THE IMPORTANCE OF IMPLEMENTING PROPER MIXING PROCEDURES IN THE PREPARATION OF HEC AND CORN STARCH MIXTURES FOR CONTROLLING FLUID LOSS

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Abstract

This paper discusses the prospect of utilising the corn starch and hydroxyetil cellulose (HEC) mixture as fluid loss control agent in workover fluid. Prior to conducting the experiment, workover fluid sample was prepared by mixing corn starch with HEC, the standard fluid loss control agent used in the petroleum industry, via the *Baroid Multimixer*. Two basic tests, namely the rheological properties and fluid loss, were conducted on the sample. The experimental results of fluid loss tests could reveal the ability of the sample to control fluid loss, a phenomenon which might lead to the pipe sticking and clay swelling problems, reduction of permeability in the vicinity of the borehole etc. In this paper, the importance of executing proper mixing procedures in the research study in order to prevent the formation of fish eyes or the corn starch from settling at the bottom of test cup will also be highlighted.

1. Introduction

In the petroleum industry, when production from an oilwell is declining due to the reduction of formation permeability around the well bore or due to increase in water-cut for that particular oilwell (with the production zones are still indicating commercial reserves), workover has to be performed on the oilwell in order to bring back oil production. Workover may involve of installation of new tubing strings in a well, re-perforation etc. Prior to conducting any workover jobs, workover fluid has to be filled into the well. The workover fluid has many function, and the most important of all is to control well pressure. Generally, the hydrostatic pressure produced by workover fluid is higher than the formation pressure (in the range of 150 psi (1034 kPa) to 450 psi (3103 kPa)), which is more commonly known as overbalance pressure (Archer and Wall, 1986). This phemonenon will prevent the influx of formation fluid which may cause undesirable problems to the workover operations. Nevertheless, the overbalance pressure may cause some of the workover fluid to disappear into formation. Fluid loss can cause several problems, such as the invasion of filtrate may create a zone of reduced permeability around the wellbore, thus lowering the production rate etc.

Oil companies have used extensively the fluid loss control agent since early 1930's to control fluid loss. Amongst the standard fluid loss control agents used are hydroxyethyl cellulose (HEC) and sodium carboxymethyl cellulose (CMC). Most of the control agents used are of polymer-based materials and have been modified in order to preserve the production zones (Gray and Darley, 1981). There is no exception for the Malaysian oil companies and presently those fluid loss control agents have to be imported at high prices. Prior to the economic turmoil, HEC was sold at RM23.00 per kilogram and generally a workover well requires about 500 kg of HEC per job.

The Drilling Mud Research Group of Petroleum Engineering Department, UTM has initiated an effort in looking for an alternative fluid loss control agent from local materials - which could maximise the exploitation of local materials and reduce the import of foreign products especially with the depreciation of Malaysia currency. This research was based on laboratory experiments which involved of ***mixing HEC with corn starch***. In order to investigate the performace of HEC-corn mixtures, several basic tests were conducted on the rheological and fluid loss properties prior to comparing them with HEC, the standard fluid loss control agent used in the petroleum industry.

Generally, HEC is a non-ionic polimer and is derived from the reaction of cellulose with chloroacetic acid in the presence of sodium hydroxide (Allen and Roberts, 1982). HEC is widely used in drilling, workover and completion fluids due to its compatibility with salts of monovalent metals and also with many divalent metals. This non-ionic polimer can be split at the acetal link acid with the resulting depolymerised solution has very little residue to cause formation damage. HEC is found to be stable up to 250°F (121°C) as compared to corn which is around 210°F (99°C). The chemical and physical properties of corn starch are explained in (Beynum and Roels, 1985).

