THE INFLUENCE OF FLUIDIZERS ON LIGHTWEIGHT CEMENT PASTES

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Abstract: *Cement paste behaves from a rheological point of view in the initial phase, according to the Bingham model. From this point of view, the variation of the rheological properties for cement pastes with or without additives is absolutely necessary. This paper looks at the effect of dispersant on the rheological properties of additive and non-additive cement pastes. For this purpose, different mixtures of cement paste were prepared with the addition of dispersant or dispersant and hydrated bentonite, for which the rheological properties were measured at the initial time and at 60, 120 minutes after maintaining the mixtures under stirring and temperature conditions.*

Key words: *cement sluries, rheology, viscosity, shear stress*

1. Introduction

Water-cement and water-cement-added mixtures behaved rheologically, in the initial phase following the Bingham model, while cement pastes treated with chemical reagents or polymers behaved according to the Ostwald-de Waele model.

The variation of the viscosity of the cement paste occurs as a result of the hydration of the mineral components of the cement, minerals that have different rates of hydration.

Therefore, in the case of deep wells it is necessary to limit the content in compounds whose hydration rate is high as C3A

Tricalcium aluminate produces a paste with reduced water separation and due to the fact that it hydrates faster, speeds up the thickening time, develops a great hydration heat in a short time. The addition of gypsum (CaSO4) serves to delay the thickening time caused by this component.

Critical speed determination for turbulent flow, as well as the pressure losses in the circulation system, requires the knowledge of the rheological properties of the cement slurries, the used drilling fluid and the necessary spacer, for the rig's circulation system.

It is known that temperature and pressure may vary widely across the well circuit, so that the rheological properties will change as well. In addition, the properties of the paste are also time dependent as a result of the hydration reactions that take place. There are attempts to express and use these addictions. But the relationships are complicated and uncertain. For these reasons, it is recommended to accept constant values determined at the maximum temperature during circulation.

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2. Theoretical and experimental data

In order to obtain more edifying results on the influence of dispersants on the rheological properties of cement slurries, the following working methodology has been proposed:

- The parameters characterizing the properties of the cement slurry are followed on a cement batch of type G;
- The dispersant used is a lignosulfonate, dark brown liquid , soluble in water and in NaCl solutions, with a density of 1220 kg/m^3 and pH = 9… 10;
- Will be establish recipes for cement mixtures in which the percentage of dispersant (between 0% and 1%) and the percentage of prehydrated bentonite (between 1% and 3%) vary;
- The determination of the rheological parameters of the cement slurries will be done using the values of the deflection angles obtained with the Fann viscometer;
- The determination of the rheological parameters will be done at the initial moment and then from 60 to 60 minutes, establishing a total analysis time of 120 min;
- The flow curves (rheograms) is done transforming, the values of the deflection angles (în), into values of the shear stress with the relation:

$$\tau = 0{,}479 \cdot \varphi \ \text{[N/m}^2\text{]}$$

and the rotation speed of the Fann viscometer's rotating sleeve into deformation speed (dv/dr) by the relationship:

$$\frac{dv}{dr} = 1{,}704\, n \ \text{[s-1]}$$

- The calculation of the rheological constants (for Bingham fluids) will be done with the relations:

$$\eta_{pl} = \varphi_{600} - \varphi_{300} \ \text{[cP]}$$

$$\tau_0 = 0{,}479\left(2\varphi_{300} - \varphi_{600}\right) \ \text{[N/m2]}$$

- to determine the apparent viscosity of cement slurries the following relationship is used:

$$\eta_{ap} = \frac{\varphi_{600}}{2} \ \text{[cP]}$$

- determination of the density of cement slurries will be done with a densimeter;
- For the free fluid test at ambient temperature a 250 cm^3 graduated cylinder is used and the amount of free fluid that separates on top of the slurry in two hours is measured.

Based on the established methodology, recipes of additive cementation mixtures were prepared with prehydrated bentonite in proportion of 1%, 2%, 3% and dispersant proportion of 0.3%, 0.6% and 1%. The simple water-cement mixtures were also analyzed to highlight the influence of additives and bentonite on G-type cement pastes.

The water/cement ratio chosen was the one corresponding to a spread of at least 180 mm, but it was found that for this value of the water/cement ratio, the prepared pastes still had a high viscosity at the initial moment, thus exceeding the measurement capacity of the Fann viscosimeter, which leads to the impossibility of calculating the rheological parameters. Therefore, cement mixtures were prepared for which the value of the water/cement ratio corresponds to a spreading diameter of approximately 220 mm initially.

