboring "layers" of nearby layers along the wall of conduit **Winson, 1956.** The variance in velocities between adjacent layers is titled shear rate. We are involved at effect of the flow at the wall anywhere both shear rate and shear stress are full **Bourgoyne, 1986.** To competition the supplies of dissimilar depth intervals, the properties of drilling mud are adapted by using many additives for the drilling mud **Dhiman, 2012.** Polymers are extended series organic molecules prepared from linking together minor molecules known as monomers. They is an elastic with tall molecular weight ranging between $2*10^6$ to $21*10^6$ gm. /mole **Scanley, 1959.** Three kinds of polymers are used at this study, CMC**,** Xanthan gum, Polyacrylamide, and, those totals produce from China. Iraqi bentonite and commercial bentonite likewise used in this study.

2. TOOLS AND APPARATUS

2.1Mud Density

The density is measured to governor subsurface pressures and for stabilizing the wellbore pressure. Drilling fluid density usually measured by using mud balance. The mud balance adjusted with fresh water and must provide reading of 8.3 lb/gal. The mud density check conducted via mud balance, **Darely, 1988.**

2.2Measuring (PH)

PH Meter: is one of many electrical devices using a glass electrode for measuring the potential variance and point out directly by dial reading the PH. of the mud. The PH meter is considering the best exact way of assessing PH **Amoco, 2009**.

2.3 Drilling Fluid Rheology Check (Mud Viscosity, Mud Yield Point Mud Gel Strength):-

The viscometer is used for measuring the values of shear rate/shear stress of a mud sample from which the Bingham Plastic factors, PV and YP, are calculated easily. This device is likewise used for measuring thixotropic belongings "gel strengths". The viscosity knows as the confrontation of the fluid to movement and is also stately as the relationship of shearing stress and rate of shearing strain, **Amoco, 2009** The Plastic Viscosity (PV) and Yield Point are calculated from the 600-RPM and 300-RPM dial readings as follows and as in Eq. (1) and Eq. (2) **Amoco, 2009**:

$$Pv = \Theta 600 - \Theta 300 \quad (1)$$

$$Yp = 2 * \Theta 300 - \Theta 600 \quad (2)$$

Where:
PV = plastic viscosity (cp)
Yp= yield point (lb/100ft.^{2})
600,300 RPM dial reading = direct reading from viscometer.

3. MATERIALS

3.1 Commercial Bentonites and Iraqi Bentonite:

Those clays used in drilling fluids are naturally occurring clays and are founded in a lot of zones of the world. They enclose the clay mineral and could have addition minerals for example quartz, mica, feldspar and calcite**.** Red bentonite is consisting of three layers swelling clays. Red bentonite is furthermost major form is calcium, but also there is sodium. This clay has the capacity to hydrate in the existence of water; these bentonites are used to viscosify the muds. Sodium bentonite is found absolutely in the northwestern zone of the United States, is the maximum commonly desirable bentonite because its hydration capability is considerably better than that of calcium bentonite. It can be say that the term of premium bentonite is known to sodium bentonite. Because of the operating need of using bentonite differs from one place to another through the globe, API recognized specifications for covering sodium and calcium bentonites, **Rabia, 2010** and as shown in **Fig. 1.** A rock sample of Iraqi bentonite was sourced and collected from west of Iraq, Anbar, Trefawi.

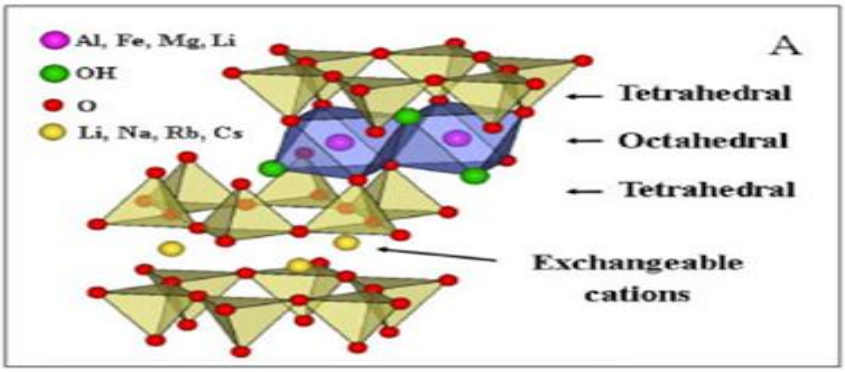

Figure 1. Structure of bentonite**, Rabia, 2010.**

3.2 Carboxyl Methyl Cellulose (CMC) HOCH2COONA:

If the cellulose is re-joined with sodium monochloroacetate, a sodium methyl acetate group is exchanged on one of the three hydroxyl groups and as shown in **Fig.2**. The grade of replacement (DS) mentions to the quantity of hydroxyl collections upon which exchange happen divided by the amount of repeating items in the molecule. The degrees of changeover will variety from zero to a full of three. Commonly the CMCs have DS in the variety of 0.4 to 0.8 with 0.45 existence demanded for better solubility. Grade of polymerization (DP) will variety from 500 to 5000. The polymers with the greater DP will impart more viscosity to the fluid. The High value of DS may be giving more acceptances to salts and action pollution. The Thermal degradation is more than 250°F **Max, 1974**.

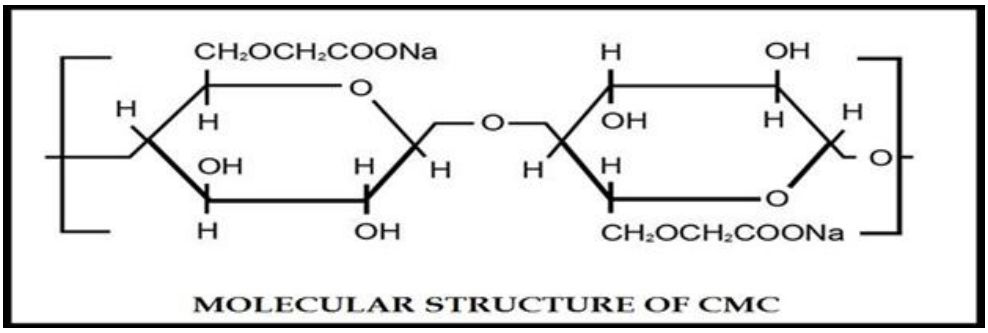

Figure 2.Structure of CMC. **Max, 1974**.

