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The Study of Effective of Added Aluminum Oxide Nano Particles to the Drilling Fluid: The Evaluation of Two Synthesis Methods

Sajjad Hosseini[1], Farshad Farahbod[2]* and Ghassem Zargar[3]

[1]Department of Petroleum Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2]Department of Chemical Engineering, Firoozabad Branch, Islamic Azad University, Firoozabad, Iran
[3]Department of Oil Engineering, Petroleum University of Technology, Ahwaz, Iran

Abstract

In this paper, the tests are designed for investigation of the effects of the synthesized Al_2O_3 nano particle prepared by ultrasonic and microwave on the drilling fluid flowing properties. Nano particles which are prepared with two different methods of ultrasonic and microwave are applied in drilling fluid. Experiments are held in heated tube section for simple drilling fluid and drilling fluid which contains 1% nano Aluminum oxide. Results illustrate on the numerical difference between values obtained from ultrasonic nano drilling fluid and those are obtained from microwave nano drilling fluid. Results show the addition of 1% nano aluminum oxide which is prepared by ultrasonic method into drilling fluid increases the amount of friction factor 6.84% and velocity about 4.4%, averagely. Also, the addition of 1% nano aluminum oxide which is prepared by microwave method into drilling fluid increases the amount of friction factor 5.8% and velocity about 3.7%, averagely.

Keywords: Rheology; Drilling fluid; Heat properties; Microwave; Ultra-sonic

Introduction

The rheology is defined as the science of deformation and flow of matter. As a theoretical subject, the rheology is a branch of physics and physical chemistry; commonly classified as a branch of fluid mechanics [1]. The rheology itself has been acknowledged as a separate scientific branch since the mid 1920's. All real materials will deform to some extent when subjected to stress. If the material is an ideal liquid it may" deform continuously" or flow when a force is applied. For ideal solids the deformation will be elastic [2]. The relationship between the applied force and the resulting deformation is a unique function of each specific material. For fluids, i.e., liquids and gases, this function is known as a rheological property of the material [3,4]. Fluids are classified by their rheological behavior American Petroleum Institute. All fluids are classified as either Newtonian or Non-Newtonian, the clearest distinction between different types of fluids.

Fluid mechanics

Fluid mechanics is the study of the forces involved in both still and flowing fluids.

Flow regimes

Flow in circular pipes can behave in different ways. Most common fluids are transported in circular pipes. This is because pipes can withstand a large difference in pressure between the inside and outside of the pipe, without being significantly distorted [5]. The theory behind fluid flow is commonly well understood, yet only fully developed laminar flow is theoretically obtained [6]. Therefore flow with other characteristics, like turbulent flow, must rely on experimental and empirical relations. The borderlines between laminar, transitional and turbulent flow regimes are set by the Reynolds number of the flow [7]. For laminar flow, the viscous forces dominate, while for turbulent flow the inertial forces play the bigger role American Petroleum Institute. All fluid flow inside a pipe has the velocity profile of zero at the pipe wall due to no-slip condition to a maximum at the center of the pipe [8].

Role of drilling fluid

The drilling fluid plays an integral part of all drilling operations, and should be optimized according to different parameters to achieve the best results and industrial effectiveness [9]. The main tasks for the drilling fluids are: A. Hole cleaning, getting the crushed material out from the well. It is important that the hole is properly cleaned with regards to completing the well. B. Controlling formation pressure (being a barrier). C. Buoyancy. Keeping the drill string submersed reduces the effective weight of the drill string on the hook load. This also reduces fatigue and costs (need less high strength steel in the top of the drill string). D. Lubrication, smoothening operation for the bit and also the drill string in long deviated/horizontal wells. E. Cooling, keeping the drill bit cool, in order to keep change the mechanical properties of the bit. F. Provide power to the bit. Hydraulic power is transmitted so that the can cones rotate (Only valid for roller-cone bits) [10]. For PDC bits the hydraulic power is used for jetting the crushed rock away from the bit teeth. G. Keeping the wellbore stable with regards to chemical reactions [11,12]. Shale can be a problem. H. Signal transfer. For real time measurements and logging, the drilling fluid itself is used as the transfer medium for pressure waves. I. Costs. Drilling fluids are an expensive part of the operations, and should be handled with care to avoid excessive spending [13]. The physical properties of Nano drilling fluid as novel drilling fluid are evaluated in this paper.

*Corresponding author: Farshad Farahbod, Department of Chemical Engineering, Firoozabad Branch, Islamic Azad University, Firoozabad, Iran, E-mail: mf_fche@yahoo.com

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Materials and Methods

Composition of drilling fluid

The composition of drilling fluid is classified according to the Table 1.

