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Evaluating An Iron-Based Mineral's Abrasiveness Via A Movable Rig.

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Abstract

This paper discusses the utilization of an abrasiveness rig in order to evaluate the abrasiveness effect of Malaysia hematite, an iron-based mineral which has the potential to be used as weighting material in drilling mud. The abrasiveness rig used in this study was developed by using an unused laboratory equipment. Two types of test pipes namely copper and aluminium were installed in the rig for abrasiveness test purposes.

Experimental results revealed that the Malaysia hematite's rheological properties were found to be comparable to barite, the standard weighting material used in the petroleum industry Neverthless, the hematite was found to give higher abrasiveness rate as compared to barite.

Introduction

In the petroleum industry, drilling mud is normally utilised when an oilwell is being drilled. The drilling mud is used in order to carry out cuttings to the surface, to cool the drilling bit and the most important of all is to provide sufficient hydrostatic pressure across the production zones. Failure to provide sufficient hydrostatic pressure across the zones will lead to influx of formation fluids (commonly known as kick) and if the kick couldn't be controlled in a relatively short period, it may trigger a blowout - a disaster which will cause massive damage to properties, loss of human lives and severe pollution problems. Practically the hydrostatic pressure imposed on the production zones has to be higher than the formation pressure in the range of 250 psi (1,724 kPa) to 450 psi (3,103 kPa).

Barite (Hurbult, 1958) is the principle weighting material which is widely used in the petroleum industry In order to elevate the density of drilling mud to a predetermined mud weight value. The current consumption of barite in the Malaysian petroleum industry is about 20,000 tonnes per year and is being sourced locally. As the Government of Malaysia has looked forward into deep sea drilling operations in order to elevate the national's hydrocarbon reserves, thus we believe the supply of barite may fall short in the foreseeable future due to the increase in drilling activities and dwindling reserves of quality barite. Thus there is a need to look for an alternate local weighting materal.

Hematite, an iron-based mineral (Haaland and Tuntland, 1981), is one of the local weighting materials being studied by the Department of Petroleum Engineering currently. This iron-based mineral could be found at many locations in Malaysia.

Generally, any newly found weighting materials must undergo several basic tests the likes of rheological properties. (such as yield strength and gel strength), particle content, HPHT fluid loss and abrasiveness prior to making any further decisions (Simposium, 1985). In this study, special attention was given to the hematite's abrasiveness characteristics since many literatures had highlighted that abrasion was the main problem when an iron-based mineral was used as weighting material in drilling mud. To assist the research group in evaluating the Malaysia hematite's abrasiveness, a movable abrasiveness test rig was developed and utilised.

Material and Laboratory Test

In this study, the raw Malaysia hematite was ground to meet the API specification set forth for hematite prior to preparing the required test samples. All the test were conducted in an oil-based mud system. Two types of test samples were prepared namely mud A and mud B with mud A comprised of barite (the principle weighting material used in the petroleum industry) and mud B utilised the Malaysia hematite as the weighting agent. The range of mud weight used in this study was in the range of 8.5 ppg (1,018 kg/m^3) to 13.0 ppg (1,558 kg/m^3).

The weight of the mud samples were measured via the conventional mud balance. Those mud samples were then measured/ tested for their solid content, rheological properties, fluid loss and abrasiveness effect. The solid content measurement were performed via the conventional method (Gatlin, 1960), whilst the rheological properties were measured by using the Baroid rheometer. The rheological properties measured in this study were viscosity, yield point and gel strength.

The fluid loss properties of those mud samples were evaluated by using the HPHT filter press and the data taken from this test were filtrate collected against time and filter cake thickness. The permeability of filter cake formed could be calculated by utilising the Darcy equation.

All the test were conducted according to the API standard procedures. The abrasiveness rate of each of the weighting materials used in this study was evaluated by utilising the movable abrasiveness rig.This test rig was developed by using an unused laboratory equipment (Figure 1). It comprised of a mud pump, a mud tank, a stirrer, two test pipes (i.e. copper and aluninium), pressure gauges, valves and PVC pipes. Whilst the flowrate in each of the pipes used was measured via an ultrasonic flowmeter.