3.3 X-anthan C35H49O29

Xanthan is a biopolymer, is a produce from the act of bacteria (Xanthomonas Campestris) on sugar. This polymer is used in at a differen range of brines and salinity ranks. Xanthan reduce thermally at temperatures of above 225°F. Xanthum gum is the lone polymer that is responsible for thixotropy, in other words creation of gel structures. This polymer is an exceptional additive for enhancing the drilling mud. Its exclusive high viscosity at little shear could support little concentration of mud for hang solids. Even at extraordinary temperature and great concentration solution of acid, alkali, salt, Xanthan gum still could keep those properties. This is exclusively of Significant at offshore drilling and other harsh Xanthan gum is suitable for the *tertiary* oil retrieval and improved oil recovery .circumstances

through oil production. Its strong heat struggle belongings create it be a dependable moving agent and mobile governor manager **Rabia, 1985. Fig.3** illustrated the Molecular structure of Xanthan.

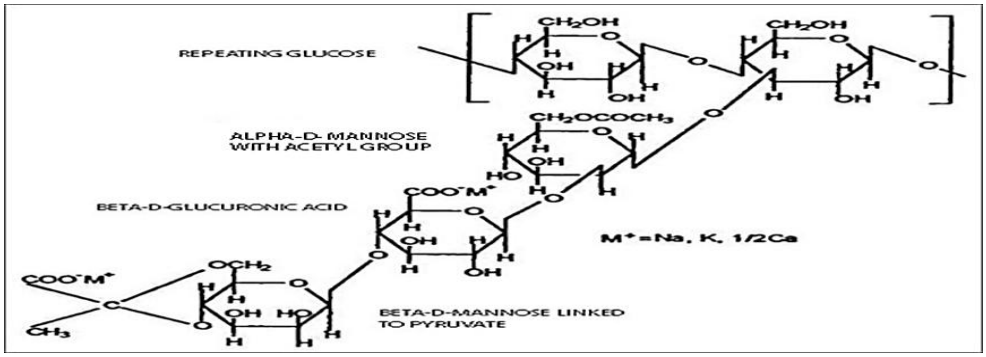

Figure 3. Molecular structure of Xanthan**, Rabia, 1985.**

3.4 Polyacrylamide ("PAM") (C3H5NO):

Polyacrylamide is a water-soluble polymer formed from acrylamide (a compound with the molecular formula C3H5NO) subunits and as shown in **Fig.4 .**This polymer is the most frequently used for rising the viscosity of water or drilling fluid (creating a thicker solution) or for inspiring the flocculation of atoms existing in the water. Polyacrylamide is synthetic chemical which could be tailored to appropriate a wide variety of requests, **Darely, 1988.**

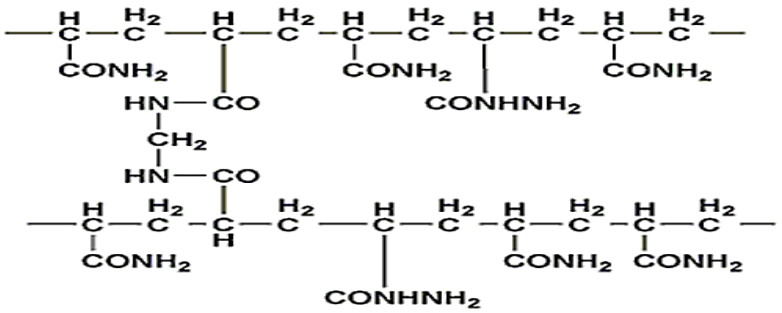

Figure 4. Molecular structure of Polyacrylamide. **Darely1988.**

4. PREPARING OF DRILLING FLUIDS:

Structures of drilling fluids samples are set in typical 350 ml research laboratory. In other meaning, both 1 gm. of any used material is supplementary to 350 ml. of the fluid and this equal to add 1 pound of additives to 1 barrel of the fluid .The rheological factors for example, plastic viscosity, yield point, gel strength of wholly o drilling muds are measured by using table summarizes the properties of drilling fluid at different concentration of polymers. The bentonite sample is prepared by mixing 22.5 gm of bentonite into 350 cc of water. The mixture is stirred for 10 minutes to achieve homogeneity. The bentonite and sample is then stored at room temperature in closed container for 24 hours. The X-anthan gum is added to the previous sample at different concentrations (1 gm., 2gm, 3gm, and 4gm ….etc. The procedure was then repeated for Polyacrylamide polymer and CMC.

5. RESULTS AND DISCUSSION:

5.2 Polymer +Water (Polymer solution): - The mixture consists of 350cc water with 2, 4 and 6 gm. of polyacrylamide, x-anthan, CMC consequently, and as shown in **Fig.5, Fig.6, and Fig.7and Fig.8.** Add of polymer to water lead to increase in shear stress and PV and YP in each addition of CMC, Xanthan gum, Polyacrylamide. The polyacrylamide has the largest effect on shear stress, then xanthan gum after both the CMC, which has the lowest effect. In 2gm additives Xanthan Gum has the largest PV and the lowest YP; while in 6gm additives the polyacrylamide has largest PV and the lowest YP. This type of mud failed to suspend the barite so we cannot use it as drilling fluid even so this mud has good Rheological properties. This type of mud has very low density also the filtration is very high and without mud cake. This type of mud hasn't ability to create gel strength. In other words we cannot use in drilling process.

