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Eco-Friendly Oil-Base Mud using Jatropha

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Abstract - **During drilling a well, the temperature and pressure increase as a depth of well increases. It is difficult to control high temperature and pressure well. So high density mud is required to balance the formation pressure (Pore pressure). But the use of high-density mud adversely affects to the vicinity of the well and can be cause of formation damage problem. On the other hand, water-based mud is not preferably used for HTHP well as it will enhance the shale instability and allow it to swell. And also, the rheological properties of water-based mud change at high temperature. Some more problems with water-based mud like corrosion of casing and other equipment. So, to avoid these problems oil-based mud used instead of water-based mud. However, Oil base-mud have also some disadvantages like OBM is toxic in nature, oil is costlier as compared to water and OBM required additional cost for disposal. The aim of this paper is to make a substitute for OBM with favorable properties like eco-friendly and cost-effective. So, in this paper, some experiment laboratory results show synthetic oil-based drilling fluid based on jatropha oil. Jatropha oil mix with water makes a feasible emulsion which is nontoxic and cheaper drilling fluid with improved rheological and filtration characteristics than the diesel/minerals oil and water emulsion drilling fluid.**

Key Words: Oil-based mud, Water-based mud, Jatropha oil

1. INTRODUCTION

An oil industry study shown that, out of total number of wells drilled globally in 2012, around 1.5% of the wells should be called as HPHT

The word HPHT means the drilled holes that have either elevated pressure or temperature— but a number of wells have both features. For HPHT wells there are some special challenges that we have to overcome if operations are to be successful.

Operators and service companies required to proceed with different methods for HPHT wells. After assessment of the level of temperature and pressure the approaches, strategies and functioning programs can be framed to drill.

One of the most significant constituents of drilling a well is the mud, because drilling mud performs important and critical jobs like eliminating drilling cuttings to the surface and provides support to the wellbore [10]. Water, Additives, oils and clay form drilling fluids which is used in today's oil industry. To get the advantage from an efficient as well as successful drilling job we have to mix several additives to make competent drilling fluids. Drilling fluid's physical and rheological properties should be wisely adjusted and measured with respect to the rock's lithology and its pressure.

Other considered thing is to confirm that the drilling mud must follow environmental policy. One of the most significant parameters of selecting a capable drilling mud is cost effectiveness [12]. The drilling fluid engineer is the main In-charge of picking the suitable choice of mud properties, for example viscosity, compositions ratio and density [13]. When drilling operation in deviated wells, HTHP wells, drilling mud properties should be matched to wellbore conditions for successful job.

So basically, type of drilling fluids, environmental impacts, cost and its performance are some vital consideration that must be focused at.

Drilling fluids is generally categorized into three types: oil-based, water-based and air-based fluids. Oil based drilling fluids have more advantages in particular situations and lithology as in deep well, where elevated pressure and temperature is present [14]. As water-based drilling fluids gives some clay swelling problem which is significant Cause of formation damage. Formation damages is totally unfavorable for oil recovery. Water based fluids are also not stable at HTHP wells. And water-based drilling fluid (WOB) may Cause the corrosion of casing and other drilling equipment. So, oil-based drilling fluid is somewhere good alternatives of water-based mud. Actually, oil-based Mud (OBM) does not lose its properties in elevated temperature and pressure. And also, not cause the corrosion.

However, using the oil-based fluids is not environment Fridley, because of this, oil-based drilling fluids have strict protocols of its use and additional disposal expenses. As the disposal cost is high so this lift soil-based drilling mud cost significantly [15]. In oceanic environment, protocols are stricter because of the great influence of the dumping of oil base drilling fluids cuttings to the nearby sea environment [16]. Drilling fluids Cuttings must be significantly processed before disposing [17]. This cutting processing increase the overall cost of oil-based drilling fluids and making OBM unfavorable to oil industries.

As discussed, the oil-based fluids are comparatively costlier than water-based drilling fluids. But oil industries

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used OBM as they have suitable rheological properties at temperatures above 500∘F and showing improved stability behavior, their efficiency against corrosion, and greater greasing characteristics. An extra advantage of Oil-based muds is their ability to drill over formations having “water swellable” clays. To make these oil-based drilling fluids primarily the base fluid, diesel oil is used because of its suitable viscosity and low flammability [18]. All petroleum-based oils (Diesel oil) used for making drilling fluids includes great quantities of aromatics and n-olefins, both of which may be unsafe or noxious to animal and plant life. So, the oil industry established modified forms of oil-based drilling fluids which are exactly called synthetic-based muds (SBMs). In the Norwegian region of the North, SBMs was used for the first time to drill a well in 1990.

