CERTIFICATE of ATTENDANCE

POSTER PRESENTER

SAFRI ABDELHAMID

INTERNATIONAL CONFERENCE ON ADVANCES
IN MECHANICAL ENGINEERING ISTANBUL

ICAME'15
MAY 13 -15, 2015
YILDIZ TECHNICAL UNIVERSITY

YILDIZ TECHNICAL UNIVERSITY 1911

Assoc. Prof. A. Selim DALKILIÇ
Chair

Assoc. Prof. Zehra YUMURTACI
Co-chair

Conference Paper

INTERNATIONAL CONFERENCE ON ADVANCES IN MECHANICAL ENGINEERING ISTANBUL 2015 - ICAME'15
13-15 May 2015, Yildiz Technical University, Istanbul, Turkey

EXPERIMENTAL INVESTIGATION OF EFFECT OF WATER CONTENT CONCENTRATION ON THE RHEOLOGICAL BEHAVIOR OF ALGERIAN CRUDE OIL

Djamal Eddine Djemiat
Laboratory LEGHYD, FGC, USTHB
Bab Ezzouar, Algiers, Algeria

***Abdelhamid Safri**
Laboratory LEGHYD, FGC, USTHB
Bab Ezzouar, Algiers, Algeria

Abdelbaki Benmounah
UR-MPE, FSI, UMBB
Boumerdes, Boumerdes, Algeria

Keywords: water in oil (w/o) emulsions, crude oil, rheology,
** Corresponding author: Phone:, Fax: + 213 21 24 72 24*
E-mail address: absafri@gmail.com

ABSTRACT

Rheological behavior of crude oil and their emulsions were investigated as a function of water content concentration, temperature, and shear rate. The aim of this work is to obtain more knowledge of the effect of water fraction on the rheological properties of crude oil emulsion of Algeria. Rheological characteristics of crude oil emulsions were measured with the rheometer AR-2000 for TA-Instruments. Several temperatures were tested under dynamic and shear testing conditions. The water content concentration ranged from 5, 10 and 30% vol/vol. The measured data were first classified into two groups for Newtonian and non-Newtonian fluids. The results showed that the Non-Newtonian emulsions exhibit shear thinning behavior and their rheological characteristics can be described by the Herschel-Bulkley model. The viscosity, the elastic modulus (G') and the viscous modulus (G") of emulsions were significantly influenced by the water contents. The results also indicated that the rheological properties of crude oil and their emulsions are significantly temperature dependent.

INTRODUCTION

The extraction of crude oil is systematically accompanied by the production of water from oil field. When transporting in pipes from the wellhead to the surface installations, these two immiscible fluids passes through intense agitation areas, such as pumps, valves and other, which often lead to the formation of a water-in-oil emulsion. The emulsions formed may separate naturally in a few minutes. However, in some cases, their separation may require several weeks if no treatment is applied to them. These water/oil (W/O) type emulsions are mostly stabilized by naturally occurring surfactants, e.g., asphaltenes and resins, which adsorb at interfaces and tend to inhibit or delay the inter drop film drainage, hence preventing drop–drop coalescence and water separation (Kilpatrick et al, 2001). Several researchers were interested in the problem of emulsification. M. Nuraini et al (2011), was interested in the effect of chemical demulsified in order to separate the water and oil from water in oil emulsions, four group of demulsifies were used; amine, polyhydric alcohol, alcohol and natural group. The rheological behavior of the emulsions has been the subject of extensive literature (Nadim, 1996), (Palierne, 1990) and (Yang et al, 2007). Understanding the rheological behavior of emulsions has been of great interest for its strong relationship to many properties of emulsions that are vital for industrial applications (yasushi et al, 2007). Several approaches have been reported to study the associated phenomena, and some trends and correlations have been found between properties Eley et al, 1988) and (Kang et al, 2006) cited by Miguel Randon et al (2008). Rajinder (2010), present a comprehensive review of the rheology of simple and multiple emulsions. Special attention has been given by author to the models describing the rheology of these systems. The key factors governing the rheology of simple and multiple emulsions were discussed. The aim of this work is to obtain more knowledge of the effect of water fraction on the rheological properties of crude oil emulsion of Algeria. The purpose of this work is to study the effect of the fraction of the water on the rheological properties of Algerian crude oil. The evolution of the rheological models and their parameters will be treated.

