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NEW MUD FOR UNDERBALANCED DRILLING****

1. INTRODUCTION

Drilling with application of mud exerting hydrostatic pressure lower than or equal to reservoir pressure is called UnderBalanced Drilling (UBD) and is being used increasingly in the industry [1, 5].

Most recently control of hydrostatic pressure is reached by applying air into the mud. It can be distinguished four main types of mud with gaseous phase:

- air mud (air-dust),
- mist mud,
- foam mud,
- gasified mud [1].

Air mud as a mixture of air and surfactants is most frequently made up on the surface and afterwards pumped into a borehole. Due to rotary blowout preventer hermetically sealed usage there is the possibility of hydrostatic pressure regulation in a wide range. Air mud provides efficient cuttings lifting and protection of producing formation. In view of this fact, it is often the most effective solution during drilling through the reservoir rock [1–3].

The advantages of an air mud application are as follow: quick drilling progress, elimination of drilling mud losses, the ability of continuous measurements in the borehole, the elimination of reservoir damage, and an increase of drill bit life. Considering air mud specificity, during its use it is important to pay attention to risk of borehole deviation, danger of blowout while drilling through the reservoir section of a wellbore in the case of high pressure occurrence, and water and reservoir brines inflows [1]. Constant progress of air and gasified

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mud technology allows its widespread application, moreover the improvement of specialist constructions of preventer destined for this type of drilling mud provides great assistance with blowout preservation.

The paper describes a research findings of drilling mud designed for UnderBalanced Drilling. The UnderDril mud formula is based on a low number of compatible components, therefore it enables an uncomplicated adjustment of its technological parameters to specific conditions and contributes to the reduction of its application costs. Moreover, the UnderDril mud is composed of biodegradable ingredients, that results in a beneficial effect on the possibility of its utilization and simultaneously makes it hazardous free for the environment.

In the framework of the project, there was performed a test of the UnderDril mud various concentrations influence on its technological parameters, a test of mono- and divalent salts effects on the mud, and a test of mud thermal resistance. Furthermore, a linear swell test of the Eocene shale was carried out the under influence of the studied mud.

2. CHEMICALS APPLIED IN THE STUDIES

UnderDril mud – technical grade – one-sack product, biodegradable mud for UnderBalanced Drilling (UBD).

Mikhart 40 – technical grade – BDC GROUP – calcium carbonate bridging material with an average granulation of 30 μm [6].

NaCl, $CaCl_2$, $MgCl_2$ – pure – Avantor Performance Materials Poland S.A.

Research Methodology

The surveys were performed according to Polish and international standards (API Spec.) [7]. Linear swelling tests have been achieved with GRACE Instrument M4600 HPHT Linear Swell Meter. During tests the mud was foamed with Hamilton Beach Mixer at 13,000 rpm.

3. TECHNOLOGICAL PARAMETERS OF THE UNDERDRIL MUD DEPENDING ON MUD CONCENTRATION

Preliminary research consists of measurement of the UnderDril mud technological parameters. Tests were undertaken for three different concentrations of the mud range from 0,5% to 3% by weight. The results are presented in Figure 1.

Conducted tests showed that the UnderDril mud is characterised by good technological parameters even at low concentrations (0,5% by weight). An increase in mud concentration results in a significant increase in the technological parameter values and a beneficial decrease infiltrate volume.