So now, synthetic oils-based muds are found to be further Eco-friendly than the conventional diesel-based drilling fluids [20]. Synthetic oils-based mud is environmental friendly and biodegradable source of oil to form OBM. Therefore, there is a need to make it cost effective and environmentally safe. But It should show same properties like OMB. Drilling mud’s basic properties are looking after hydrostatic pressure, cooling and lubricating and removal of cuttings.

This paper includes two oil-based drilling fluids which are formed and matched; one of them is prepared from diesel oil and another from jatropha oil. The foundation of the evaluation is from the rheological characteristics and the filtration properties of the drilling fluids.

When we are looking for eco-friendly oil-based drilling mud, we did some relative experiments between diesel and jatropha oil-based mud. These experiments represented various outcomes, one of them was that diesel oil was more toxic than jatropha. This makes jatropha based drilling fluids (synthetic oils-based muds) more eco-friendly as a oil-based mud than diesel.

2. LITERATURE REVIEW

In oil and gas sector, new technologies and products are invented mainly because of two reasons, which are:

- Different working conditions where previously used techniques are not working.
- Government regulations and legislations, which are different at different places.

Due to these reasons, we are working to find a substitute for oil-based muds that we are currently using [20]. In past years we have found that the government regulations and legislations do not allow the use of diesel as a drilling fluid because it affects the nearby environment. [21]

The only solution to this problem is to develop a drilling fluid that is environment friendly and having properties similar to that of oil-based drilling fluid. In recent years, the origination of biodegradable oil-based fluids is gaining attention. Using this fluid reduces the adverse effects on environment and lessens the overall budget of dumping and have similar characteristics of oil-based mud we are using.

A lot of research studies recommends the use of vegetable oil in place of current oils which we are using [22]. The environmental friendly characteristics of this oil seized the consciousness of oil and gas industry to overcome problems.

A lot of vegetable oils are present, so selection of most appropriate oil is needed. Several tastings on different vegetable oils such as palm oil and soybean oil, but some problems remain existed. The mud properties and PH values were not so satisfying to be used them as mud.

Then we moved towards the third vegetable oil “jatropha oil” to use as an oil-based mud in oil and gas processes. The values of trans fat and saturated fat is low in jatropha oil. Jatropha oil showed advantageous effects which gives an indication to be used as a replacement of diesel [23]. Nontoxic behavior of jatropha oil make it ecofriendly.

Its cost as compared to diesel is also a beneficial factor to compare. Another advantage is its capability to grow in deficient, dry and unfriendly environments. Jatropha’s rich oil content, malleability, anti-drought nature and low nutrients requirement for growing also gives it an advantage. It can be grown by the wastewater produced on working site as the nitrogen and chemical compounds present in wastewater acts as nutrients for this plant.

One more useful advantage of jatropha is it doesn’t require agricultural land and can be grown in lands not suitable for farming and so provides flexibility. Jatropha curcas is a division of flowering plant and generally found in American tropic soil content from jatropha fruits (seeds) having up to 28 to 30% and with 80% extraction. On an average, one hectare of plantation will give 400 to 600 liters of oil.

The biofuel produced from jatropha can be additionally processed to jet fuel, while the deposit left besides can be used as raw feed to power electricity plants, and can also be used as fertilizer. [times online,28 July 2007].

1. MATERIAL REQUIRED AND EXPERIMENTAL WORK

3.1. Apparatus Included

Weighing machine, mud balance, sample flasks, mixer, measuring cylinders, viscometer, thermometer, mixer, beakers and heaters.

3.2. Materials

Jatropha oil, diesel oil, bentonite and barite

4.3. Preparation of the Mud Samples

Two drilling fluids samples of the same composition but base oil used were prepared. the quantities of the different components used to make drilling mud (Table 1).