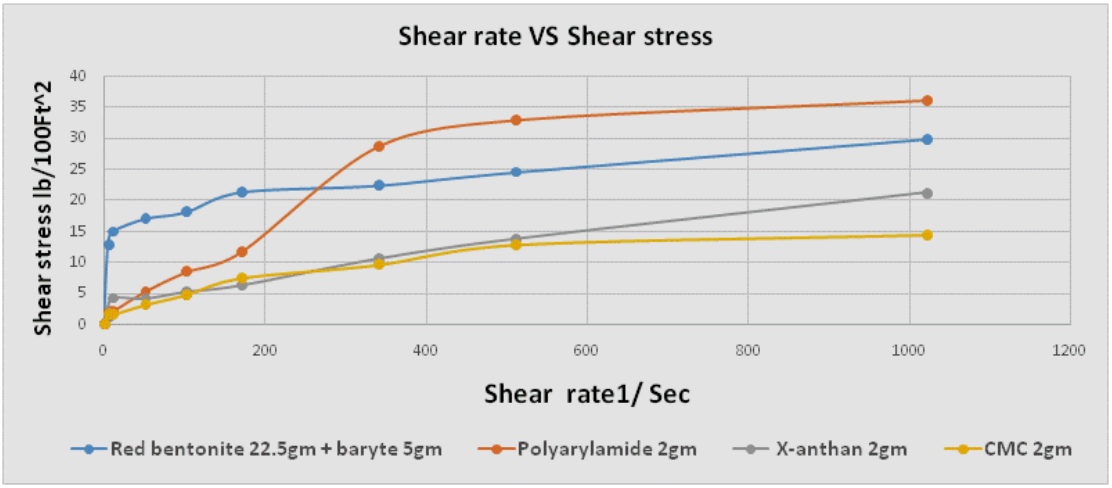

Figure 5. Shear rate .vs. Shear stress for Polymer mud 2 gm of CMC,X-anthan and poly.

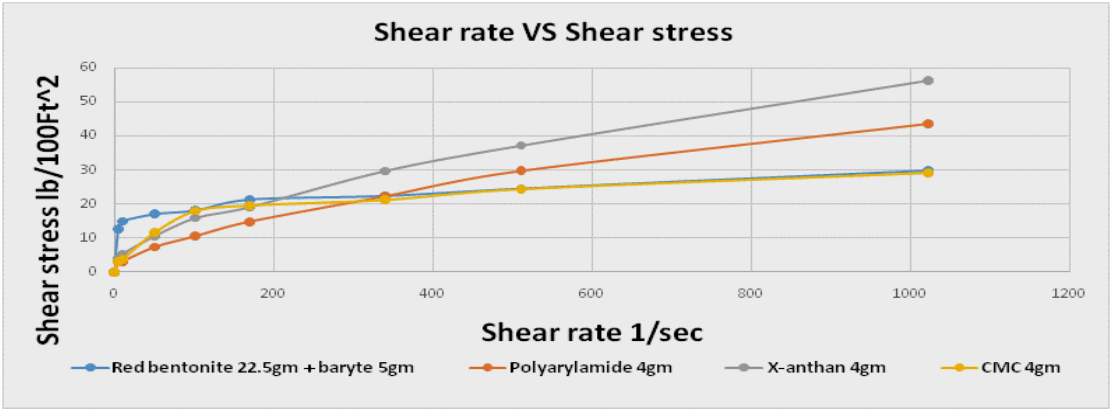

Figure 6. Shear rate .vs. Shear stress for Polymer mud 4 gm of CMC, X-anthan and poly.

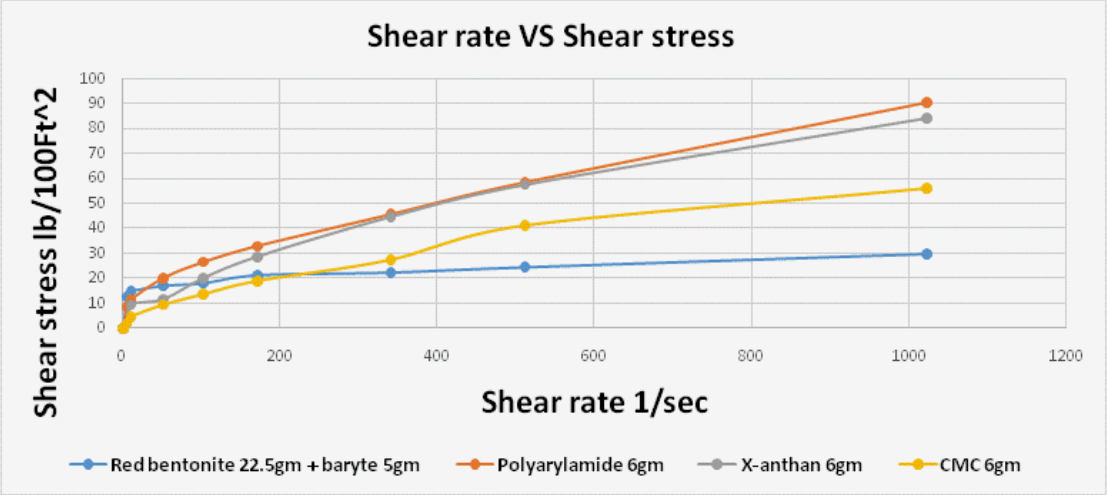

Figure 7. Shear rate vs. Shear stress for Polymer mud 6 gm of CMC, X-anthan and poly.

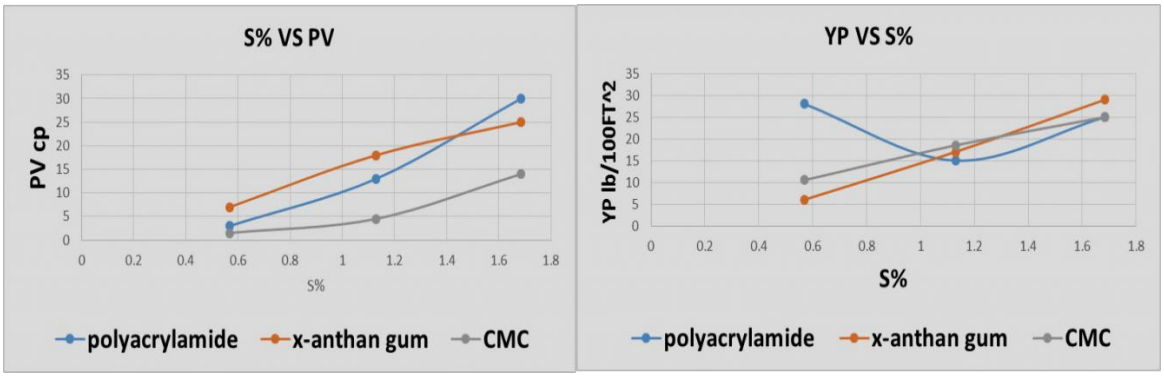

Figure 8. PV vs. %S and YP .vs. %S for Polymer mud.

