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RECONSTRUCTION FLUID WITH NEW PT-86 POLYMER***

1. INTRODUCTION

Well workover is a process leading up to restore the borehole to its production abilities. Carrying out the work safely entails presence of the reconstruction fluid, although it is generating a risk of damaging reservoir rock's permeability. Decrease of permeability has various reasons and it can be hard to eliminate them entirely. Intensity of phenomena causing damage of permeability can be weakened by treating borehole with its conditions fitting fluid. It is significant for reconstruction fluid to have sufficient technological parameters providing: borehole stability, reservoir pressure balance, transport and maintenance of particulate matter in suspension. Moreover, another relevant conditions are low corrosiveness of fluid and its chemical compatibility with a field [1–3].

While reconstructing partially exploited boreholes located in south-eastern part of Poland there were several issues. The main of them were:

- cavings: running sand with clay binder in shale interval of the developed horizon,
- reservoir pressure gradient decreases,
- lost circulation during workover,
- complications in obtaining satisfying transport values of working fluid.

Standard procedures were not efficient enough to fulfil the requirements for fluid to work properly. Thus, Faculty of Drilling, Oil and Gas AGH UST Krakow developed and compared various formulas for reconstruction fluid to work in those extreme conditions.

Laboratory research were the first stage of the studies. During this stage reconstruction fluid's formulas have been developed, those mixtures weaken loam hydration

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and improve borehole wall stability. Furthermore, adequate flocculant have been selected for developed fluids flocculation. For the second stage the idea is to test developed fluids in a selected boreholes in industrial conditions.

The article contains laboratory research findings of fluids often applied in industry (Mud A and Mud D) and also of the three other fluids developed in Laboratory of Drilling Fluids at the Faculty of Drilling, Oil and Gas AGH UST Krakow. The new PT-86 polymer was an addition to one of developed fluids. It is an anionic-cationic synthetic polymer containing anionic groups $–COO^{-}$, $–SO^{3-}$ and amino groups $–NH^{3+}$. PT-86 polymer was synthesized at the Faculty of Drilling, Oil and Gas AGH UST Krakow.

2. LABORATORY RESEARCH

In preparation for laboratory tests a few hypothesis were made. Characteristics of developed fluid should efficiently allow:

- inhibition of argillaceous rock hydration,
- reduction of casing and tubing corrosion,
- lowest loss of filtrate.

Rest of fluid's technological parameters should allow effective cleaning of borehole. Furthermore, subsequent assumption for development of fluid was to compress the components list. This solution will make easier both regulation of the fluid's technological parameters (if it is necessary) and cleaning process in fluid cleaning system. Another relevant point is that it will reduce the production costs.

The studies were performed according to API specification standard [4] and polish industry standard [5].

Preliminary research consist preparation of different reconstruction fluid's formulas and its technological parameters measurement. Based on the results, three fluids (marked by Mud B, Mud C and Mud E) were chosen for following research. For comparison two of the formulas for reconstruction fluid often applied in industry (Mud A and Mud D) were included to studies. Reconstruction fluid's formulas are presented in Table 1. Test results are presented on Figures 1–5.

Table 1

Developed reconstruction fluid's formulas

Mud A	PHPA 0.3%	XCD 0.5%	KCl 5.0–8.0%
Mud B	PHPA 0.3%	XCD 0.5%	K_2CO_3 3.0–6.0%
Mud C	PHPA 0.3%	XCD 0.5%	$CaCO_3$ 3.0–6.0%
Mud D	Guar Gum 0.5%	Citric acid 20.0%	KCl 3.0%
Mud E	XCD 0.5%	PT-86 3.0%	K_2CO_3 4.0%

