PHYSICAL AND RHEOLOGICAL PROPERTIES OF CLASS "G" GILSONITE CEMENT SLURRIES (EXPEIMENTAL STUDY)

Akram H. Al-Hiti, and Riadh H. Hana
Petroleum Engineering Department – College of Engineering – University of Baghdad – Iraq

ABSTRACT

The present work deals mainly with low-weight cement slurries using class "G" cement different percentage of prehydrated bentonite (204, 3% and 4%) and gilsonite as low weight material (addititve).

The experimental tests which are slurry density, thickening time, compressive strength free water content and rheological properties have been done in order to obtain the required cement slurries, to perform cementing job operations.

Correlation between the measured rheological properties of gilsonite class (G) cement slurries with the thickening time and the free water cement for 2,3 and 4 percent of prehydrated bentonite has been developed in general charts in order to make rapid engineering commence and discussion for primary well cement program design and to enable the operator to optimize the composition of he cement slurry.

INTRODUCTION

The high density of cement slurries may cause lost circulation during primary cementing (I)• The density of neat cement slurries ranges between 2.1 and 1.90gm/cc (17.5- 15.8 lb./gal) while by using gilsonite base additive the slurry density can be,reduced up to 1.88-1.46gm/cc (15.66-12.66 lb./gal) with practical limits of free water less than 1.5 and compressive strength greater than 500 psi after eight hours.

A prehydrated bentonite is used to prevent floating of gilsonite because it increase the viscosity of the slurry [(2)(3)].

Gilsonite and prehydrated bentonite treated class "G" cement, is an excellent controller of lost circulation zones, due to the granular bridging effect of gilsonite [(3)]. In addition the compressive strength of these slurries are higher than other slurries prepared with other low- weight additives [(4)]. Furthemore less gilsonite- cement is normally required to obtain desired fill- up than other additives.

Results of primary cementing jobs in lost circulation areas using gilsonite with cement slurry indicate 80 to 90 percent fill-up can be realized.

EXPERIMENTAL WORK

All materials used in this study met the API specification, and all tests are done according to API procedure[(5)]. The materials used are:

Cement. Dyckerhoff class "G" cement high sulfate -resistance type (HSR).

Gilsonite. Gilsonite is solids hydrocarbon. it has been generally grouped as a form of native asphalt, black color, powder arich brown and bum with a brilliant flam, much like sealing wax and particle size from fine to 1/4 in.

Bentonite. Bentonite is a sodium monto-monilonite clay type in according with API specification RP 13 A and B.

Apparatus Used

1. Standard mud balance (Baroeid type), used to determine the cement slurry density.
2. Pressurized consistometer (Chandler Engineering Company USA) was used to measure the thickening time of the cement slurry according to schedule (5) of API specification (sec. 8) [(5)].
3. Rotational 6-speed viscometer (magcober 35 A type) was used to measure the rheological properties f cement slurry. All tests are

measured under 80 and 125 °F and atmospheric pressure.

4. Carver hydraulic press machine is used to determine the compressive strength.

Laboratory Tests

The following laboratory testes are done:

1. Determination of slurry density.
2. Determination of free water cement.
3. Thickening time tests (125 °F- 5200 PSI).
4. Determination of rheological properties (at 80, 125 °F, and atmospheric pressure).
5. Compressive strength tests (140 °F. atm).
6. Free water cement measurement.

RESULTS AND DISSCUION

More than 108 samples of Gilsonite- cement slurries have been tested. Each test includes slurry density, apparent viscosity, thickening time, free water content and compressive strength. The results are plotted as characteristic charts for different physical properties and different concentrations of prehydrated bentonite (2%, 3% and 4%). Figs A-i, A-2 and A-3 respectively.

Each chart can be used to determine the main component and their ratios for certain properties required to complete the primary cementing operation.

