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INFLUENCE OF IONIC HYDRATION INHIBITORS ON TRIPLE INHIBITION SYSTEM MUD PROPERTIES – TECHNOLOGICAL PARAMETERS

1. INTRODUCTION

One of the vital features of clay rock is its ability to swell under influence of the water. This feature depends on quantity and type of clay minerals, which are essential components of those rocks. Clay minerals are fine crystalline, hydrated silicates of aluminum or of magnesium. They are characterized by platelet structure. Each of those platelets consist of layers: octahedral metal hydroxyl ($Al_2(OH)_8$ or $Mg_3(OH)_8$) and tetrahedral silica oxide (Si_4O_{10}). Quantity and quality of the layers vary in different minerals.

In wide range of clay minerals, phenomenon of diadochy can be observed, that is partially isomorphic substitution of the ions: Si^{4+} ions are substituted by Al^{3+} ions in silica oxide layers, whereas ions of aluminum (Al^{3+}) can be substituted by ions of iron (Fe^{2+}), magnesium (Mg^{2+}) or calcium (Ca^{2+}) in metal hydroxyl layers. In consequence of those changes, negative charge majority occurs in the mineral platelets. Mentioned excess is balanced with placement of positive ions in interplatelets space: Ca^{2+}, K^+, Mg^{2+}, Na^+, H_3O^+. Those ions, except K ion, can be relatively easy removed and replaced with others, thus they are termed exchangeable ions.

Phenomenon of ionic exchange are used for limitation of drilled clay rock hydration and swelling. For this purpose, so called ionic inhibitors are applied – organic or inorganic low-molecular mass agents, which are donors of cations.

Functions of ionic hydration inhibitors are to: reduce hydration of clay rock, counteract osmotic pressure generation and binding elementary platelets composing clay minerals. Nowadays, the most common clay rock hydration inhibitor is potassium chloride.

The paper presents studies on influence of the chosen inhibitors (KCl, K_2CO_3, HCOOK, $CaCl_2$) on technological parameters of the developed drilling muds with triple

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inhibition system. Obtained results indicate good parameters of the mud. For HCOOK and $CaCl_2$ increase of the inhibitor concentration causes major changes in mud parameters, however for K_2CO_3 and KCl those parameters do not change significantly [1, 2, 3].

2. FORMULA OF THE TEST MUD

In order to conduct studies of ionic hydration inhibitors influence on clay rock swelling, it was composed test mud, into which afterwards were added different ionic inhibitors. The mud was composed as a non-bentonite mud, thus it can be also applied as a drill-in fluid. In the mud as the structure-builders and agents providing proper technological parameters were applied polymers: PAC LV, modified starch and XCD biopolymer. As the hydration inhibitors there were used polyglycol and PHPA polymer which was synthesized at the laboratory of Drilling and Geoengineering Department of Drilling, Oil and Gas Faculty. The mud was weighted with carbonate bridging agent. General formula of the studied mud is presented in Table 1.

Table 1

Formula of the test mud

Reagent	Concentration [%]
PAC LV	1
Starch	2
XCD	0.2
PHPA PT-123/33	0.1
Ionic inhibitor	0–7
Polyglycol	3
Bridging agent 40 μm	7

In the studies following ionic hydration inhibitors were applied:

- Mud-0: comparative mud without ionic inhibitor.
- Mud-1: KCl.
- Mud-2: K_2CO_3.
- Mud-3: HCOOK.
- Mud-4: $CaCl_2$.

3. METHODOLOGY OF THE RESEARCH

In each case, the influence of ionic hydration inhibitor on rheological parameters, filtration and density of test mud was examined. Tests of drilling mud technological parameters have been performed according to polish and international standards

(API Spec.) [4]. Moreover, tests of composed muds influence on QSE Pellets clay samples swelling and linear swelling (LST) of the Miocene shale were conducted (results are presented in [5]).

4. MUD-1 WITH KCl ADDITION

First of tested ionic hydration inhibitors was potassium chloride. Test results are presented in Figure 1.