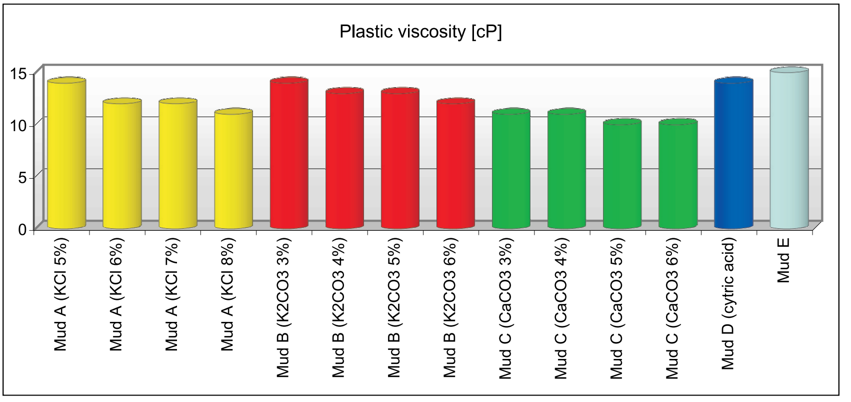

Fig. 1. Plastic viscosity of tested fluids

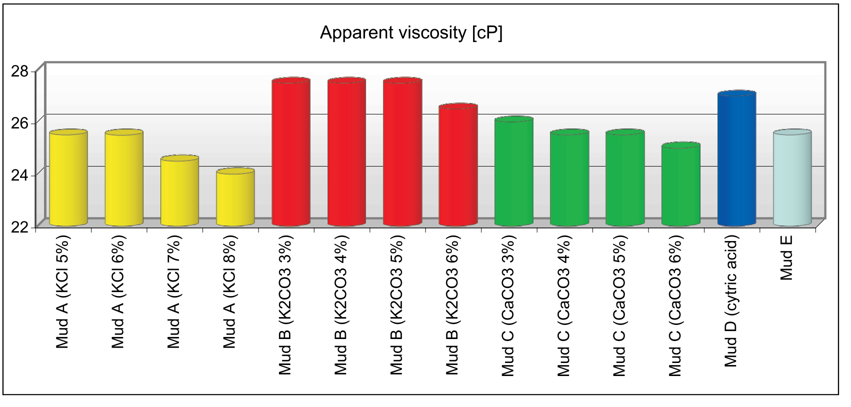

Fig. 2. Apparent viscosity of tested fluids

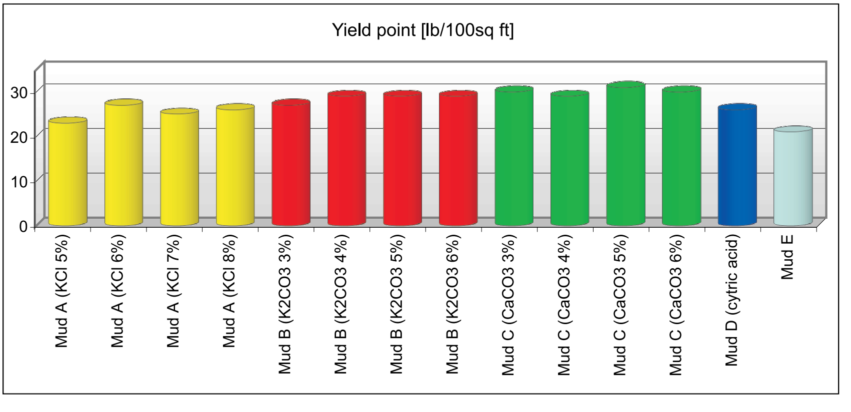

Fig. 3. Yield point of tested fluids

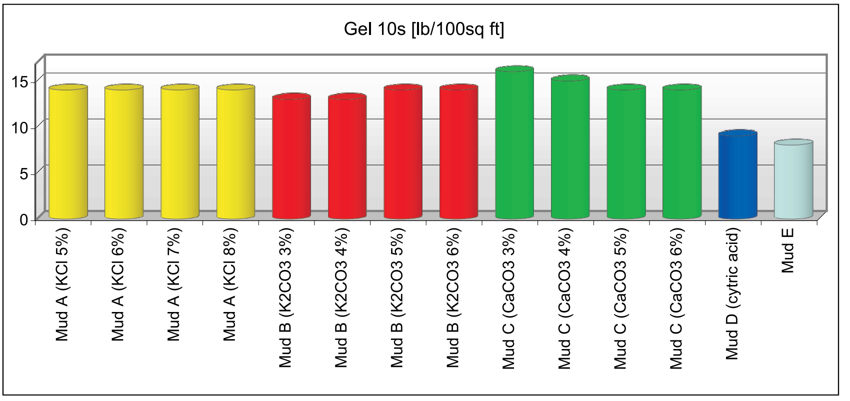

Fig. 4. Gel after 10 seconds of tested fluids

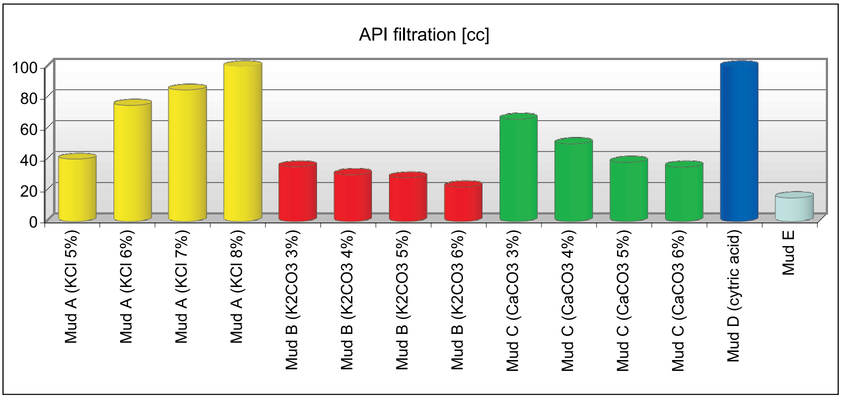

Fig. 5. API filtration of tested fluids

Based on the test results, it has been found that fluid marked as Mud E has best technological parameters. Filtrate loss lowest level can be as well observed for the Mud E. Likewise Mud E, fluid marked as Mud B has satisfying technological parameters. Industrials fluids (Mud A and Mud D) filtrate losses are excessive, this creates negative impact on inhibition of argillaceous rock hydration as a consequence.

Following phase of research was to study behaviour of QSE Pellets artificial clay samples and samples collected from the borehole. For that purpose 24 h laboratory swelling tests of conditioning clay samples in studied fluids and its filtrates were performed. The results of tests are presented on Figure 6.

The conclusion based on the swelling tests of the QSE Pellets artificial clay samples is that fluids marked as Mud C and Mud D do not provide inhibition of argillaceous rock hydration. Due to this fact, disintegration tests of rock samples collected from the borehole were made for fluids marked as Mud A, Mud B and Mud E. Test results are presented on Figure 7.

