MANAGING THE ENVIRONMENTAL FRIENDLY DRILLING FLUIDS IN PETROLEUM INDUSTRIES

Abdul Razak Ismail

Faculty of Chemical & Natural Resources Engineering
Universiti Teknologi Malaysia
81310 Skudai Johor Bahru, Malaysia

ABSTRACT

Drilling operation in the petroleum industries requires various types of drilling fluid system. Some of the drilling fluids used are toxic and will create environmental problems when they were discharged to onshore or offshore environment. The disasters can be expected in the short term or long term effects. For normal drilling operation, water-based drilling fluids which is less toxic are normally used. However, for certain condition or troublesome situations, oil-based drilling fluids are the best option in terms of technical requirement. These oil-based drilling fluids will normally create short and long term disasters and therefore other alternatives are required.

This paper discussed the comparison between the commercially oil-based drilling fluids and the laboratory formulated biodegradable Malaysian palm oil-based drilling fluid system. The study involved the basic properties and performance of the systems and the toxicity tests on marine organisms. The analysis for each of the system were presented.

The results showed that the properties and performance of the new formulated ester, derived from Malaysian palm oil as the based drilling fluid system are comparable with the commercial drilling fluids. The analysis also showed that this new system will reduce the environmental problems and will prevent the long term disasters to marine life.

Introduction

The use of invert-emulsion drilling fluids has increased substantially in recent years because they offer definite advantage over water-based drilling fluids in many difficult drilling situations. Invert-emulsion drilling fluids provide excellent borehole stability, are stable under conditions of high temperatures and pressures, and tolerate contamination by salt and acid gases. These fluids also provide necessary lubricity and protection from corrosion during drilling operations.

The most pressing concern about diesel-based oil drilling fluid systems is their potential impact on the environment, particularly on the marine environment in offshore applications. U.S. Clean Water Act prohibits the discharge of any material that will result in a sheen or discoloration of the surface water or adjoining shoreline. The diesel replacement i.e., an environmentally safe base fluid should be an oil that will not create a sheen or discoloration with current-market oil-drilling fluid additives and be capable or producing a stable invert-emulsion oil drilling fluid with performance properties equal to diesel-oil-drilling fluid systems (Hinds & Clements, 1986).

Mineral-oil drilling fluid were introduced as drilling-fluid systems in 1980-81 to offer a low toxicity, non-polluting alternative to diesel-drilling fluid systems. However, the use of material oil can still produce toxic effect to the micro organisms although the oil is less hazardous than diesel (Baroid product manual, 1989).

Vegetable oils including palm oil are one alternative introduced as a replacement for diesel oil and mineral oil in oil-based drilling fluid, believed to be able to overcome pollution problems (Hodder *et. al.*, 1991). Vegetable oils have advantages among others non toxic to environment, non aromatic and require less cost compare to mineral and diesel oils.

Various synthetic derivatives of vegetable oils were then examined. The organic compounds, which were found that best meet the requirements, were esters. Ester are known to be exceptionally lubricating, they exhibit very low levels of toxicity and are biodegradable both aerobically and an aerobically (Peresich *et. al.*, 1991).

Research into alternative biodegradable base fluids began in the mid 1980's. The first such fluids to be considered were common vegetable oils. These included palm, palm kernel, rape seed and soy bean oils. Invert emulsion drilling fluids formulated from these natural oils did not however, fulfil the technical requirements of a drilling drilling fluid. Failure resulted from three factors:

(a) A tendency of these oils to hydrolyse
(b) The naturally high viscosities of these oils, and
(c) The low temperature stability of the resultant drilling fluid

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The advantages associated with the use of oil drilling fluid in difficult drilling situations, on one hand, and the environmental concerns associated with their use, on the other, present a conflict that must be resolved. To better understand the environmental problems accompanying a conventional diesel-oil drilling fluid system, it is imperative that we consider the components of a typical oil drilling fluid (Boyd *et. al.*, 1987). These include:

- the base fluid (Usually no.2 diesel oil) as the external, continuous phase,
- a salt solution (usually $CaCl_2$) to provide the internal, emulsified, discontinuous phase,
- an emulsifier (usually the calcium soap of a fatty acid mixture) to accomplish the emulsification of the brine in the oil (an invert emulsion),
- lime [$Ca(OH_2)$] for alkalinity control and as an additional source of calcium ions for the formation of calcium soaps,
- a viscosifier (usually an amine-reacted clay) to provide solids-suspension character to the fluid,
- a filtration media reagent (usually amine-treated lignite and/or blown asphalt compounds) to provide the desired fluid loss properties,
- a weighting agent (usually barite, $BaSO_4$) to provide the desired drilling fluid weight, and
- secondary emulsifiers and surfactants used to oil-wet the solid in the system.

Although a number of these individual components would have the potential for adverse environmental impact at high concentrations (i.e., higher than normally required in an oil drilling fluid), only the base fluid, diesel, presents a major concern in an oil-based whole drilling fluid. Diesel oil has been used as an oil-drilling fluid base fluid for many years because of its worldwide availability, consistent properties, reasonable cost, and proved reliability.

