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Bacteria as a Filtration Loss Reducing Agent during Drilling

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ABSTRACT
One of the desired properties of a drilling mud is that it should minimize fluid loss from the wellbore into the surrounding permeable formation. It is preferable that the quantity of liquid lost to the surrounding formation and the thickness of the filter cake formed be held to a minimum. The fermentates employed for purposes of the invention are produced by the fermentation of carbohydrate solutions with bacteria of the genus Xanthomonas. Specific Xanthomonas organisms employed includes Xanthomonas begonia, Xanthomonas campestris, Xanthomonas hederae etc. Experimental work showed that fermentates produced by members of this genus have properties, which are used for purposes of this invention.
Keywords–Drilling Fluid, LCM, Filtration, Drilling

I. INTRODUCTION

The drilling mud used in the oil and gas wells are generally aqueous solutions containing suspended solids designed to impart the required density, viscosity and thixotropic properties. When such a mud is exposed to the porous formation, the liquid constituent of the mud tends to separate out and is lost to the formation. Filtration loss (also known as fluid loss) is a measure of the relative amount of fluid lost (filtrate) through permeable formations or membranes when the drilling fluid is subjected to a pressure differential [1]. The control of the flow properties and the filtration rate of drilling fluids in drilling operations are important aspects of drilling fluid technology. Low viscosities are desirable in the interest of efficient hydraulic horsepower utilization; low filtration rates imply thin filter cakes, which are desirable in order that annular clearances are restricted to a minimal extent. Fluid loss control agents are commonly employed during drilling operations to lower the rate of mud filtrate loss under dynamic (and static) conditions.

Fluid loss additives function primarily by promoting the deposition of a low porosity cake consequently limiting the rate of filtrate loss to permeable strata. After the mud has been placed, the continued loss of filtrate increases the solid-water ratio, which impedes the transfer of hydrostatic pressure to its formation [2]. This inability to transmit a full hydrostatic pressure prior to strength development is a primary cause of annular gas flow.

It is preferable that the quantity of liquid lost to the surrounding formation and the thickness of the filter cake beheld at a minimum, since the loss of large quantity of liquid and the formation of a thick mud cake adversely affects critical properties of the mud [3]. Operators in many oil fields have encountered difficulties in drilling and completing wells without adversely affecting the well's potential to produce oil or accept injection fluids. Such well damage results from the interaction of the drilling or completion fluid with the exposed formation face, which can be influenced by proper fluid formulation.

Fluid loss control, natural or supplemented, is necessary during drilling to remove cuttings, prevent kicks and minimize mud costs [4]. Recognizing this fact and accepting the mechanism of damage by filtrate invasion, operators have been inclined to select drilling fluids that minimize fluid loss [1]. Often this has involved the use of particulate matter to seal the pores of the wellbore face and thus limit fluid loss. The most effective additives for minimizing fluid loss however, have been the fine, hydratable particles such as bentonite, starch, lignosulfates and some polymers [4]. These particles tend to aggravate the particle-blocking problem, and in some cases, their use may have increased damage even though limiting filtrate invasion. This work proposes the use of biomass generated from injected bacteria to achieve the aim of fluid loss control.

Pelger [5] commented on the nature of particle invasion, correlating reductions in permeability to testing time and cumulative filtrate loss. Berea sandstone cores were used because of the absence of water sensitive clays. An interesting result of their work is that all fluids tested produced an equivalent amount of damage in a core for a given fluid loss. Bryant and Lockhart developed [6] a process of preparing a formation plugging material which may be readily unplugged without causing damage to the formation. The basic plugging mechanism consists of the injection of fluids with dispersed solids or semisolids that will bridge after penetrating into the targeted zone, causing a reduction in permeability and a change in the preferential flow of the displacing fluid [7],[8],[9].

On the subject of bacteria-induced filtration control, Yarbrough and Clotty [10] focused on factors like bacteria concentration, formation permeability, pore size distribution, species and size of bacteria, injection rates, and formation pressure in the study of plugging operations. This study concluded that higher bacteria concentration, slime and large aggregated bacteria, caused more efficient plugging. Separately, it also concluded that bacteria of smaller size than the formation pores accomplishes more penetration along the core even though less plugging efficiency is observed in comparison with larger microorganisms.

Many other investigations have been developed to try to successfully plan for the use of bacteria in selective plugging operations to decrease filtration loss in stratified formations or formations in which thief zones or fractures are present. More recent studies have evaluated the in situ growth of bacteria and the relationship between permeability reduction and transport and concentration of nutrients such as Carbon, Nitrogen and phosphates [11], [12], [13].

II. METHODOLOGY

2.1 Sterilization Method

All media and physiological saline were sterilized by autoclaving at 121^{o}C for 15 minutes at 15 psi. Glass wares as petri dishes, pipettes, test tubes and bottles were sterilized in a hot air oven at 160^{o}C for 1 hour. Inoculating wires or loops were sterilized by flaming to red hot using Bunsen flame while hockey stick was sterilized by dipping it in alcohol.

2.2 Solvent used

The solvent used for serial dilution and subsequent work was physiological saline. It was prepared by dissolving 0.85g of Sodium Chloride in 100ml of diluted water. It was then dispersed in 9ml into test tubes and sterilized by autoclaving at 121^{o}C for 15mins.

2.3 Culture Media Used

Chemically defined selective media for cellulolytic, amylolytic and proteolytic organisms were used. Deionized water was used as solvent and agar powder (at a concentration of about 1.5%) was added as a solidifying agent. The pH of the media was adjusted as specified using 0.1M Sodium Hydroxide solution. All media were sterilized at 121^{o}C for 15mins at 1.21kg/cm^{2} pressure in a portable autoclave. The media were allowed to cool from 45^{o}C to 50^{o}C, later poured into sterile petri dishes, allowed to set and dried in an oven before use.

