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Evaluation of stability and viscosity measurement of emulsion from oil from production in northern oilfield in Thailand

O Juntarasakul and K Maneeintr*

Carbon Capture, Storage and Utilization Research Group, Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, 10330 Bangkok, THAILAND

Email: Krengkrai.M@chula.ac.th

Abstract. Emulsion is normally present in oil due to the mixing occurring during oil recovery. The formation of emulsion can cause some problems in production and transportation. Viscosity and stability of emulsion play a key roles in oil transportation and separation to meet sales specification. Therefore, the aims of this research are to measure the viscosity of oil an emulsion and to evaluate the stability of emulsion of light oil from Fang oilfield in Thailand. The parameters of this study are temperature, shear rate and water cut ranging from 50 to 80 °C, 3.75 to 70 s^{-1} and 0 to 60%, respectively. These effects of parameters on viscosity and stability of emulsion are required for the design of the process and to increase oil production with various conditions. The results shows that viscosity decreases as temperature and shear rate increase. In contrast, viscosity becomes higher when water cut is lower. Furthermore, droplet sizes of water-in-oil emulsion at different conditions are investigated the stability of emulsion. The droplet sizes become smaller when high shear rate is applied and emulsion becomes more stable. Furthermore, correlations are developed to predict the viscosity and stability of the oil and emulsion from Thailand.

1. Introduction

For petroleum industry in Thailand, oil and gas business become more important because of the need of energy supply. Emulsion, a mixture of oil and produced water can be formed from oil recovery. It is found in many processes such as production, pipeline transportation and separation [1]. This emulsion can cause some production problems such as oil flow in pipe with higher viscosity, higher heat requirement to reduce viscosity and to separate oil and water to meet sales specification, longer time-consuming for separation in the tank and corrosion [2,3]. These current problems result in higher cost for oil treatment.

Stability of emulsion attributes to surface-active films consisting of several components implicated with viscosity [4] because stable emulsions might be classified by their viscoelastic, elastic and viscosity, properties [5]. Viscosity and stability of emulsion are the key parameters to transport and separate oil and water to meet sales specification [6]. If the viscosity and stability of oil and emulsion in Thailand have been investigated, the oil production can be improved. Therefore, the objectives of this work are to measure and investigate the viscosity and stability of emulsion as well as to evaluate the effects of parameters on oil and its emulsion such as temperature, shear rate and water cut in order to increase oil production from Fang oilfield in Thailand. Furthermore, the correlation for predicting viscosity with parameters will be developed.

2. Materials and Methods

Viscosity measurements are performed by Brookfield viscometer model LVDV2T with spindle number 40Z and 52Z .Temperature is controlled by using constant temperature water bath with a glycol solution as a heating media. The droplet size distribution is investigated by light microscope with trinocular head and eyepiece for droplet size measurement. The oil sample is obtained from Fang oilfield, the Northern oilfield in Thailand. Emulsion of oil is prepared with various percent values of water content at 0%, 20%, 40% and 60% by volume and mixed with distilled water at the speed of 600 rpm for 15 minute at 50 °C. Each viscosity measurement uses 0.5 cm^3 of emulsion for various conditions, i.e. temperature at 50°C, 60°C, 70°C and 80°C and water content from 0 to 60% by volume. Also, shear rate ranges from 3.75 s^{-1}, 7.5 s^{-1}, 15 s^{-1}, 30 s^{-1} and 60 s^{-1}. The measurement is performed for 90 minutes and recorded for every 3 minutes. The droplet size is investigated by using microscope with 100 times magnification and photograph of emulsion is taken.

3. Results and Discussion

3.1 Effect of temperature on viscosity

The results of the effects of temperature from 50°C to 80°C on viscosity of oil and its emulsion are presented in figure 1. The results shows that viscosities of the light oil and its emulsions decrease as temperature increases because at higher temperature, oil and emulsion molecules obtain higher energy from heat thus making them less viscous and oil can flow easily [7]. From this study, temperature can reduce viscosity up to 54.68%.