MATERIALS AND METHODS

The rheological behavior of different samples was studied by exploiting the performance of the rheometer AR-2000 from TA-Instruments. Couette geometry with a diameter of 14 mm and a gap of 1 mm between upper and lower plates were used in all tests. Because of its large contact area, we can obtain good accuracy with this kind of apparatus and measurements can be obtained for very small values of viscosity. The crude oil sample is subjected to shear rate of 700 s^{-1} to remove the memory of the sample. All the samples will be subjected to pre-shear of 60 seconds with a shear rate of 0.15 s^{-1} to establish a uniform initial state. The samples will be left at rest during one minute. Then, the procedure of acquisition is started; the rheological measurements begin by applying a very low shear rate 0.01 s^{-1} and 120 s^{-1}. The rheological tests will be carried out at the temperatures 10 °C and 20°C respectively. The dynamic tests were conducted in the linear viscoelasticity domain for the frequency range of 0.01rd/s to 20 rad/s.

RESULTS AND DISCUSSION

The rheological behavior of emulsions depend by many parameters the water-oil fraction, shear rate and the temperature. Crude oil emulsions of different volume fractions were prepared in order to study the effect of water volume fraction on emulsion viscosity. The apparent viscosity of the formulated emulsions was measured at 10 and 20°C for shear rates ranging between 0 and 120 s^{-1}. The evolution of the shear stress and apparent viscosity versus shear rate of the emulsions at 10°C and 20°C, are presented in figures 1 and 2.

The rheogram of the viscous emulsions present a shear-thinning behavior Figure 1. This rheological behavior is often attributed to the arrangement of overlapped asphalten under shear rate (Pal et al, 1992) and (Pierre et al, 2004), cited by (Fournanty et al, 2008). The flow curves show an increase of the apparent viscosity of the emulsion when the water volume fraction increases. All the flow curves tend toward Newtonian behavior. For low temperatures, it is necessary to apply a higher shear rate; this can be explained by the result of the reversible structural breakdown of the emulsion under shear, which causes the deformation of the droplets. When the shear rate increases, the droplets are more elongated, and their major axis is aligned gradually in the direction of the flow (Pal, 2003).

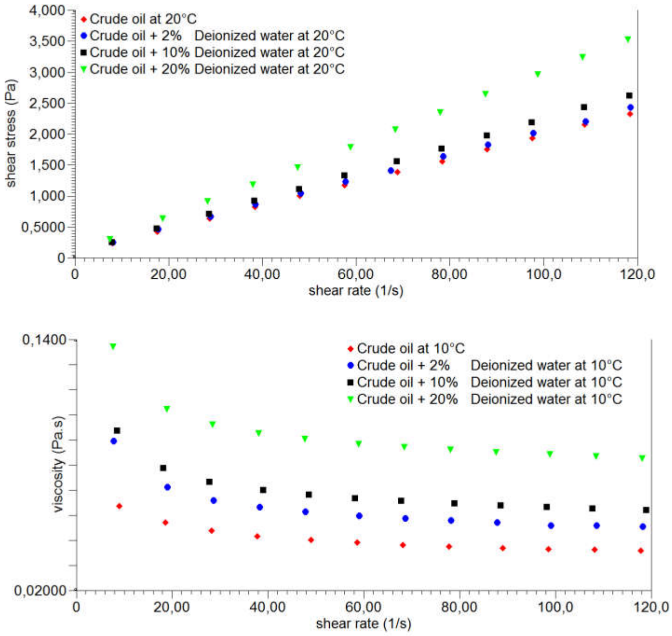

Fig.1: Shear stress and viscosity vs shear rate of crude oil and emulsion at different water concentrations at 10°C