As shown by the values shown in Table 1, the increase of the percentage of dispersant leads to an increase in the value of the spreading diameter, which confirms that the dispersant used has a cement dispersing effect in the solution, reducing the viscosity of the cement paste.

Table 1. *Experimental results for the tested cement slurry samples*

W/C ratio	Prehydrated bentonite	Dispersant	Spreading diameter	Slurry density	Free fluid
-	%	%	mm	kg/m^3	cm^3
0,45	0	0	230	1890	0,5
0,45	0	0,3	250	1854	1,5
0,45	0	0,6	250	1840	7
0,45	0	1	260	1877	31
0,6	1	0	255	1732	4
0,6	1	0,3	255	1732	3
0,6	1	0,6	260	1700	2
0,6	1	1	265	1684	1
0,8	2	0	230	1614	8
0,8	2	0,3	250	1596	7
0,8	2	0,6	260	1592	6
0,8	2	1	270	1596	4
1	3	0	230	1520	10
1	3	0,3	235	1514	6
1	3	0,6	240	1506	4
1	3	1	260	1510	2

Initially (Fig. 1), the plastic viscosity has a tendency to decrease with the increase of used dispersant quantity. After 60 and 120 minutes of keeping the slurry under stirring and temperature conditions, it is observed that the plastic viscosity has minimum values at the concentration of 0.3% dispersant and maximum values at the concentration of 0.6% dispersant, and in the case of a percentage of 1% dispersant a sharp decrease of the values of the plastic viscosity is noticed (fig, 2, 3).

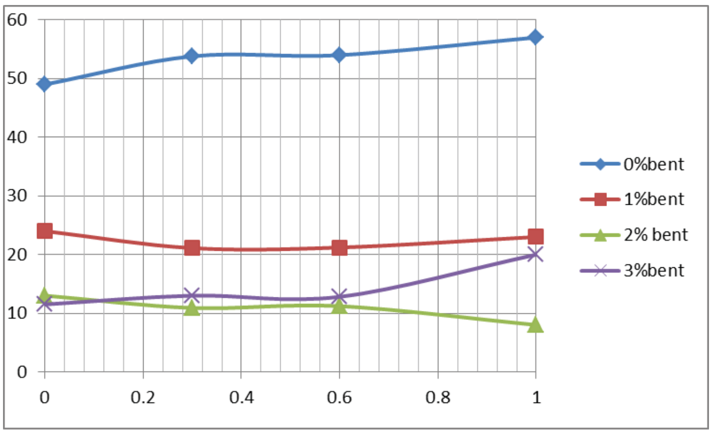

Fig. 1 *The variation of the plastic viscosity according to the dispersant percentage at the initial moment*

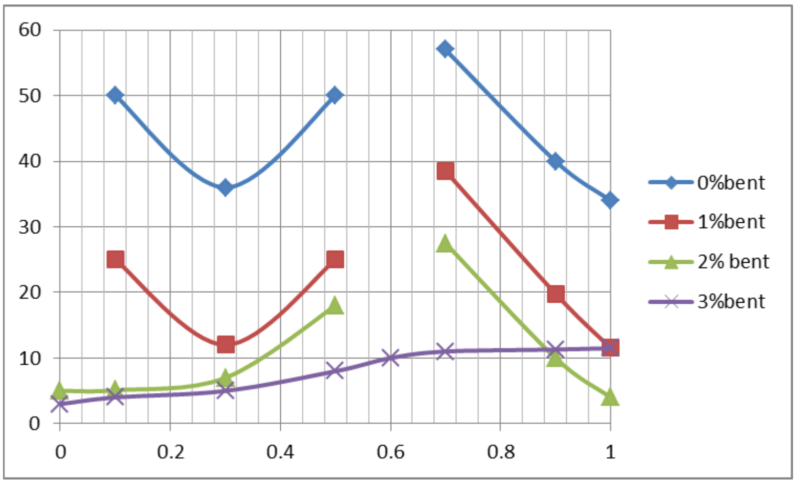

Fig. 2 *The variation of the plastic viscosity according to the dispersant percentage after 60 minutes*