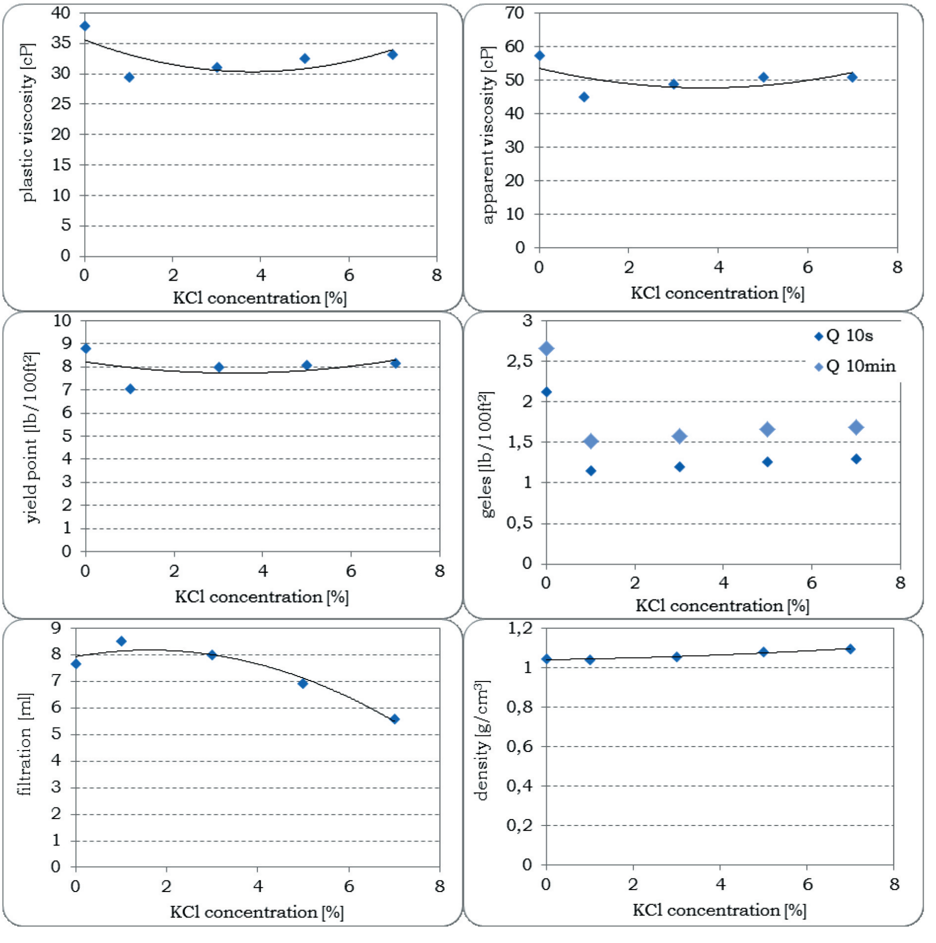

Fig. 1. Changes of technological parameters of test mud under influence of KCl

Test results showed that 1% of potassium chloride addition causes slight drop of test mud rheological parameters. Further increase of potassium chloride concentration insignificantly rises values of the studied parameters.

Filtration test indicates that increase of potassium chloride concentration in the mud causes decrease of filtration down to 5.6 ml for 7% addition. Whereas for 1% of KCl addition it can be observed irrelevant increase of the filtration comparing to filtration value of the mud without inhibitor addition.

Change in mud density values, under influence of potassium chloride concentration increase, is minor. Its value rises up to 1.095 g/cm^3 for 7% of the KCl addition.

5. MUD-2 WITH K_2CO_3 ADDITION

Graphs (Fig. 2) show test outcomes of test mud with addition of potassium carbonate (K_2CO_3) as an ionic inhibitor of hydration.

