Managing Drilling Mud Weight Using Ilmenite

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ABSTRACT

Drilling mud plays an important role when drilling an oilwell, where it produces sufficient hydrostatic pressure that could prevent the influx of formation fluids into the wellbore. Barium sulphate, which is more commonly known as barite in the petroleum industry, is the principle weighting material used to increase mud weight. With the expected increase in drilling activities and dwindling reserves, quality barite supply may fall short in the foreseeable future. Ilmenite, an iron-based mineral, is being investigated by the Drilling Fluid Research team of UTM of it's potential to be used as an alternative weighting material. The study involved of laboratory experiments, and amongst the parameters studied were mud weight/density, rheological properties of drilling mud with all the weighting materials, and the abrasiveness effect. Experimental results reveal that even though ilmenite is found to be more abrasive than barite, but it has the potential to substitute barite as weighting material. Two significant advantages could be realised via ilmenite; it produces lower solids content and fluid loss which in turns increases rate of penetration but reduces formation damage respectively.

Keywords
Drilling Mud, Ilmenite, Weighting Material, Solids Content, Fluid Loss

INTRODUCTION

In producing crude oil from a reservoir, located thousands of feet in the earth's crust, a production hole needs to be drilled and later completed to form a conduit between the reservoir and surface. The success of drilling a production hole does not depend solely on the capability of the state-of-the-art drilling equipments, but it is also found to be relied on the drilling mud used (Rabia, 1985). In the drilling activities, drilling mud is usually used to remove cuttings from the borehole, to prolong bit's life, to minimise fluid loss, to control well pressure etc (Gatlin, 1960).

Drilling mud should be able to impose sufficient hydrostatic pressure, normally in the range of 250 psi (1,724 kPa) to 450 psi (3,103 kPa) higher than the formation pressure. Failure to produce the expected hydrostatic pressure will initiate the influx of formation fluid – a phenomenon commonly known as well kick – which may lead to blowout. Generally, blowout will only occur if well kick could not be controlled/killed in a relatively short period. The catastrophe can cause massive damage to properties, loss of lives and severe pollution problems (Adam, 1985).

In order to increase mud weight to a predetermined value, barite – the principle weighting material used in the petroleum industry – is added into the mud. Barite is the commercial name for barium sulphate – an inert substance (Gray and Darley, 1981). Presently, barite reserves could be found in many places the likes of Trengan River of Terengganu, Cini Lake of Pahang, Pencuri Hill of Kelantan etc. The consumption of barite in the Malaysia petroleum industry is around 20,000 tonnes annually. Nevertheless, with the aggressive approach adopted by Petronas in increasing the national's hydrocarbon reserves, coupled with the incentives given by the Malaysian government of venturing into deep sea drilling, it is anticipated that the supply of quality barite may fall short in the foreseeable future. Thus, there is a need to look for an alternative weighting material.

Ilmenite, an iron-based mineral (Gribbel and Hall, 1985), is currently being studied by the Drilling Fluid Research team of UTM, in order to determine its potential to be used as weighting material. This mineral source comes from three different locations, namely Kuantan of Pahang, Gopeng and Batu Gajah of Perak. The performances of all ilmenites in mud were evaluated via a series of laboratory experiments. Amongst the parameters investigated were mud weight/density, rheological properties, fluid loss, and solid content, as outlined in the API specifications. The abrasiveness characteristics of ilmenites were also evaluated by using an abrasiveness rig. The ilmenites' results were then compared with the commercial barite prior to making concluding remarks.

MATERIALS AND METHODS

This investigation involved with a series of laboratory works which was initiated with the preparation of water-based mud as the continuous phase system. The mud sample was prepared as per the field formulations, which comprised of fresh water, potassium chloride, caustic soda, soda ash, PAC R, PAC UL, Foralys, Resinex, and Glycol (Juhari, 1998). The weighting materials were then added into the mud separately to form the required mud weight, ranging from 9 ppg to 12 ppg. Four types of mud sample with respective weighting materials were prepared:

Sample 1: water-based mud with commercial barite.
Sample 2: water-based mud with Gopeng's ilmenite.
Sample 3: water-based mud with Batu Gajah's ilmenite.
Sample 4: water-based mud with Kuantan's ilmenite.

Barite, which was sourced from the Kota Minerals (M) Sdn. Bhd. of Kemaman Supply Base, was received in powder form and conformed with the API specifications. In contrast, all the ilmenite samples were received in coarse form and had to be grounded and sieved to meet the API specifications (American Petroleum Institute, 1979).

