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The Impact of Durian Rind in Water-based Mud in Combating Lost Circulation

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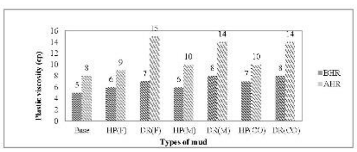
Graphical abstract



Abstract

A laboratory investigation has been done on durian rind, a fibrous material, as an alternative lost circulation material in water-based mud. The experimental works covered the rheological properties and lost circulation tests which were conducted before and after the hot-rolling tests as per API RP 13B. Those tests involved the use of standard mud testing equipment and a lost circulation test cell. The optimum concentration of the durian rind—which had been cleaned, cut into small pieces, dried in an oven at 60°C for 24 hours, and ground into small fine particles—was determined before a performance comparison study was done on both Hydro-plug (i.e., a commercial lost circulation material) and durian rind of different sizes, namely fine (0.5 mm), medium (1.0 mm), and coarse (2.0 mm). The experimental results showed that the durian rind worked well in combating the lost circulation. At its optimum concentration of 20 lb/bbl, the coarse durian rind was found to have performed excellently in combating lost circulation in 1 mm and 2 mm fractures. The standard rheological test showed that the rheological properties of drilling fluid were not too affected at standard temperature of 75°F but they changed significantly after the hot-rolling tests. The change in rheological properties was due to the flocculation of bentonite and chemical reaction of the pectin in durian rind.

Keywords: Durian rind; Hydro-plug; lost circulation; lost circulation test cell; water-based mud

Abstrak

Suatu kajian telah dilaksanakan terhadap kulit durian, yang merupakan bahan berserabut, sebagai bahan kehilangan edaran dalam lumpur dasar air. Kajian mencakupi sifat-sifat reologi dan ujian kehilangan edaran, yang dilakukan sebelum dan selepas ujian bersuhu tinggi berdasarkan API RP 13B. Kajian makmal melibatkan penggunaan kelengkapan piawai pengujian lumpur dan sel ujian kehilangan edaran. Kepekatan optimum ditentukan terlebih dahulu untuk kulit durian—terlebih dahulu dibersihkan, dipotong menjadi kepingan kecil, dikeringkan di dalam ketuhar pada suhu 60°C selama 24 jam, dan dikisar menjadi halus—sebelum dilaksanakan kajian pembandingan prestasi terhadap kedua-dua palam-hidro (kehilangan edaran bahan komersial) dan kulit durian, yang terdiri daripada saiz halus (0.5 mm), sederhana (1.0 mm), dan kasar (2.0 mm). Keputusan uji kaji menunjukkan bahawa kulit durian berjaya mengawal kehilangan edaran. Pada kepekatan optimum 20 lb/bbl, kulit durian bersaiz kasar berjaya dengan cemerlang dalam mengawal kehilangan edaran bagi retakan 1 mm dan 2 mm. Ujian reologi menunjukkan bahawa sifat-sifat reologi lumpur tidak begitu terjejas pada suhu piawai 75°F tetapi mengalami perubahan dengan ketara selepas ujian bersuhu tinggi. Perubahan sifat reologi adalah disebabkan oleh penggumpalan bentonit dan tindak balas kimia yang berlaku terhadap pektin yang terkandung di dalam kulit durian.

Kata kunci: Kulit durian; palam-Hidro; kehilangan edaran; sel ujian kehilangan edaran; lumpur dasar air

■1.0 INTRODUCTION

Lost circulation is a phenomenon where drilling mud lost to the fractures at the formation when the hydrostatic pressure exerted by a drilling fluid is higher than the formation pressure [1]. Lost circulation materials (LCM), which can be in the form of fibrous, flake, granular, or blended, have been used to overcome this problem but in many cases, some conventional LCM may not be able to seal effectively the porous formation, thus causing more serious mud loss [2]. This problem can be overcome through the use of a relatively expensive LCM. Therefore, this paper forwards the impact of local waste material, durian rind which is water wet and fibrous, on combating lost circulation faced by many drilling operations in the oil and gas industry.