2. Materials and Methods

2.1 Workover Base Fluid Preparation

The workover fluid sample was prepared as per the formulations used in the Malaysian oil field. Thus, to prepare one lab barrel (equivalent to 350 ml) of workover base fluid sample, the composition of additives added into the 350 ml of distilled water were as follows:

Additive	Composition (gm)
Sodium chloride	52.5
Calcium carbonate	10.5
HEC, corn or HEC-corn	Depend on viscosity

The density of workover base fluid used in this study was fixed at 9 ppg, whilst the fluid loss control agents namely HEC, corn starch and HEC-corn starch were added separately in proportion into the base fluid to form the required viscosity. The range of workover fluid viscosity and temperature used in the research study were in the range of 15 cp (15×10^{-3} Pa.s) to 45 cp (45×10^{-3} Pa.s) and 170°F (77°C) to 200°F (93°F) respectively.

2.2 Equipment and Procedures

Mixing of distilled water with the additives should be conducted with extra care. This process could be achieved by using a conventional mixer, so called the Baroid Multimixer. The multimixer's cup was filled with 350 ml of distilled water and re-installed at it's original position. The multimixer's stirrer was then activated. Mud additives were added separately and steadily into water, and the mixture was agitated continuously for 10 minutes in order to prevent the formation of fish eyes, a phenomenon that might yield lower viscosity.

Prior to the evaluation of rheological properties via the Baroid Rheometer, each of the sampels was heated to the predetermined temperature. The rheological properties measured were viscosity, gel strength and yield point. The HEC-corn starch samples were found to be capable of forming paste at 170°F (77°C). During the heating process, the sample has to be agitated continuously. Generally, it is important to note that only HEC can form viscosity at ambient temperature but corn starch must exceed it's gelatinisation temperature (Beynum and Roels, 1985).

The fluid loss tests were performed by using the High Pressure-High Temperature (HPHT) Filter Press with pressure differential of 500 psi (3448 kPa). As the filter press was heated to the predetermined value, the HEC-corn starch mixture must also be heated separately to form paste before it was placed in the cell of HPHT Filter Press. Generally, the use of Baroid Multimixers is to prevent the formation of fish eyes, but agitation during heating is to prevent corn starch particles from settling at the bottom of cell.

3. Results and Discussion

The use of Baroid Multimixer in the mixing process of distilled water and additives was found to be capable of producing workover fluid samples which were free from fish eyes, thus giving true values of rheological properties when tested.

3.1 The Effect of Temperature on Rheological Properties

Figure 1 shows that the gelatinised corn starch was capable of producing equivalent viscosity as the HEC at temperature of 170°F (77°C). Nevertheless, at temperature below 158°F (70°C), the corn starch was found to be unable to produce the required viscosity due to the presence of hydrogen bonds. Generally, when corn starch in the workover fluid is heated beyond it's critical temperature, the starch granules start to absorb water and swell to many times their original size. Further heating will cause the swollen starch granules to disintegrate into swollen starch aggregates. The experimental results revealed that eventhough the corn starch was able to form the required viscosity above the gelatinisation temperature, but larger amount was needed than the HEC, which was about five times. It was also found that the mixture of 75%HEC-25% corn starch gave comparable performance as the HEC (Figure 2).

Figure 3 shows that the yield points of corn starch and HEC samples increased as temperature and viscosity increased, due to the flocculation of solid particles. Again, it was found that the mixture of 75%HEC-25% corn starch gave comparable performance as the HEC. Yield point is an important parameter as it could furnish the ability of workover fluid to carry debris or tiny solid particles to the surface.

Figure 4 shows the relationship between temperature and gel strength. Gel strength is a parameter which shows the ability of workover fluid to suspend debris or tiny solid particles when pump is halted temporarily. The experimental results revealed that the gel strength of workover fluids were found to increase with viscosity and temperature due to the greater attraction between HEC and corn starch particles. This study also showed that the mixture of 75%HEC-25% corn starch gave comparable performance as the HEC.

3.2 The Effect of Temperature on Fluid Loss

The fluid loss experienced by workover fluid samples were shown in Figure 5. Workover fluid samples with corn starch or with the mixture of both gave better fluid loss control as compared to the HEC. Nevertheless, all of them were found to experience fluid loss well below the maximum allowable fluid loss limit. This phenomenon revealed that the corn starch paste could produce mud cake of lower permeability. The loss of fluid into formation must be prevented or reduced as minimum as possible as it could damage the formation in the vicinity of the well.

