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Experimental Investigation of Thermal Properties of Nano Crude Oil; Light and Heavy Types of Crude Oil

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Abstract

The operating conditions chosen in petroleum industries depend on the characteristics of oil which is processed. Knowing about the behavior of oil fluid flow at different amounts of pressure and temperature is essential to manufacture the proper equipment and handling the processes. This is more important especially about the new type of oil which contains nano particle. Results show, changes in nano vole percentage values from 1% to 5% increases the amount of density from 8 to 8.34 ppg for light oil and also 8.9 to 9.36 ppg for heavy nano oil, respectively. Average increase in the amount of density by addition of nano zinc oxide is about 9.6%.

Keywords

Crude Oil, Thermoelectric, Kinetic Property, Nano Particle, Dimensionless Number

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1. Introduction

1.1. Crude Oil

Access to oil was and still is a major factor in several military conflicts of the twentieth century, including World War II, during which oil facilities were a major strategic asset and were extensively bombed. The German invasion of the Soviet Union included the goal to capture the Baku oilfields, as it would provide much needed oil-supplies for the German military which was suffering from blockades [1 and 2]. Oil exploration in North America during the early 20th century later led to the US becoming the leading producer by mid-century. As petroleum production in the US peaked during the 1960s, however, the United States was surpassed by Saudi Arabia and the Soviet Union [3].

Today, about 90 percent of vehicular fuel needs are met by oil [4]. Petroleum also makes up 40 percent of total energy consumption in the United States, but is responsible for only 1 percent of electricity generation. Petroleum's worth as a portable, dense energy source powering the vast majority of vehicles and as the base of many industrial chemicals makes it one of the world's most important commodities [5]. Viability of the oil commodity is controlled by several key parameters, number of vehicles in the world competing for fuel, quantity of oil exported to the world market (Export Land Model), Net Energy Gain (economically useful energy provided minus energy consumed), political stability of oil exporting nations and ability to defend oil supply lines [6 and 7].

The top three oil producing countries are Russia, Saudi Arabia and the United States. About 80 percent of the world's readily accessible reserves are located in the Middle East, with 62.5 percent coming from the Arab 5: Saudi Arabia, UAE, Iraq, Qatar and Kuwait. A large portion of the world's total oil exists as unconventional sources, such as bitumen in Canada and extra heavy oil in Venezuela. While significant volumes of oil are extracted from oil sands, particularly in

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Canada, logistical and technical hurdles remain, as oil extraction requires large amounts of heat and water, making its net energy content quite low relative to conventional crude oil. Thus, Canada's oil sands are not expected to provide more than a few million barrels per day in the foreseeable future [8 and 9].

In its strictest sense, petroleum includes only crude oil, but in common usage it includes all liquid, gaseous, and solid hydrocarbons [10]. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane occur as gases, while pentane and heavier ones are in the form of liquids or solids [11]. However, in an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions and on the phase diagram of the petroleum mixture [12].

An oil well produces predominantly crude oil, with some natural gas dissolved in it. Because the pressure is lower at the surface than underground, some of the gas will come out of solution and be recovered (or burned) as associated gas or solution gas. A gas well produces predominantly natural gas [13]. However, because the underground temperature and pressure are higher than at the surface, the gas may contain heavier hydrocarbons such as pentane, hexane, and heptane in the gaseous state. At surface conditions these will condense out of the gas to form natural gas condensate, often shortened to condensate [14]. Condensate resembles petrol in appearance and is similar in composition to some volatile light crude oils.

1.2. Petroleum as Main Hydrocarbon

The proportion of light hydrocarbons in the petroleum mixture varies greatly among different oil fields, ranging from as much as 97 percent by weight in the lighter oils to as little as 50 percent in the heavier oils and bitumen’s [15].

The hydrocarbons in crude oil are mostly alkanes, cycloalkanes and various aromatic hydrocarbons while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium [16]. The exact molecular composition varies widely from formation to formation but the proportion of chemical elements varies over fairly narrow limits as follows [17].

2. Materials and Method

2.1. API of Crude Oil

The API of crude oil is classified according to the Table 1.