These charts can be divided into two regions. The first region is of cement slurries which are bounded among free water less than 1.5%, thickening times of 90-120 minutes and compressive strength of 500 to more than 2500 psi. The region includes slurries of adequate viscosity's, that are pumpable in good conditions.

The second region includes slurries of free water more than 1.5% which are unpractical cement slurries.

For Gilsonite- cement slurries, the 2% and 3% (prehydrated bentonite) charts have two regions, while the 4% bentonite cement chart has the region of casing cementing slurries only (F.W. < 1.5) except few points.

For rheological properties study, thirty- six selected slurries were tested under 125 0F and atmospheric pressure. The samples were prepared with prehydrated bentonite of 2%, 3% and 4% concentrations.

By using a computer program to select the best representative model for each test, it was found that the most of the slurries correspond with the Robertson- stiff model that gave the Lowest Average Absolute Percent Error (AAPE) than other models. Also was found that very small difference compared with power low model and modified Robertson- stiff model.

Figs. (B-i), (B-3) and (B-5), indicate that for any prehydrated bentonite percentage for plug flow- cross plot, correspond the relation ships between $\{(Q_c)_p- (V_e)_p\}$, because it is a general relation depends on the selected area only while the relation between $\{(Q_c)_p- (V_e)_p\}$, are different as the prehydrated bentonite percentage is changed because $(V_c)_p$ depends on the rheology.

For turbulent flow it is found also the correspondance in Figs B-2, B-4 and B-6 for the relationship between $\{(VC)_T - A_e\}$ for any prehydrated bentonite percentage, because it depends on the selected $(Q_c)_T$ only, but the relation between $\{(V_c)_T - D_e\}$ varies as prehydrated bentonite percentage is changed because $(V_c)_T$ depends on the rheology, and the pressure losses varies as prehydrated bentonite percentages are changed.

CONCLUSIONS

1. Gilsonite has particle size up to ¼ in, therefor for the same prehydrated — Bentonite and w/s ratio, as the Gilsonite/ cement ratio increases, the apparent viscosity is increased.

2- Gilsonite does not absorb water therefor the free water content did not reach zero for any prehydrated- bentonite (in this work), and at the same prehydrated- bentonite and w/s ratio, as Gilsonite/ Cement ratio increases the free water content increases and this will reduce the stability of the slurry.

3- For the same perehydrated- bentonite, the Gilsonite has no significant effect on thickening time. Therefor, there is no plug cementing region in Gilsonite- class (G) cement slurries charts.

4- For the same perehydrated- bentonite and slurry density, as the Gilsonite ratio increases the compressive strength increases, but for the same perehydrated- bentonite and W/S ratio, as the Gilsonite/ cement ratio increases the compressive strength decreases.

5- All the Gilsonite- cement slurries have the free water content as the limiting factor for any perehydrated Bentonite and Gilsonite/ cement ratio levels.

6- The Gilsonite - class "G" cement slurries charts presented in figures (A-1) through (A-3) for different perehydrated — Bentonite can be used to select the most practical and economical Gilsonite — class "C" cement slurries for a given slurry density for casing cementing.

7- The plug and turbulent flow — cross plots for Gilsonite — class "G" cement slurries presented in figures (B-1) through (B-6) for different perehydrated — Bentonite correlate the critical flow rate, slurry properties critical velocity and pressure drop for any casing well Geometry.

NOMENCLANTURE

A_e: Hydraulic area, in

De:Hydraulic diameter, in

F.W: Free water content of cement slurry, percent.

$(Qc)_p$: Critical flow rate to plug flow, bpm.

$(Qc)_T$: Critical flow rate to turbulent flow, bpm.

$(vc)_p$: Critical velocity to plug flow, ft/sec.

$(vc)_T$: Critical velocity to turbulent flow, ft/sec.

W/S: water solids ratio.