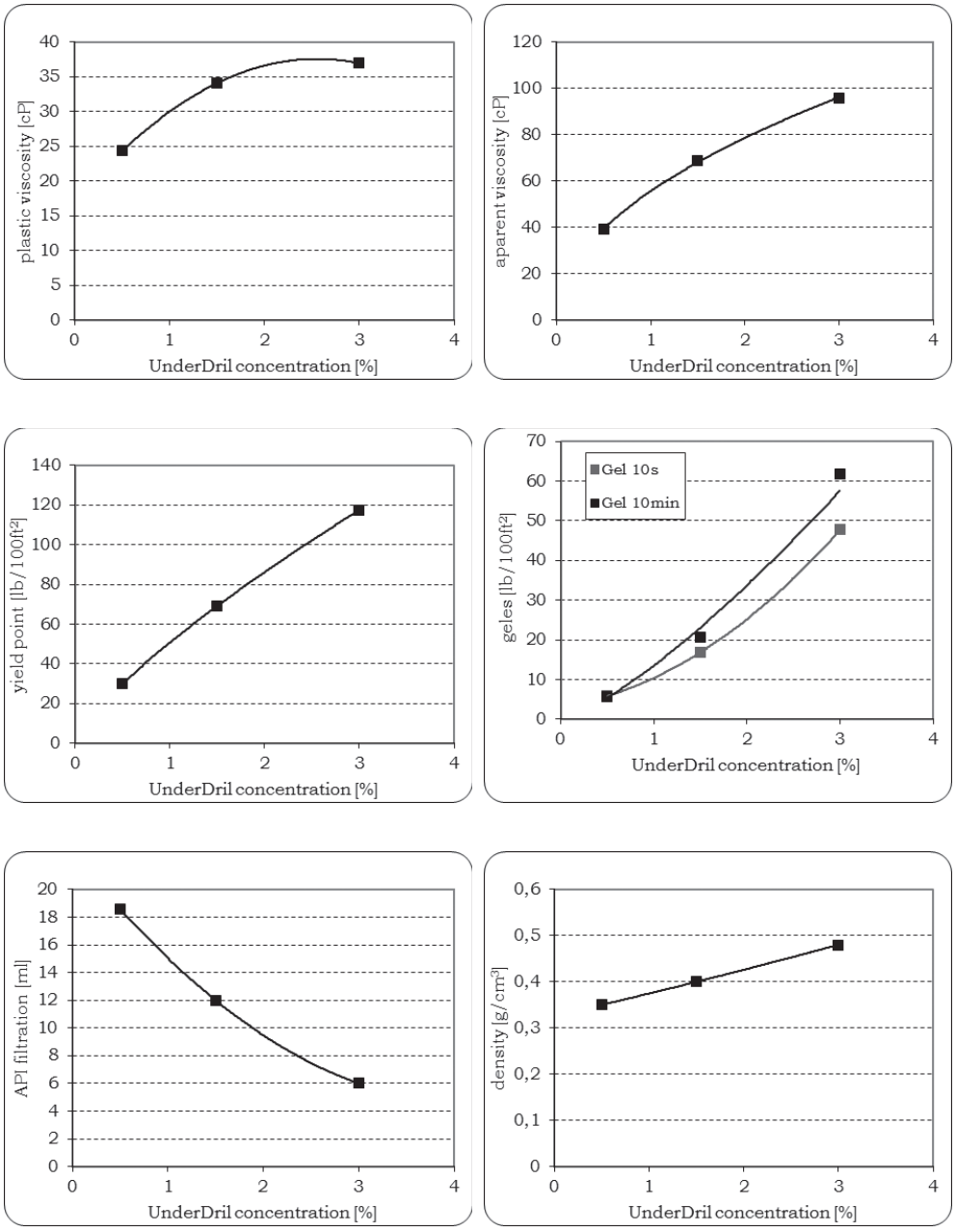

Fig. 1. Technological parameters of the UnderDril mud depending on mud concentration

4. TECHNOLOGICAL PARAMETERS OF THE UNDERDRIL MUD SELECTED FOR FURTHER STUDIES

For a further part of the studies it has been chosen UnderDril mud with concentration of 1,5% by weight. The technological parameters of the mud are summarized in Table 1.

Table 1

Technological parameters of the UnderDril mud with concentration of 1,5%

Mud formula		Technological parameters	
UnderDril	1.5%	Density	0.4 g/cm^3
		Plastic viscosity	33.4 cP
		Apparent viscosity	64.6 cP
		Yield point	62.5 lb/100 ft^2
		Geles	19/24 lb/100 ft^2
		Filtration	12 ml

5. FILTRATION MEASUREMENTS

For filtrate volume measurement, it was conducted filtration tests of the UnderDril mud in standard conditions as well as in HPHT conditions (at 80°C temperature and under differential pressure of 500 psi). In the test it was used mud with a concentration of 1,5% by weight. The results are presented in Figure 2.

The test results showed that the examined mud is characterised by low filtration also in high pressure and high temperature conditions.