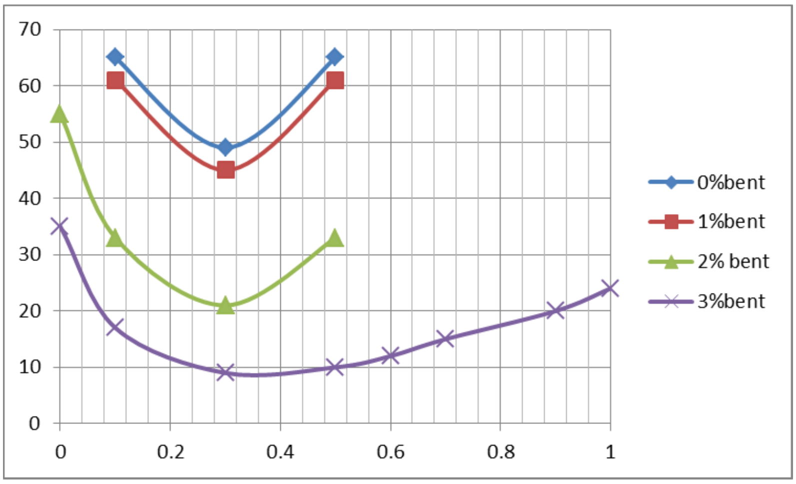

Fig. 3 *The variation of the plastic viscosity according to the dispersant percentage after 120 minutes*

The values of apparent viscosity determined at the initial moment decrease with the increase of the percentage of dispersant (fig. 4). After 60 minutes of maintaining the cement slurry under the stirring and temperature conditions, a significant increase of the apparent viscosity is observed for the concentration of 0.6% dispersant, but this variation is greatly attenuated by the presence of bentonite (fig. 5); the higher the percentage of bentonite in the composition of the cementation mixture, the lower the apparent viscosity.

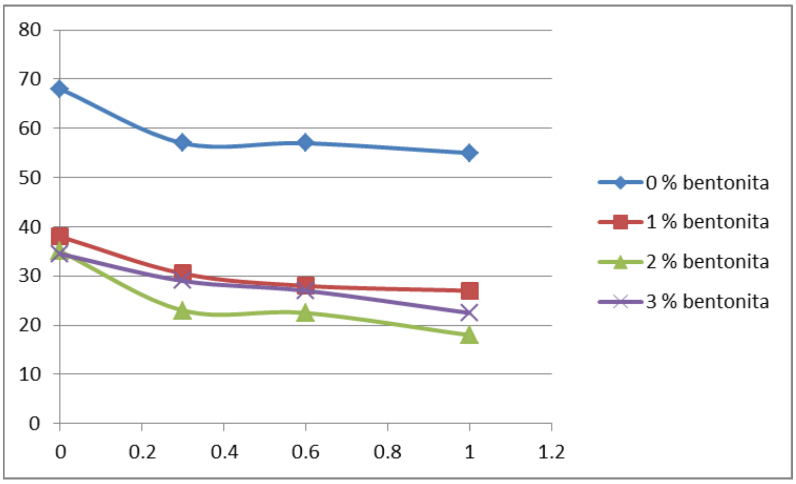

Fig. 4 *The variation of the apparent viscosity according to the dispersant percentage at the initial moment*

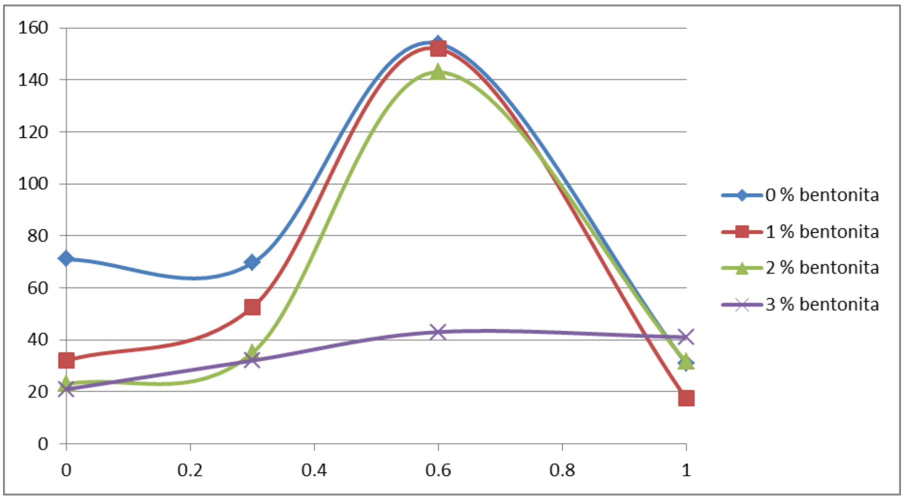

Fig. 5 *The variation of the apparent viscosity according to the dispersant percentage after 60 minutes*

Analyzing the allure of the curves in Figs. 6, 7, and 8, it is found that the values of dynamic shear stress have a variation similar to that of the plastic viscosity.