3.3 Formation of True Mud Cake's Thickness

Mud cake is a layer of substance formed on a filter paper at the end of a fluid loss test. Apart from measuring the thickness, Darcy equation could be utilised to compute the permeability of the mud cake. Generally, the experimental data gives some idea to the engineers pertinent to the mud cake that will be formed on the wall of an oil well which could prevent workover fluid from disappearing into the formation excessively. A good quality mud cake should be of low permeability and thin, as thick mud cake might pose problems to the workover operations.

The use of Baroid Multimixer could avoid the formation of fish eyes in the workover fluid, but it will not prevent the corn starch particles from settling at the bottom of the test cell as corn starch was insoluble in cold water. Thus in the fluid loss test, as the HPHT Filter Press was heated to the predetermined temperature, the mixture was also heated separately exceeding the corn starch's gelatinization temperature. During this process, the mixture must be agitated continuously in order to form a *balanced* sample. The mixture was then placed in the Filter Press' test cell for further analysis.

If the mixture was placed immediately in the test cell without heating separately, the corn starch particles would settle at the bottom of the test cell as temperature of HPHT Filter Press was elevating to the predetermined value. Eventually, an excessive thickness of mud cake would be formed at the end of the test (Figure 6). The results would be misinterpreted which might lead to costly failures.

4. Conclusion

In a laboratory work, it is not umcommon that a researcher will follow the testing procedures or the equipments' operating procedures as outlined in the manual. Generally, the modus operandi works well with standard materials, but in the studying of new materials, the researcher must take into account the behaviour of the materials prior to taking any further actions.

The study revealed that the Baroid Multimixers had successfully avoiding the formation of fish eyes in the workover fluid sample, but the mixture must be agitated continuously during the heating process (to form starch paste) to prevent corn starch particles from settling at the bottom of the test cell. Failing to agitate the mixture continuously during the heating process would produce mud cake with *excessive thickness* and nearly zero fluid loss, which might lead to serious misinterpretation of the results.

Generally, the experimental results showed that the *true* corn starch paste has the potential to be used as fluid loss control agent. This statement was strongly supported especially by the fluid loss test results that 100% corn starch paste or it's mixture with HEC gave lower fluid loss than 100% HEC. It was found that the mixture of 75%HEC-25%corn starch gave comparable performance as HEC.

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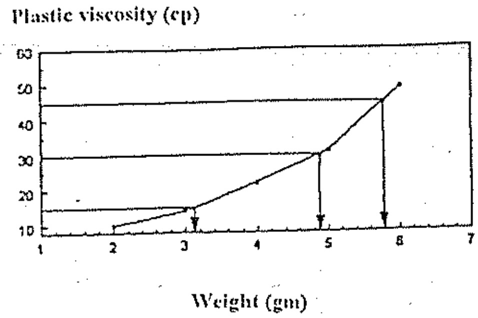
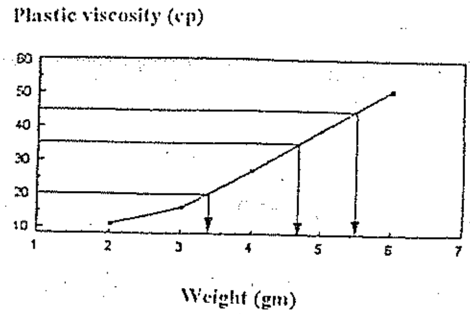
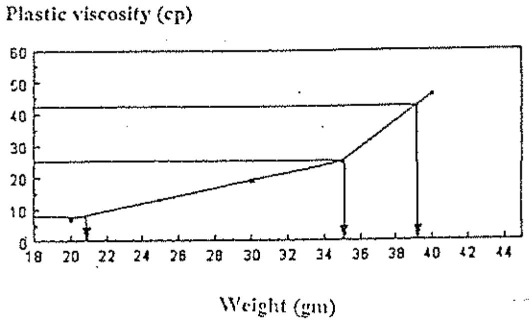


