International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

Validation of Apparent Viscosity Formula Using Different Drilling Fluid Samples

Mohmad Afzal Mohmad Sidik[1], Azfarhaad Kadri[2], Rishabh Raj[3] and Bhairab Jyoti Gogoi[4]

[1]*Student, Dept. of Petroleum Engineering, Presidency University Bangalore, Karnataka, India*
[2]*Student, Dept. of Petroleum Engineering, Presidency University Bangalore, Karnataka, India*
[3]*Student, Dept. of Petroleum Engineering, Presidency University Bangalore, Karnataka, India*
[4]*Assistant Professor, Dept. of Petroleum Engineering, Presidency University Bangalore, Karnataka, India*

Abstract - *A Marsh Funnel is a simple device which uses a simple technique to measure the apparent viscosity of a drilling fluid. In this experiment we will validate M.J Pitts and Faleh H. M. Almahdawis formula for apparent viscosity, i.e., $\mu_{eff} = \rho\ (t - 25)$ and $\mu_{app} = \rho\ (t - 28)$ respectively, where μ_{app} = apparent viscosity in centipoise, ρ = density in g/cm^3, t = quart funnel time in seconds. To validate we will check the apparent viscosity of a drilling fluid using a marsh funnel and a hand crank viscometer and compare the reading gained using the above formula and the reading from the hand crank viscometer. By this method we will be able to check which of the above two formula is more accurate and suitable for checking the apparent viscosity of a drilling fluid. The drilling fluid prepared will contain different types of additives to ensure that the formula will be applicable for a variety of drilling fluids.*

Key Words: **Validation, Drilling fluids, Apparent viscosity, Marsh Funnel, Viscometer.**

1. INTRODUCTION

Drilling mud is a Non-Newtonian fluid and is used in oil and gas wells, there are three main types of drilling fluids, Oil based, Water based and Gaseous. These fluids have multiple essential functions such as providing hydrostatic head, removal of drill cuttings, lubricate and cool the drilling bit [4]. The most commonly used drilling fluid is water based and we mostly use bentonite as the reactive phase as it has better properties compared to others. Viscosity is an important rheological property of a drilling fluid. Viscosity is the measure of its resistance to the flow. A drilling fluid must have certain viscosity in order to be effective. Viscosity plays an important role in removal of drill cutting to the surface; high viscosity fluid will lead to high friction pressure while very low viscosity will be ineffective in carrying the drill cuttings to the surface. In Non-Newtonian fluids the viscosity is not constant and varies with the shear rate. The viscosity of a fluid under certain amount of shear rate is known as apparent or effective viscosity. Apparent viscosity of a drilling fluid can be roughly estimated using a marsh funnel by obtaining the marsh time of the fluid and substituting it in the formulas given above. Since there are two formulas given by two different authors we will check which of the formulas is more suitable for determination of the apparent viscosity using the marsh funnel.

2. MATERIALS AND METHODOLOGY USED

2.1 Equipment used

Marsh Funnel (OFITE): A marsh funnel is a funnel shaped equipment which has a small diameter hole at the end through which mud flows down. It was invented by Hallan N. Marsh of Los Angeles in 1931 [2]. The marsh funnel consists of a screen on the tube which prevents large particles from entering the funnel and blocking the outlet. According to the test standardized by API for calculating the funnel viscosity of water based and oil based mud, the measurement is taken by knowing the time required for one quart (946 ml) of mud to flow out of a marsh funnel. By substituting the marsh time in the formula given by M.J Pitt, i.e.

$$\mu_{eff.} = \rho(t - 25)\ [3] \qquad \ldots(1)$$

Where: $\mu_{eff.}$ = effective viscosity (cp); ρ= density (gm/cc); t=time (sec), we can obtain the effective viscosity of the drilling fluid, and by substituting the marsh time in the formula given by Faleh H. M. Almahdawis, i.e.

$$\mu_{app} = \rho(t - 28)\ [4] \qquad \ldots(2)$$

Where: $\mu_{app.}$ = apparent viscosity (cp); ρ= density (gm/cc); t=time (sec), we can obtain the apparent viscosity of the drilling fluid.