Table 1. Composition of crude oil.

Component	API
Heavy crude oil	27.8, approximately
Light crude oil	48. approximately

2.2. Properties of Zinc Oxide

The zinc oxide nanoparticle is usual element with a vast variety of applications. The zinc is an essential mineral at various concentrations and is nontoxic in low concentration, undoubtedly. Data shows a good relation between healthy and suitable concentration of zinc oxide composition [17 and 18].

2.3. Method of Preparation of Zinc Oxide Nano Particle

The nano particles used in this empirical study is prepared in below instruction. At the beginning the nano powder of zinc oxide is made and then the produced powder is mixed with the light and heavy oil as basic fluid.

2.4. Experimental Set up

The experimental set up includes mixing tank, adiabatic tube test section and electrical heater is used to survey the thermo electrical behavior of light and heavy nano crude oil. The Figure 1 illustrated the process, schematically.

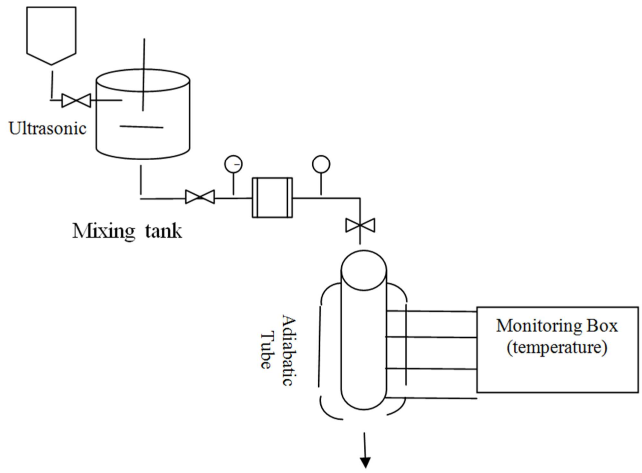

Figure 1. A view of applied setup.

3. Results and Discussion

The experiments are held to investigate the thermo-electrical properties and behavior of light and heavy nano oil comparing with simple oil. Thermo-physical properties such as electrical conductivity, density, viscosity, thermal conductivity, thermal diffusivity, specific heat with changes in temperature and amount of nano particle are surveyed.

3.1. Effect of Volume Percentage on Density

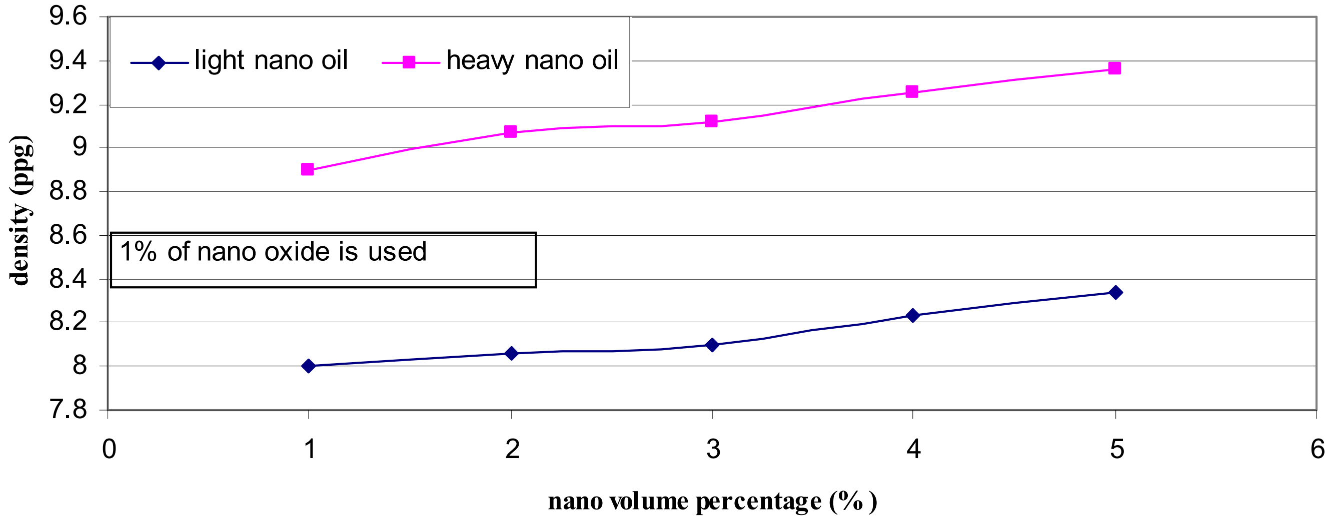

Figure 2. Effect of nano volume percentage on density of nano oil.