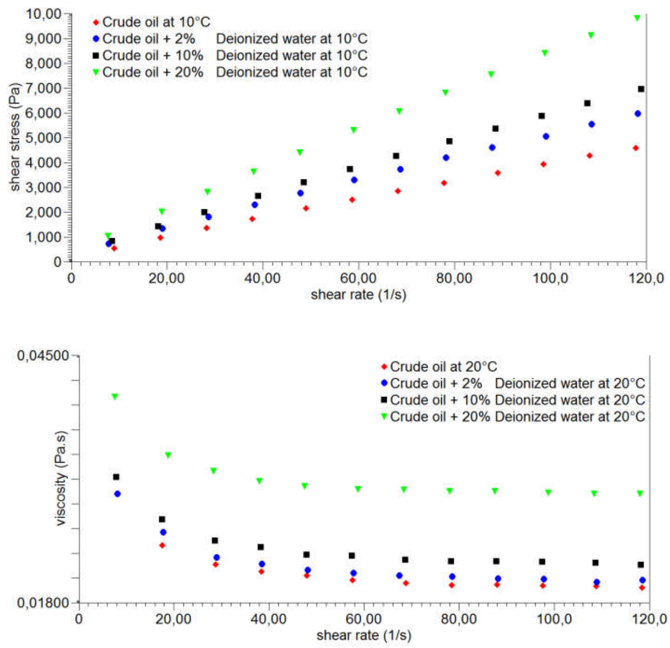

Fig. 2: Shear stress and viscosity vs shear rate of crude oil and emulsion at different water concentrations at 20°C

The effect of water percentage of w/o emulsion was investigated with different temperature. The experimental results of emulsions with different water fraction ranging from 0% to 20%, are presented in Table 1. It is shown that the yield stress of the sample increased up with the increase of water fraction. This is in line with the conclusion reported in the literature (Visintin et al, 2008) and (Guo et al, 2011).It is possible that the addition of dispersed water droplets can increase the strength three-dimensional of the emulsion network by forcing the particle fluid into closer contact, this, in the case where the shear stress is high enough to break the network structure and overcome the applied force of dispersed water droplets.

Table 1. Effect of water fraction on the yield stress (pa) of the crude oils with different temperatures

T (°C)	Fraction of Water			
	0%	2%	10%	20%
10°C	0,5442	0,7150	0,8272	1,050
20°C	0,2382	0,2429	0,2493	0,3052

Specifically, as can be seen in Table1, the yield stress increasing weakly when the water content was less than 10%. However, at higher water fractions at 20%, there was a sharp increase in yield stress by 0, 5442 Pa at 1,050Pa at 20% of water containing, respectively. By the Comparison of the yield stress measured at 10°C for the same water fraction, the yield stress decrease rapidly from 1.05 to 0.30 Pa with the 20% and from 0,8272 Pa to 0,2493 Pa at 10% of water fraction, respectively. With increase in temperature, higher molecular components of emulsions are not able to agglomerate and form aggregates and hence breaking the bond between the solid particles, which leads to reduction in yield stress. To access the extent of the variation of viscosity, the degree of the viscosity increase (DVI) is introduced and it can be calculated with equation 1:

$$\textbf{DVI (\%)} = (\eta_r - \eta_c)/\eta_r \times 100 \qquad (1)$$

where : η_r, is the reference viscosity at 78.02 s^{-1} and at 10°C, 20°C, and η_c is the corresponding viscosity at 78.02 s^{-1} and corresponding temperature.
In Table 2, it represents the values of the viscosity for different concentrations of water in the crude oil

Table 2. Effect of water fraction on the viscosity at 78.08 s^{-1} of the crude oil at different temperatures

T(°C)	Viscosity (mPa.s)			
	Without Water	With water		
		2%	10%	20%
10	41,01	53,39	61,57	87,40
20	19,93	20,81	22,53	30,20

From the Table 3, it was observed that there is a considerable increase in DVA% from 23.18% to 53.07% at 10°C. The increase in DVA% can be explained by: When the water fraction increased in the emulsion, each droplet is not sufficiently distant from others, and the strong three-dimensional network can form at a low temperature.