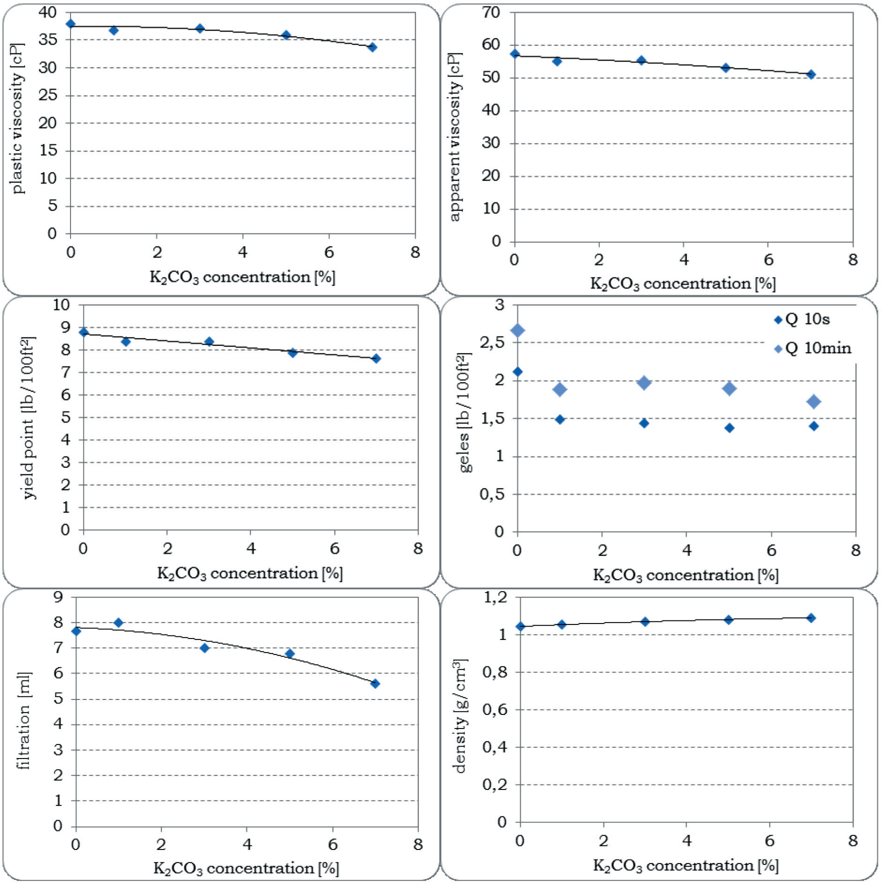

Fig. 2. Changes of technological parameters of test mud under influence of K_2CO_3

It can be observed that the increase of potassium carbonate in studied mud causes slight decrease of its rheological parameters.

Along with potassium carbonate concentration rise, the filtration of studied mud beneficially decreases, achieving the value of 5.6 ml for 7% of K_2CO_3 concentration.

Under the influence of increasing salt concentration, the density of mud slightly grows up to 1.09 g/cm^3 at 7% of potassium carbonate addition.

6. MUD-3 WITH HCOOK ADDITION

Test findings of test mud with addition of HCOOK as an ionic hydration inhibitor are presented in Figure 3.

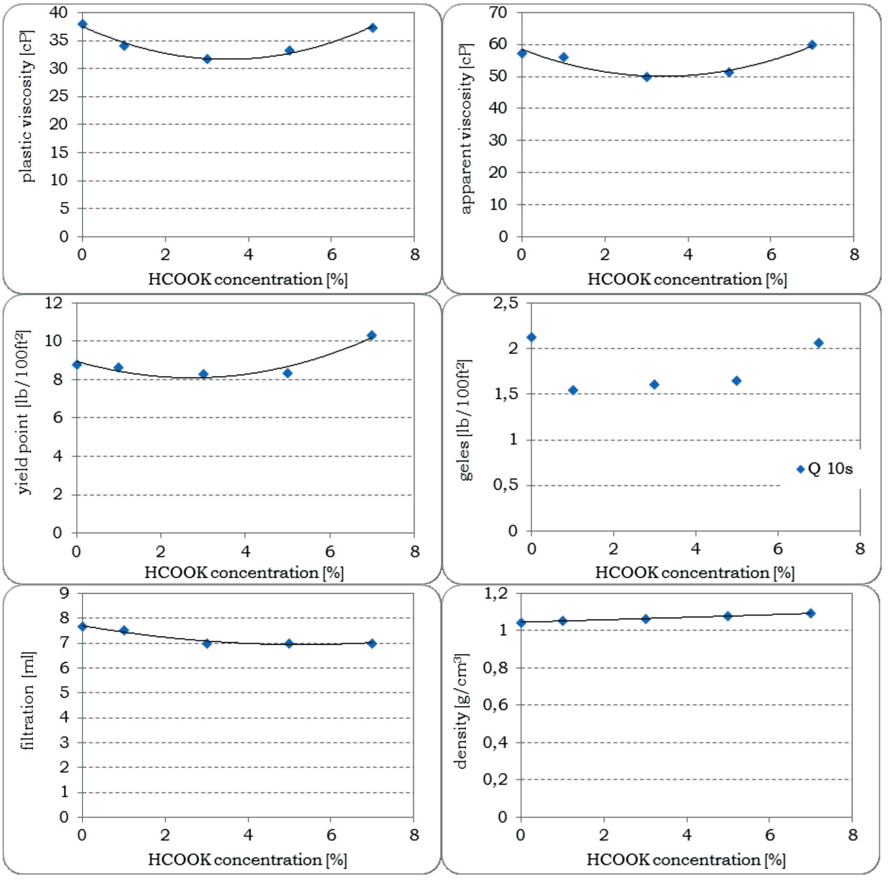

Fig. 3. Changes of technological parameters of test mud under influence of HCOOK

Addition of potassium formate, in low concentration (1–3%), causes decrease of rheological parameters of the mud. Further HCOOK concentration growth causes gradual increase of the parameters. At 7% of potassium formate addition, the return of rheological parameters to values comparable to results obtained for the mud without addition of inhibitor can be observed.