Firstly, 250 ml diesel oil is poured in a plastic beaker and then positioned under a mixer. The definite amounts of water and bentonite were then correspondingly mixed to the oil in the beaker and kept stirring continuously. Then eventually a specific amount of Barite was added to the

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fusion until it was finally well merged into a smooth and steady paste. It was then put in storage into a drilling fluid sample flask and categorized. The above procedure was repeated taking jatropha oils in the place of diesel oil while keeping other components unchanged.

Table 1. Constituency of Drilling Mud

Mud	Oil	water	Barite	Bentonite
Sample 1	250ml	100ml	105gm	20gm
Sample 2	250ml	100ml	105gm	20gm

The next substantial collected was jatropha seeds, Oil is extracted by a mechanical procedure of crushing. After some filtration process of the oil, we have to confirm that no impurities are present. The seeds were crushed and get 35% yield of jatropha oil. Density of jatropha oil was 0.931g/liter (931kg/m^3).

4. PHYSIOCHEMICAL PROPERTIES

Now, the next phase was to match physicochemical properties of jatropha oil and diesel oil, which gives a primary indication of desirability of the expressed drilling fluid base on favorable criteria. We selected three properties to match which were density, pour point and flash point.

4.1. Results of the physiochemical properties:

4.1.1. Density: the jatropha oil density was higher than that of diesel oil. Though, advantages of the higher density of jatropha oil includes less amount of barite could be used which saves the cost of mud preparation.

Density of jatropha oil = 931 kg/m^3
Density of diesel oil = 830 kg/m^3

4.1.2. Pour point: jatropha oil has a greater pour point, this recommends that it would not be used in cold environments. So, the jatropha oil is more appropriate in Egypt.

Pour point of jatropha oil = 7 ^{O}C
Pour point of diesel oil = -14 ^{O}C

4.1.3. Flash point: jatropha indicated a high flash and fire point temperatures, which have proven tough to achieve in a university lab.

Flash point of jatropha oil = 210 ^{O}C
Flash point of diesel oil = 66 ^{O}C

5. MUD FORMULATION AND RHEOLOGICAL PROPERTIES

By making a sample of drilling fluid from both type and testing its rheological properties as per the criteria to choose the most appropriate and unconventional drilling fluids.

5.1. Mud Density

The increasing order of densities was diesel oil and jatropha oil. The greater the density of the drilling fluids sample, the better it aids to maintain hydrostatics pressure and hold cuttings in the mud for better clearance of the borehole. Generally, weighting additives are purposely mixed to drilling fluids formulations to attain this important property of the drilling fluids.
Some reservoirs need a denser drilling fluid specially when problems like wellbore influx into the bore. The results of the jatropha oil-based drilling fluids in comparison to diesel oil-based drilling fluids is quite Hopeful in high pressure reservoir or deep reservoir. So, it may serve as probable substitutions of diesel oil base drilling fluids formulations.
When we mixed barite into both oil-based drilling fluids to increase the density. To measure the effect of the barite on the mud sample we get the ideal density that is used in the oil industry.
Table (2) illustrated that density of jatropha oil-based fluid is more as compared to diesel mud after mixing a fixed amount of barite. And we take same amount of oil-based mud (Jatropha oil based and diesel oil based).

Table 2. Variation of Density of Diesel oil-based drilling fluid and Jatropha based drilling fluids with different barite content.

Barite (gm)	Diesel based mud, ppg	Jatropha based mud, ppg
5	7.2	7.9
10	8.05	10.25

5.2. Rheological Properties by FAN V-G Viscometer

The rheological properties of the diesel oil base drilling fluids and jatropha oil base drilling fluids are illustrated.

5.2.1. Plastic viscosity: Plastic viscosity of the jatropha oils is a much higher than diesel oil. So, considering this, viscosity modifiers and reducers should be used. Therefore, the treatment of high viscosity oil is more satisfactory than low viscosity oil.

5.2.2. Rheology Test: For the rheology experiment, we use a viscometer. the viscosity for each drilling fluids was measured three times at altered temperatures. It was measured first at 50º C, then at 80ºC and lastly it was measured at 100ºC.
The tests done by the viscometer at 600 RPM, 300 RPM, 200 RPM, 100 RPM, 60 RPM, 30 RPM, 6 RPM and then it was permitted to measure the gel strength for 10 seconds and 10 minutes.
First, the drilling fluids which going to be tried was agitated and mixed again by the mixer. Then the drilling fluids sample was heated at that temperature at which its viscosity was to be measured.
Readings were recorded at 6 RPM and then stirring of mud was done. Then viscometer was turned off and the mud was allowed to get gelling property for 10 seconds. After

10 seconds the viscometer is turned on and the first reading seen is instantly taken and measured. This process is repeated for 10 minutes gel. This entire process was repeated for both samples.