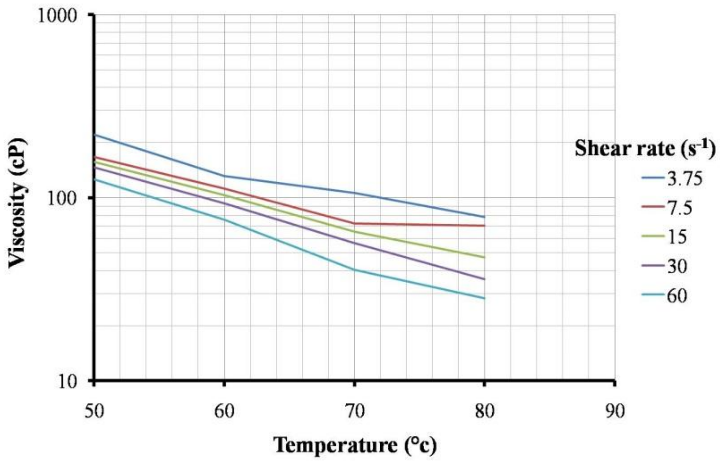


Figure 1. Effect of temperature on viscosity of oil emulsions at 20% water content

3.2 Effect of water content on viscosity

Water contents for this study is at 0%, 20%, 40% and 60%. The oil and emulsion are measured and the results are shown in figure 2. The viscosity becomes higher when water content is increased corresponding to Maneeintr et al., [6] and Farah et al., [9] which is found that when volume of water increases, the droplet-droplet interaction and water-oil interfacial area are greater. This phenomenon influences the contribution of the increase in interfacial viscosity. In addition, the effect of water content can increase viscosity ranging from 37.91% to 221.95%.

3.3 Effect of water content on viscosity

Shear rates used for this study are 3.75 s^{-1}, 7.5 s^{-1}, 15 s^{-1}, 30 s^{-1} and 60 s^{-1}. The result is presented in figure 3. At high water content, once the larger the shear rate is applied, viscosity becomes lower. At lower water content, on the other hand, the larger shear rate in original oil, viscosity becomes higher.

The shearing effects upset the stability of the drop, oscillate in to smaller drops [5]. This phenomena can be explained from the break-up of water droplet to form smaller size [8] as shown in figure 4.

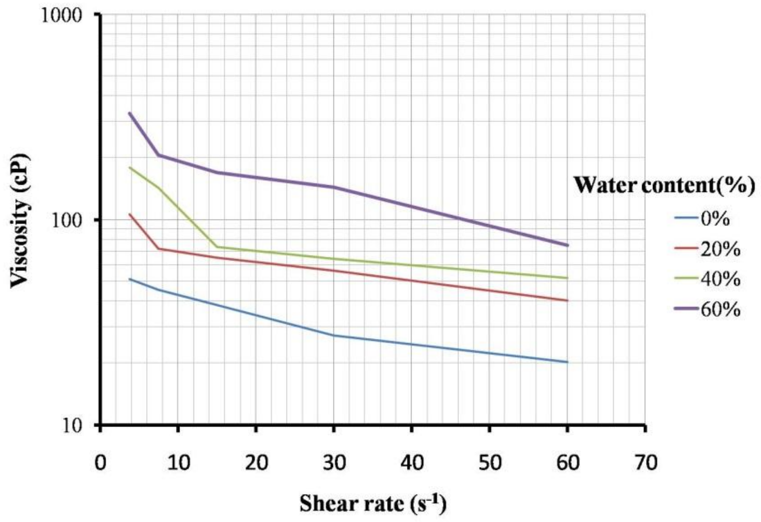


Figure 2. Effect of water content on viscosity of oil emulsions at 30 s^{-1} shear rate