Durian or its scientific name *Durio zibethinus L.* is hailed as the king of fruits. This fruit is very popular in Asian countries especially Malaysia. In Malaysia, approximately 376,273 metric tonnes of durian was produced in year 2008 [3]. Depending on the species and age of a durian tree, only 20-35% of durian that can be eaten, i.e., the yellow creamy flesh. The rest of the durian, such as durian rinds and seeds, are dumped as trashes. The durian rinds are about 60-75% of the whole durian [4].

Durian rind contains pectin 18.6% and a high percentage of cellulose, which is 73.45%, which is further divided into α-cellulose and hemi-cellulose [3]. The fibrous nature of durian rind is believed to be able to seal the fractures as effectively as other LCMs [5], if not better. The fibrous LCM forms a mat-like bridge over the porous formation which reduces significantly the size of the openings of the formation [2]. Durian rind also has the potential to be used as a gelling agent although this has not been fully exploited.

■2.0 MATERIALS AND METHOD

The method to prepare durian rind powder can be sourced from the technical paper entitled 'Durian Peel as Biosorbent for Removal of Cadmium Ions from Aqueous Solution' [6]. The durian rind was cleaned, cut into small pieces, and dried in an oven at 60°C for 24 hours. The dried durian rind was ground into smaller pieces before performing the sieve test to get the desired sizes of durian rind: 0.5 mm (fine), 1.0 mm (medium), and 2.0 mm (coarse). The size distribution of the durian rinds was determined using the Abrams' rule which stated that the particle size of the bridging additive should be equal to or slightly greater than one-third the pore size of the formation [7].

In this research work, the performance of durian rind in water-based mud was compared with a commercial lost circulation material, namely Hydro-plug [8]. The water-based mud formulation was obtained from Scomi Energy, as shown in Table 1, while the standard rheological tests on the mud samples before and after the hot-rolling tests were conducted as per the API RP 13B [9]. The rheological properties measured were mud density, plastic viscosity, apparent viscosity, yield point, and gel strength using a rheometer, which were then followed by the bridging test using a lost circulation test cell. The bridging test was done at 100 psi differential pressure and ambient temperature. The simulated fracture sizes used in the research work were 1 mm, 2 mm, and 3 mm.

The base mud and the base mud mixed with durian rind prepared using the compositions of 5 lb/bbl, 10 lb/bbl, 15 lb/bbl, and 20 lb/bbl, were tested for their rheological properties and lost circulation using 1 mm simulated fracture. The experimental results would enable us to determine the optimum concentration of durian rind as a lost circulation material. The same composition was then used to add Hydro-plug in the water-based mud, and the same experimental procedures were repeated for the said mud. The rheological properties and bridging tests were also done for medium and coarse size particles of both lost circulation materials at conditions before hot-rolling (BHR) and after hot-rolling (AHR).

Table 1 Base mud formulation

Additives	Quantity (ppb)
Bentonite	15.0
Soda ash	0.25
Caustic soda	0.25
Starch	1.00

The bridging test was conducted on all the mud samples including those with Hydro-plug and durian rinds and their performances were evaluated at the end of seven minutes testing time. The quantitative performance evaluation was done based on criteria shown in Table 2 [2].

Table 2 Quantitative performance evaluation of LCM

Total mud loss (ml)	Indication
< 350	Excellent control
350 – 700	Good control
700 – 1050	Moderate control
1050 – 1400	Fair control
> 1400	No control

■3.0 RESULTS AND DISCUSSION

The experimental results revealed that the lost circulation control was affected by the concentration of lost circulation material as the higher the concentration of lost circulation material, the better its performance to control mud loss. Nevertheless, Nayberg [2] had proposed that the LCM concentration should be in the range of 5 lb/bbl to 20 lb/bbl as it had been proved that any further increase of LCM concentration would not improve further the performance of LCM.

Figure 1 shows that the 20 lb/bbl of fine durian rind was the optimum concentration for sealing the 1 mm simulated fractures. Apart from applying to the medium and coarse durian rind samples, the optimum concentration was also used to compare the durian rind performances with Hydro-plug of different sizes, namely fine (F), medium (M), and coarse (C).