This experiment not only displayed the different viscosities of the two oil-based drilling fluids, it also displayed the influence of temperature on the viscosity of drilling fluids.

5.2.2.1. Results:

5.2.2.1.1. Viscometer data of Jatropha oil-based drilling fluid:

Table 3. Viscosity variation with Temperature at different viscometer Reading for jatropha oil-based drilling fluid.

Viscometer Dial Configuration	Viscosity Values at different Temperature		
	50ºC	80ºC	100ºC
600	156	109	58
300	107	94	41
200	72	74	24
100	41	34	18
60	26	20	14
30	18	13	11
6	9	6	6
Gel 10 secs	8	8	9
Gel 10 mins	9	9	9
Plastic Viscosity	49	15	17
Apparent Viscosity	78	54.5	29

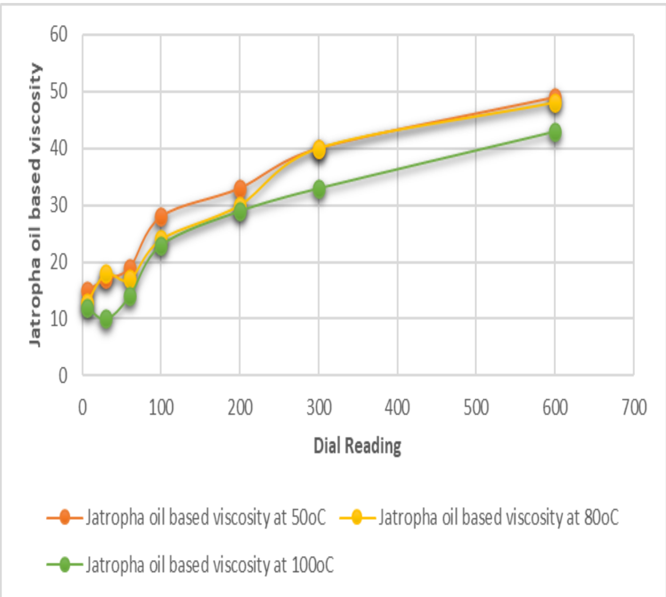

Fig. 1. Viscosity of Jatropha Oil based mud at Different Temperatures.

5.2.2.1.2. Viscometer data of Diesel oil-based drilling fluid:

Table 4: - Viscosity variation with Temperature at different viscometer Reading for Diesel oil-based drilling fluid.

Viscometer Dial Configuration	Viscosity Values at different Temperature		
	50ºC	80ºC	100ºC
600	49	48	43
300	40	40	33
200	33	30	29
100	28	24	23
60	19	17	14
30	17	18	10
6	15	13	12
Gel 10 secs	17	15	12
Gel 10 mins	17	15	9
Plastic Viscosity	9	8	10
Apparent Viscosity	24.5	24	21.5

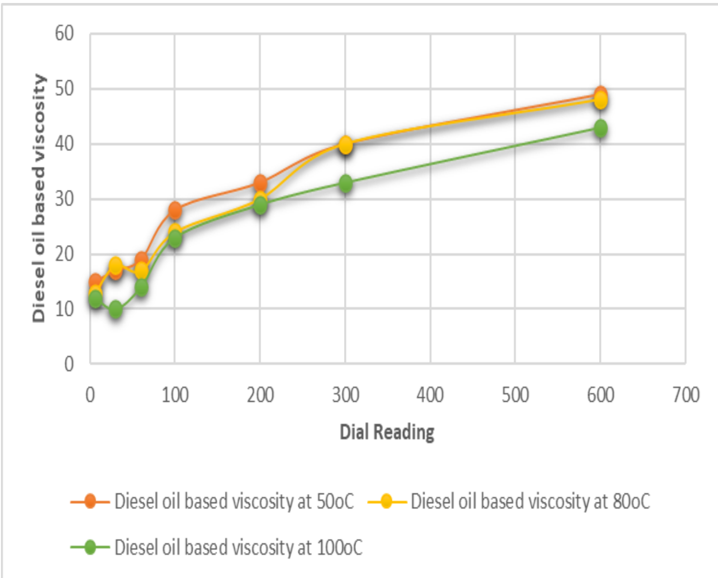

Fig. 2. Viscosity of Diesel Oil based mud at Different Temperatures.