The mud weight of the mud samples were determined by using the conventional mud balance, whilst the rheological properties, namely viscosity, yield point, and gel strength, were measured via the Baroid rheometer. The retort apparatus was used to determine the solid content of a mud sample (Gatlin, 1960). The fluid loss experienced by the mud samples was measured by the utilisation of HPHT filter press, where the data taken from this experiment was volume of filtrate collected against time. All the laboratory works were conducted according to the API standard procedures (American Petroleum Institute, 1978).

The abrasiveness of ilmenites were analysed by using an abrasiveness test rig (Juhari, 1998). The test rig comprised of a mud tank (which could accommodates 40 liters of mud), a mud pump, a stirrer, an aluminium test pipe, pressure gauges, valves, PVC pipes and an ultrasonic flowmeter. In the abrasiveness test, each of the mud samples was circulated through the test pipe at a velocity ranging from 1.5 m/s to 10 m/s. The test pipe was weighed initially prior to installing in the system. Each of the mud samples was then circulated continuously through the test pipe for a period of 3 hours, before the abrasiveness test was halted. The test pipe was disconnected from the system and was weighed again. Thus by utilising the experimental data, the abrasiveness rate of each sample could be computed; the net weight loss experienced by the test pipe divided by circulation time.

RESULTS AND DISCUSSIONS

The experimental results of mud weight/density, solid content analysis, rheological properties, fluid loss, and abrasiveness tests are shown in Figures 1-6.

All the ilmenites used were found to be able to produce same mud weight as barite. However, the quantity of ilmenites required was smaller than barite, thus produced lower solid content. Figure 1 shows the relationship between solid content and the given mud weight. Generally, solid content analysis involves the measurement of weighting material and sand content of mud in order to prevent abrasion of pump and drill pipe, and usually expressed in percentage. It was found that the solid content increased proportionally with mud weight. Of the four curves, mud sample with barite gave the highest solid content. Gopeng's ilmenite was found to produce the lowest solid content because it has the highest specific gravity as compared to the other weighting materials (Juhari, 1998). The significant advantage that could be realised from the utilisation of lower solid content drilling mud is the increase in rate of penetration, due to the presence of less solids in the vicinity of the rotating drill bit.

Plastic viscosity, which is produced from the friction between solid particles in the mud and the viscosity of the dispersed phase, is shown of its relations with mud density in Figure 2 – revealed that barite started to give higher viscosity values at 11.0 ppg of mud weight. At 11.7 ppg, mud sample with barite had dominated the ilmenites, by producing the highest viscosity. This was due to the presence of 25% (by weight) of 6 μm of barite particles in the mud sample, which was higher than ilmenite (less than 12%). Generally, friction between particles becomes apparent with the increased in number of particles in the mud sample, which in turns elevate the plastic viscosity. This effect is found to be significant as mud weight increases. This phenomenon revealed that Gopeng's ilemenit, which gave comparable performance as barite, has the potential to be used as weighting material in heavy mud, as it could increase the rate of penetration, increase the efficiency of well cleaning, and easy to be separated from cuttings at the surface.

Figure 3 shows the relationship between gel strength and mud weight. Generally, gel strength of mud is a measure of the shearing stress necessary to initiate a finite rate of shear. The experimental results revealed that mud sample with barite gave higher gel strength than ilmenites. Again, it was found that Gopeng's ilmenite gave comparable performance as barite. This phenomenon was due to the presence of large quantity of barite particles in the mud, coupled with their stronger tendency to attract to each other than ilmenites. Mud with moderate gel strength could suspend mud particles including drill cuttings when mud circulation is halted temporarily. However, mud with high gel strength may cause many operational problems such as increase torque on drill string etc.

The relationship between yield point and mud weight is shown in Figure 4. Yield point is the maximum stress that a solid can withstand without undergoing permanent deformation either by plastic flow or by rupture. The experimental results showed that all three ilmenites gave lower yield point than barite, with Kuantan's ilmenite produced better performance than others did. This might be due to the ilmenites' hardness (5.0 – 6.0, based on Mohs scale) which are higher than barite (2.5 – 3.5). Generally, mud with optimal yield point could carry cuttings to the surface in a more effective manner.