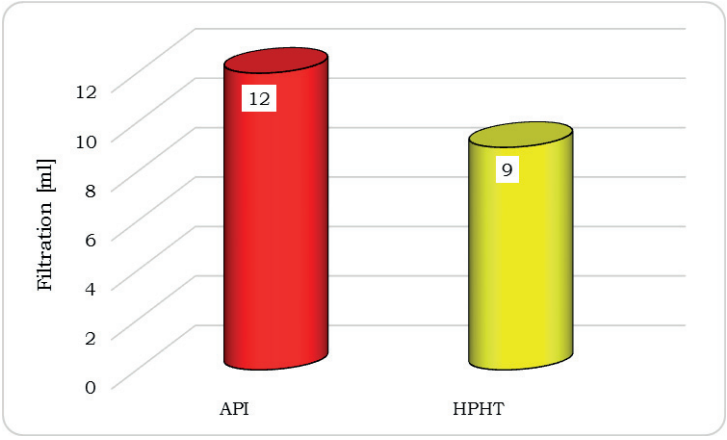

Fig. 2. Filtration measurements of the UnderDril mud

6. RESISTANCE OF THE MUD TO MONOVALENT SALT CONTAMINATION (NaCl)

In order to examine the monovalent salt influence on the technological parameters of the UnderDril mud, tests were conducted of the mud with NaCl addition in different concentrations. Foamed UnderDril mud with a concentration of 1,5% by weight, after the addition of a proper amount of salt, was mixed for 15 min. with a rotational speed of 13,000 rpm, afterwards, it was undertaken tests of its technological parameters. The test results are presented in Figure 3.

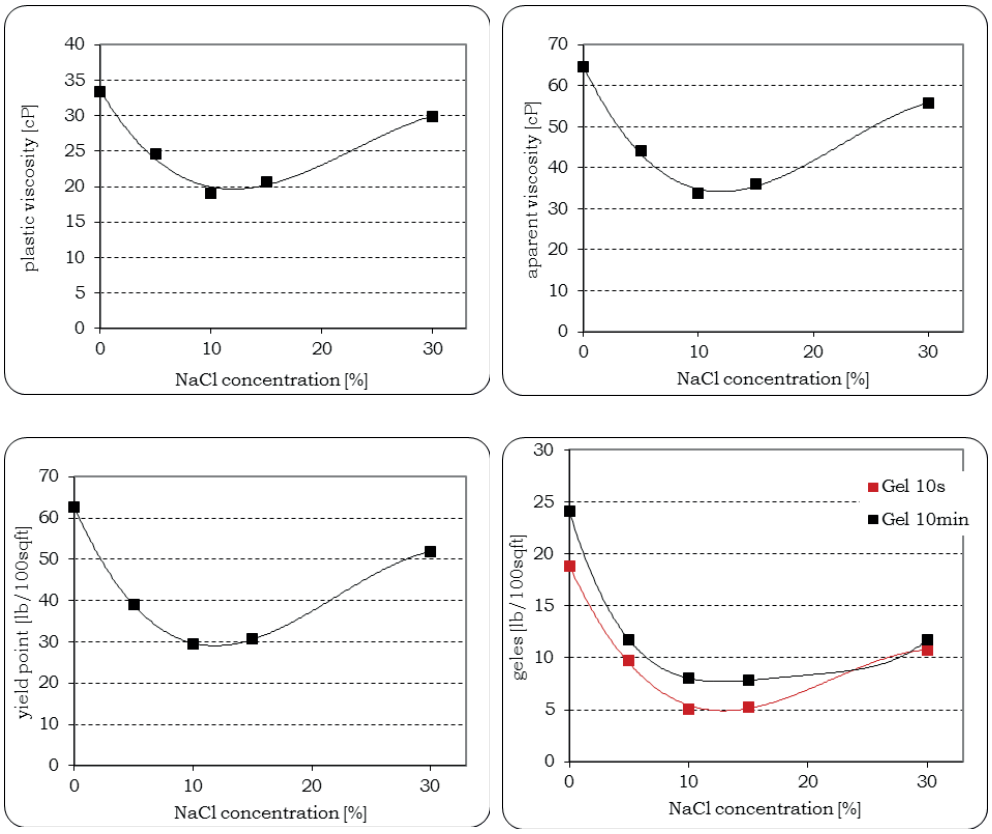

Fig. 3. Monovalent salt influence on the parameters of the UnderDril mud

The undertaken tests showed that the UnderDril mud is characterised by good resistance to monovalent salt contamination. It can be observed a decrease of the rheological parameters due to salt concentration growth. After reaching the minimum (with a salt concentration of about 10%), the technological parameters of the mud rise with the increase of salt concentration. For this reason, the UnderDril mud can be used as a saturated mud. It enables the use of crystal salt as a bridging agent of the near-wellbore zone (instead of a calcium carbonate

bridging agent), contributes to less complicated drilling operations and additionally improves the protection of human health and environment due to lack of necessity to wellbore acidizing (with HCl acid). Instead of the mentioned wellbore cleaning procedure, unblocking of the near-well zone can be achieved with water or light brine.

7. RESISTANCE OF THE MUD TO DIVALENT SALT CONTAMINATION ($CaCl_2$ AND $MgCl_2$)

The subsequent step of the studies was to test divalent salt contamination (Ca^{2+} and Mg^{2+} ions) influence on the technological parameters of the UnderDril mud. Foamed UnderDril mud with a concentration of 1.5% by weight, after the addition of the proper amount of salt, was mixed for 15 min. at 13,000 rpm and afterwards tests of technological parameters of the mud were conducted. The results are presented in Figure 4.