Based on Figure 2, the base mud was found to have failed in controlling the mud loss because bentonite and other basic additives failed to seal the 1 mm simulated fracture. But drilling fluid with 20 lb/bbl of coarse durian rind and Hydro-plug performed excellently in controlling the lost circulation in 1 mm simulated fracture. Nevertheless, the mud samples with medium durian rind and Hydro-plug showed a good performance in controlling the mud loss in 1 mm simulated fracture while fine durian rind and Hydro-plug failed to combat lost circulation as they were unable to form the mat-like bridge on the openings.

The mud samples with coarse durian rind and Hydro-plug also showed a good loss circulation control in 2 mm simulated fracture, as shown in Figure 3. But mud samples with medium durian rind and Hydro-plug showed a fair performance in controlling the mud loss in 2 mm simulated fracture. Nevertheless, both fine LCMs produced no lost circulation control.

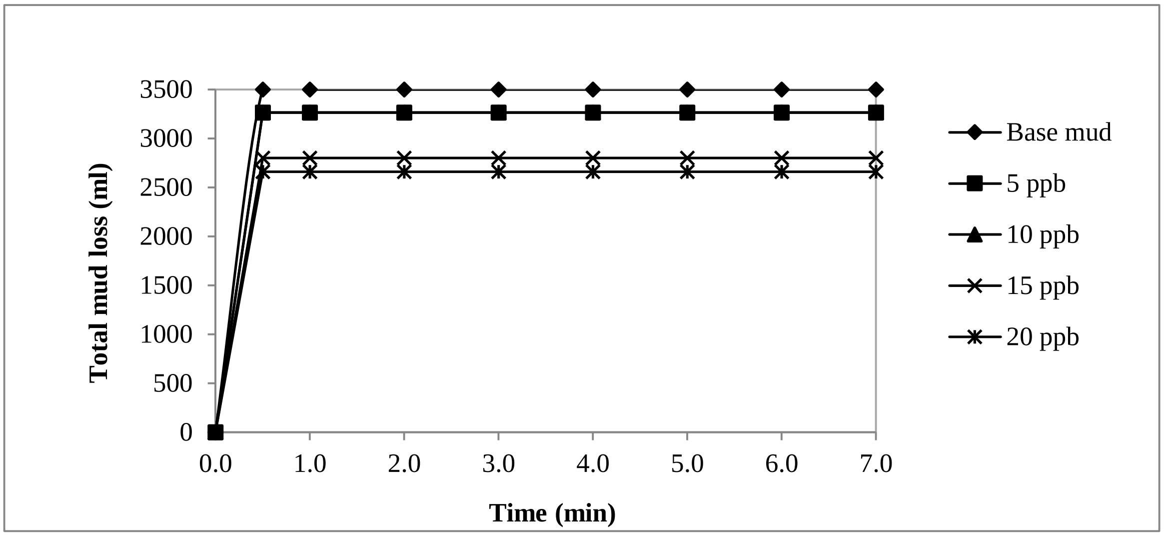


Figure 1 Total mud loss of base mud and fine durian rind of different concentrations, 1 mm simulated fracture, ΔP = 100 psi, T = 75°F

