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Decreasing of water loss and mud cake thickness by CMC nanoparticles in mud drilling

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ABSTRACT

CMC polymer is used as an additive to decrease water loss and mud-cake-thickness in mud drilling. In this study, the effect of CMC and CMC nanoparticles on water loss and mud-cake-thickness in mud drilling is investigated. CMC nanoparticles are made by using of ball milling and their size is measured by Particle size analyzer. CMC and CMC nanoparticles which were prepared by Hamilton batch mixer and with certain percent suggested by API, were added to the water-based mud drilling. The amount of water loss and mud cake thickness was measured by filter press. It was found that adding CMC nanoparticles in comparison with conventional CMC resulted in desirable reduction of amount of water loss and mud cake thickness.

Keywords: *CMC; Nanoparticles; Mud drilling; Water loss; Mud cake thickness.*

INTRODUCTION

Drilling fluid (also called "drilling mud") performs a variety of functions in rotary drilling. It carries cuttings from beneath the rotary bit, transports them up the annulus, and permits their separation at the surface, while cooling and cleaning the rotary bit at the same time. It reduces friction between the drill string and the sides of the borehole and maintains stability of uncased sections of the borehole. By forming a thin, low permeability filter cake which seals pores and other openings in the formations penetrated by the drill bit, drilling fluid also prevents unwanted influxes of formation fluids into the borehole from permeable rocks penetrated during drilling. Drilling fluids are typically classified according to their base material. They are classified as water-based muds and oil-based muds. In water-based muds, water is the continuous phase and solid particles are suspended in water or brine. Oil can be emulsified in the water, but the water is the continuous phase. Oil-based muds are exactly the opposite. Oil is the continuous phase and solid particles are suspended in oil, water or brine is emulsified in the oil [1, 2].

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To obtain the features that mentioned above, some additives are mixed with the mud drilling. One type of these additives is the polymers [3, 4, 5].

Polymers can be classified as natural polymers (Starch, Bio-Polymers,…), Cellulosic polymers(Carboxyl Methyl Cellulose(CMC), Hydroxyl Ethyl Cellulose(HEC),….) and synthetic polymers(Polyacrylate, Polyacrylamide ,….) [6].

Nanotechnology is a branch of science and technology where the size particles between 1 – 100 nm are studied. It can be used to solve a lot of problems associated with drilling engineering. The nanoparticles have high surface to volume ratio, which give them a high surface area for an interaction with surrounding medium, hence for any application the quantity of nanoparticles required will be less and hence there is cost advantage when using nanoparticles. The applications of nanoparticles in drilling fluids is mainly to form a thin layer of non-erodible and impermeable nanoparticles membrane around the wellbore which prevents common problems like clay swelling, spurt loss and mud loss due to the circulation [6]. Nanoparticles required will be less and hence there would be cost advantage when it comes to the use of nanoparticles. The application of nanoparticles in drilling fluids is mainly to form a thin layer of non-erodible and impermeable nanoparticles membrane around the wellbore which prevents common problems like clay swelling, spurt loss and mud loss due to the circulation [6].

There are different methods for the synthesis of nanoparticles. These techniques are divided into two categories namely dry and wet synthesis methods. Dry synthesis methods consist of jet milling, ball milling, micronizer whereas the wet milling consists of solvent evaporation, emulsion/double emulsion method, spray drying, fluidized bed coating and others [7].

Ball milling can be used with or without a liquid. In this method, a rotating cylinder is filled with the material to grind and balls which collide with each other and the grinding material to be ground and exert shear forces on the grinding material. This method causes lot of friction and wear in the material so is not ideal for the soft matter like biodegradable polymer. This method is useful for formation of micro/nano meter sized particles or composites where the distortions in the particles due to friction are not crucial [8].

In the present study, the effect of CMC polymeric nanoparticles produced by ball milling on the two main parameters of water-base-mud drilling which are mud cake thickness and water loss are investigated.

EXPERIMENTAL

Material

Bentonite and Carboxymethyl cellulose (CMC) with an average molecular weight of 41,000 were both highly pure.

Preparation of CMC Nanoparticles

Ball milling with high energy production and transferring the energy to the balls, causes the nanoparticles to be produced in according to the shear stresses forced with the balls. The amount of energy depends on slipping velocity, size and number of balls and residence time in ball milling. To produce the CMC nanoparticles with the ball milling method, CMC was feed and the mill was set on 500rpm rotational velocity for about 1hr to 1.5hr. The temperature of experiment remained at 25°C to 30°C. The shear stress inserted by the balls on the CMC particles caused the gridding of the CMC particle and production of CMC nanoparticles. CMC powders size distributions before entering to the mill and after exiting from the mill are showed in Figure 1 and Figure 2.