5.2 Effect Of Adding Red Bentonite To Polymer Mud (Low Solid Mud)

The word of low solid mud is not applied for every specific configuration. Somewhat it has been practical to the number of composition which used chemical and mechanical ways to keep the lowest practical solid content. **Wheless, 1990** determined from his clarifications and observations of the drilling periods on field improvement wells in Ark-La-Tex area that buildup of drilling solids in the drilling fluid slow down the rate of penetration. Tow mixture are used as low solid mud; the first mixture consists of 1gm polyacrylamide, with 2, 4 and 6gm of bentonite as shown in **Fig. 9**. In addition, the second mixture consists of 1gm x-anthan, with 2, 4 and 6gm of bentonite as shown in **Fig.10.** Addition of bentonite to polymer leads to increase shear stress, Pv and reduce filtration. The experimental work shows that the polyacrylamide has not ability to suspend barite particles therefore adding bentonite is necessary to suspend the barite particles and the lowest weight of bentonite that lead to suspend barite is 6gm.The filter cake thickness is 1mm for the first mixture.While with xanthan gum the bentonite is more stable with a lowest percent than with polyacrylamide. In other words adding 2gm of bentonite lead to increase in PV, YP, and Gel and reduce filtration. The mud cake thickness for the second mixture is 1.5 when 6gm of bentonite is added.

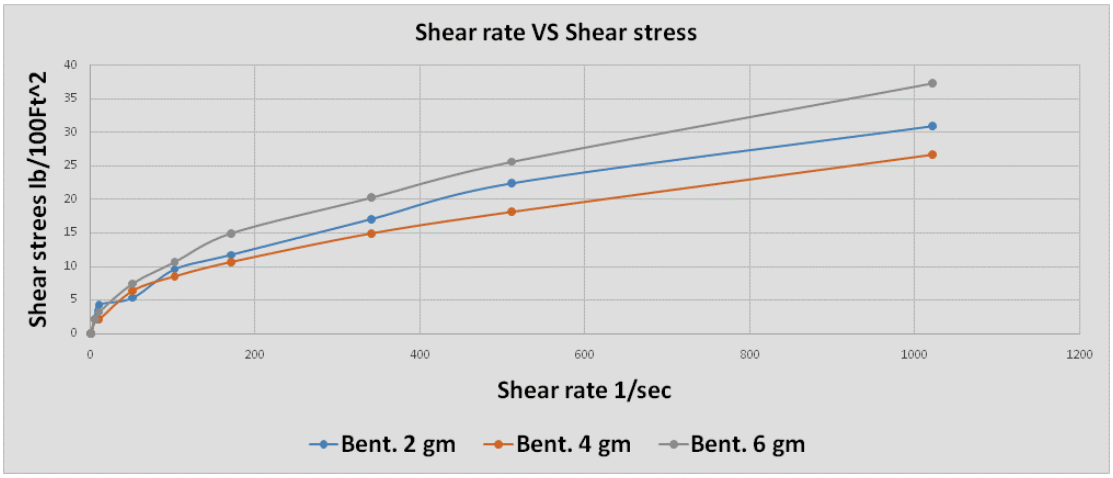

Figure 9. Shear rate .vs. Shear stress for Add Red Bentonite to polyacrylamide.

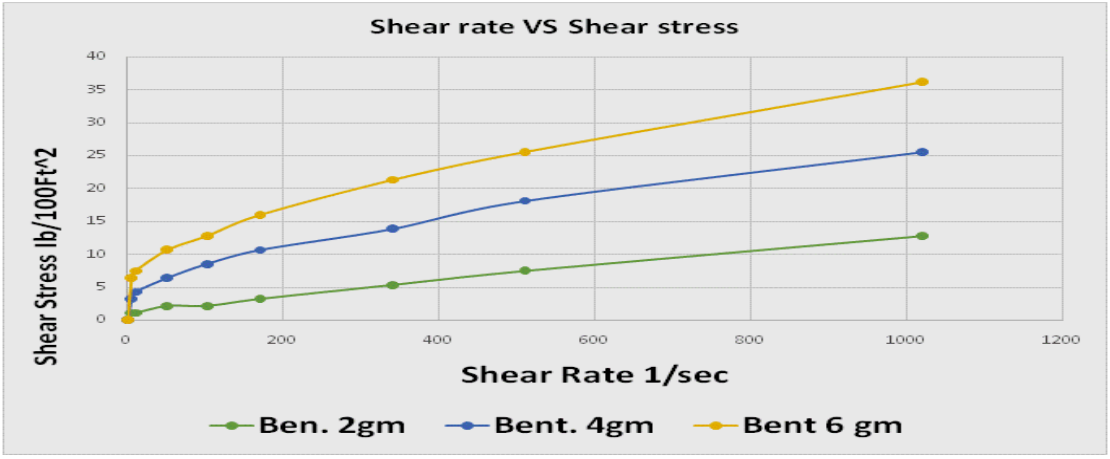

Figure 10. Shear rate .vs. Shear stress for Add Red Bentonite to X-anthan.