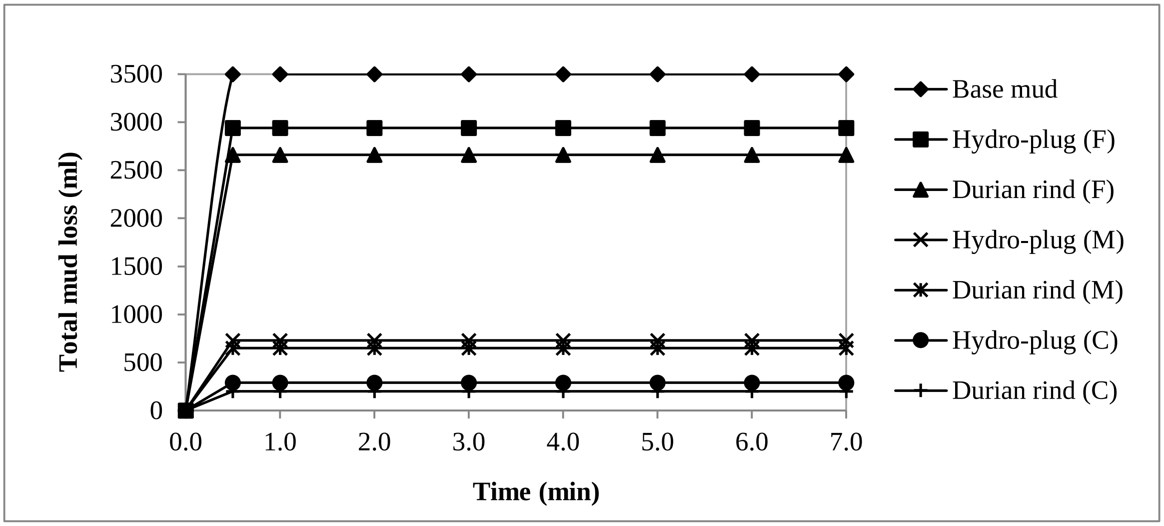


Figure 2 Total mud loss of base mud, Hydro-plug, and durian rind at 20 lb/bbl concentration for fine, medium, and coarse size, 1 mm simulated fracture, ΔP = 100 psi, T = 75°F

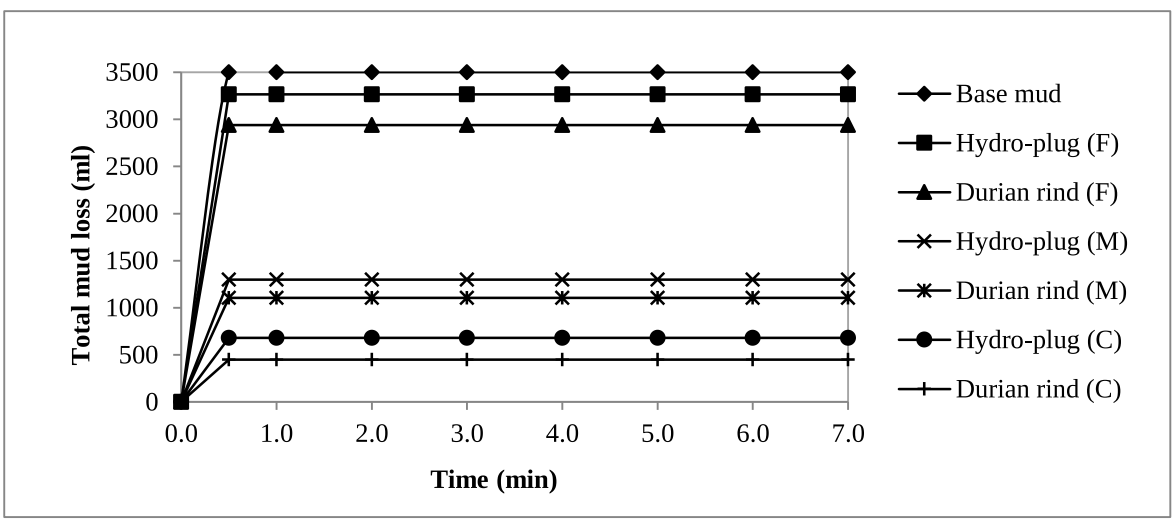


Figure 3 Total mud loss of base mud, Hydro-plug, and durian rind at 20 lb/bbl concentration for fine, medium, and coarse size, 2 mm simulated fracture, ΔP = 100 psi, T = 75°F

Figure 4 shows that mud sample with coarse durian rind produced a moderate performance as compared to fair performance by mud sample with coarse Hydro-plug in controlling lost circulation in the 3 mm simulated fracture. But mud samples with medium and fine durian rind and Hydro-plug showed no lost control ability for this size of simulated fracture. Overall, the experimental results revealed that coarse and medium durian rind and Hydro-plug gave mixed performances but fine durian rind and Hydro-plug were found to have failed to produce any lost circulation control ability in all three simulated fractures.