Figure 5 shows the experimental results of fluid loss tests, which were conducted on every mud sample at a differential temperature of 500 psi and 200°F. It was found that mud sample with barite experienced higher fluid loss compared to ilmenites. The phenomenon was due to the inability of differential pressure to compress larger quantity of particles presence in the mud sample with barite effectively, thus prevented the formation of thin and low permeability mud cake. Generally, excessive fluid loss can cause formation damage, which in turns reduce well productivity.

Figure 6 reveals the abrasiveness test results. It was found that ilmenite was more abrasive than barite as ilmenites' hardness was twice the value of barite. Gopeng's ilmenite was found to be less abrasive than other ilmenites. Higher abrasiveness rate indicates that drilling equipments will get worn out at a faster rate.

CONCLUSIONS

The experimental results revealed that smaller quantity of ilmenites could produce same mud weight as barite, which in turns yield lower solid content. This phenomenon would increase drilling performance. The use of ilmenites might reduce formation damage problems as they experienced lower fluid loss than barite. In terms of rheological properties, ilmenites were found to give comparable results as barite. Generally, the main drawback of ilmenites is of their abrasiveness characteristics which is higher than barite. This will cause drilling equipments to get worn out at a faster rate. Of the three ilmenites, Gopeng's ilmenite is found to give better performance compared to the other two ilmenites. The study shows that ilmenite has the potential to be used as weighting material especially in a heavier drilling mud.

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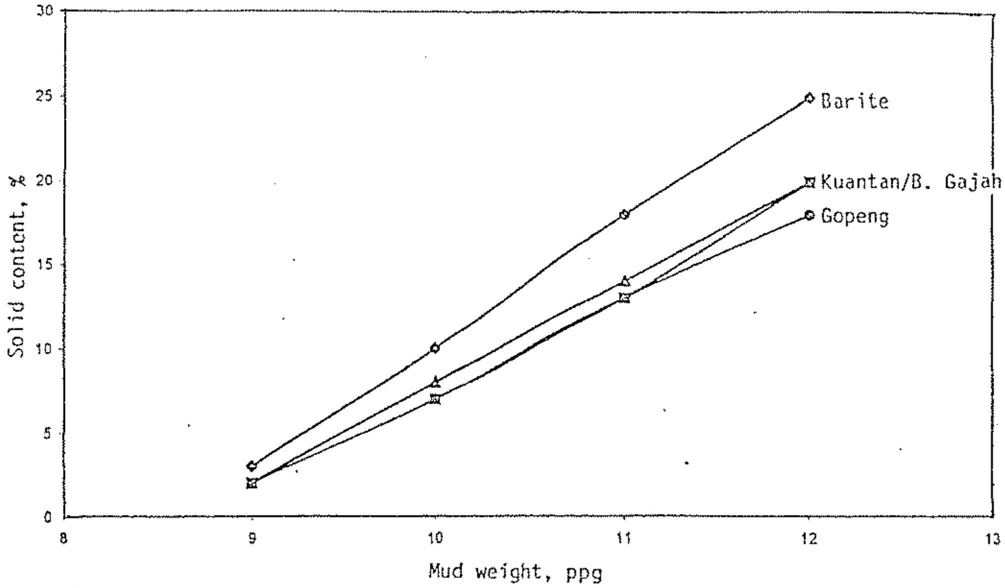