The effect of nano zinc oxide addition on the amount of density is shown in Figure 2. The incraese in nano volume percentage increases the density value since the increasing accumulated mass per unit of volume increase, usually. The changes in nano vole percentage values from 1% to 5% increases the amount of density from 8 to 8.34 ppg for light oil and also 8.9 to 9.36 ppg for heavy nano oil, respectively. Average increase in the amount of density by addition of nano zinc oxide is about 9.6%.

3.2. Investigation of Nano Oil Viscosity

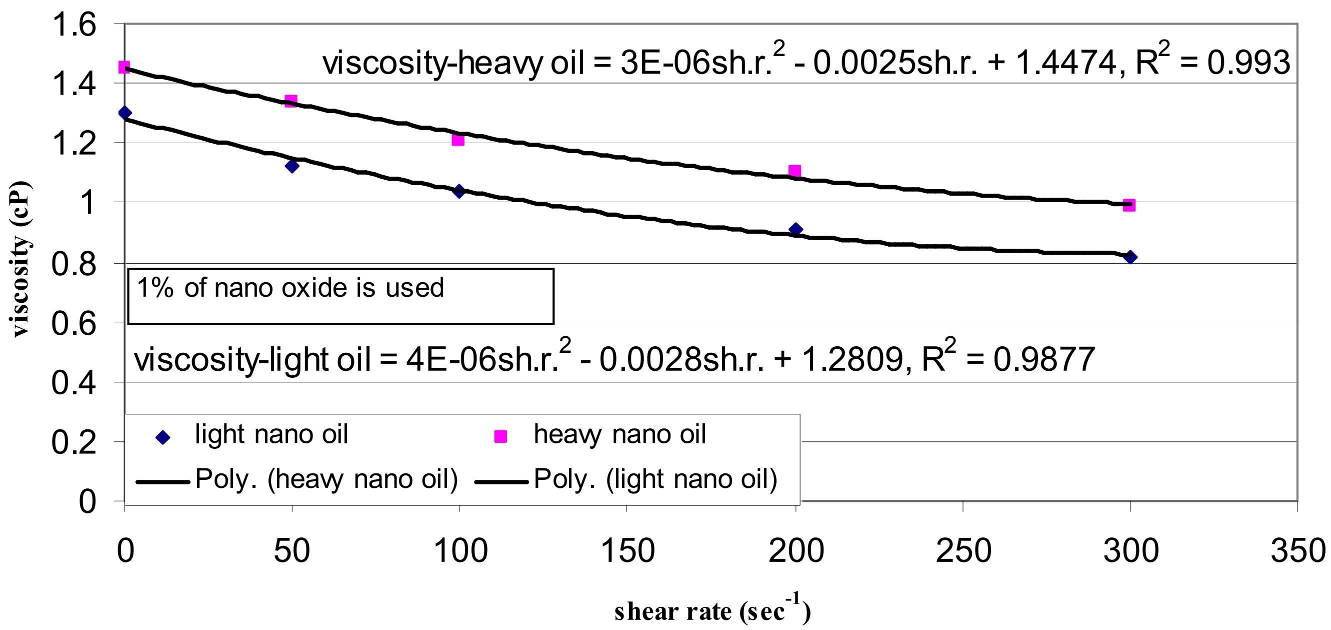

Figure 3. Relation between shear rate and nano oil viscosity.