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5.2.2.1.3. Comparition of both drilling fluid viscosities at 50 º C:

Viscometer Dial Configuration	Diesel oil-based mud viscosity	Jatropha oil-based mud viscosity
	50ºC	50ºC
600	49	156
300	40	107
200	33	72
100	28	41
60	19	26
30	17	18
6	15	9

Table 5. Comparition of both drilling fluid viscocities at 50 ºC

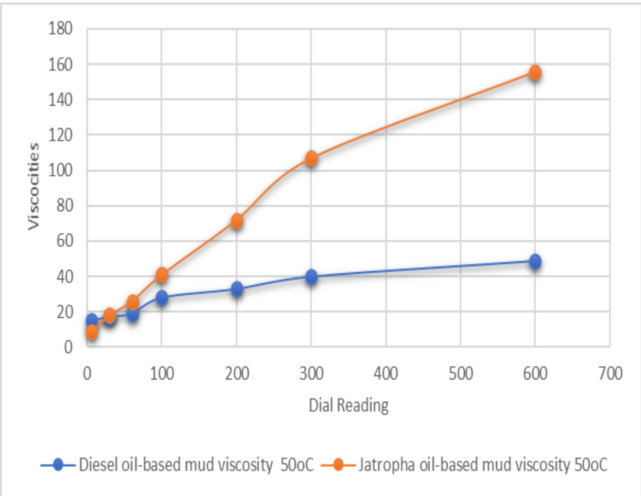

Fig. 3. Comparative Analysis of the Viscosities of Jatropha and Diesel Oils At 50ºC

5.2.2.1.4. Comparition of both drilling fluid at 80 ºC:

Viscometer Dial Configuration	Diesel oil-based mud viscosity	Jatropha oil-based mud viscosity
	80ºC	80ºC
600	48	109
300	40	94
200	30	74
100	24	34
60	17	20
30	18	13
6	13	6

Table 6. Comparition of both drilling fluid viscocities at 80 ºC

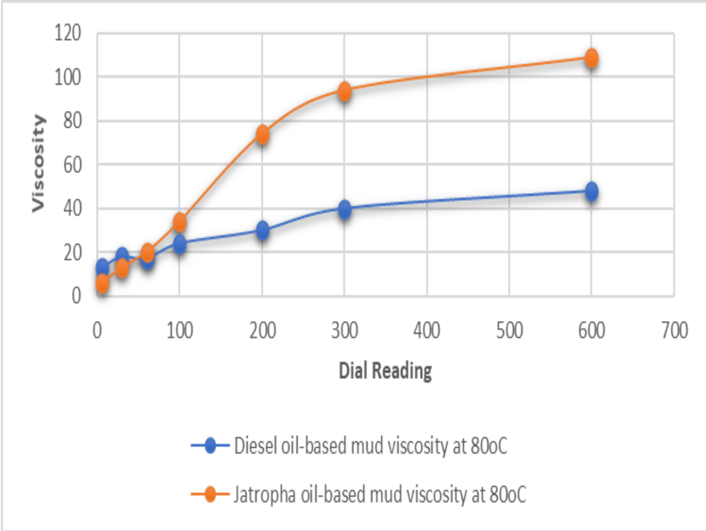

Fig. 4. Comparative Analysis of the Viscosities of Jatropha and Diesel Oils At 80ºC

5.2.2.1.5. Comparition of both drilling fluid at 100 ºC:

Viscometer Dial Configuration	Diesel oil-based mud viscosity	Jatropha oil-based mud viscosity
	100ºC	100ºC
600	43	58
300	33	41
200	29	24
100	23	18
60	14	14
30	10	11
6	12	6