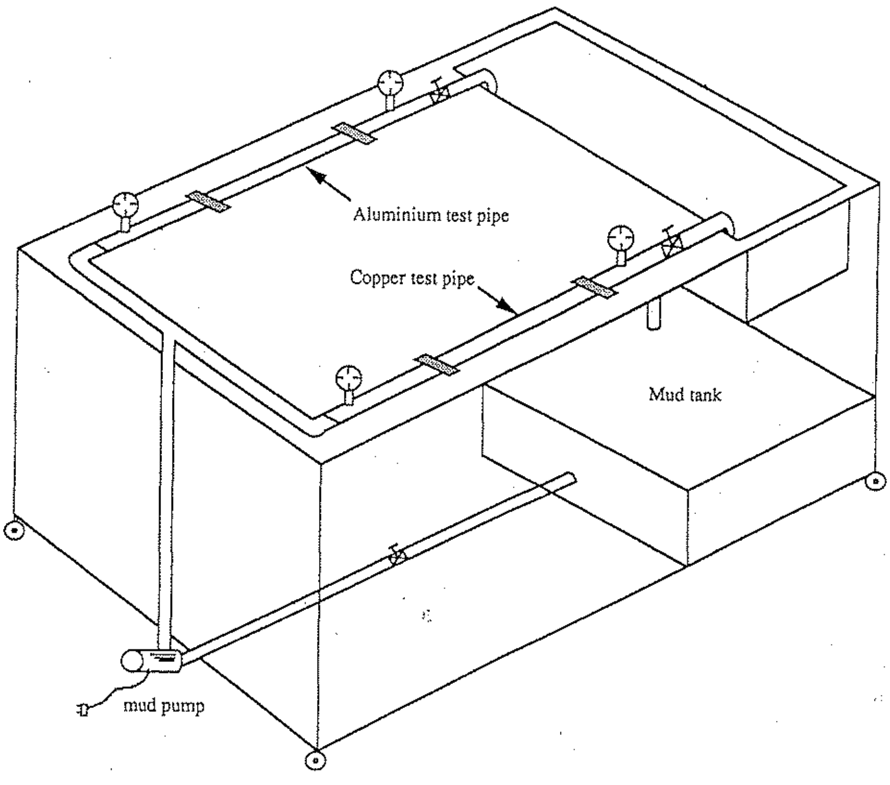

Figure 1 The Abrasiveness test Ric

During the abrasiveness test, mud A and mud B were circulated through both the test pipes separately at a velocity of 1.5 m/sec to 10 m/sec. Prior to installing the test pipes in the system, both pipes were weighed at the first place. After circulating mud A or mud B through the test pipes for 4 hours, the mud pump was stopped and both test pipes were then disconnected from the test rig prior to weighting them again.

The abrasiveness rate for each of the test pipes used was computed by dividing the weight loss experienced by each of the test pipes used by circulation time i.e. 4 hours.

Results and Discussion

Generally, as depicted in Figures 2 to 7, the experimental results show that the Malaysia hematite has the potential to be used as weighting material in drilling mud (Zulkefli, 1994.)

The solid content of mud B was found to give lower readings than mud A, as shown in Figure 2. This revealed that the use of Malaysia hematite in drilling mud would result in less solid content as compared to barite - a situation which will increse the drilling rate and thus reducing the rig time (Issham and

Ahmad Kamal, 1994). Generally, this is due to the specific gravity of the hematite which has higher value than barite.

Figure 3 showed the relationship between mud density and apparent viscosity. The viscosity curve of hematite sample was found to be comparable to barite sample.

Figure 4 revealed the relationship between the mud density and plastic viscosity. The relationship showed that at higher densities, the plastic viscosity of barite sample was higher than the hematite sample. In contrast, at lower densities, the plastic viscosity of hematite was found to give higher values as compared to barite sample. This might be due to the presence of large amount of suspended particles in the barite sample. The collision occured amongst those suspended particles had increased the plastic viscosity and the effect was found to be dominant at higher densities.