5.3Effect of Adding Polymer to the Red Bentonite Mud (Polymer Mud):

The mixture consists of 350cc of water, 22.5 gm. bentonite, and additives **and as shown in Figs.11, 12, 13, 14 and 15,** and illustrated in **Tabel.1** .The used polymers are CMC, Xanthan and Polyacrylamide. From our results, it can be notice that adding polymer to red bentonite mud lead to increase PV, YP, and Gel and decrease filtration loss. The effect differs among polymers where polyacrylamide has the highest shear stress and Yp than the others polymers, but Xanthan has the highest effect on PV than other polymers. All polymers reduce filtration loss. CMC and Xanthan increase gel strength more than polyacrylamide, which show the lowest effect on gel strength so it can use as visosifier. Also, the limit of add polymers can be determine by add more solid by weight (S%), until viscometer reading get out of scale reading such as polyacrylamide and xanthan. where they gives out of scale reading when 4gm of each one is added to blank mix as shown in the below tables; while CMC is 5gm to give out of scale reading. So the maximum amount of polyacrylamide and xanthan is 3gm for 350 cc of water and 22.5 gm. Of red bentonite and the maximum amount of CMC is 4gm for350 cc of water and 22.5 gm.

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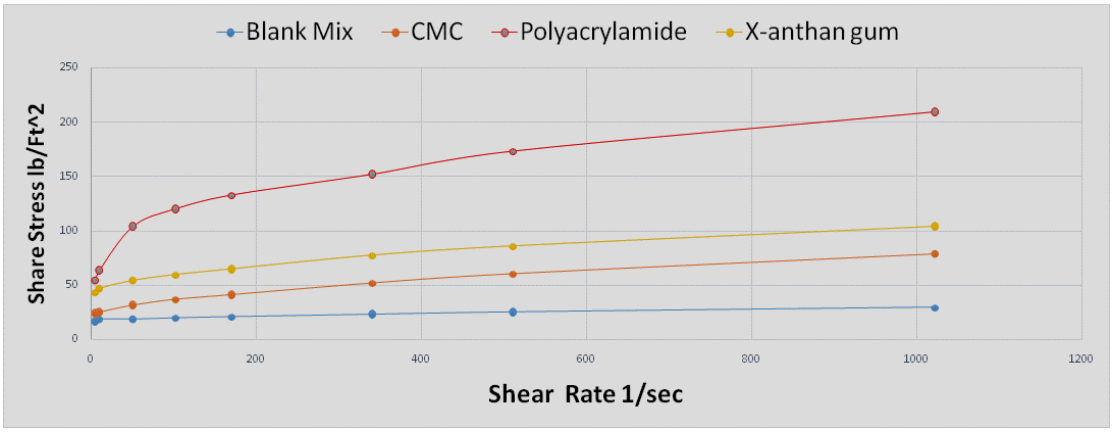

Figure 11 . Shear rate .vs. shear stress Effect of add (1gm) of polymer on the red bentonite mud.

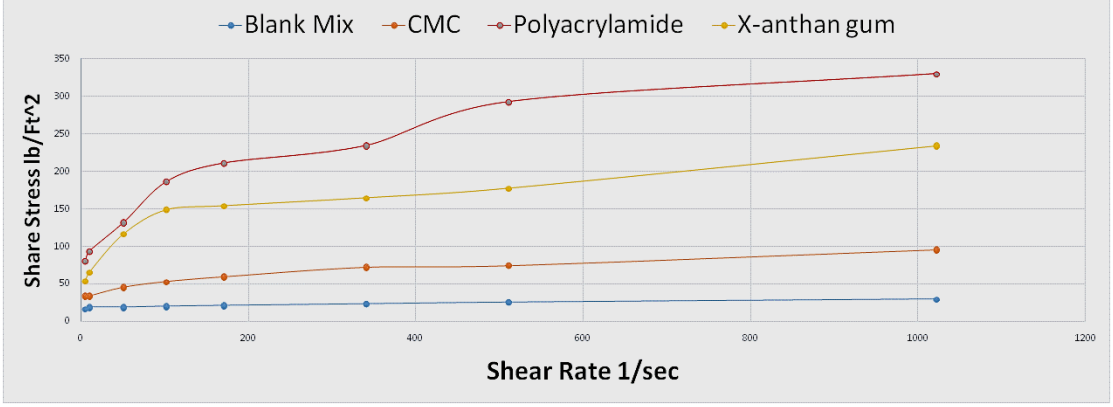

Figure 12. Shear rate .vs. shear stress Effect of add (2gm) of polymer on the red bentonite mud.

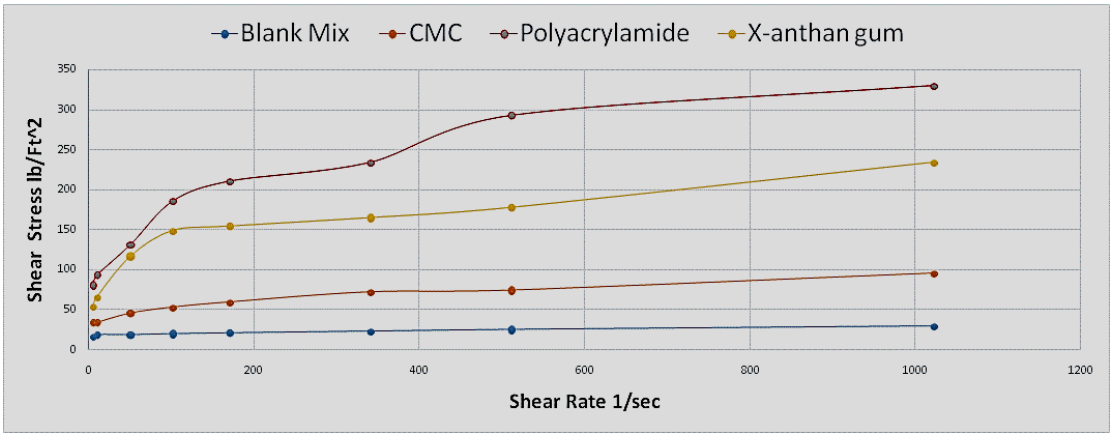

Figure 13. Shear rate .vs. shear stress Effect of add (3gm) of polymer on the red bentonite mud.