Table 3. Viscosity increase in percent at 78.08 s^{-1} of the emulsions

T (°C)	Fraction of Water		
	2%	10%	20%
10°C	23.18	33.39	53.07
20°C	4.22	11.54	34.00

Figures 3 and 4, show the evolution of G' and G" of the treated crude oil at temperatures 10 and 20 °C versus frequency. The frequency range used is from 0.01 to 20 rad/s. The water concentrations tested are 2%, 10% and 20 %. These measures can give us information on the structure of the emulsion at different concentrations to explain the variation in viscosity. The analysis's resultants of Figure 2 shows that the viscous modulus G" was always higher than the elastic modulus G' within the experimental frequency. The viscous modulus of the emulsion increases significantly with the addition of 2%, 10% and 20 % of water.

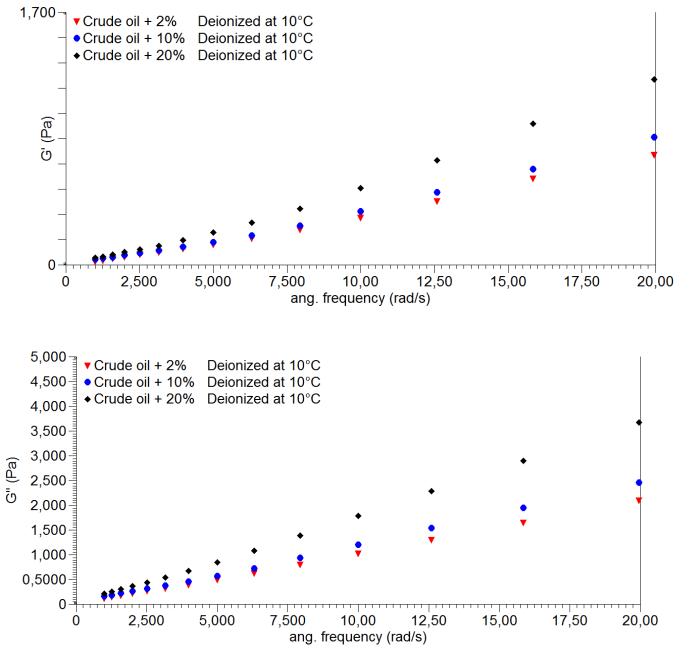

Fig.3 : Variation of the elastic and viscous modulus of emulsions at10°C

figure 3 show, the frequency dependence profiles of G′ and G″ modulus for the emulsions. The emulsions show linear relationship response over the examined range of frequency.
These results show the energy stored in the emulsion oil is less than the energy dissipated as heat and thus lost per cycle. Therefore, the emulsion with different water concentration tends to behave in a viscous liquid behavior more than it behaves as a solid-like material. The storage and loss moduli of emulsions decrease significantly by the increase of temperature. However, for the temperature at 20°C (Fig. 4), the experimental results display a slight change for both of G′ and G″ at 2% and 10% of water. However, at 20% of water the elastic modulus takes a low value at 20°C. These concentrations correspond to the maximal values of viscosity for the same temperature in the over the examined range of shear rate shown in Figure 2.

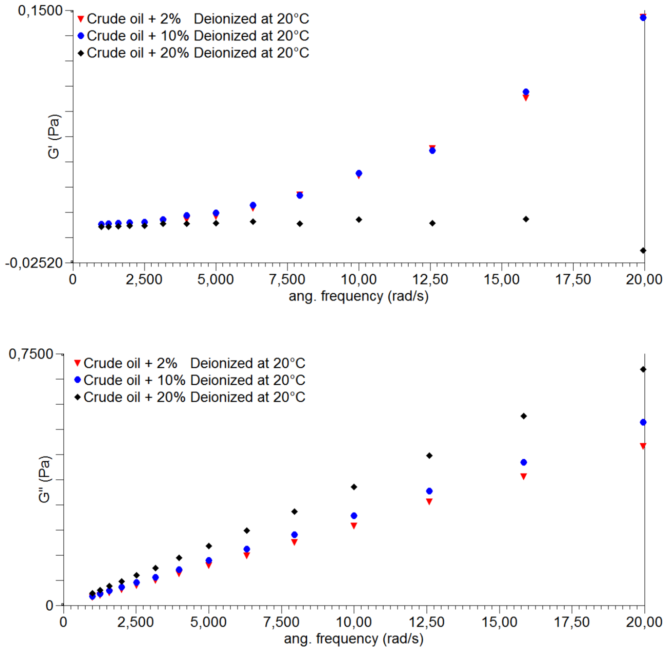

Fig.4: Variation of the elastic and viscous modulus of emulsions at 20 °C

CONCLUSION

The effect of water content addition, the shear rate and the temperature on viscosity and the yield stress of crude oil were studied. Different concentrations, 2%, 10% and 20% were used to understand the rheological behavior of emulsion. There remain a number of conclusions to be drawn from our work:

-Crude oil shows non-Newtonian behavior for shear rate lower 60 s^{-1} and Newtonian flow behavior over a shear rate range of 60 s^{-1} at 120 s^{-1}. By adding a certain concentration of water, the emulsions w/o shows non-Newtonian behavior for shear rate lower 90 s−1 and Newtonian flow behavior over a shear rate range of 90 s^{-1} at 120 s^{-1}.

- Due to addition of water fraction in the crude oil, the viscosity and yield stress of the mixture have increased significantly.
- Dynamic analysis shows that the emulsions behave as a viscous liquid whatever the concentration of water in the crude oil.

ACKNOWLEDGMENTS

This research was supported by the LEGHYD laboratory, USTHB. We thank the Research Unit Materials, Processes and Environment (UR-MPE), University M'Hamed Bougara Boumerdes, Algeria, and the Division of Tin Fouye Tabankourt Sonatrach.

REFERENCES

Eley, D. D., Hey, M. J., Symonds, J. D. Colloids Surfaces 1988, 32, 87–101.
S. Fournanty, Y. ; Le Guer,1 K. , El Omari, and J.-P. Dejean. Laminar Flow Emulsification Process to Control the Viscosity Reduction of Heavy Crude Oils, Journal of Dispersion Science and Technology, 29:1355–1366, 2008.
Guo, L.P., Wang, L., and Song, Y.B. (2011) Sci. Tech. Eng.,11: 1671–1815.
Kang, W.; Jing, G.; Zhang, H.; Li, M.; Wu, Z. Colloids Surfaces A 2006, 272, 27–31.
Kilpatrick, P. K., Spiecker, P. M. Encyclopedic Handbook of Emulsion Technology; Sjöblom, J., Ed.; Marcel Dekker: New York, 2001; Chapter 30, pp 707–730.
Miguel Rondón and al., Breaking of Water-in-Crude-Oil Emulsions. 2. Influence of Asphaltene Concentration and Diluent Nature on Demulsifier Action, Energy & Fuels 2008, 22, 702–707.
Nadim A. A concise introduction to surface rheology with application to dilute emulsions of viscous drops. Chem Eng Commun 1996:391–407.
M. Nuraini, H. N Abdurahman and A. M. S. Kholijah Effect of chemical breaking agents on water-in-crude oil emulsion system. International Journal of Chemical and Environmental Engineering. August 2011, Volume 2, No.4
Pal. R Rheology of simple and multiple emulsions. Articles in press (2010). Current Opinion in Colloid & Interface Science
Pal, R. (2003) J. Colloids Interface Sci., 263: 296–305.
Pal, R., Yan, Y., and Masliyah, J. (1992) In Emulsions: Fundamentals and Applications in the Petroleum Industry; Advances in Chemistry Series 231, edited by L.L. Schramm; Washington, DC: American Chemical Society; pp. 295–312.
Palierne JF. Linear rheology of viscoelastic emulsions with interfacial tension. Rheol Acta 1990; 29:204–14.
Pierre, C., Barre, L., Pina, A., Moan, M. (2004) Oil Gas Sci. and Technol., 59(5): 489–501.
Visintin, R.F.G., Lockhart, T. P., Lapasin, R., and D'Antona, P. (2008)J. Non-Newtonian Fluid Mech., 149:34–39.
Yang X., Verruto V. J., Kilpatrick P. K. Dynamic Asphaltene-Resin Exchange at the Oil/Water Interface: Time-Dependent

W/O Emulsion Stability for Asphaltene/Resin Model Oils. Energy & Fuels, 2007, 21, p. 1343-1349.
Yasushi Saiki, Clive A. Prestidge, Roger G. Horn. Effects of droplet deformability on emulsion rheology. Colloids and Surfaces A: Physico chem. Eng. Aspects 299 (2007) 65–72.