Aluminium oxide nano particles

Aluminium oxide nano particle is an environmental friendly element and has a huge variety of applications. Aluminum is available as essential mineral and is non-toxic in low concentration.

Experimental set up

The experimental set up includes mixing tank, adiabatic tube test section and electrical heater is used to survey the behavior of Nano drilling fluid with two types of ultrasound Nano and microwave Nano.

Results and Discussion

Peclet number

Figure 1 shows the amounts of Peclet number through the tube length. Peclet number shows the effect of Reynolds and Prandtl number, together. The decrease trend is shown through the tube for three types of drilling fluid according to the Figure 1. The decrease trend in amounts of Prandtl number can indicate this trend in amounts of Peclet number. Addition of Nano particle (1%) shows a little bit higher values of Peclet number. The highest values of Peclet number are related to the Nano drilling fluid which is prepared by microwave method.

Hydrodynamic properties

Velocity changes through the tube are important in properties of drilling fluid. Figure 2 shows the values of velocity versus tube section. Figure 2 shows the average velocity in the pipe line. The values of velocity commonly decrease in tube because of friction and viscous dissipation. The changes in velocity through 0.3 meter of tube for simple drilling fluid without Nano particle are from 1.7 m/sec to 1.53 m/sec. Addition of 1% Nano particle decreases the velocity loss through the tube. Ultrasonic method prepared Nano fluid changes the values of average velocity from 1.7 m/sec to 1.68 m/sec. The changes in velocity using microwave method Nano fluid are from 1.7 m/sec to 1.66 m/sec. So, ultrasonic Nano drilling fluid seems to present better hydrodynamic performance. This may relate to the lower viscosity of Nano drilling fluid. So, values of viscosities are measured below.

Component	Weight Percentage
Water	48.67
glycol	2.38
Polyacrylamide	17.37
Sodium bicarbonate	3.6
Calcium carbonate	9.2
NaCl	16
Potassium chloride	2.78

Table 1: Composition of drilling fluid.

Figure 3 shows values of dynamic viscosity versus temperature. Dynamic viscosity is responsible of amount of viscous dissipation. Obviously, the increase in temperature values decreases values of fluid dynamic viscosity. This trend is obtained for Nano drilling fluid. Also, the lower values of dynamic viscosity are obtained using Nano drilling fluid. This may describe the lower changes in amounts of average velocity for Nano drilling fluid. Temperature changes from 25°C to 85°C, changes the values of dynamic viscosity from 40cp to 25cp for simple drilling fluid. The same mentioned temperature changes causes the changes from 31cp to 18cp for ultrasonic prepared Nano drilling fluid 30cp to 14cp for microwave prepared Nano drilling fluid. The effect of temperature on the amount of cinematic viscosity is shown in Figure 4. The increase in temperature values decreases values of cinematic viscosity. Of course, the lower values of dynamic viscosity describe the lower values of cinematic viscosity.

Effective viscosity versus temperature is shown in Figure 5. The amounts of effective viscosity decrease with temperature increase from 30°C to 80°C. Values of effective viscosity for drilling fluid without Nano changes from 51.2 to 7.7. The changes of effective viscosity for microwave Nano drilling fluid and for Ultrasonic Nano drilling fluid are from 41.12 to 2.12 and from 39.7 to 1.9, respectively.

Figure 6 shows the values of yield point versus different temperatures. The increase in the amount of temperature from 30°C to 80°C decreases the amount of yield point from 18.7 to 13.05 for simple drilling fluid without Nano particle. Addition of Nano particle (1%) by method of ultrasonic and microwave decreases the values of yield point from 13.8 to 10.03 and from 12 to 5.9, respectively. Amounts of yield point indicate on the ability of drilling mud to carry rocks out of well.

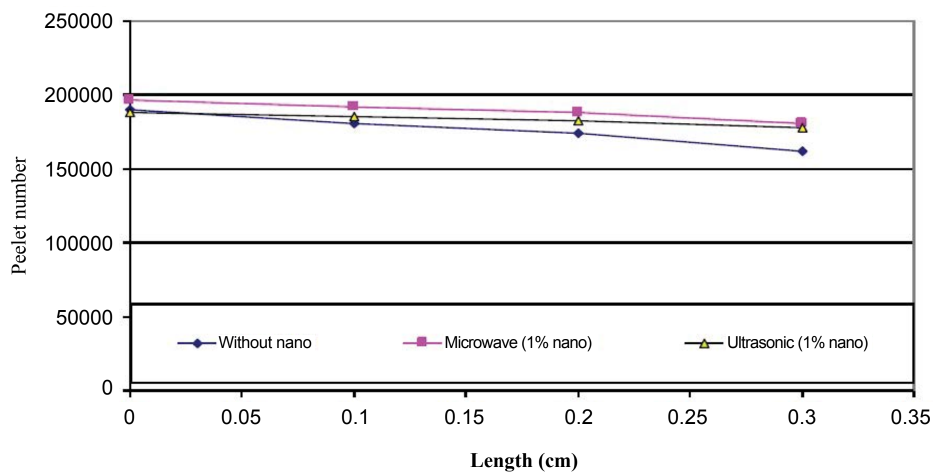

Figure 1: Peclet number versus length.