2.4 Enumeration of Heterotrophic Bacteria

10g of refuse sample was weighed and grounded using sterile mortar and pestle. This was added to 90ml of physiological sterile saline in a conical flask and shaken for about 1min to allow the microbes get suspended in the saline. After the solids have settled, 1ml of the supernatant was aseptically collected and tenfold serial dilution was performed. In the case of the used lubricating oil, 1ml lubricant was aseptically added to 9ml of physiological saline to give 10^{-1} dilution.

The third and sixth dilutions (for refuse sample) were plated out, while the zero, the first and third dilutions (for used lubricating oil) were also plated out. This was achieved by aseptically pipetting 0.1ml of the dilution indicated above into duplicate set of sterile nutrient agar plates. The spread plate technique was used. The inoculation plants were incubated at 37^{o}C from 24 hours to 48 hours, after which plate count were taken.

Plates with colony-forming unit ranging from 30 – 300 were counted. The process is elaborated for each group of organisms (i.e., proteolytic, cellulolytic and amylolytic) in the following section. The method used for enumeration was based on the assumption that each viable cell present in the sample will develop into a single colony after incubation of an inoculated medium. The number of colonies was then multiplied by the degree of dilution (dilution factor) to obtain the number of organisms in the original sample.

2.5 Maintenance for Stock Cultures

Pure cultures based on results obtained from above were inoculated into sterile nutrient broth and incubated for 18 – 24 hours at 37^{o}C. The cultures were then streaked and incubated at 37^{o}C for 24 hours. The stock cultures were then preserved in the refrigerator at 40^{o}C for further identification or use. The starter culture of each isolate used for various biochemical tests was prepared by picking from the stock culture of the isolates and inoculating into sterile nutrient broth. The cultures were then incubated at37^{o}C for 24 hours. After incubation, purity was ascertained and the culture was prepared from time to time when required for biochemical test.

2.6 Addition of Xanthomonas bacteria in Bentonite to determine fluid loss

A fermentation medium was inoculated for with *Xanthomonas vesicatoria* organisms and fermented for a period of about 3 days at room temperature. The resultant fermentate was a viscous yellow liquid that was then divided into two portions. One of these wad dried in an oven at a temperature of 173^{o}F to obtain a powdered material suitable for use as a drilling fluid additive. The other portion of the fermentate was diluted with distilled water and Methanol and filtered to remove bacterial cells. The purified polymer thus produced was dried in an oven at a temperature of 173^{o}F used in drying the fermentate sample in order

to obtain a finely divided powder. The dried products prepared were added to separate volumes of distilled water. Sodium Hydroxide was added to each sample to raise the pH to about 7.5. The tests were carried out in a standard API filter loss apparatus using standard filter paper.

III. RESULTS

The results after the addition of *Xanthomonas* bacteria in Bentonite to determine fluid loss is presented in Table 1and the results obtained after the laboratory analysis of filtration loss control using bacteria are presented in Table 2.

Table 1 Viscosity and API filter loss measurement

Sample	Apparent viscosity, cp	API Filter loss, ml/30mins
Solution containing bacteria	4	31.53
Bentonite	2.5	22.5

Table 2 Results of the Analysis of the Filtration loss using Xanthomonas bacteria

Filter time, min	Filter press differential, psi	Filtrate recovered, ml	Cumulative filtrate recovery
0	6	0	0
½	6	4.40	4.40
1	6	0.30	4.70
2	6	0.16	4.86
3	6	0.12	4.98
4	6	0.04	5.02
5	6	0.08	5.10
10	6	0.25	5.35
15	6	0.19	5.54
20	6	0.16	5.70
25	6	0.17	5.87
30	6	9.14	6.01

1.

It can be seen from Table 2 that the solution had a fluid loss value of 6.01ml in 30 minutes and at a constant pressure. The figure below illustrates the result of the filtration test. It shows that the rate at which the liquid is being lost into the formation depends on filtrate time.

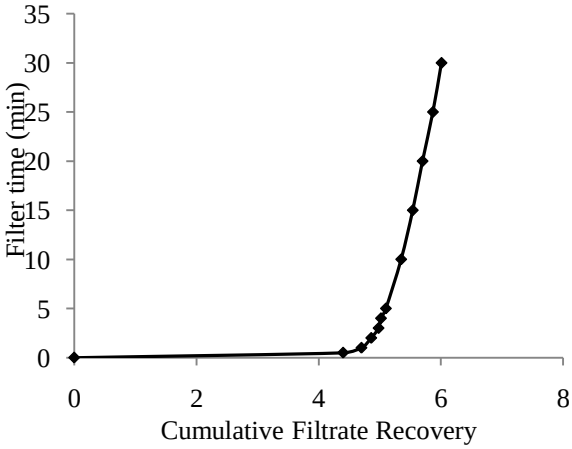

Fig. 1 Analysis of Filtration Loss Control using Bacteria

IV. CONCLUSION ANDRECOMMENDATION

It is apparent from the results described, it can be seen that *Xanthomonas* genus are effective additives for use in oil field drilling mud, completion fluid, workover fluid etc. The low concentrations required to prepare an effective drilling fluid, the absence of maintenance problems, the reduction in friction losses, the excellent fluid loss properties, the greater bit life, and the stability of the borehole wall are all significant and emphasize the unexpected effectiveness of the additive. However, the right conditions under which the microbes can act must be simulated ex-situ and maintained in the reservoir for optimum performance.

It can also be seen that the use of bacteria as the additive in the drilling fluid causes no hazard. The reduced cost is also known as is the environmental friendliness.

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