The relationship between mud density and yield point, and mud density and gel strength, were depicted in Figures 5 and 6 respectively. The hematite sample was found to give higher yield point and gel strength values as compared to barite. These phenomena migh be due to the mixing process which the Malaysia hematite (i.e iron-based in nature) had to undergo when mud sample preparation was in progress.

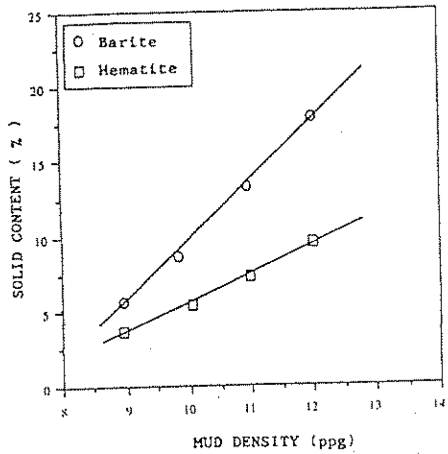

FIGURE 2: SOLID CONTENT VERSUS MUD DENSITY

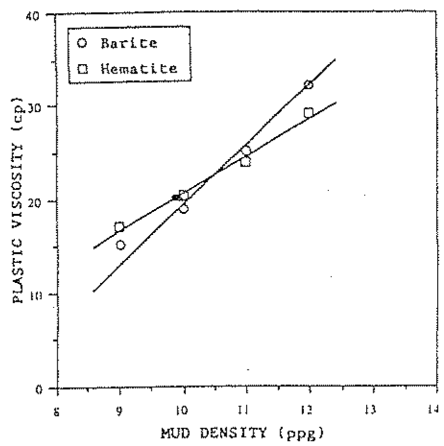

FIGURE 4: PLASTIC VISCOSITY VERSUS MUD DENSITY

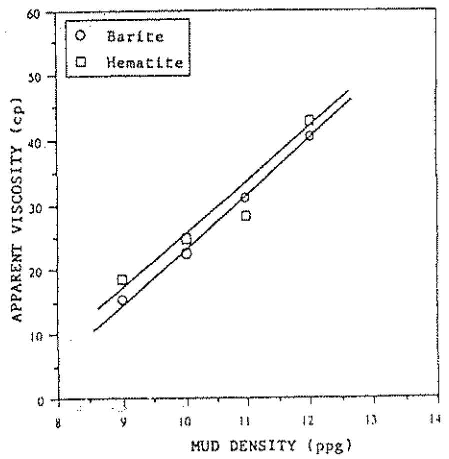

FIGURE 3: APPARENT VISCOSITY VERSUS MUD DENSITY

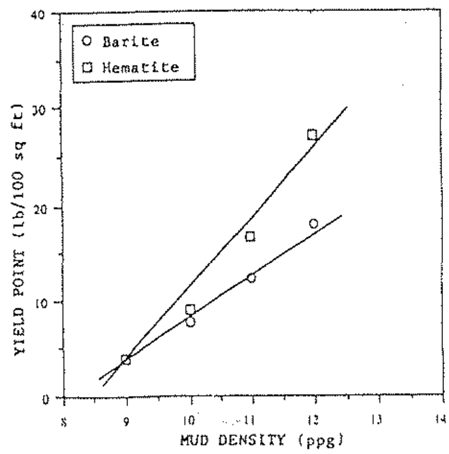

FIGURE 5: YIELD POINT VERSUS MUD DENSITY

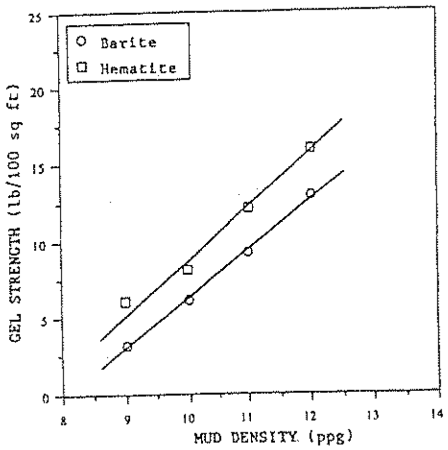

FIGURE 6: GEL STRENGTH VERSUS MUD DENSITY

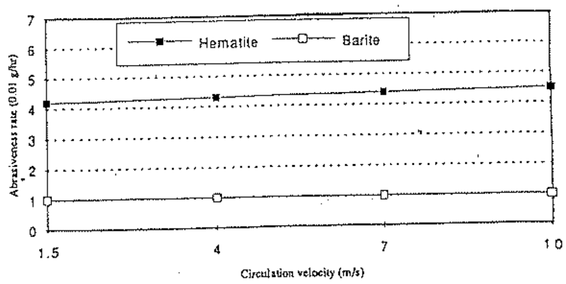

FIGURE 8: ABRASIVENESS RATE VERSUS CIRCULATION VELOCITY (FOR ALUMINIUM)

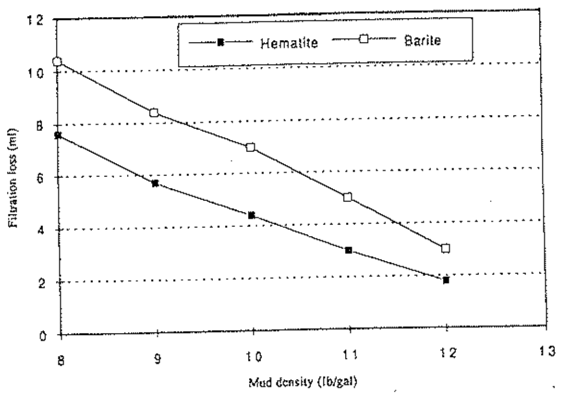

FIGURE 7: FILTRATION LOSS VERSUS MUD DENSITY

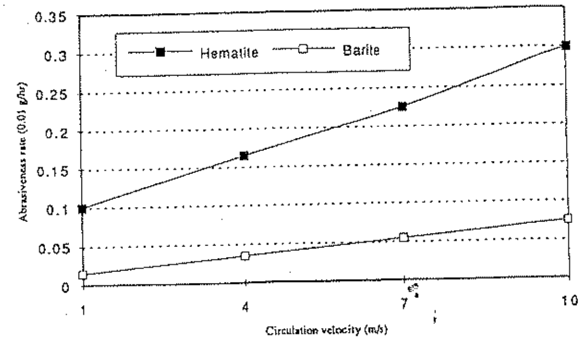

FIGURE 9: ABRASIVENESS RATE VERSUS CIRCULATION VELOCITY (FOR COPPER)

The fluid loss test which was conducted at a differential pressure of 500 psi and 2000 F, revealed that the mud A experienced higher filtration loss as compared to mud B. This statement was supported by Figure 7. Generally, mud sample with lower solid content will enable the solid particles to be compressed more effectively by the differential pressure, thus forming a thin and low permeability cake.

Figures 8 and 9 showed the abrasiveness test results for both mud samples. The experimental results indicated that mud sample with hematite was more abrasive as compared to mud sample with barite. This was due to the hematite's hardness which has higher value than barite.

Conclusion

Based on this study, it could be concluded that Malaysia hematite has the potential to be used as weighting material in drilling mud. This statement was supported by the rheological and fluid loss properties of hematite sample which were found to be comparable to barite. The significant advantage realised of utilising hematite as compared to barite was it gave lower solid content - a phenomenon which could increase drilling rate thus reducing the rig time required. Neverthless, the abrasiveness test results revealed that the hematite sample was found to be more abrasive than barite. Another point to note was the movable rig could also be used to evaluate the abrasiveness effect of other minerials.

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