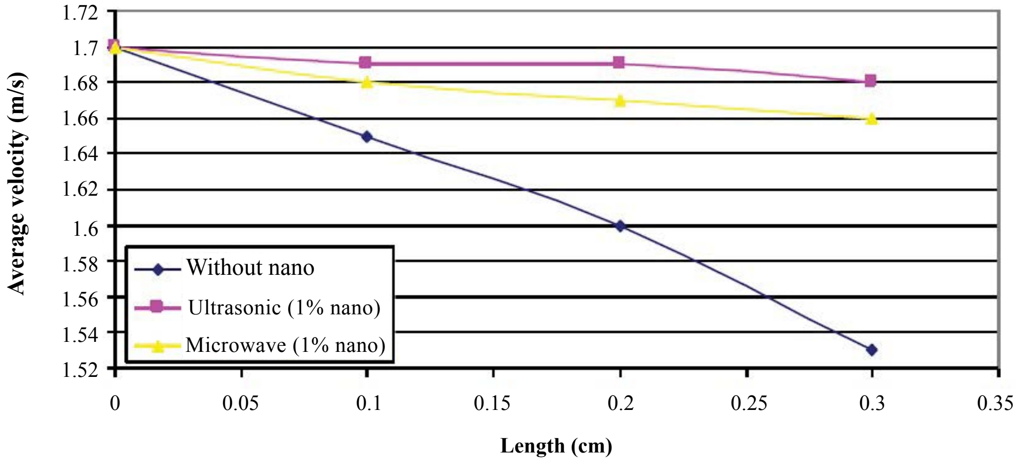

Figure 2: Average velocity versus length.

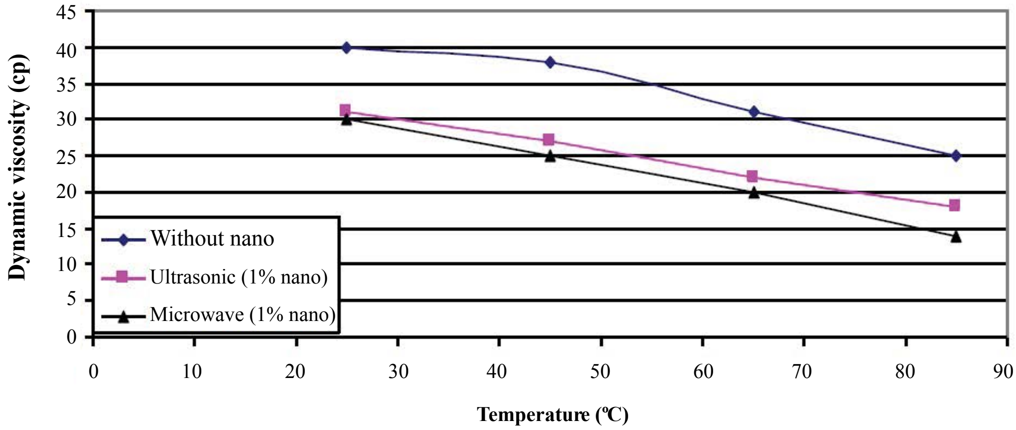

Figure 3: Dynamic viscosity versus temperature.

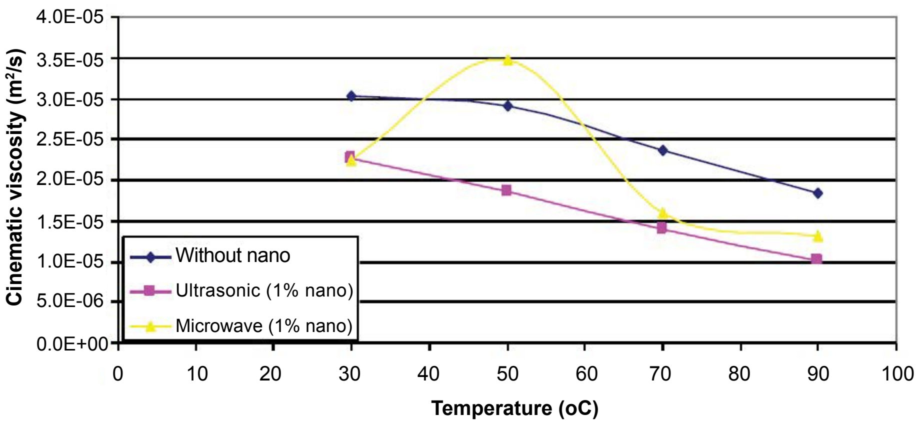

Figure 4: Cinematic viscosity versus temperature.