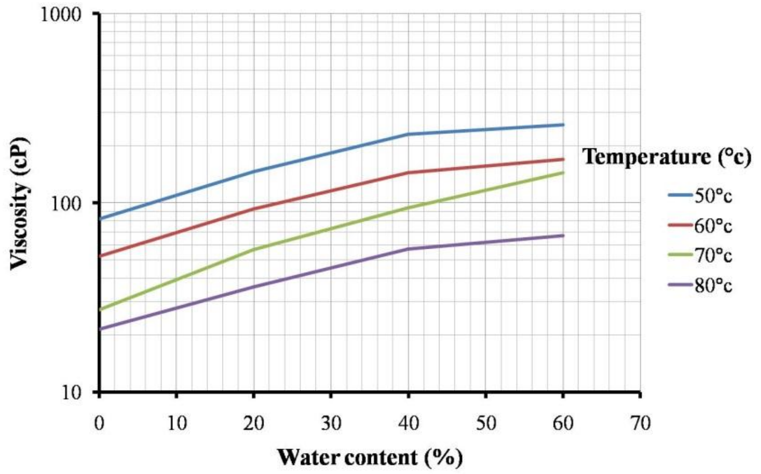
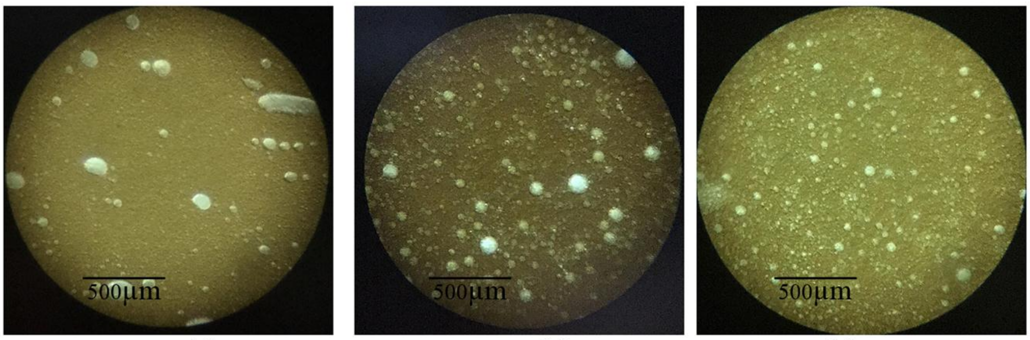


Figure 3. Effect of shear rate on viscosity of oil emulsions at 70°C



(a) (b) (c)

Figure 4. Microscopic observation of water droplet in 20 % water content at (a) shear rate 3.75 s^{-1} (b) shear rate 7.5 s^{-1} and (c) shear rate 15 s^{-1} at temperature 70°C

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3.4 Effect of water droplet size on stability of emulsion

Figure 4 shows the result of water droplets dispersed in emulsion of oil at different shear rate at 70°C and 20% water cut. From figure 4a to 4c, it is obvious that the droplets become smaller with increasing shear rate because when high shear rate is applied, the droplets of water split to small droplets thus making emulsion stable because interfacial tension and area of oil and water is increased [10].

3.5 Correlation Development

The viscosities of oil and its emulsions from Fang's oilfield, Thailand are correlated with equation developed from Al-Roomi's [9] as shown in equation 1. Table 1 and figure 5 show the viscosities from experiment and correlation.

$$\ln \mu = A + B\ln\gamma + C\Phi + D/T \tag{1}$$

where μ is viscosity, γ is shear rate, Φ is water content.
A, B, C and D are constants depending upon the system and
T is the temperature in degree Celsius.

Table 1. Experimental and correlation results of viscosity measurement at 70°C

Water content (%)	Shear rate (s^{-1})	Viscosity (cP)	
		Experiment	Correlation
0	3.75	51.40	61.69
	7.5	45.37	47.15
	15	38.32	36.04
	30	27.29	27.29
	60	20.23	20.23
20	3.75	106.01	102.90
	7.5	72.04	78.65
	15	65.00	60.12
	30	56.43	45.95
	60	40.31	35.12
40	3.75	178.80	171.66
	7.5	142.80	131.21
	15	73.50	100.29
	30	94.20	76.65
	60	52.09	58.59
60	3.75	328.30	286.35
	7.5	206.10	218.87
	15	169.90	167.29
	30	143.90	127.87
	60	74.90	97.74

From the experiment results, A, B, C and D in equation 1 can be calculated by linear regression method. The percent average absolute deviations (%AADs) between experimental and correlated viscosity estimated from equation 2 [6]:

$$\%AAD = \frac{100}{n}\sum_{i=1}^{n}\left|\frac{P_{exp}-P_{cor}}{P_{exp}}\right| \quad (2)$$

Where n is number of data.