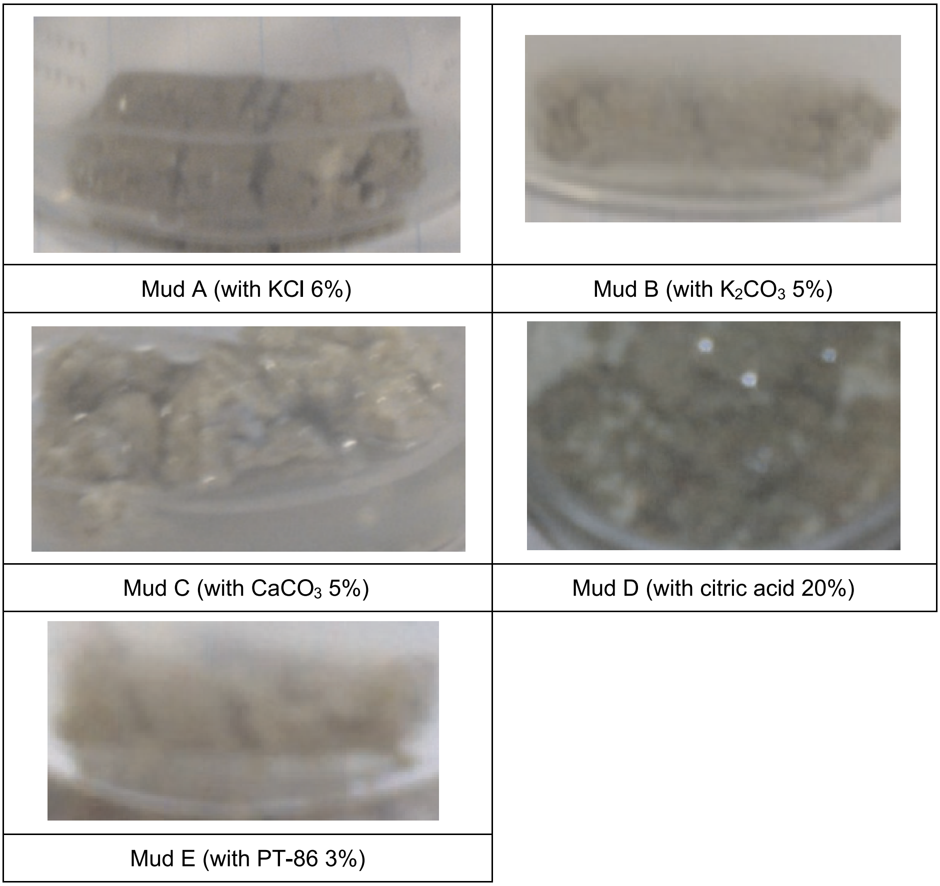

Fig. 6. Swelling of QSE Pellets clay samples under influence of studied fluids

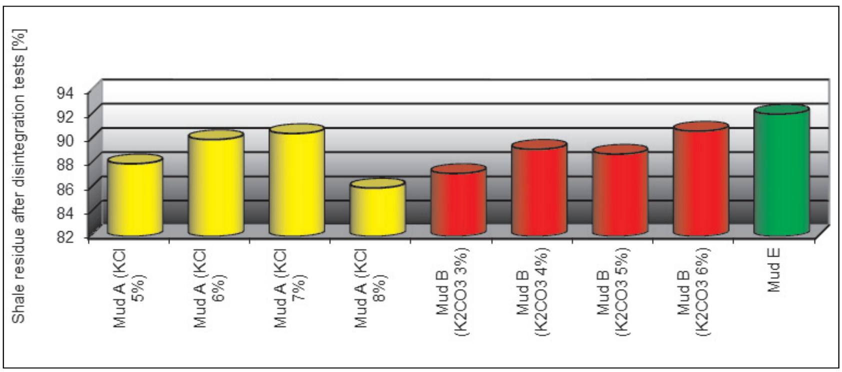

Fig. 7. Disintegration tests of rock samples collected from the borehole under influence of studied fluids

In view of the shale disintegration tests findings, best inhibition of hydration guarantees fluid marked as Mud E. It grants 92% recovery of the shale.

As the next point of the laboratory research was to conduct a corrosiveness tests of selected fluids. With a corrosion coupon, made out of steel and applied in drilling industry, the corrosiveness was tested by conditioning it in studied fluids for 168 h in 40°C temperature. As the following step the mass loss of the corrosion coupons and a type of corrosion was determined. The results are summarized in Table 2 and on Figure 8.

Table 2

Type of corrosion caused by studied fluids

Fluid	Type of corrosion
Mud A (with KCl 5%)	Pitting
Mud B (with K_2CO_3 5%)	Uniform
Mud C (with $CaCO_3$ 5%)	Uniform
Mud D (with citric acid 20%)	Pitting
Mud E (with PT-86 3%)	Uniform

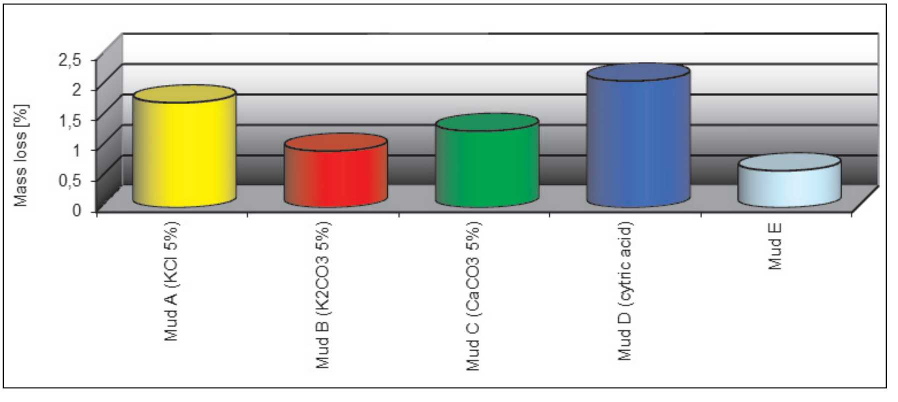

Fig. 8. Corrosiveness of tested fluids. Mass loss [%]

Based on tests results, linear and mass corrosion rate have been calculated. Results are presented on Figures 9–10.