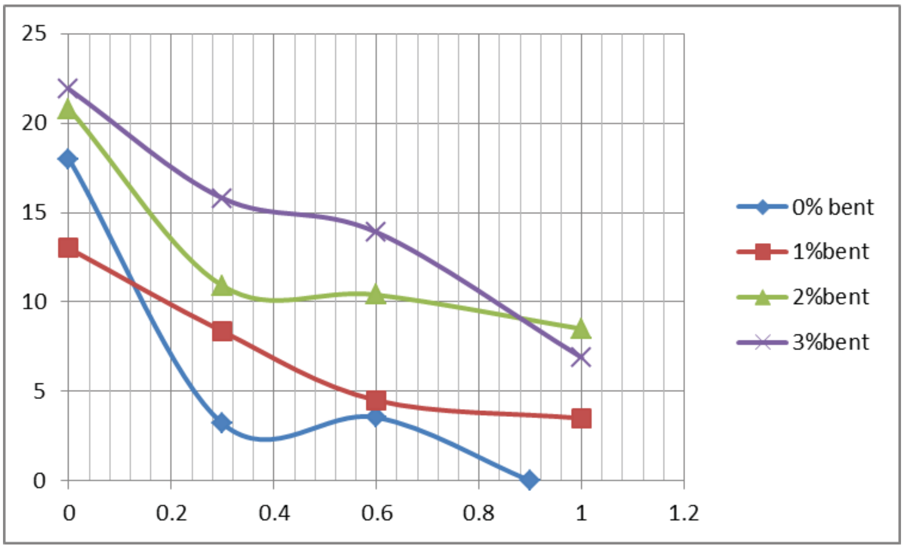

Fig. 6 *Variation of the dynamic shear stress according to the percentage of fluidizer at the initial moment*

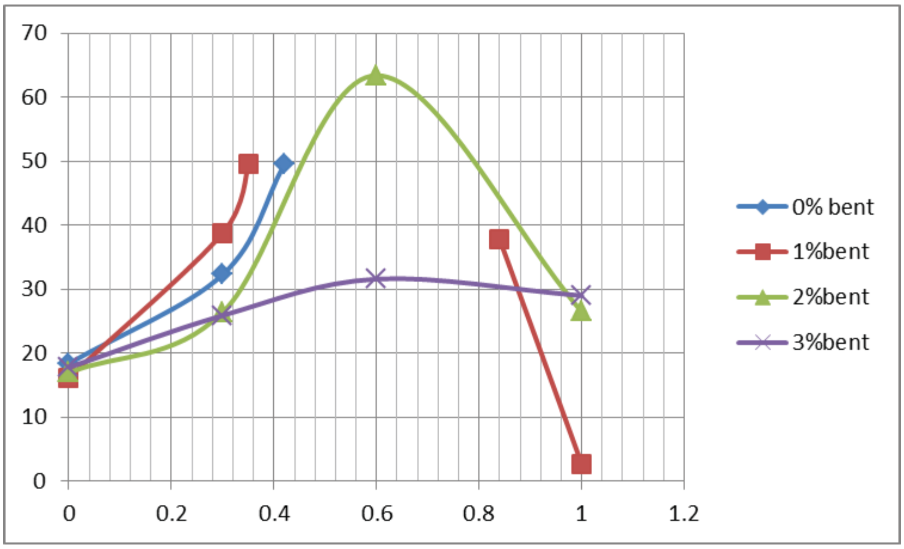

Fig. 7 *Variation of the dynamic shear stress according to the percentage of fluidizer after 60 minutes*