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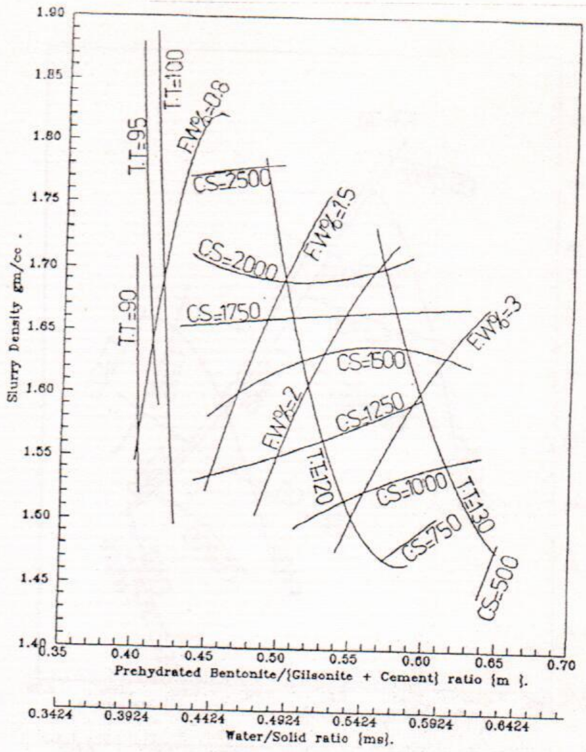

Fig. (A-1) The gilsonite class "G" cement slurries chart prepared with 2% prehydrated bentonite

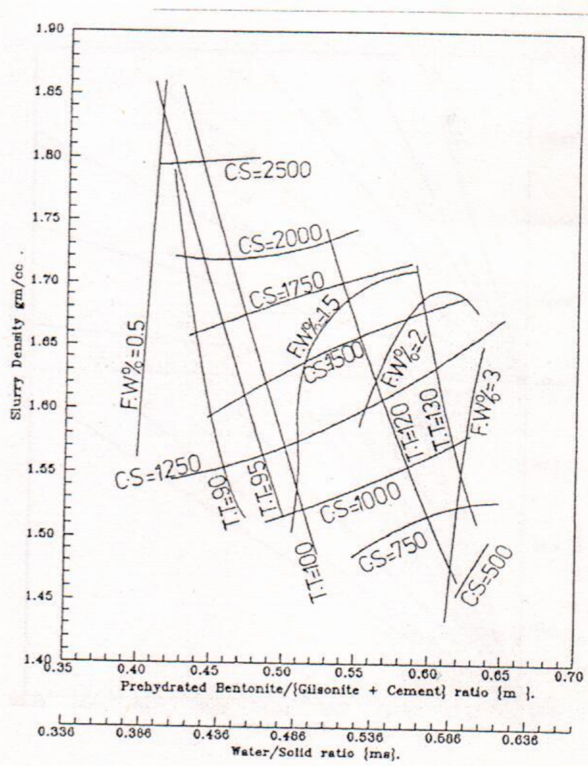

Fig. (A-2) The gilsonite class "G" cement slurries chart prepared with 3% prehydrated bentonite