In this paper we validate the above two formulas to check which one is more suitable to check the apparent viscosity of the drilling fluid.

Hand Crank Viscometer (OFITE): A hand crank viscometer is a direct indicating, manually operated, rotational viscometer. It applies certain amount of shear rate to the fluid to calculate the apparent or effective viscosity. We use 600 RPM to find the apparent viscosity of the fluid. A hand cranked viscometer gives more accurate readings for apparent viscosity compared to the readings obtained by a marsh funnel. The formula used to find apparent viscosity using hand crank viscometer is,

$$\mu_{app} = \Theta_{600}/2 \quad [1] \qquad \ldots(3)$$

Mud Balance (OFITE): A mud balance is a device used to measure the density of a drilling fluid. It consists of a beam which has a mud cup on one end and a counter weight on other. The reading is obtained by balancing the beam using the rider. The accuracy of the mud balance is up to 0.01 g/cm3.

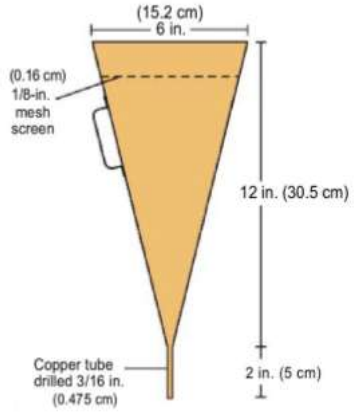

Fig -1: Marsh Funnel

2.2 Methodology

All the experiments were perform on water based drilling fluid. These samples were prepared by using Hamilton Beach Mixer. After preparing the samples, 946 ml of it is discharged into the marsh funnel and the marsh time is recorded until the sample leaves the funnel completely. Then mud balance was used to find out density. The values of marsh time (t) and density (ρ) are substituted in formulas (1) and (2) and apparent viscosity is obtained for the samples. Readings for tap water and distilled water were also obtained. Once Marsh Funnel viscosity was calculated, a hand crank viscometer was used to find out the Θ_{600} value of the samples which was then substituted in formula (3) given above, this gives us the apparent viscosity of the drilling fluids. A comparison between the value obtained from the marsh funnel and viscometer is then made.

3. RESULTS AND DISCUSSION

After the values of apparent viscosity are obtained by substituting the readings into the formulas (1), (2) and (3) a comparative graph is plotted between the apparent viscosity values obtained from the three formulas. Table 1 shows the readings of different samples of native mud and chart 1 gives comparison between the values of its apparent viscosities. Table 2 shows the readings of different samples of the mud prepared with an additive (starch) and chart 2 gives the comparison between the values of its apparent viscosity.

4. TABLES AND CHARTS

Table -1: Native mud apparent viscosity calculation

SI No.	Marsh Funnel			Mud Balance	Hand Crank Viscometer	
	t (sec)	μ = ρ (t - 25) cP	μ = ρ (t - 28) cP	ρ (g/cc)	Θ_{600}	A.V=(Θ_{600}/2) cP

1	30	5.025	2.01	1.005	2.5	1.25
2	30	5.05	2.02	1.01	3	1.5
3	30.1	5.151	2.121	1.01	3.5	1.75
4	29.95	5.00445	1.97145	1.011	4	2
5	29.65	4.70115	1.66815	1.011	4.5	2.25
6	29.82	4.8923	1.8473	1.015	4	2
7	30	5.095	2.038	1.019	4.5	2.25
8	29.78	4.87082	1.81382	1.019	4	2