The higher amounts of yield point cause higher pressure loss during drilling. So, Nano drilling fluid which is made by microwave method shows the best amounts of yield point comparing with the other simple drilling fluid and ultrasonic drilling fluid.

Figure 7 shows the amounts of Reynolds number through the tube at 38°C operation temperature. Reynolds number includes the effect of some important properties which are average velocity and kinematic viscosity. The decrease trend of density by temperature

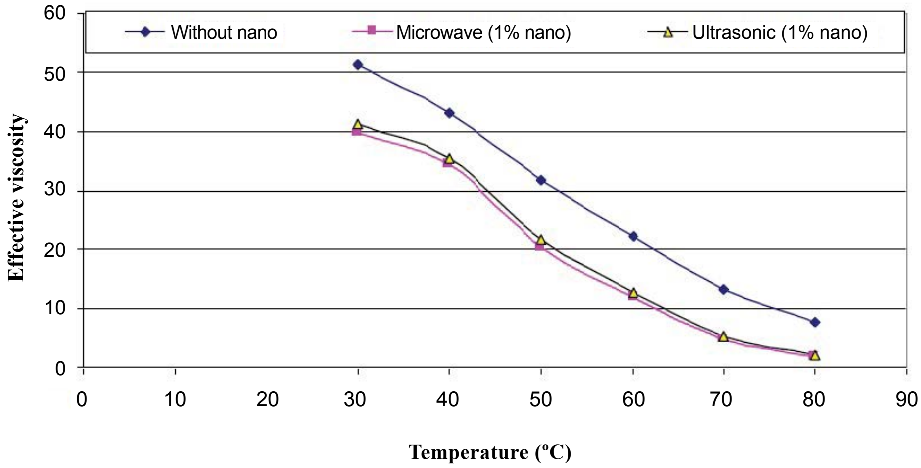

Figure 5: Effective viscosity versus temperature.

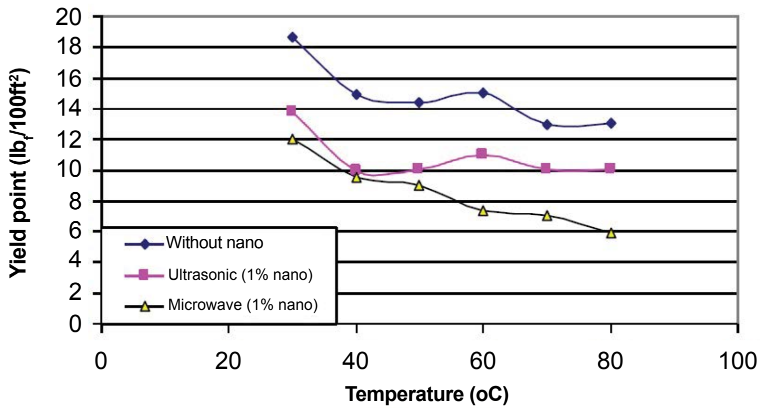

Figure 6: Yield point versus temperature.

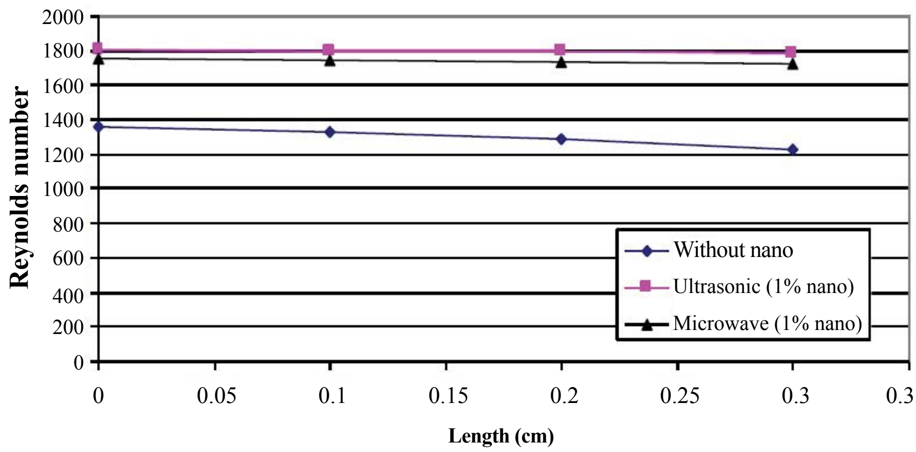

Figure 7: Reynolds number versus length.