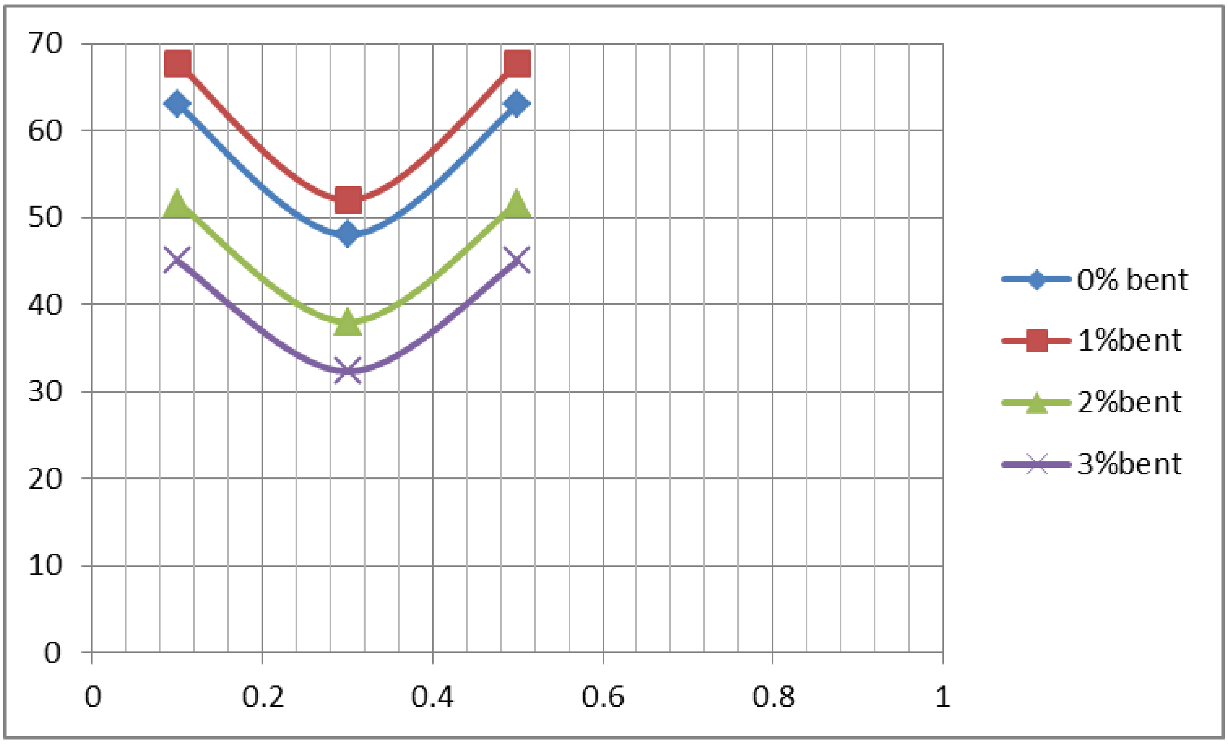

Fig. 8 *Variation of the dynamic shear stress according to the percentage of fluidizer after 120 minutes*

It is observed that although at the initial moment the values of the shear stress decrease as the percentage of dispersant increases, after 1, 2 or 3 hours of keeping the cement paste under stirring and temperature conditions, these values show a rapid increase in the case of the aditivated cement slurry with 0.6% dispersant and a much slower increase when the percentage of dispersant is 0.3%.

Both non-additive and aditive mixtures (taking into account that suspension stability is not affected) are part of the Bingham flow pattern.

The rheological properties of all the analyzed mixtures change over time (due to the hydration process of the minerals from the cement composition) so that after 1, 2 or 3 hours (depending on the composition) the mixtures become difficult to pump.

The rheological properties get worse when the cement slurry is treated with 0.6% dispersant.

If the cementation mixture also contains bentonite it is found that the dispersant effect on the rheological properties changes:

- Analyzing the allure of the curves in figs 1 - 3, it is found that as the percentage of bentonite increases, the values of plastic viscosity decrease, while the dynamic shear stress (fig. 6 - 8) has increasing values. It should be noted that in the case of a paste containing 3% bentonite, after keeping under stirring and temperature conditions for 1-2 hours the values of dynamic shear stress are minimal.
- The variation of apparent viscosity according to the percentage of dispersant (fig. 4, 5) is greatly attenuated in the presence of bentonite.

3. Conclusions

Addition of dispersant in cement slurry mixtures leads to the improvement of the rheological properties, which allows a good dislocation of the drilling mud and the success of the cementing operation.

The increase of the percentage of bentonite in the composition of the cement slurry mixture, leads to the stabilization of the values of the parameters that characterize the rheological properties of the cement paste.

The presence of additives in the composition of cement pastes has a strong effect on the rheological properties and therefore the use of chemical reagents, to treat these pastes should be done only after conducting behavioral tests in laboratory conditions.

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