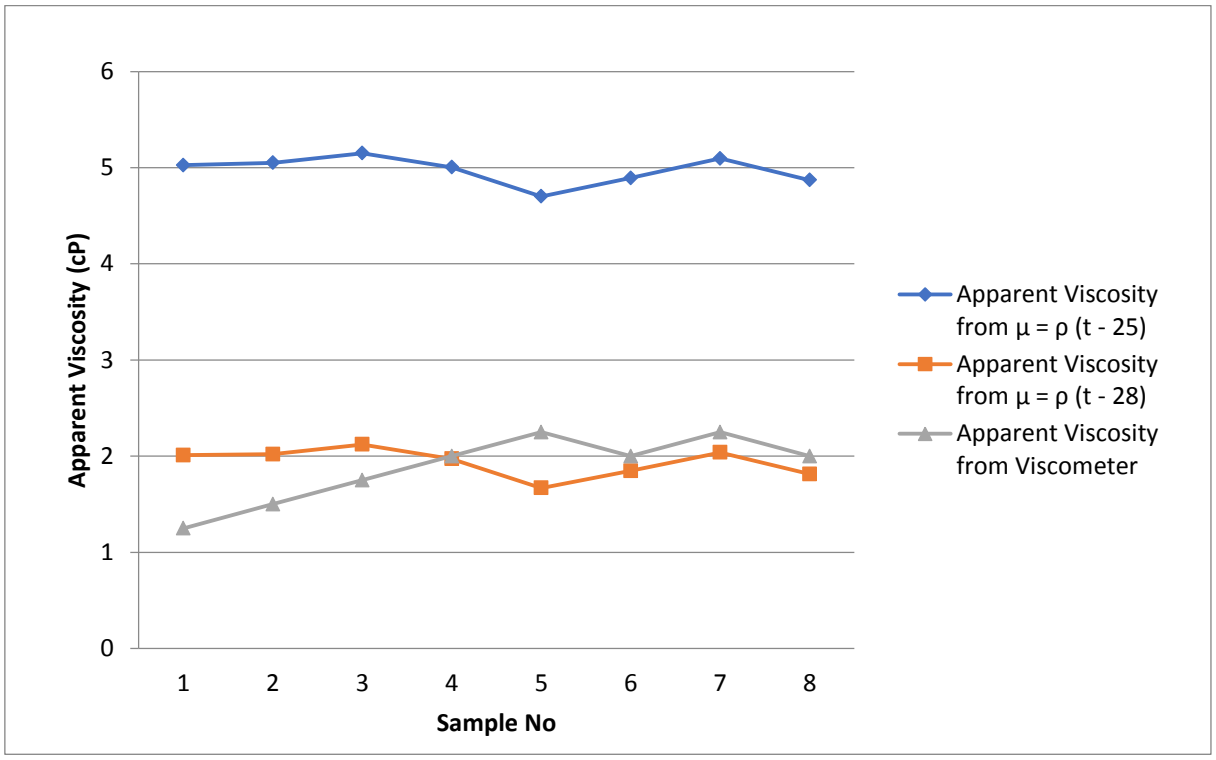

Chart -1: Apparent viscosity graph for native mud with starch

Table -2: Apparent viscosity calculation for the mud with Starch

Sl No.	**Marsh Funnel**			**Mud Balance**	**Hand Crank Viscometer**	
	t (sec)	**μ = ρ (t - 25) cP**	**μ = ρ (t - 28) cP**	**ρ (g/cc)**	**Θ_{600}**	**A.V=(Θ_{600}/2) cP**
1	29.6	4.646	1.616	1.01	3	1.5
2	29.92	4.9692	1.9392	1.01	3.5	1.75
3	29.67	4.72137	1.68837	1.011	3.5	1.75
4	29.55	4.6046	1.5686	1.012	3.5	1.75
5	29.5	4.554	1.518	1.012	4	2
6	29.37	4.42244	1.38644	1.012	4	2