On the basis of above results, lowest corrosiveness of fluid marked as Mud E with addition of PT-86 polymer can be noticed. Mass loss reached 0.6%, mass corrosion rate – 0.36 kg/(m^2·year), linear corrosion rate – 2.98 mm/year. Moreover, the fluid Mud E creates uniform type of corrosion which has lower impact than pitting corrosion.

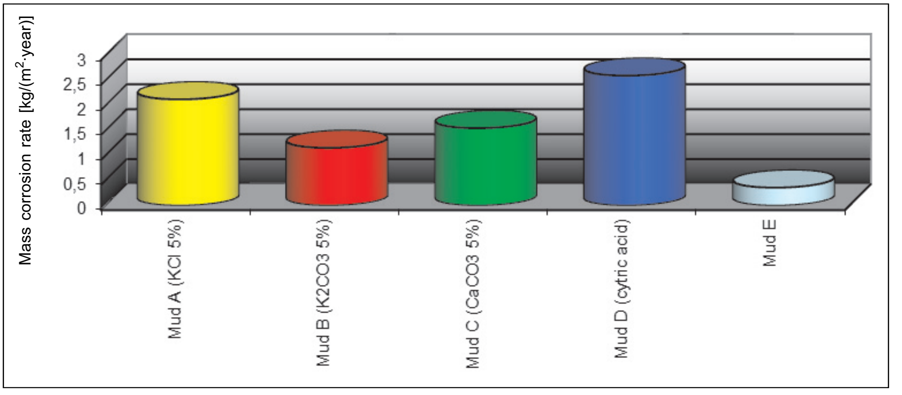

Fig. 9. Corrosiveness of tested fluids. Mass corrosion rate [kg/(m^2·year)]

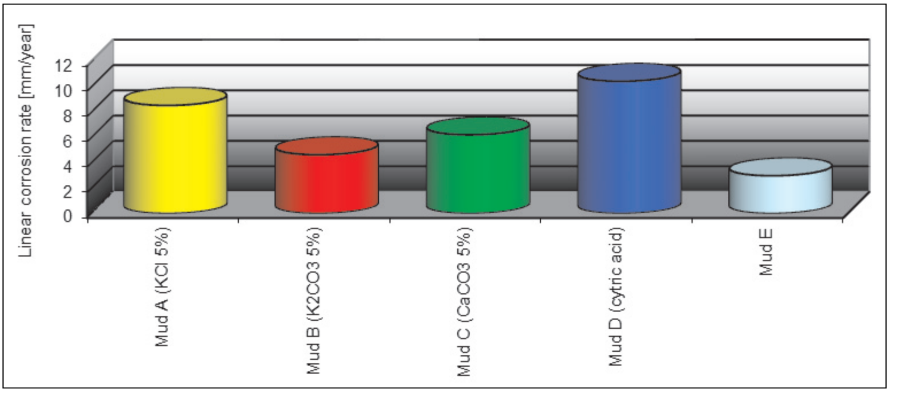

Fig. 10. Corrosiveness of tested fluids. Linear corrosion rate [mm/year]

3. SUMMARY

Studies on reconstruction fluid have been made in the Laboratory of Drilling Fluids at the Faculty of Drilling, Oil and Gas AGH UST Krakow. Two of studied fluids are often applied in industry (Mud A and Mud C). However, above mentioned fluids do not fulfil established requirements. Fluid Mud A has both filtrate loss and corrosion at a high level, while fluid Mud D made the disintegration of tested samples of argillaceous rock. Therefore, to achieve best results, three reconstruction fluid formulas were developed. Fluid Mud C inhibits hydration of argillaceous rock weakly. Fluid Mud B has satisfying properties, although the most advantageous research findings were observed for fluid Mud E.

4. CONCLUSIONS

Research findings indicates high effectiveness of the PT-86 polymer when applied with reconstruction fluid.

Developed fluid with addition of the PT-86 polymer shows good rheological behaviour. It inhibits hydration of argillaceous rock what prevents disintegration of the rock. Moreover, as an advantage, it affects corrosion of the casing by decreasing its impact.

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