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FULL LENGTH ARTICLE

Evaluation of some natural water-insoluble cellulosic material as lost circulation control additives in water-based drilling fluid

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Abstract Circulation losses have always been a serious and expensive problem to the drilling industry. Even with the best drilling practices circulation losses do occur. In order to reduce such losses to acceptable level fluid Loss Control Material (LCM) is used.

In this work, three natural water-insoluble cellulosic materials; peanut hulls, bagasse and sawdust were investigated as lost circulation control materials. One hundred and eight different LCM samples made of various materials were tested with mud. The experiments were conducted in a permeability plugging apparatus (PPA) at a differential pressure of 100 psi and 300 psi, using 10, 60 and 90 ceramic discs. The performance of each LCM sample was determined based on the amount of spurt loss and total fluid loss of the mud according to the American Petroleum Institute (API) standard. The obtained results showed that, the amount of the fluid loss depends on the LCM material, concentration and size distribution, testing results show that, the peanut gives the best results among the bagasse and sawdust, especially fine size which exhibited better results in the filtration characteristics due to the better filling properties of this size. Peanut hulls, bagasse and sawdust show a slight effect on the rheological properties of the mud. The results were discussed on light of particle size distribution.

1. Introduction

To function properly, a drilling fluid must be circulated through the well and back to the surface. Occasionally, highly permeable or cavernous formations and fractured zones, both natural and induced by the mud pressure, are encountered and circulation is partially or completely lost [1]. Loss of drilling

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Table 1 The chemical composition and its abbreviations for materials used in this paper.

Material used	Chemical composition/structure	Abbreviation
Peanut hulls	Cellulose (25%), Crude fibre (60%), Water (8%), Crude protein (6%), Ash (2%) and Fat (1%)	Mud with peanut hull with fine size **(PF)** Mud with peanut hull with coarse size **(PC)** Mud with peanut hulls **(MP)**
Bagasse	Cellulose (55%), Hemicellulose (25%), Lignin (24%), Ash (4%) and Waxes (⩽1%)	Mud with bagasse with fine size **(BF)** Mud with bagasse with coarse size **(BC)** Mud with Bagasse **(MB)**
Sawdust	Cellulose (58.2%), Lignin (28.4%), OCH3 (5.1%), Moisture (4.8%) and Ash (0.21%)	Mud with sawdust with fine size **(SF)** Mud with sawdust with coarse size **(SC)** Mud with sawdust **(MS)**

fluid, owing to openings in the formation, can result in the loss of hydrostatic pressure at the bottom of the hole and allow influx of formation fluids and possibly loss of well control. It is essential that circulation be regained for drilling to continue [2]. Most common thief zones are highly permeable formations. Because of higher permeability (because of large pore size), loss of drilling fluid into formation initiates [3]. Depending on loss rate, different kinds of solutions could be applied, and most common among them is the use of particulate lost circulation control agents (LCM) [4]. Properly sized LCM is added to the drilling fluid which plugs the pores of the permeable formation and arrests the losses [5]. A wide variety of materials can be added to the drilling fluid to reduce the loss of drilling fluids in the high permeable zones [6,7]. A fibrous materials; peanut hulls, bagasse and sawdust, to be acceptable as a lost circulation control additive, must possess the properties of high tensile strength, great flexibility, being chemically neutral and it is extremely desirable that the material shall be economical with regard to cost [8,9]. The particle sizes of these materials are much larger than the particle sizes of solids normally suspended in the mud [10].

Particle Size Distribution (PSD) of LCM is the most important criterion on which treatments are designed [11]. The optimum size of the LCM combinations is selected based on several models like "Abrams Median Particle-Size Rule" as Abrams [12] suggested that; the particle size of the bridging material should be at least equal to or greater than one-third of the medium pore openings of the reservoir rock and the concentration of the sized particles should be in abundance of at least 5% by volume of the solids in the final mud composition, including drill solids.

In this work, three natural water-insoluble cellulosic materials were investigated as lost circulation control material depending on their physical and chemical structure. The work should be extended to investigate the rheological properties. The structure of the three materials [13,14] and its abbreviation are shown in Table 1.

2. Experimental & techniques

2.1. Preparation of sawdust, bagasse and peanut hulls

Sawdust, bagasse and peanut hulls were cleaned by water at 45 °C for about 3–4 h. The dried materials were then ground and sieved into different sizes. The grain size which was selected for this work was situated between 3.35 mm and 0.037 mm by using (400, 270, 200, 70 and 6 mesh) US Sieves. A dry Screen Analysis for fine and coarse size of sawdust, bagasse and peanut hulls is shown in Fig. 1.

2.2. Preparation of water-based drilling fluids

The base component of the water-based muds was prepared by adding 350 ml of fresh water into a cup then 22.5 g of bentonite was measured and poured into the fresh water while mixing by using Hamilton-Beach mixer for 20 min [15]. At the end of the mixing, the different investigated materials were added at different concentrations. When high permeable formations (simulated by ceramic discs with mean pore throat 10, 60 and 90 micron) are drilled with this local mud, a seepage loss occurs. The results are shown in Table 2.

2.3. Permeability plugging test (PPT Test)

The lost circulation control materials were evaluated by using Fann permeability plugging apparatus [15]. This work was carried out using the ceramic discs with Mean Pore Throat

Table 2 Filtration parameters for local water-base mud* using different ceramic discs at different pressures.

Conc. gm	$V_{7.5\ min}$ [ml]		$V_{30\ min}$ [ml]		PPT value [ml]		Spurt loss [ml]		Static filtration [ml/min$^{1/2}$]	
	100 psi	300 psi	100 psi	300 psi	100 psi	300 psi	100 psi	300 psi	100 psi	300 psi
At 10 micron ceramic discs										
6.4%	80	130	100	160	200	320	120	200	14.6	21.9
At 60 micron ceramic discs										
6.4%	90	150	122	200	244	400	116	200	23.3	36.5
At 90 micron ceramic discs										
6.4%	112	170	151	235	302	470	146	210	28.5	47.5

* Mud formulation: 22.5 gm bentonite + 350 ml distilled water.