ARTICLE IN PRESS
Egyptian Journal of Petroleum (2016) xxx, xxx–xxx

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Egyptian Journal of Petroleum

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FULL LENGTH ARTICLE

Effects of sugarcane and polyanionic cellulose on rheological properties of drilling mud: An experimental approach

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Received 24 March 2016; revised 2 May 2016; accepted 17 May 2016

KEYWORDS

Bagasse;
Drilling mud;
Bentonite;
Rheological properties;
Sugar cane

Abstract Invasion of fluids into porous media during drilling can lead to irreparable damage and reduced well productivity. Minimizing formation damage, enhancing well productivity and saving cost will thus depend on the introduction of less invasive fluid formulations.

In this study four different mud formulations were prepared to investigate the effect of bagasse on rheological properties of the bentonite-based mud.

These fluid properties were determined according to API standard. Statistical analyses showed that adding bagasse could successfully enhance the rheological behavior of the bentonite-based mud. Moreover, the formulation containing sugarcane increased viscosity up to almost two times. Gel strength and viscosity also increased overtime.

1. Introduction

Invasion of fluids to productive regions can exert negative effects on well productivity. Since the invasion of filtrate and particles can result in irreversible formation damage and decreased permeability, the mud cake needs to be formed as fast as possible to prevent the damage caused by solid particles and cuttings.

Drilling fluids (commonly prepared as suspensions of bentonite in water) are crucial to not only oil and gas industry, but also geothermal drilling. In addition to their role in facilitating hole cleaning and enhancing lubricity and wellbore stability, such fluids are expected to prevent damage by forming a mud cake on the wellbore [1–16]. Considering their capability to modify mud viscosity and minimize fluid loss within the formation, bentonites are widely administered as supplements to drilling fluids [17–21]. Due to its swelling capacity and ability to form a mud cake with low permeability and viscosity, montmorillonite is generally regarded as the most favorable bentonite [22].

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Peer review under responsibility of Egyptian Petroleum Research Institute.

http://dx.doi.org/10.1016/j.ejpe.2016.05.009
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Since fluid loss control additives are supposed to plug all pores and provide the core for filter cake formation, they need to have a laminar, fiber, or granular shape. We were hence the first to study the potential of bagasse, a material with fiber-like characteristics, for fluid loss control.

Various types of chemicals and polymers are incorporated in the composition of drilling fluids based on the required rheology, density, activity, and fluid loss control effects [17,20,23].

The present study used a Polyanionic cellulose (PAC) polymer to improve the rheological properties of the drilling mud and to minimize formation damage by reducing mud loss into the formation.

2. Material and methods

2.1. Sample collection and preparation

Fresh samples of bagasse were collected and sundried for five days to ease pulverizing and sieving. The samples were then ground in a mortar and the obtained powder was sieved with a Rota Shaker(WiseShake SHO-2D, Germany) to reach a grain size of 150 μm. Na-Bentonite (B) was also prepared to achieve a particle size of 75 μm.

Polyanionic cellulose (PAC) with 0.95 degree of substitution(DS), 700,000 g/mol molecular weight(MW),was prepared.

PAC is a high-quality sodium carboxymethyl cellulose with great uniformity, degree of substitution, and salt resistance whose structure $[C_6H_7O_2(OH)_2CH_2COONa]_n$, properties, and usage in drilling fluid are similar to those of carboxymethyl.

2.2. Mud formulation

Bentonite was dispersed in distilled water using a hotplate stirrer(HMS8805, IRAN) and then shaken overnight (WiseShake SHO-2D, Germany). In order to stabilize the obtained slurry, it was sonicated at 50% sonication (Elma Ultrasonic S80H, USA) amplitude for 15 min.

Patches were prepared by adding either 10.5 or 17.5 g bentonite to 350 ml water and mixing for a specific time in a mixer (EUROSTAR digital IKA-WERKE, Germany).

2.2.1. Preparation of clay-PAC dispersion

The above-mentioned patches were mixed with 1.05 g of PAC for 30 min in a mixer and then labeled as B3PAC and B5PAC, respectively.

17.5 g and 10.5 g bentonite to 350 ml water and 1.05 g of poly anionic cellulose was mixed for 30 min in a mixer and then labeled as B5pac and B3Pac respectively. Afterward, in order to prepare a fluid with properties similar to those of muds administered in industrial operations, sodium hydroxide (NaOH) and sodium chloride (NaCl; 10 g in 350 ml mud) were used to alkalize and chloride the bentonite solvent, respectively.

Mud pH needs to be set at 9–10.5 since the solubility of polymer in mud would be practically impossible at higher pH values.

2.2.2. Preparation of clay-PAC-sugarcane dispersion

According to API standards, the drilling fluid (350 ml) contained 17.5 g B, 1.05 g PAC, and 2.8 g bagasse. All components were mixed in a mechanical mixer(EUROSTAR digital IKA-WERKE, Germany)and then labeled as B5PACSC.

2.3. Mud testing

2.3.1. Rheological properties

Rheological properties of the bentonite mixture, including viscosity, shear rate ($\dot{\gamma}$), and shear stress (τ) of dispersions, as well as gel strength and steady flow curves, were measured using an MCR 300 rheometer (Anton Paar GmbH, Graz, Austria) before and after the addition of PAC and bagasse. Viscosity diagrams for each fluid were drawn at a constant shear rate (0.1 1/s) and temperature (120 °F). Evaluations revealed that the viscosity of the mixture had changed with the addition of bagasse.

3. Results

3.1. Rheological properties

3.1.1. Time test

In order to determine mud stability, Viscosity vs. time Graph was plotted at constant shear rate (0.1 1/s) and temperature (120 °F). As Fig. 1 shows, adding sugarcane to the mud (B5PACSC) resulted in favorable behavior, i.e. viscosity was stabilized after 360 s. However, a sharp drop in viscosity was observed in case of bentonite suspension (B5). While mixing the polymer with the bentonite dispersion (B3PAC) increased viscosity, no steady state was detected. Since two phases of sharp reduction in viscosity were noticed in case of B5PAC, adding only polymer to the mud could not yield the desirable properties.

3.1.2. Flow test

Fig. 2 demonstrates changes in viscosity by increasing shear rate. According to the produced curves, the formulation containing sugarcane showed the best behavior. In fact, at a shear

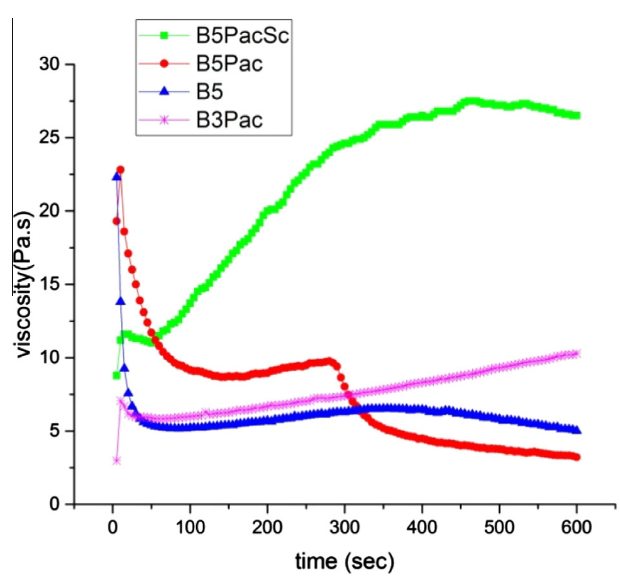

Figure 1 Viscosity vs. time curves of the drilling fluids at 120 °F.