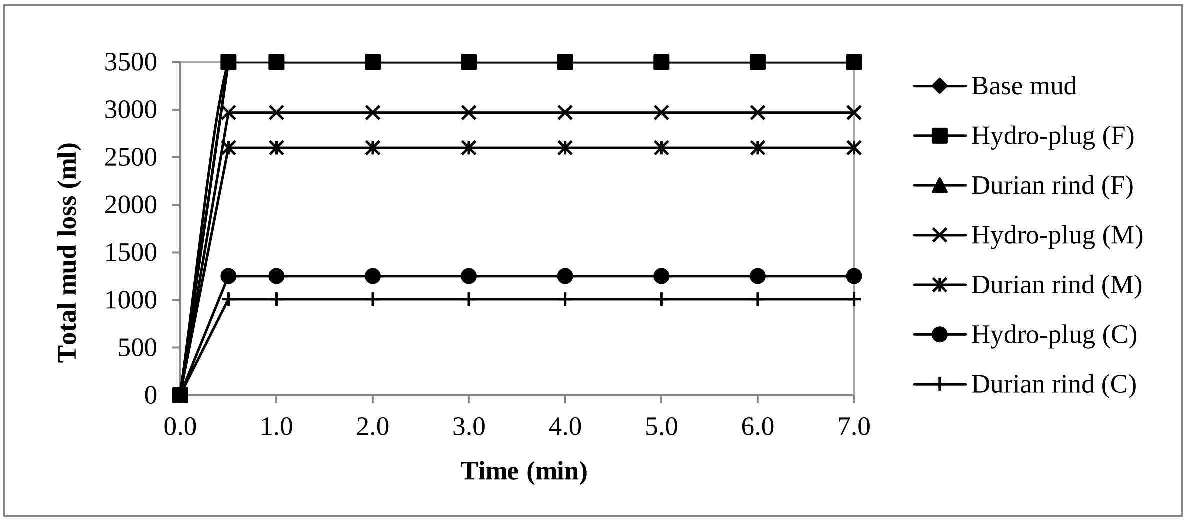


Figure 4 Total mud loss of base mud, Hydro-plug, and durian rind at 20 lb/bbl concentration for fine, medium, and coarse size, 3 mm simulated fracture, ΔP = 100 psi, T = 75°F

The results proved that the lost circulation materials should have an appropriate particles sizing for the fracture opening to be sealed as stated by Abrams [7]. The tests also showed that the durian rind could perform better than Hydro-plug. The excellent performance of coarse durian rind was due to its suitable fibrous nature and the optimized particle sizing of LCM. As specific sizes of LCM particles were used, the Hydro-plug which is a granular LCM that if it is used in the form of a specific particle size, it is found to be ineffective to combat the loss of mud.

The rheological properties of drilling fluid with Hydro-plug and durian rind were found to have experienced some changes after the hot-rolling tests. But mud weight was found to be unaffected before and after hot-rolling tests. The experimental results showed that plastic viscosity changed drastically after hot-rolling process, as shown in Figure 5, but still within the acceptable field limit. It is of utmost importance to maintain the viscosity of drilling fluid of about 15 cp in order to effectively lift drilled cuttings to the surface [10].

According to Hiller [11], when particles of bentonite are flocculated, higher temperatures disperse the thicker particles which cause both the yield stress and plastic viscosity to increase. It was also stated that pectin is a polysaccharide component which is highly hydrophilic and permeable to water. The pectin of durian rind would absorb water from the drilling fluid after it was hot-rolled for 16 hours that caused the mud to thicken [12].

The durian rind's yield point was higher when compared to Hydro-plug, as shown in Figure 6. The difference was due to the inertness of Hydro-plug compared to durian rind. It was also due to the pectin content of durian rind, which also caused durian rind to experience greater gel strength than Hydro-plug, as shown in Figure 7.