The average absolute deviations (%AAD) from this correlation is 13.97%. Therefore, it can be concluded that this correlation can be used to predict the viscosity of oil and its emulsion from this oilfield in Thailand.

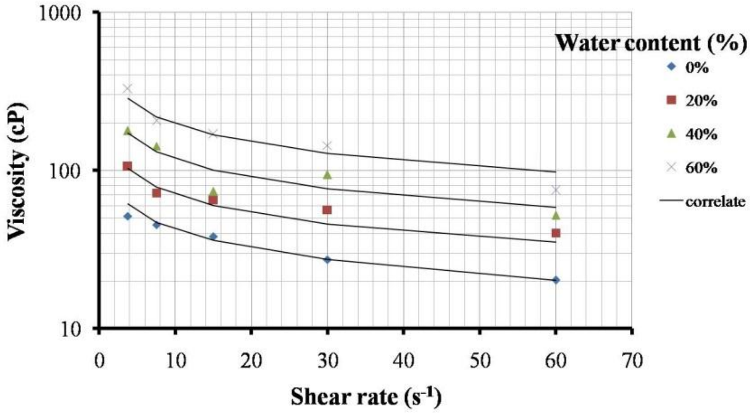

Figure 5. Correlation for viscosities of oil and its emulsion at 70°C

4. Summary

The viscosities of light oil and its emulsion are measured and evaluated. In this work, the properties of emulsions are studied and investigated with various operating conditions such as temperatures varying from 50 to 80°C, water cut ranging from 0 to 60% and shear rate from 3.75 to 60 s^{-1}. The results show that increasing temperature can decrease significantly the viscosity and viscosity of emulsion increases with water content. However, shear rate has less effect of viscosity reduction. Furthermore, emulsion stablility is studied by observing the droplet size. It is shown that at high temperature, droplet size is bigger and emulsion becomes less stable. On the other hand, high water content and shear rate can result in smaller size of water droplet and make it more stable. Moreover, the correlation representing the experimental results has been developed to predict the viscosity for oil and its emulsion with 13.97% average absolute deviation of these results. This correlation can be used to calculate and predict the viscosity of oil and its emulsion for oil from Thailand.

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References

[1] Fanchi, J R 2006 Directional permeability *SPE Annual Technical Conference and Exhibition* Society of Petroleum Engineers
[2] Schramm L L 1992 Petroleum emulsions: basic principles *American Chemical Society* Washington DC **pp** 1–51.
[3] Fingas M F and Hollebone B P 2014 Oil behaviour in ice-infested waters *International Oil Spill Conference Proceedings* **2014** (1) **p**. 1239-1250.
[4] Neumann H J and Paczynska-Lahme B 1996 Stability and demulsification of petroleum emulsions Interfaces, Surfactants and Colloids in Engineering **pp**. 101-104.

[5] Richardson E G 1950 The formation and flow of emulsion *Journal of colloid science* **5**(4) **pp**. 404-413.
[6] Maneeintr K Sasaki K and Sugai Y 2013 Investigation of the Effects of Parameters on Viscosities and Correlation of Heavy Oil and Stability of Its Emulsion *Journal of the Japan Institute of Energy* **92**(9) **pp**. 900-904.
[7] Ronningsen H P 1995 Correlations for predicting viscosity of W/O-emulsions based on North Sea crude oils *SPE International Symposium on Oilfield Chemistry* Society of Petroleum Engineers.
[8] Waltra, P 1993 Principles of emulsions formation *Chemical Engineering Science* **48**(2) **pp**.333-49.
[9] Farah M A, Oliveira R C, Caldas J N and Rajagopal K 2005 Viscosity of water-in-oil emulsions: Variation with temperature and water volume fraction *Journal of Petroleum Science and Engineering* **48**(3-4) **pp**.169-184.
[10] Al-Roomi Y, George R, Elgibaly A and Elkamel A 2004 Use of a novel surfactant for improving the transportability/transportation of heavy/viscous crude oils *Journal of Petroleum Science and Engineering* **42**(2-4) **pp**.235-243.