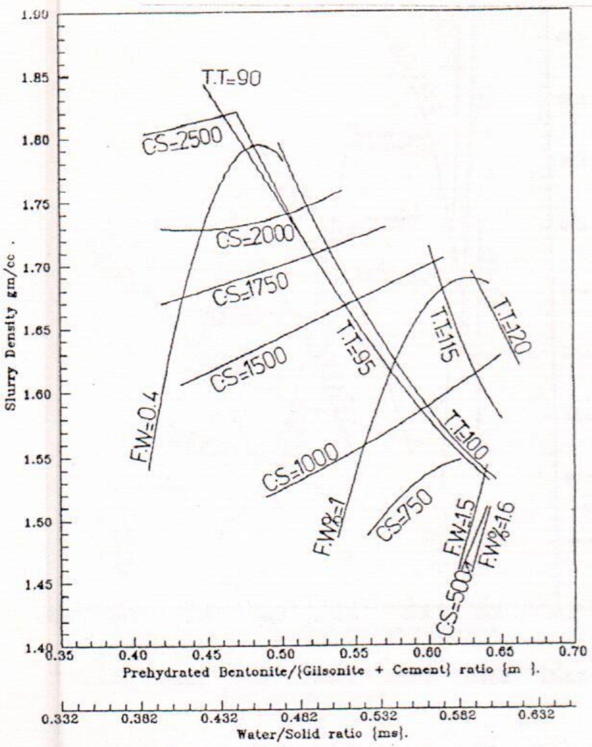

Fig. (A-3) The gilsonite class "G" cement slurries chart prepared with 4% prehydrated bentonite

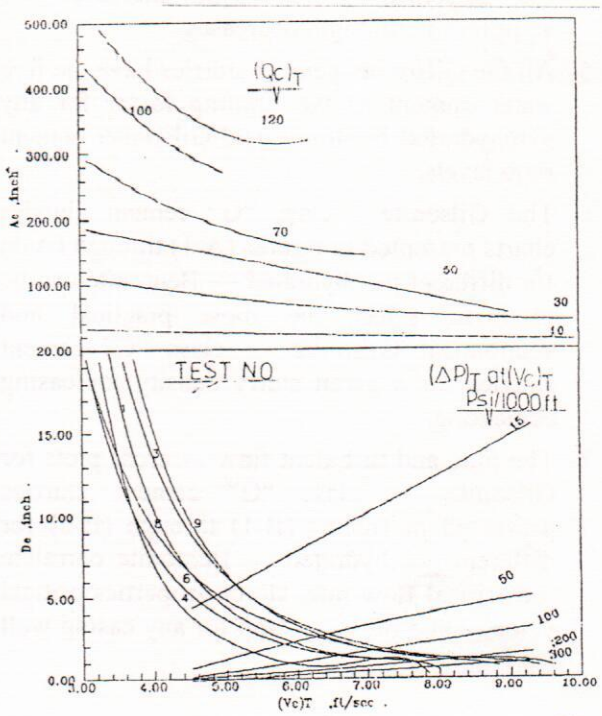

Fig. (B-2) Turbulent flow cross-plot for gilsonite class "G" cement slurries prepared with 2% bentonite solution.

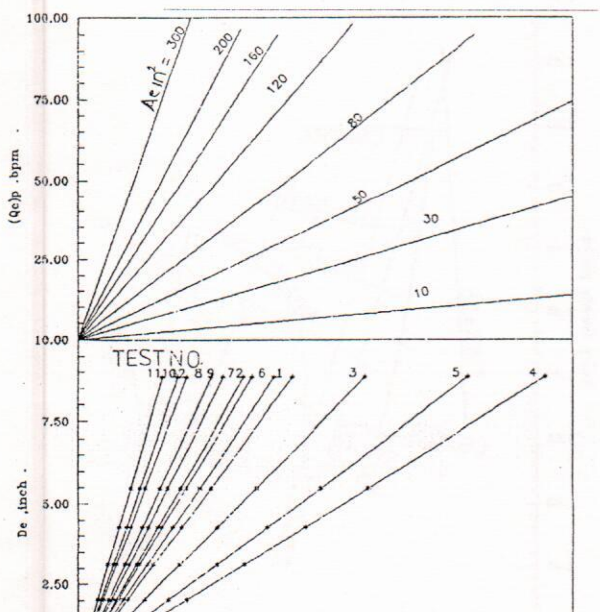

Fig. (B-1) Plug flow cross-plot for gilsonite class "G" cement slurries prepared with 2% bentonite solution.