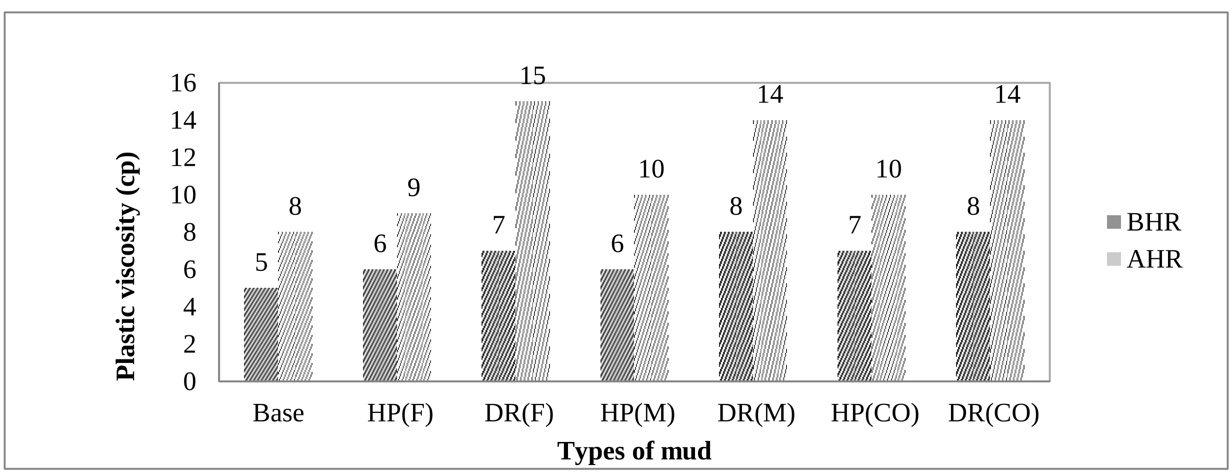


Figure 5 Comparison of plastic viscosity between base mud and optimum LCM concentrations of 20 lb/bbl BHR and AHR measured at 120°F

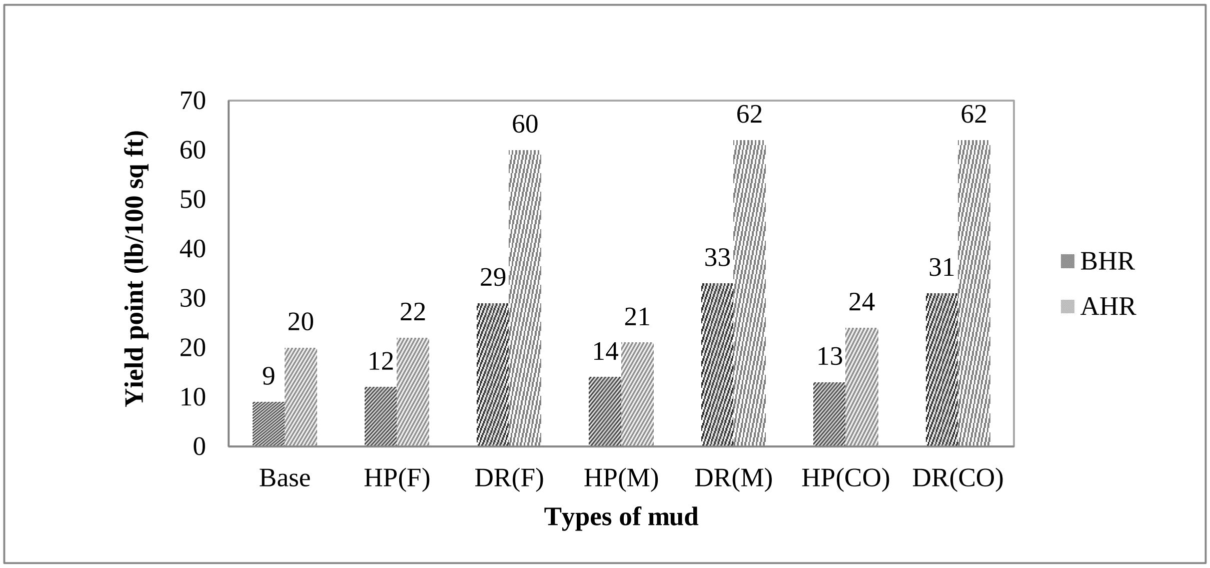


Figure 6 Comparison of the yield point of base mud and optimum LCM at concentrations of 20 lb/bbl BHR and AHR measured at 120°F