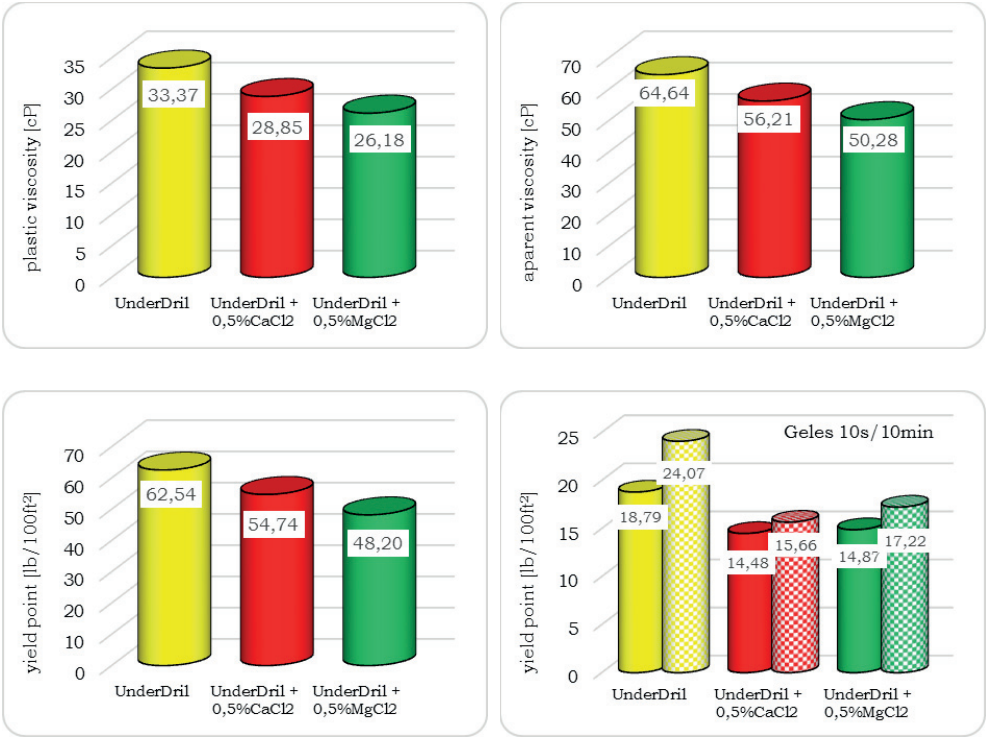

Fig. 4. Divalent salt influence on the parameters of the UnderDril mud

From the test that has been carried out, it can be concluded that the UnderDril mud is characterised by great resistance to divalent salt contamination.

8. THERMAL RESISTANCE

In order to investigate the thermal resistance of the UnderDril mud a test of temperature influence has been coducted on the technological parameters of the mud. Tests of foamed UnderDril mud with a concentration of 1.5% by weight were undertaken with the thermo cup designed for rotational viscometer. Tests were undertaken in the temperature range of 20–80°C. The results are presented in Figure 5.