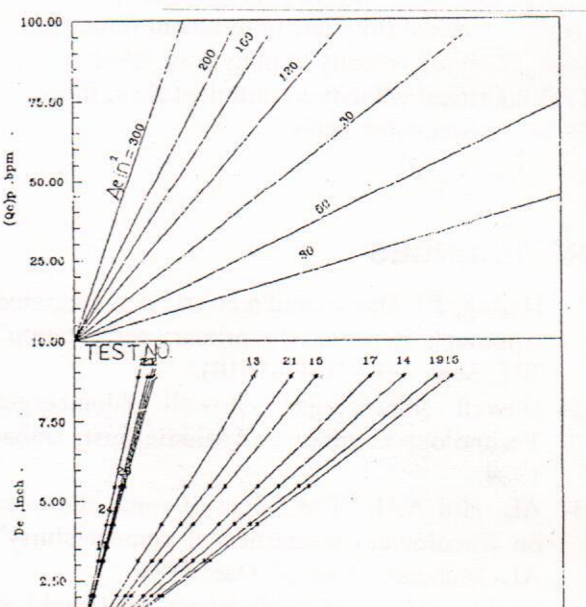

Fig. (B-3) Plug flow cross-plot for gilsonite class "G" cement slurries prepared with 3% bentonite solution.

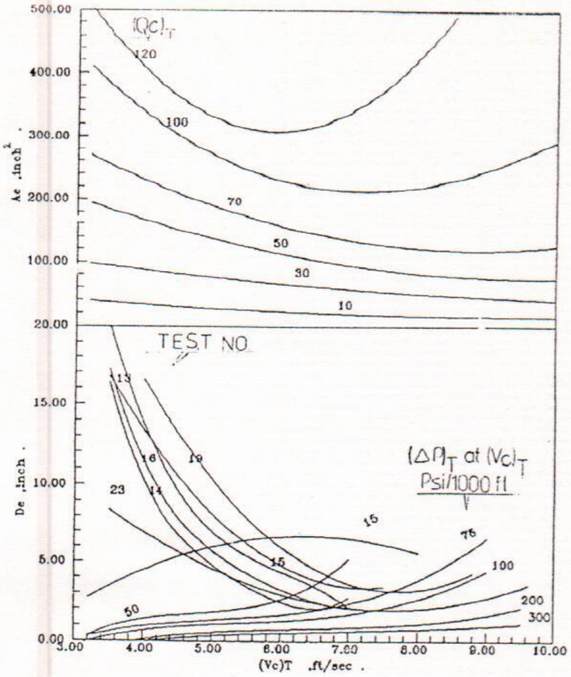

Fig. (B-4) Turbulent flow cross-plot for gilsonite class "G" cement slurries prepared with 3% bentonite solution.

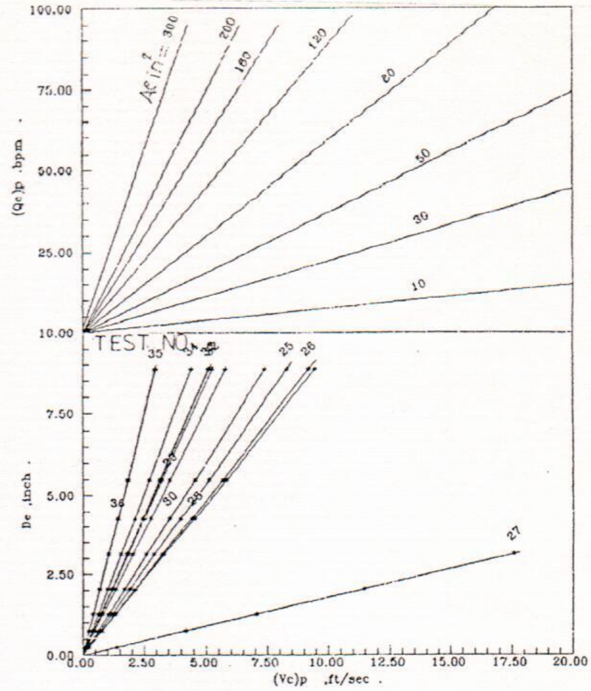

Fig. (B-5) Plug flow cross-plot for gilsonite class "G" cement slurries prepared with 4% bentonite solution.