Figure 1 Solid content vs mud weight

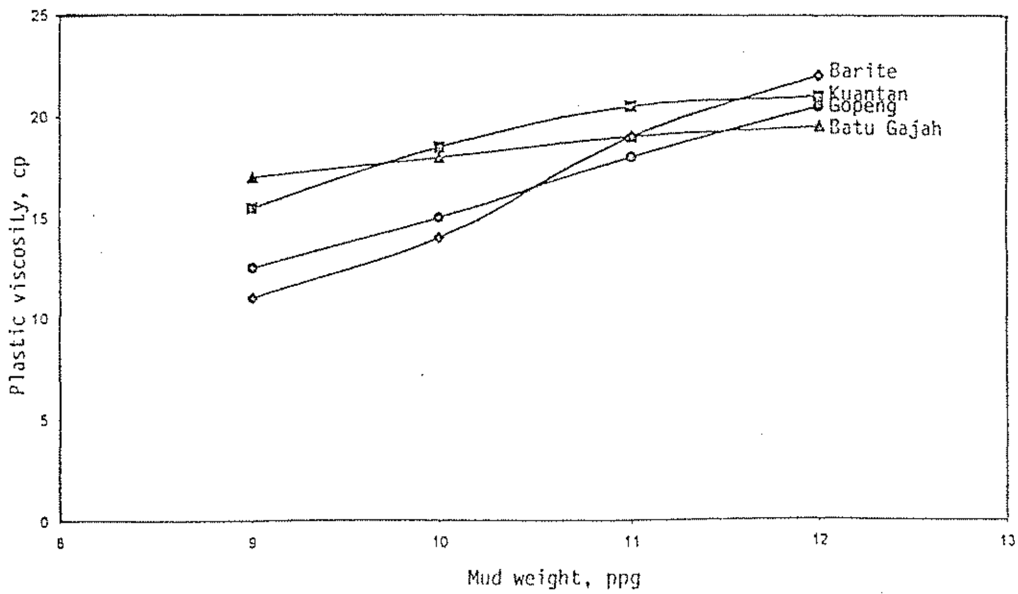

Figure 2 Plastic viscosity vs mud weight

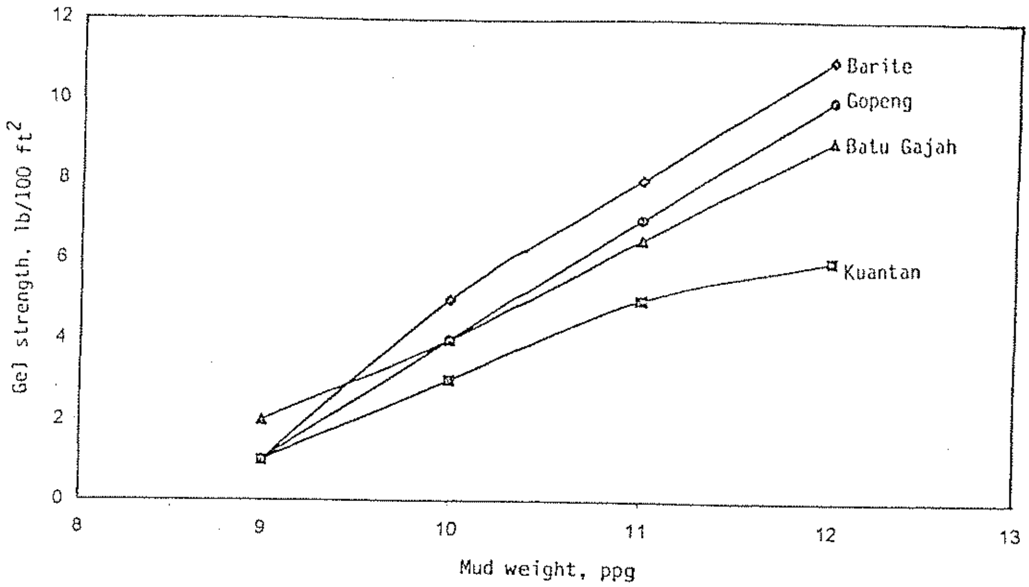

Figure 3 Gel strength vs mud weight

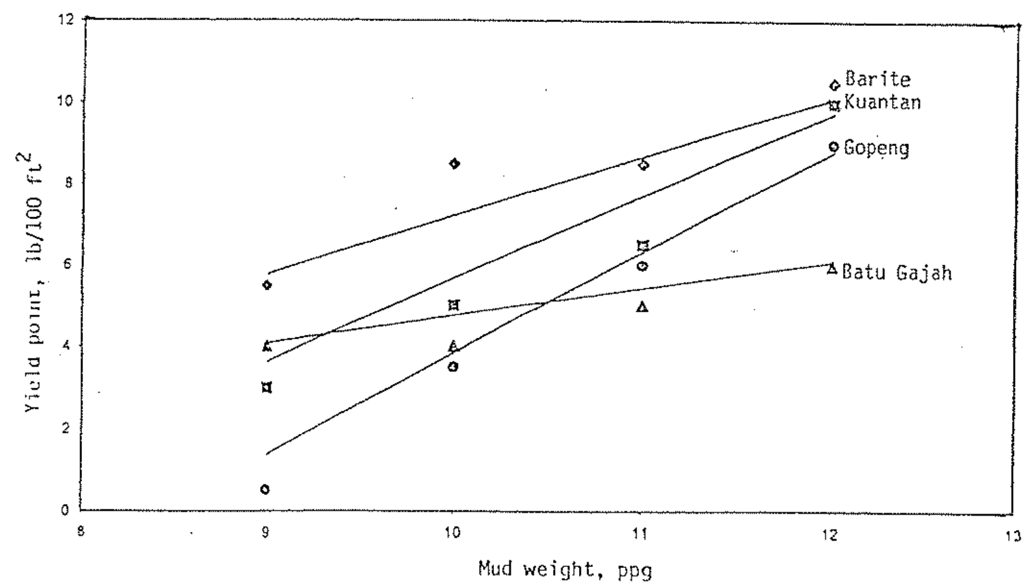