Laboratory Tests

Table 1 shows drilling fluid formulations of 80/20 oil-water ratio and their properties. The following general trends are typical when comparing the properties of the three different oil-drilling fluid systems.

Malaysian palm oil deravative (ester) drilling fluid systems were tested for their toxicity level to compare with diesel and commercial mineral oil. A 1:4 vol/vol mixture of each drilling fluid and artificial seawater was prepared by vigorously stirring 3 liters of drilling fluid with 12 liters of seawater in a clean beaker glass for 30 minutes.

Table 1 - Comparison of Oil-Drilling Fluid Formulations and Properties

	Methyl Lauric Oil	Commercial Mineral Oil	Diesel Oil
Oil, ml	263	263	263
Primary emulsifier, ml	6	6	6
Secondary emulsifier, ml	4	4	4
Lime,g	6	6	6
$CaCl_2$ brine,g	17	17	17
Water	67	67	67
Organophilic clay, g	8	8	8
Filtration control agent,g	9	9	9
Wetting agent, ml	1	1	1
Barite, g	148	148	148
Drilling fluid Properties			
Drilling fluid density, lbm/gal	10	10	10
Plastic viscosity, cp	23	19	38
Yield point, lbm/100 sq ft	24	27	26
Gel strengths, lbm/100 sq ft	17/18	9/14	19/28
Emulsion stability, V	991	565	649
HTHP filtrate, ml	3.6	0.16	0.24

The mixture was allowed to settle for 1 hour, after which time the mixture had separated into a clear upper portion and a darker lower portion. The upper portion was filtered through a 0.45 μm filter to produce the liquid phase (LP). The lower portion was decanted and used as the suspended particulate phase (SPP). The solid phase (SP) test was prepared by allowing the test organisms to establish themselves in a base of pure sand, then adding sufficient oil drilling fluid to the seawater to form, after 1 hour of settling, a 0.6 in. [1.5 cm] thick layer. This same methodology was used in setting up the reference control, while a 0.6 in. [1.5 cm] layer of sand was added to the true control.

The sea bass (Lates Calcarifer) and the tiger prawn (Penameous Monodon) were the test organisms for the suspended particulate phase (SPP), while the cockle (Anadara Granosa.L) was used in solid phase (SP). The test organism were acclimated for several days before their introduction into test containers. Test solution of 0.1, 0.18, 0.32, 0.56, and 1.00 % of the suspended particulate phase (SPP) were prepared by dilution with artificial seawater.

The organism in the SPP was counted after 0, 1, 2, 4, 8, 24, 72, and 96 hour in all containers. Counts were made in the SP on days 0 and 10. Temperature, dissolved oxygen, salinity, and pH were measured at 24-hour intervals in all three phases.

Results and Discussion

The results of the SPP bioassays are shown in Table 2. These results reveal a significant differences in the survival/mortality rates of the organisms between the palm oil ester drilling fluid, commercial drilling fluid and the diesel-based drilling fluid.

Table 2- Survival of Lates Calcarifer And Penaeus Monodon in the SPP of Drilling Fluids After 96-hours Exposure

Mud concentration (ppm)	Survival (%) palm oil ester drilling fluid	
	Lates Calcarifer	Penaeus Monodon
100,000	77.1	68.5
56,000	84.8	81.8
32,000	91.1	88.9
18,000	95.6	95.2
10,000	99.3	99.3
Control	100	100

Mud concentration (ppm)	Survival (%) commercial drilling fluid	
	Lates Calcarifer	Penaeus Monodon
100,000	78.2	69.3
56,000	87.8	85.6
32,000	95.2	92.2
18,000	97.8	95.9
10,000	99.6	98.2
Control	100	100

Mud concentration (ppm)	Survival (%) diesel drilling fluid	
	Lates Calcarifer	Penaeus Monodon
100,000	73.7	60
56,000	81.5	66.7
32,000	88.5	75.9
18,000	93.3	83.7
10,000	98.5	93.3
Control	100	100

The above result showed that the toxicity of palm oil ester drilling fluid is comparable to the commercial drilling fluid on the experiments conducted on the tiger prawn (Penaeus Monodon) and sea bass (Lates Calcarifer). The diesel oil based drilling fluid, however, shows higher toxicity value.

The result of toxicity tests on the three drilling fluids for three replicates of toxicity test of solid on the phase cockles (Anadara Granosa L.) after 10 days showed that palm oil ester drilling fluid gives the highest survival rate compared to the other tested drilling fluids. an average 23.3% of life percentages of cockles (Anadara Granosa L.). The result of the SP bioassays are shown in Table 3.

Table 3 - Survival of Anadara Granosa L. in the SP of the Drilling fluids After 10 Days Exposure

Oil based	Survival (%)
Palm oil ester drilling fluid	82
Commercial drilling fluid	73
Diesel drilling fluid	61
Control	97

Conclusions

1. Managing environmental problem can be successful in petroleum industry if non-toxic drilling fluids such as palm oil ester is used as oil based system in drilling operation.

2. The Malaysian palm oil ester showed that it has potential replacements for oil-based drilling fluids. It has low toxicity compared to diesel and are comparable to commercial drilling fluid. Their use will thus minimize environmental damage caused by the disposal of oil contaminated cutting in offshore.

References

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