is obviously depends on the higher amount of mean length of free path of molecules of drilling fluid at higher temperatures and the decrease in the amount of molecules in one unit of volume. So, the total difference in Reynolds number through 0.3 m is 135.3, 18 and 13 units for drilling fluid without Nano, ultrasonic and microwave drilling fluid respectively. So, ultrasonic nano drilling fluid seems to show more stable Reynolds number and flow regime through the tube. Figure 8 shows the values of friction factor through the tube length. Values of friction factor decreases through the length. According to the Figure 8 addition of Nano particles increases slightly the amount of

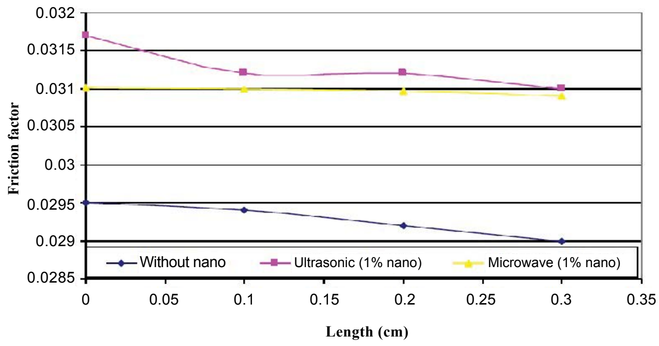

Figure 8: Friction factor versus length.

Property	Re	Pr	Pe
Ultrasonic Nano particle + drilling fluid	1.38	0.222	1.07
Microwave Nano particle + drilling fluid	1.34	0.223	1.04

Table 2: The comparative results of basic parameters.

friction factor compares with simple drilling fluid. Due to the previous results of Reynolds number, the changes in amounts of this number affect obviously the amounts of friction factor. The decrease trend of this number through the length is obeyed by the amounts of friction factor. Also, addition of 1% Nano fluid prepared by ultrasonic and microwave increases the amount of friction factor respectively 6.84% and 5.8%, averagely. This indicates the effect of preparation method of Nano particle on the amounts of friction factor besides the effect of Reynolds number and tube roughness on the amount of friction factor.

Conclusions

Drilling fluids play a major role in drilling purposes in oil and gas industries. In this study, thermal and rheological specifications of drilling fluid in ranges of temperature through the experimental tube section, resembling well condition, are obtained. Thermal specifications are also considered. The purpose of this experimental work is to find the answer of this question:" Does the method of preparation of Nano Al_2O_3 particle affect the behavior of Nano drilling fluid?" So, experiments are handled to find the amounts of Prandtl and Stanton number, average velocity, dynamic viscosity, kinematic viscosity, yield point, Reynolds number and friction factor. The obtained results are valuable to predict the behavior of Nano drilling fluid in the determined conditions. However, this area needs more investigations. All experimental values of Nano drilling properties are compared with the amounts which are obtained for simple drilling fluid. Summary of the obtained results are mentioned. The addition of 1% Nano aluminum oxide into drilling fluid decreases values of plastic viscosity, effective viscosity, dynamic viscosity and yield point, generally. Ultrasonic Nano drilling fluid decreases value of effective viscosity about 40%, dynamic viscosity about 30% and yield point about 27%. Microwave Nano drilling fluid decreases value of effective viscosity about 44%, dynamic viscosity about 30% and yield point about 44%. Addition of 1% Nano aluminum oxide which is prepared by ultrasonic method into drilling fluid increases the amount of friction factor 6.84% and velocity about 4.4%, averagely. The addition of 1% Nano aluminum oxide which is prepared by microwave method into drilling fluid increases the amount of friction factor 5.8% and velocity about 3.7%, averagely. Also, the comparative results are briefly presented in below chart as the fraction of value of Nano drilling fluid to the value related to the simple drilling fluid. The Table 2 shows the ratio of Reynolds, Prandtle and Peclet numbers.

Final conclusion introduces a new viewpoint about the effect of method of preparation of Nano aluminum oxide on the Nano drilling fluid. So, although the preparation method of Nano particle affects the behavior of Nano drilling fluid but this doesn't show any considerable effect. The difference between the results of ultrasonic drilling fluid and microwave Nano fluid can be bold under high temperature and high pressure conditions.

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