The value of dynamic viscosity versus shear rate is shown in the Figure 3. The incraese in shear rate decreases the value of dynamic visocity for both samples of nano oil. The value of shear rate changes from 0.0 to 300 1/sec and the value of dynamic viscosity changes from 1.3 to 0.82 cPoise for light nano oil and 1.45 to 0.99 cpoise for heavy nano oil. The increasing of shear rate decreases the value of dynamic viscosity about 28%, averagely. In addition, the decreasing in the value of dynamic viscosity may be related to the interaction between oil and nano particle.

3.3. Evaluation of Yield Stress of Nano Oil

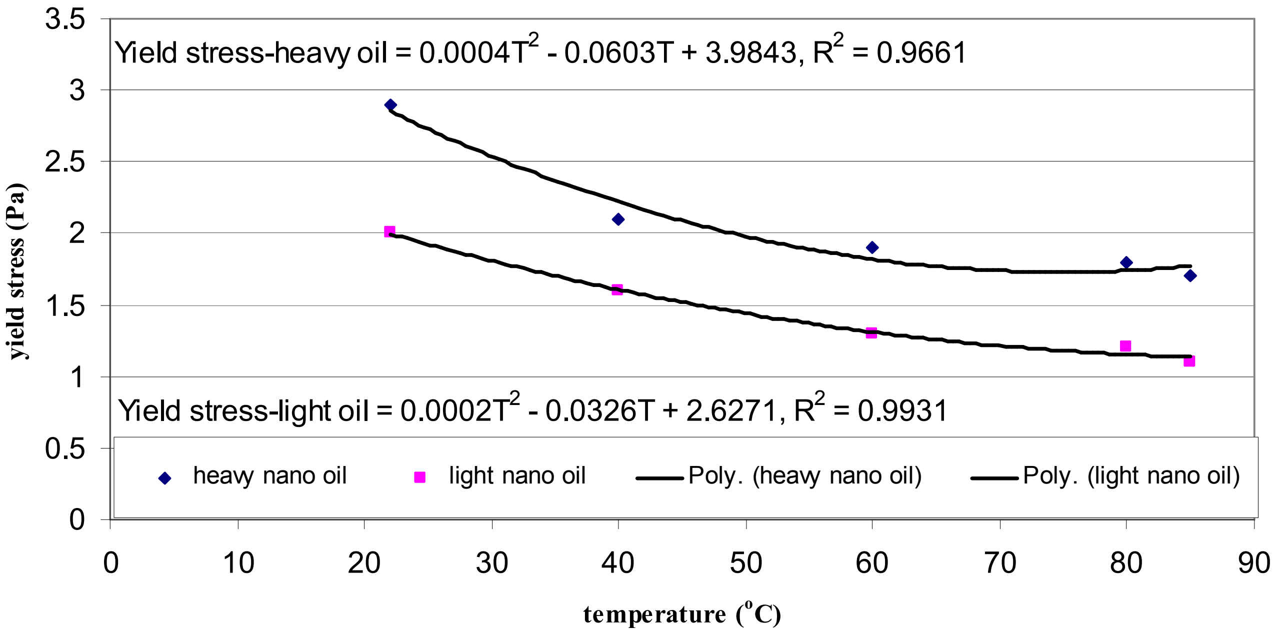

Figure 4. Effect of temperature on yield stress of nano oil.

The Figure 4 shows the relation between temperature and yield stress. The experimental results show the yield stress decreases with increasing the temperature from 22°C to 85°C. The variation of yield stress for light nano oil is 1.1 to 2 Pa and is 1.7 to 2.9 Pa for heavy nano oil. Two experimental correlations are defined for prediction of yield stress versus operating temperature. The regressions of two experimental correlations are near one. So, the accuracy of curves is feasible. The average difference between yield stress of light and heavy nano oil is 39.6%.