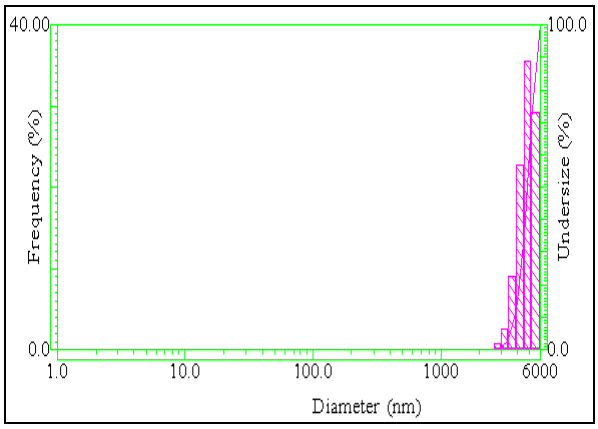

Fig. 1. CMC particle size distribution

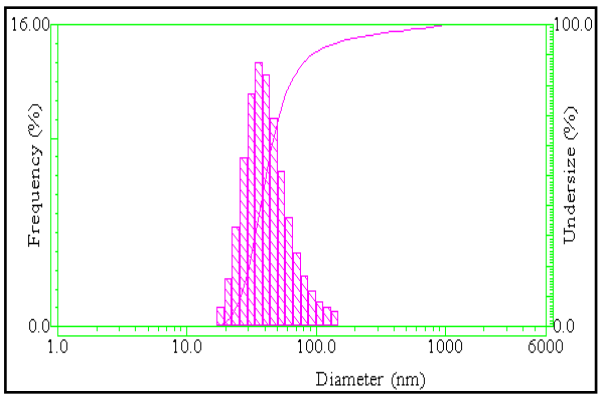

Fig. 2. CMC nanoparticle size distribution

Test section

In this study, the effect of nanoCMC additives on the main parameters of water-base-mud drilling which are mud cake thickness and water loss was investigated. The experiments which were done on the mud drilling were proposed by API. The water-base-mud based on 10lb/bbl bentonite was prepared by Hamilton Batch Mixer. CMC and nanoCMC with specific percents was added to the mud drilling. The experiment related to the amount of water loss and mud cake thickness was done with the filter press device. In the filter press device air was used as a pressure factor on the mud drilling. The pressure of the device was set on 100 psi for 30 minutes. The temperature remained constant on 25°C during the experiment.

RESULTS AND DISCUSSION

CMC powder size distribution which was measured by particle size analyzer device is showed in Figure 1. In this Figure particle size distribution is in the rage of 2.6µm to 6µm and the average of 4.66µm.

NanoCMC powder size distribution which was measured by particle size analyzer device is showed in Figure 2. In this figure particle size distribution is in the range of 27nm to 930nm and the average of 47nm. The range of particle size is narrow and it can be seen that ball milling method is an appropriate method for nanoparticles production. Because particles are/ narrower, they have more common specifications. It should be noted that in the milling method accurate amounts for slipping velocity, residence time and also high temperature control are needed. Because as the slipping velocity is lower, the shear stress on the particles is decreased and the size of the produced particles is increased. Also as the residence time is lower, the particle size distribution is increased.

The results of experiments on water-based mud for CMC and nanoCMC are shown in Figure 3 and Figure 4. Increasing the area to volume ratio in nanoparticles causes the increase of the ionic group molecular weights for absorption on the clay particle surface and attaching the particles to each other also polymeric nanoparticles cause more colloidal particle formation by relating with solid particles which are present in the mud. Finally the amount of water loss and mud cake thickness in decreased and the mud can preserve gel specification for longer time.

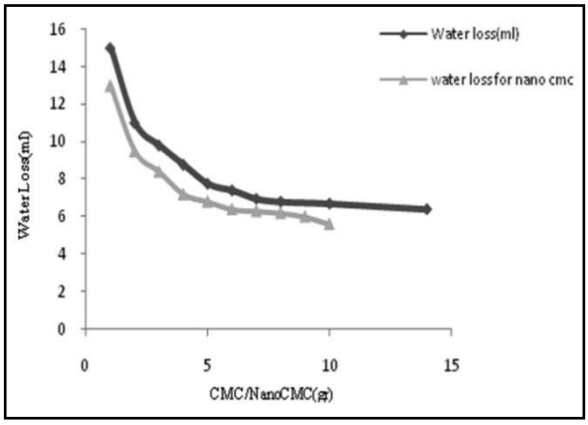

Fig. 3. Amount water loss for mud drilling

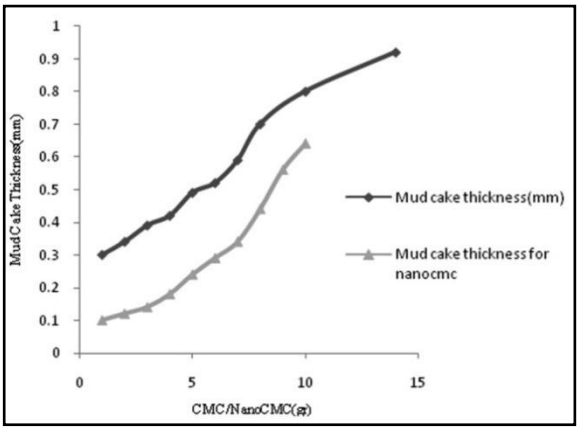

Fig. 4. Mud drilling thickness for mud drilling

CONCLUSION

In this study CMC nanoparticles at 500rpm rotational velocity, 1-1.5hr residence time and the temperature of 25°C to 30°C were produced by the ball milling method. The CMC particle size before entering to the milling and after exiting from the mill was measured by the particle size analyzer (Figure 1 and Figure 2). Specific percents of CMC nanoparticles proposed by API were added to the water-base-mud. The amount of water loss and mud cake thickness was measured by filter press device. Results are presented in Figure 3 and Figure 4 and show that existence of nanoparticle causes the amounts of water loss and mud cake thickness to decrease.

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