Increase of the potassium formate concentration causes beneficial decrease of the filtration.

Density of the mud slightly rises with the increase of potassium formate concentration and reaches value of 1.093 g/cm^3 at 7% of salt concentration.

7. MUD-4 WITH $CaCl_2$ ADDITION

Last of the studied ionic hydration inhibitors was calcium chloride. Test results are presented in Figure 4.

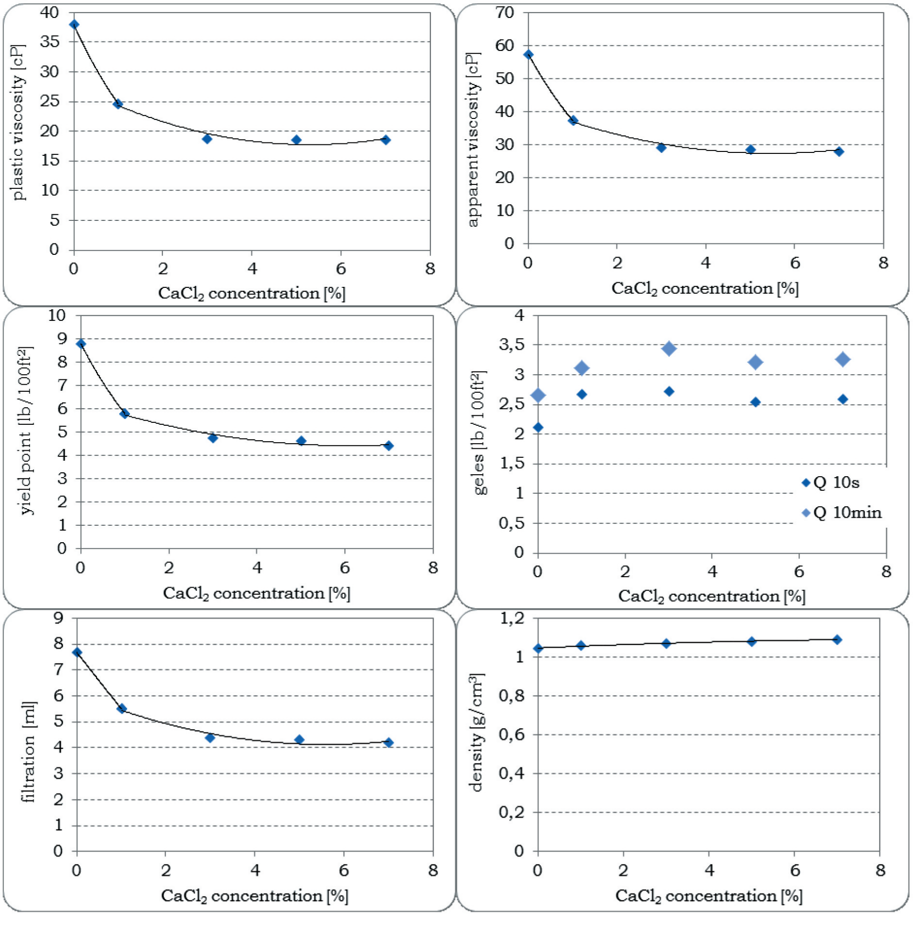

Fig. 4. Changes of technological parameters of test mud under influence of $CaCl_2$

Addition of calcium chloride, in 1–3% concentrations, effects in decrease of rheological parameters of the mud. Increase of $CaCl_2$ concentration (above 3%) does not cause further decrease of the parameters.

It can be observed reduction of filtration value with the increase of calcium chloride concentration.

Density of the mud with addition of calcium chloride rises up to 1.09 g/cm^3 value for 7% of $CaCl_2$ concentration.

8. CONCLUSIONS

Based on findings of the studies, it can be concluded that potassium carbonate has the lowest influence on the rheological parameters of the mud with triple inhibition system. On the contrary, the most significant drop of those parameters is caused by calcium chloride. Filtration of each studied mud similarly diminishes with the increase of inhibitor concentration, regardless of the type of applied salt. For different inhibitors, density of the mud with triple inhibition system is increasing with salt concentration growth.

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