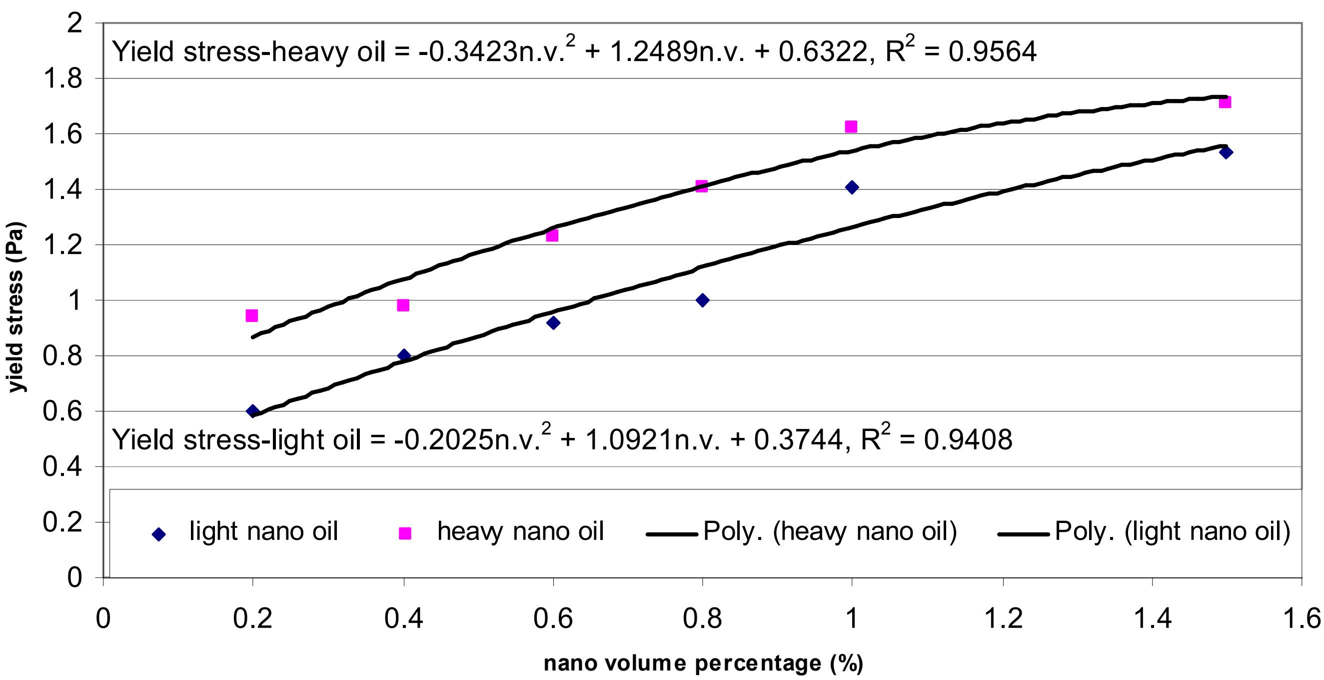

Figure 5. Effect of nano volume percentage on yield stress.

The relation between yield stress and nano volume percentage is shown in the Figure 5. The obtained results illustrate this relation is positive. These variations are defined for heavy and light nano oil and the regressions are described in this Figure. The average difference between two curves is 25.2%, approximately. The regression of first curve which is defined for heavy nano oil is 0.9564 and regression of second curve which is related to light nano oil is 0.9408, respectively.