Table 7. Comparition of both drilling fluid viscocities at 100 ºC

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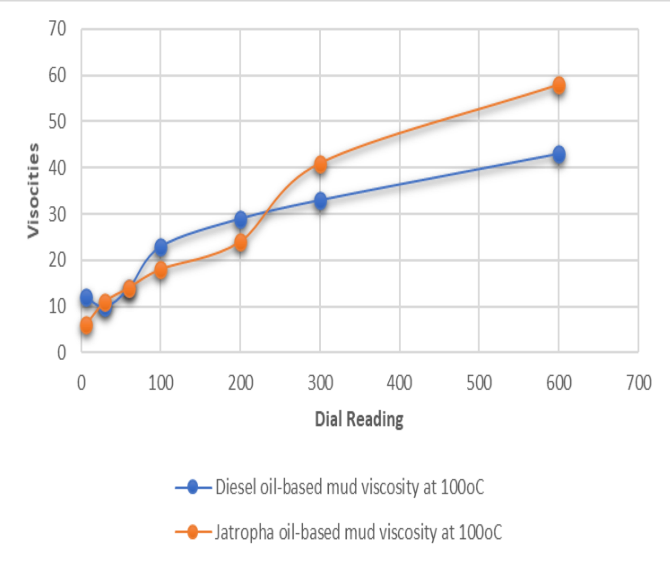

Fig. 5. Comparative Analysis of the Viscosities of Jatropha and Diesel Oils At 100^{O}C

6. DISCUSSION OF THE RESULT

The comparison of jatropha with respect to diesel-based drilling fluid gives some favorable outcomes. The jatropha oil is a bit denser than the diesel which is beneficial because high density rises the capability of drilling fluid to transport cuttings.
Some other benefits include the capability of jatropha based fluid to gain weight more efficiently. Let's take an experiment, the increase in weight percent of jatropha based mud when we add 5 gram of barite is approx. 18% while in case of diesel, the percentage of weight gain is only 6% for same quantity of barite to be added.
When it comes to yield point, jatropha based fluid has more suitable yield point as compared to diesel-based fluid. As the diesel-based fluid has a greater yield point, it shows more pressure losses. So, jatropha based fluid will do the identical functions as diesel-based fluid but more competently and with minimum frictional pressure losses.
The plastic viscosity of jatropha based fluid is 14 cp, while that of diesel-based fluid is 16 cp. The difference is not that much larger but the decrease in plastic viscosity of a substance reduces the resistance to flow. Less circulation pressure will be needed, if we replace diesel-based fluid with jatropha oil-based fluid. This will lead to low pumping cost and the possibility of lost circulation during the drilling operation minimizes too.
Gel strength also plays an important role to check the progress of drilling fluid as it is the capacity of drilling fluid to hold the cuttings. The gel strength of both jatropha based fluid and diesel-based fluid is approximately equal. Both of them have a good gel strength.
The rheological comparison explains that the jatropha oil is ideal candidate to be used in place of diesel.
When we take a look of filtration results, we found that the amount of water and oil collected by jatropha based fluid is less than that of diesel-based fluid. Low oil and water filtrate volume gives an indication of stable emulsion between oil and water. So, it is better to use jatropha based fluid as it provides strong emulsion between oil and water. The mud cake thickness by using jatropha based fluid comes to be 2mm while it is 3mm in case of diesel-based fluid.
It is important to check the toxicity level of both drilling mud before using and when it comes to toxicity, diesel is much more toxic as compared to biodegradable oils.

7. CONCLUSION AND RECOMMENDATIONS

In oil and gas industry, laws and government regulations pushing the industry to think about toxic oil-based drilling muds and their adverse effects on the nearby environment. The disposal cost after the completion of work is also a major problem, which is pushing the industry to find alternatives of currently using oil-based drilling mud and jatropha is found to be the most appropriate replacement of diesel-based mud.
The experimental results show the following advantages of jatropha based fluid over diesel-based fluid:

- Better physiochemical properties
- Rheological properties are also better
- The toxicity of jatropha is less
- Better thermal stability in HTHP wells
- More fire resistance than diesel
- Less filter loss and mud cake deposition
- Better density than diesel
- No need of farming land to grow jatropha plant and can be grown in unfriendly conditions
- Resolves the dumping issues
- More environment friendly

All these characteristics of jatropha oil makes it a perfect replacement of diesel oil to be used as a drilling fluid in oil and gas industry without violating the government rules and regulations and most importantly without harming the environment.

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