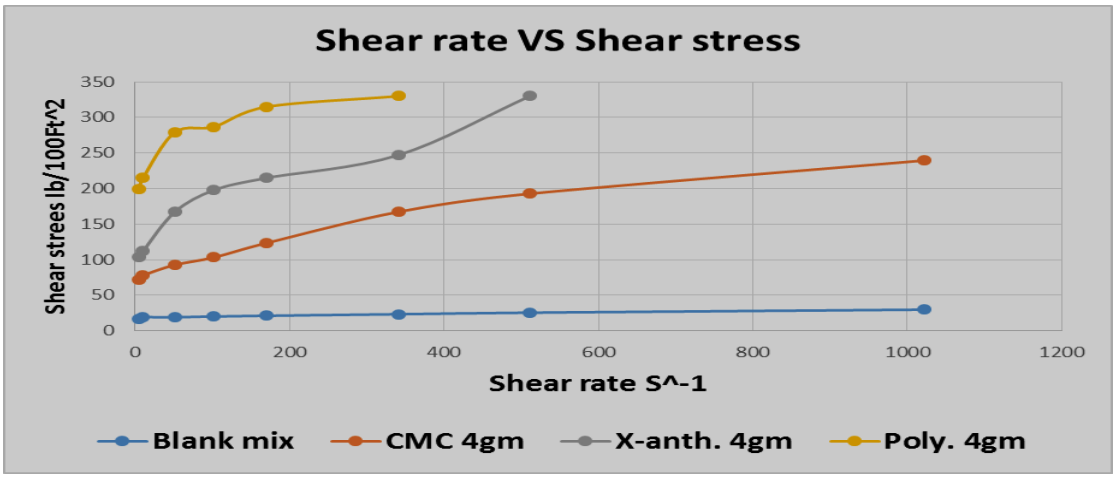

Figure 14. Shear rate vs. shear stress Effect of add 4gm of polymer on the red bentonite mud.

Table 1. Effect of add polymer on the red bentonite mud.

property	CMC 1gm	CMC 2gm	CMC 3gm	CMC 4gm	X-anthan 1gm	X-anthan 2gm	X-anthan 3gm	polyacylamide 1gm	polyacylamide 2gm	polyacylamide 3gm
pv (cp)	17	20	39	44	17	53	76	34	35	40
yp	40	50	79	140	64	114	112	129	245	259
10 sec Gel	24	26	57	69	38	64	92	48	54	61
10 min Gel	46	61	90	105	42	87	137	53	59	67
PH	8.45	8.5	8.54	8.76	8.57	8.49	8.63	8.53	8.52	8.78
filter size cc	8	6.5	5	4.45	7.5	6.2	5.2	6.9	5.5	5

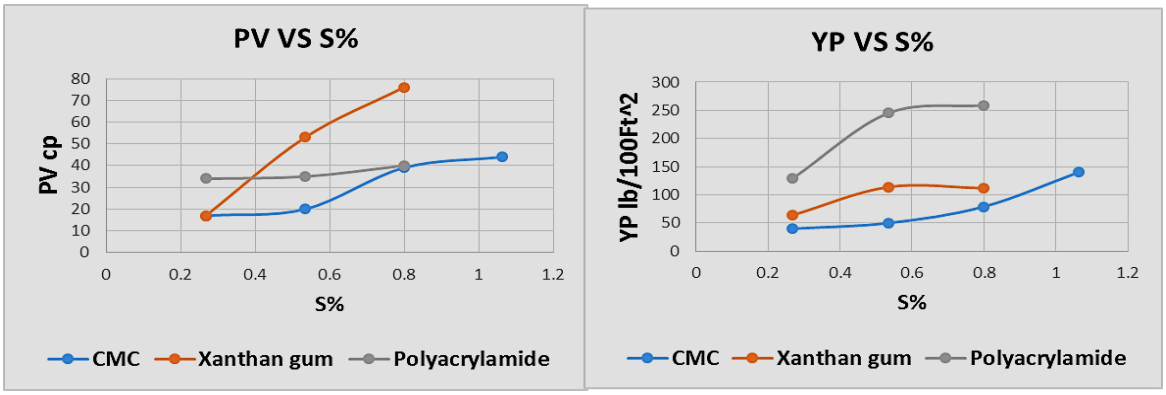

Figure 15. Pv .vs. %S and YP .vs. %S for polymer on the red bentonite mud.

5.4 Effect of Polymers Additives on Iraqi Bentonite Mud:

The mixture consists of 350cc of water, 22.5gm of Iraqi bentonite and polymers additives**.** The polymers can used to enhance the rheological properties of Iraqi bentonite mud. The three used polymers are (CMC, polyacrylamide, Xanthan gum). The blank mix show very low values of shear stress, gel, PV,YP ,it cannot be used it in drilling process. But after adding the polymers to the blank mix all the mud properties is enhanced. We found that there are increase in the values of shear rate and PV, YP and Gel but with different values depend on the polymer type and solids by weight (S %), and as shown in **Fig.16, Fig.17, Fig.18 and Fig.19.** Polyacrylamide gives the highest value of PV than others; CMC gives the highest value of YP and Gel strength than others. The maximum S% that the mud mix can be accepted until gives out of scale reading is: polyacrylamide 9gm, CMC 8gm and Xanthan gum 7gm. It can be say that we can use any of these polymers to enhance the rheological and filtration of Iraqi bentonite mud.