3.4. Investigation of Pr Number of Heavy and Light Nano Oil

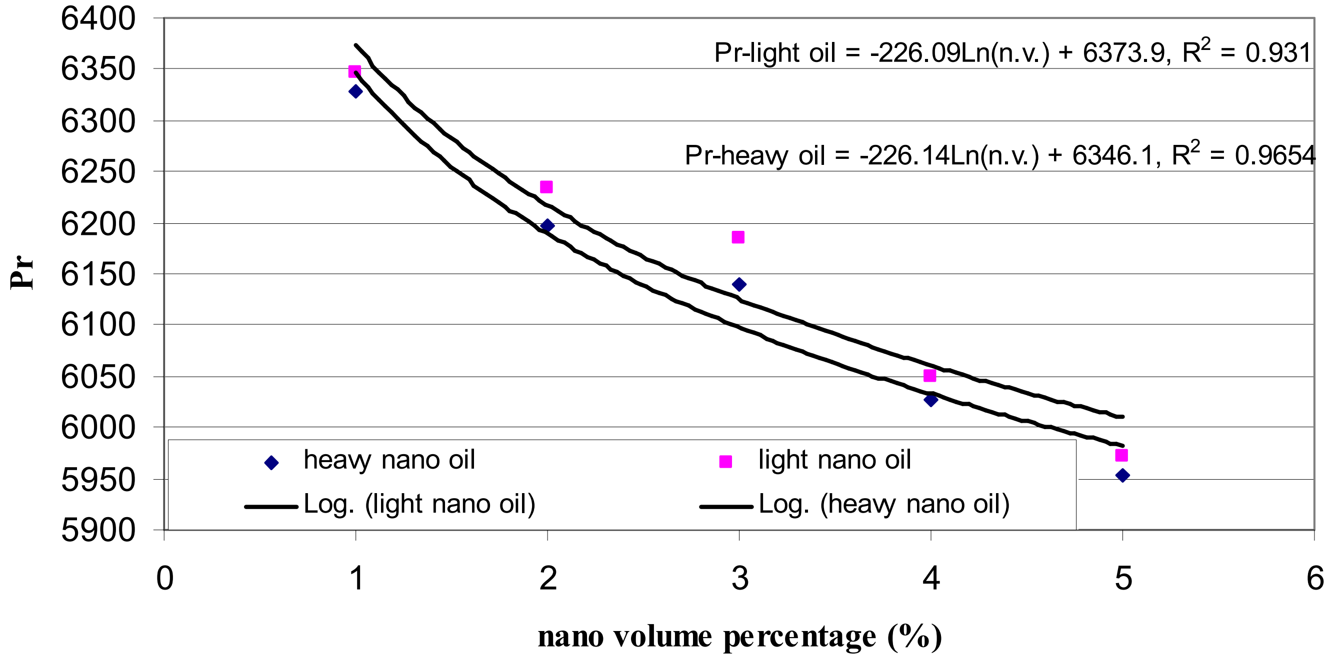

Figure 6. Effect of nano volume percentage on Pr number of nano oil.

The variation of Prandtle number versus nano volume percentage is shown in the Figure 6. Obtained results illustrate the trend of both of curves for light and heavy nano oil is decresisng and can predictable by logarithmic function. The regressions of two curves are near one. This is 0.931 for light nano oil and 0.9654 for heavy nano oil. Changes in the value of Pr for both heavy and light nano oil is presented in the Figure 6. The somwhat decrease in the amount of Pr can be seen for both light and heavy nano type. Addition of nano zinc oxide decreases the value of Pr. The average deviation between values of Pr number of simple and nano oil is about 0.85%.

4. Conclusions

Application of nano ferric oxide in oil is studied in this manuscript. The effect of addition of different weight percentage of nano particle into the oil which flows vertically under different temperatures in a tube section is investigated, experimentally. Test tube with 0.025 m in diameter and 0.3 m in length is used in the study. Some important thermo-electrical and physical properties are measured of heavy and light nano oil. Besides, some applicable dimensionless groups in hydrodynamic calculations and heat transfer are presented. The effect of length of tube, temperature and also the amount of nano particle is investigated on the amount of dimensionless groups and also on the thermo physical property. The obtained results are listed below.

A). The changes in nano vole percentage values from 1% to 5% increases the amount of density from 8 to 8.34 ppg for light oil and also 8.9 to 9.36 ppg for heavy nano oil, respectively. Average increase in the amount of density by addition of nano zinc oxide is about 9.6%.

B). The value of shear rate changes from 0.0 to 300 1/sec and the value of dynamic viscosity changes from 1.3 to 0.82 cPoise for light nano oil and 1.45 to 0.99 cpoise for heavy nano oil.

C). Variation of yield stress for light nano oil is 1.1 to 2 Pa and is 1.7 to 2.9 Pa for heavy nano oil. The average difference between yield stress of light and heavy nano oil is 39.6%.

D). The average difference between two curves is 25.2%, approximately.

E). Addition of nano zinc oxide decreases the value of Pr. The average deviation between values of Pr number of simple and nano oil is about 0.85%.

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