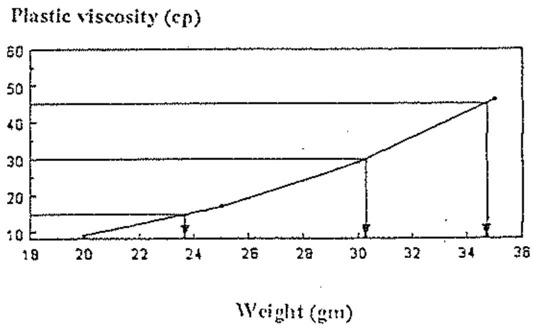
(*a*) 100% HEC at 170°F



(*b*) 100% HEC at 180°F



(*c*) 100% corn starch at ~~180~~ 170°F



(*d*) 100% corn starch at 180°F

Figure 1: Plastic viscosity vs weight

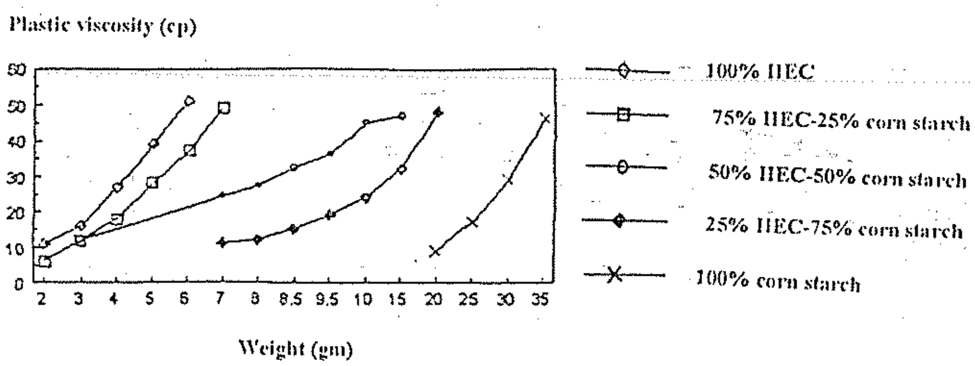


Figure 2: Plastic viscosity vs temperature at 180°F

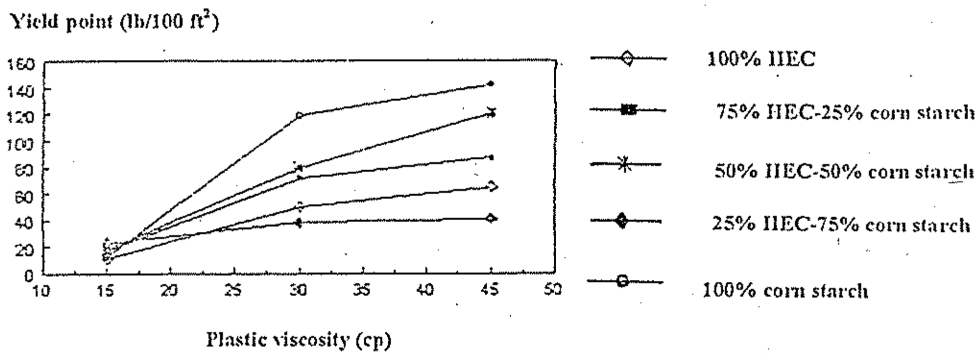