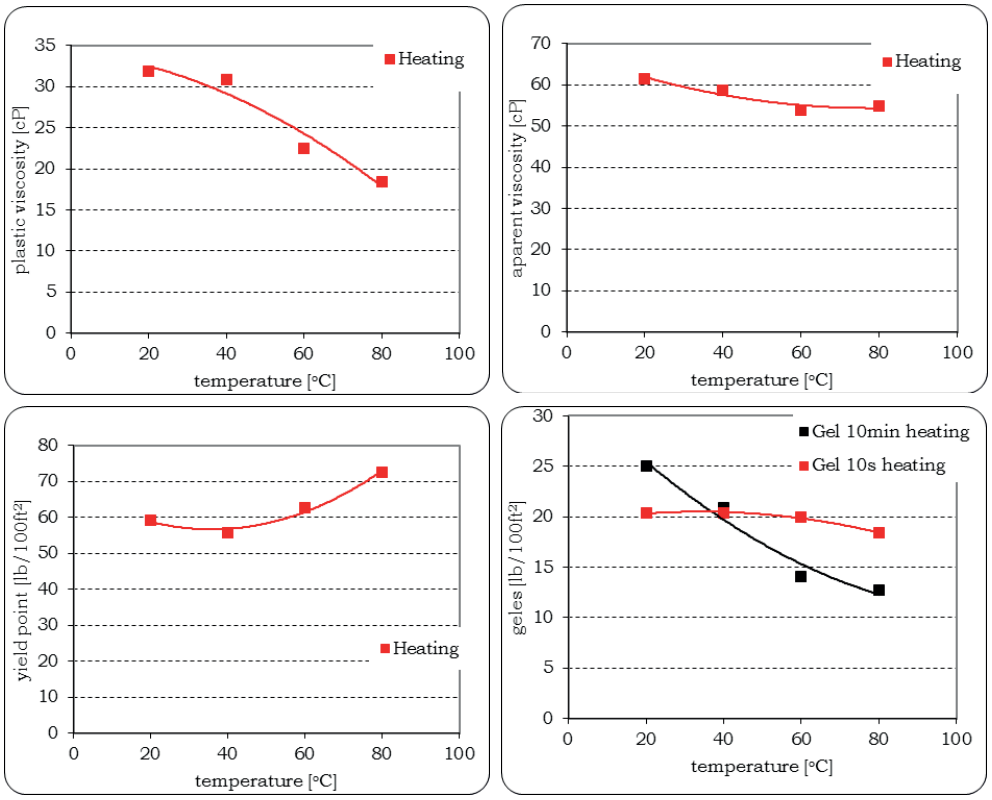

Fig. 5. Influence of temperature on the parameters of the UnderDril mud

Based on the test outcome, it can be noticed that the plastic viscosity of the mud decreases with temperature increase, however, yield point value increases.

9. LINEAR SWELL TEST

In order to examine the clay rocks hydration inhibition properties of the UnderDril mud, a linear swell test of the Eocene shale was undertaken. Tests of the foamed UnderDril mud with a concentration of 1.5% by weight were conducted with the Linear Swell Meter apparatus. The results are presented in Figure 6.

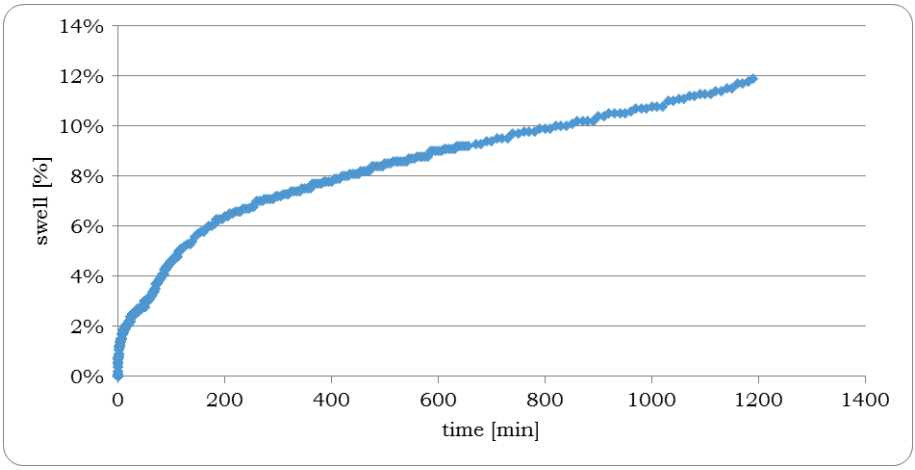

Fig. 6. Linear swell test of the Eocene shale under the influence of the UnderDril mud

Linear swell test of the Eocene shale under the influence of the UnderDril mud showed that the swelling of the sample after 20 hours was 11.9%.

10. DENSIFICATION OF THE UNDERDRIL MUD

A further step of the studies was to validate the ability of the UnderDril mud to densify. Tests were conducted with mud of 1.5% concentration by weight. As a weighting agent was used the calcium carbonate bridging agent with a granulation of 30 μm. Figure 7 presents a picture of the weighted mud.

It has been found that UnderDril mud can be effectively weighted up to 1,1 g/cm^3.

Fig. 7. The UnderDril mud weighted with calcium carbonate bridging agent

11. CONCLUSIONS

The UnderDril mud presented in the article is destined for a specific method of drilling – UnderBalanced Drilling (UBD). It is one-sack mud, hence its preparation for use is substantially quick. After mixing with the water and foaming, it is ready to apply in just few minutes. The density of the mud can be adjusted to drilling conditions in the range of 0.35–1.1 g/cm^3. In its formula there are biodegradable anionic and amino polymers stabilizing the foam and simultaneously providing good technological parameters of the mud. Parameters of the mud can be simply regulated by adjusting its concentration. Additionally, easy biodegradation is a feature that makes the mud environmentally friendly.

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