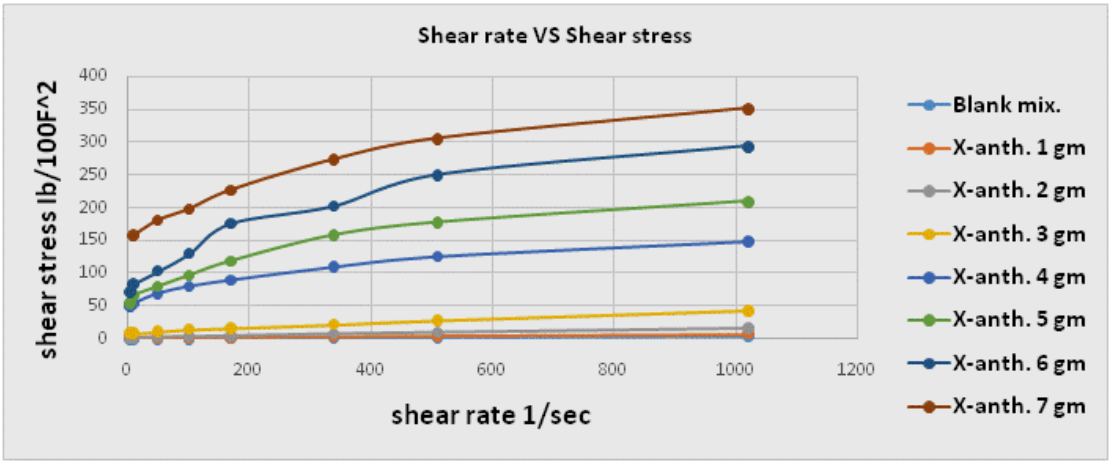

Figure 16. Shear rate .vs. shear stress Effect of X-anthan additives on Iraqi bentonite. mud

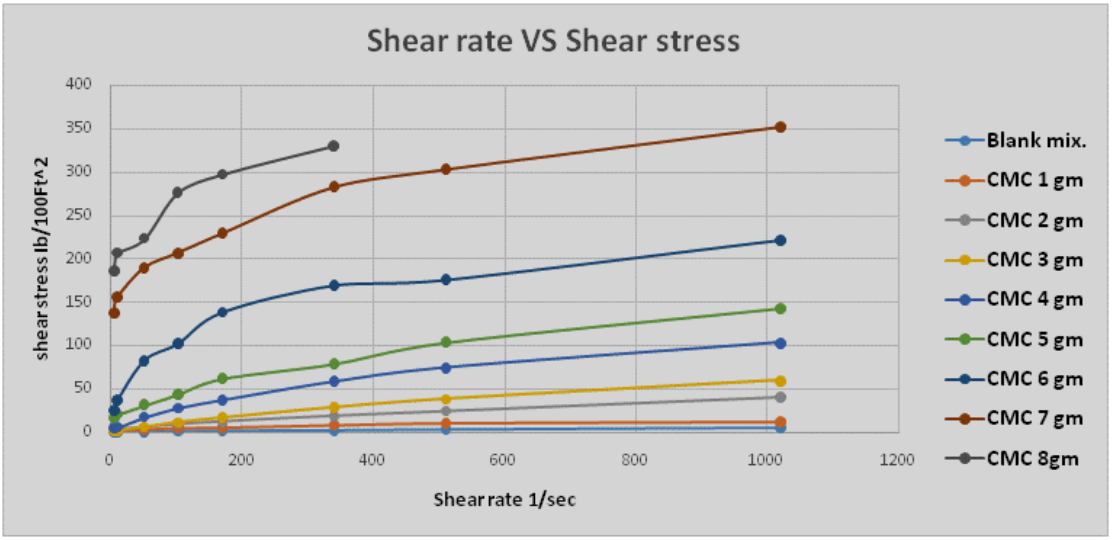

Figure 17. Shear rate vs. shear stress Effect of CMC additives on Iraqi bentonite mud.

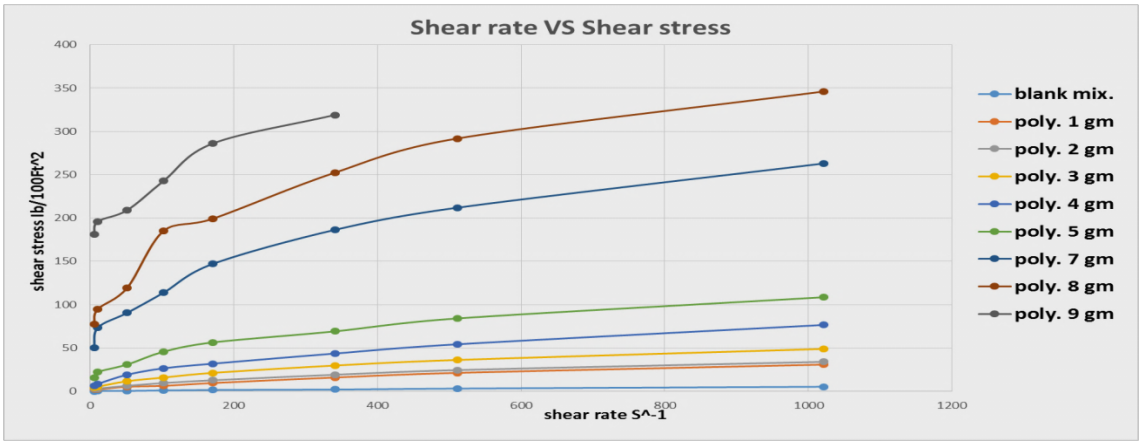

Figure 18. Shear rate vs shear stress Effect of Poly. Additives on Iraqi bentonite mud.