Figure 3: Yield point vs plastic viscosity at 180°F

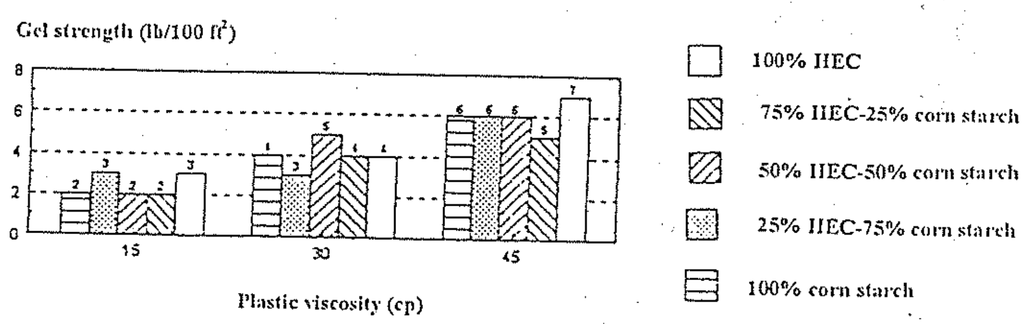


Figure 4: Gel strength vs plastic viscosity at 180°F

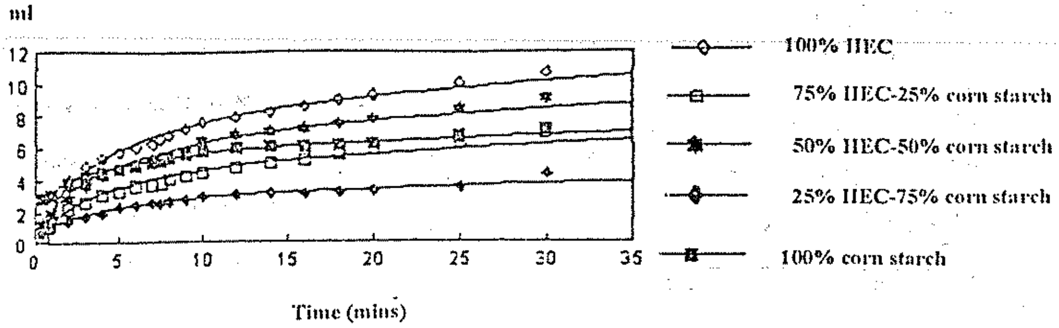
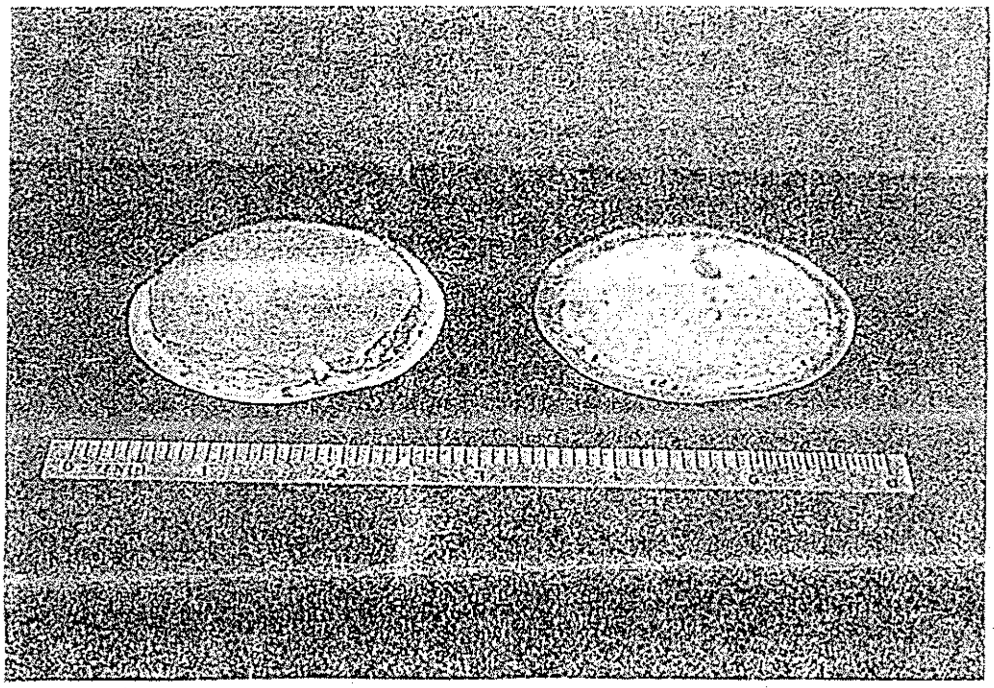


Figure 5: Fluid loss vs time at 15 cp and at 180°F



(*a*) Without agitation (*b*) With agitation

Figure 6: Mud cake