Figure 4 Yield point vs mud weight

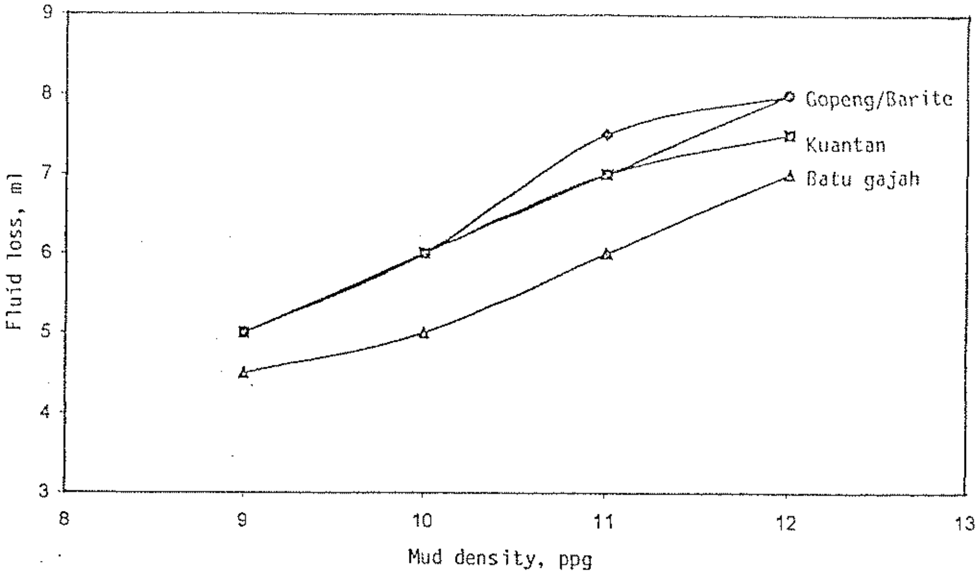

Figure 5 Fluid loss (after 30 minutes) vs mud weight

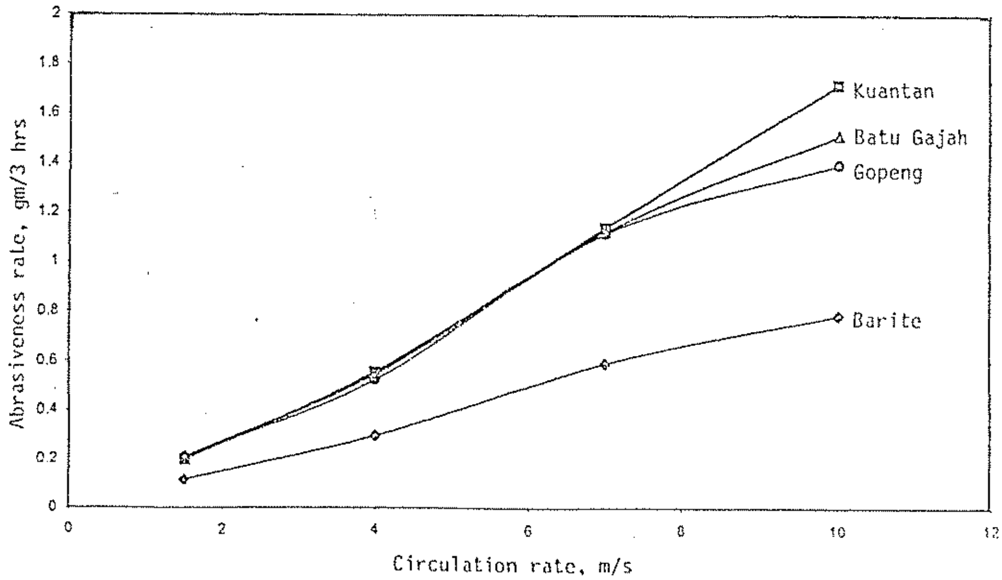

Figure 6 Abrasiveness rate versus mud circulation rate