7	29.27	4.33405	1.28905	1.015	4	2
8	29.15	4.2247	1.1707	1.018	4	2

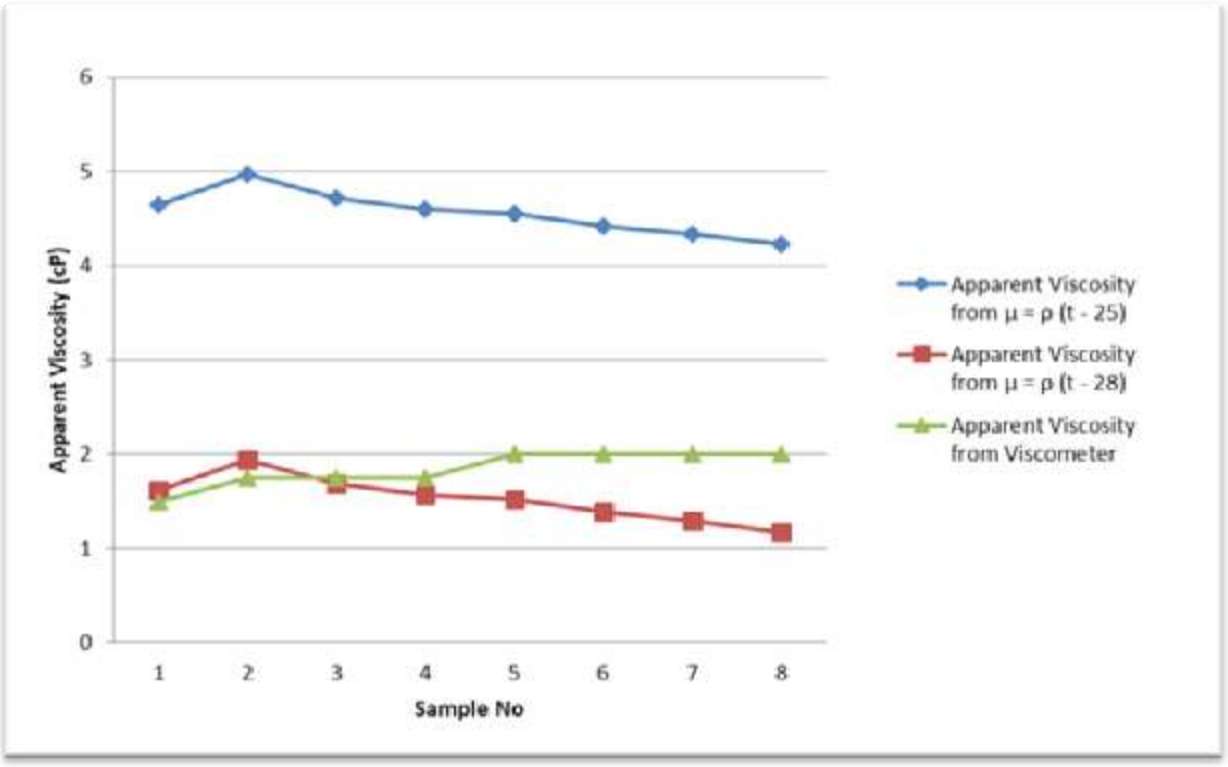

Chart -2: Apparent viscosity graph for mud with additive

5. CONCLUSION

This study shows relationship between apparent viscosity and the viscosity obtained from marsh funnel. The above results show that the equation given by H.M.Almahdawi. I.e. μ_{app}= ρ (t-28) is more accurate than the equation given by M.J. Pitt i.e. μ_{app}= ρ (t-25) for the use as a relation for the apparent viscosity obtained from marsh funnel.

ACKNOWLEDGEMENT

We would like to express immense gratitude towards our department and university to help us with our project and a sincere thanks to the supervisor, Mr. Bhairab Jyoti Gogoi, Assistant Professor, Department of Petroleum Engineering who supported and guided us throughout. We are also thankful to Dr. Suman Paul Head of the Department of Petroleum Engineering and all the faculty and staff of Petroleum Engineering.

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