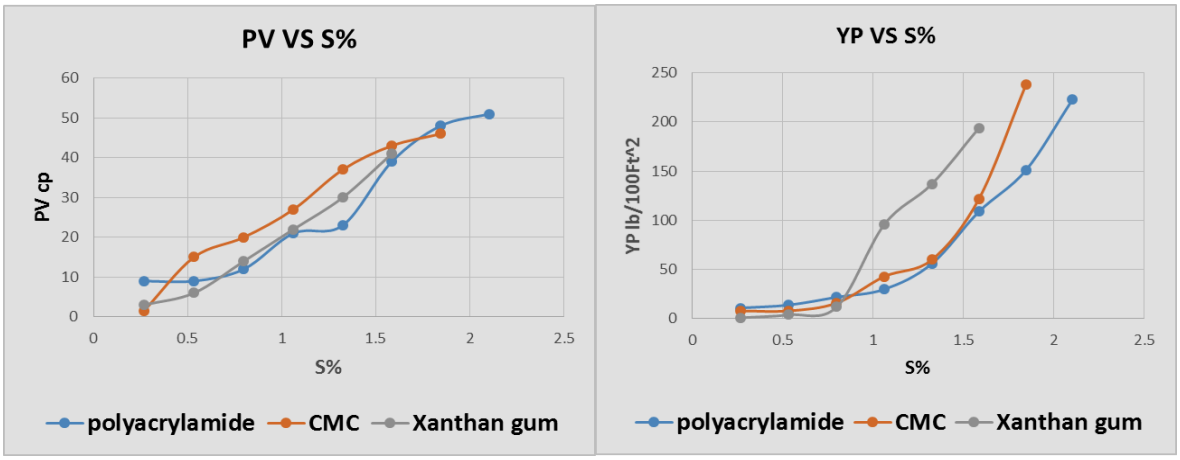

Figure 19. PV vs %S and YP vs%S Effect of Polymer additives on Iraqi bentonit mud.

5.5 The Effect of Polymer Additives on PH. of Drilling Mud:

The results of experimental work show that adding the polymer to the drilling mud lead to increase the value of PH. And as show in **Fig.20 and Fig.21.**

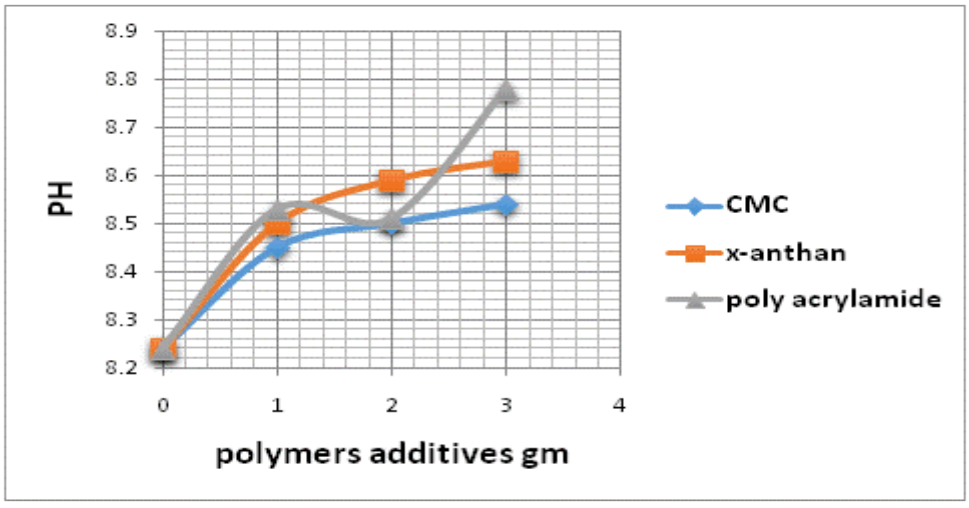

Figure 20. The effect of polymer on ph of red bentonite(polymer mud).

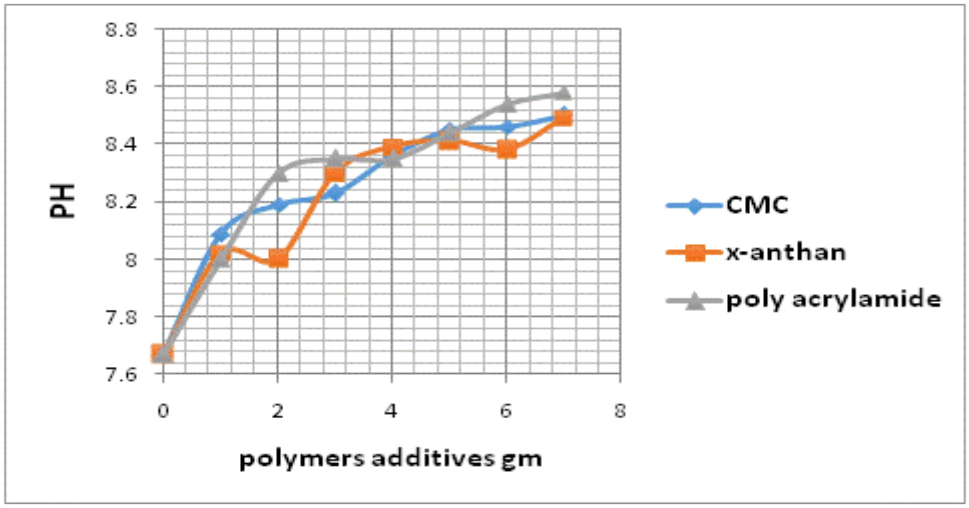

Figure 21. The effect of polymer on PH. of Iraqi bentonite(polymer mud).

6. CONCLUSIONS:

1- The results show that for polymer solution, The PV in 2gm additives is largest for Xanthan Gum and also less YP, when reach to 6gm additives the polyacrylamide has largest PV and lowest YP, Xanthan gum And CMC vice versa.

2- the polymer has not ability to suspend barite particles therefore bentonite add is necessary to suspend the barite particles and the lowest weight of bentonite that lead to suspend barite is 6gm .

3- For the red bentonite, Polyacrylamide has the highest shear stress and Y p than the others polymers, but Xanthan has the highest effect on PV and gel strength than other polymers.

4- The mud properties of Iraqi bentonite blank are enhanced after adding the polymers to the blank mix. X-anthan gives the highest value of yp than others; CMC gives the highest value of PV and Gel strength than others.

5- The results show that adding the polymers lead to increase the value of PH.

6- The experimental work shows that for each studied polymer there is a maximum amount should be don't exceed it, because if we exceed that maximum amount the viscometer dial will give us scale out also the mud sample will be more thick and sticky.

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- **NOMENCLATURE:**
- CMC= carboxyl methyl cellulose.
- YP= yield point lb. /100ft^2.
- PV= plastic viscosity cp.
- RPM= revolution per minute.