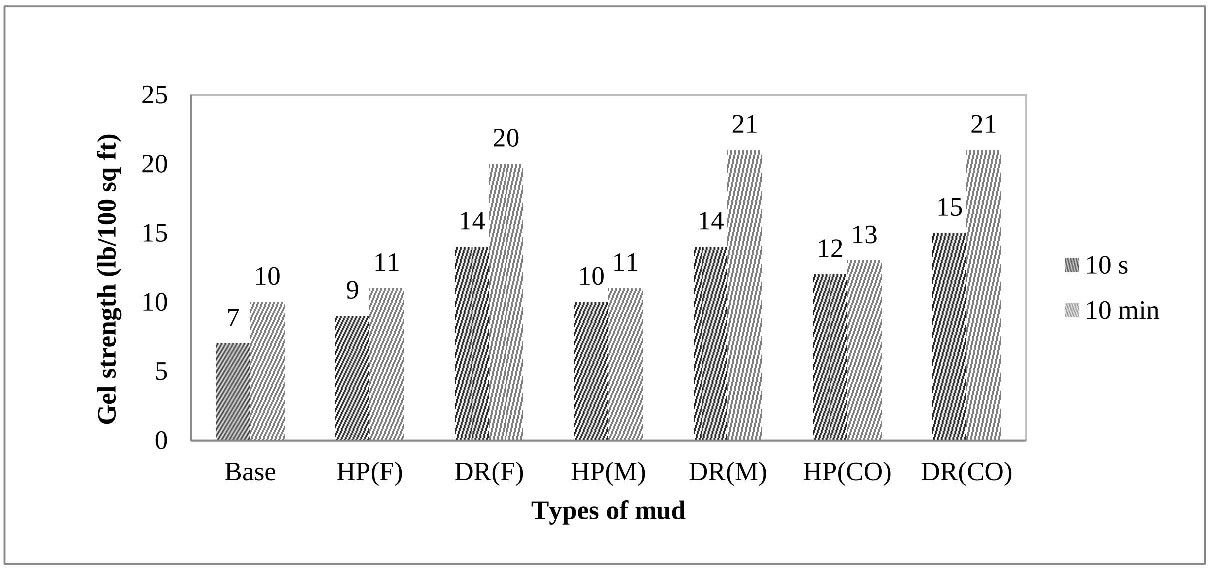


Figure 7 Comparison of gel strengths (10 seconds and 10 minutes) of base mud and optimum LCM concentration of 20 lb/bbl AHR measured at 120°F

4.0 CONCLUSIONS

The following conclusions have been framed out accordingly from the research work:

(1) The experimental results showed that durian rind has the sealing ability and it has the potential to be used as lost circulation materials in water-based mud. The optimum concentration of durian rind was found to be 20 lb/bbl.

(2) The mud loss tests showed that durian rind performed better than Hydro-plug in sealing the simulated fractures. The coarse durian rind and Hydro-plug outperformed the medium and fine durian rind and Hydro-plug in sealing the 1 mm simulated fracture at optimum concentration of 20 lb/bbl measured at 75°F. For 2 mm and 3 mm simulated fractures, the suitable mud formulation should comprise coarse durian rind at its optimum concentration of 20 lb/bbl.

(3) Mud samples with fine durian rind and Hydro-plug were found to have failed to produce any lost circulation control ability in all the simulated fractures, i.e., 1 mm, 2 mm, and 3 mm.

(4) The rheological properties of the durian rind were not significantly affected at standard temperature of 75°F. But the rheological properties of durian rind were greatly affected after the hot-rolling tests of the mud at 120°F whereas the rheological properties of Hydro-plug were stable for both conditions.

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