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Parametric Study on the Physical Properties of Nano Crude Oil

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Abstract: Operating conditions chosen in petroleum industries depends on the characteristics of oil which is processed. Knowing about the behavior of oil fluid flow at different amounts of operating 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. In this study, the dimensionless groups and thermo physic parameters of the nano oil are considered to determine the nano oil behavior. Results show the average increase in the amount of density by addition of 1% of nano ferric oxide is about 1.8%. The addition of nano ferric oxide decreases the value of effective viscosity about the 27%, averagely than the simple oil. The increase in temperature shows the same decraese in the value of effective viscosity for simple oil and nano oil.

Keywords: Oil, Viscosity, Reynolds, Friction Factor, Conductivity

1. Introduction

1.1. Crude Oil

Today, about 90 percent of vehicular fuel needs are met by oil [1-4]. 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 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. 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].

1.2. Nanotechnology

In recent years, development in the miniaturization technologies results in fabrication of micro-scale electronic devices which is used in various industries such as aerospace and automotive. For maximum performance of these micro devices which is known as MEMS (Micro Electromechanical Systems), the temperatures should be in a certain range. Micro channel as Compact and efficient cooling devices have been developed for the thermal control of MEMS [18]. Utilizing nano fluid as working fluid could improve the cooling and heating performance. Because of more stable nature of nano fluid compared with its pioneer generation (including micro and millimeter particles) and exceptional thermal conductivity of nanoparticles, it could considerably enhance the convective heat transfer coefficient in micro channel. During the last decade, many studies on convective heat transfer with nano fluids have been considered [19]. Some researchers revealed that the heat transfer coefficients of the nano fluids increase with increasing the volume fraction of nanoparticles and the Reynolds number. Scientifics studied the laminar mixed convection of an Al2O3/water nano fluid in a horizontal tube numerically using a two-phase mixture model [20]. They showed that the nanoparticle concentration did not have significant effects on the hydrodynamics parameters, but its effects on the thermal parameters were important for the fully developed region. The other Scientifics considered the laminar forced convection of an Al2O3 /water nano fluid flowing in an annulus [21]. Their results indicate that the friction coefficient depends on the nanoparticle concentration when the order of magnitude of heating energy is much higher than the momentum energy. Thermal transport of nano fluid flow in micro channels has also attracted a few investigators due to its promising applications [22]. In a study in previous literature the cooling performance of the micro channel was significantly improved by the significant reduction in the temperature difference between the heated wall and the nano fluids [23]. The other researchers experimentally assessed forced convective cooling and heating performance of a copper micro channel heat sink with Al_2O_3/water nano fluid as a coolant [24]. Their results show that the nano fluid cooled heat sink outperforms the water-cooled one, having significantly higher average heat transfer coefficient and thereby markedly lower thermal resistance and wall temperature at high pumping power, in particular. Meanwhile, in an experiment using SiO_2–water nano fluids in an aluminum heat sink consisted of an array of 4 mm diameter circular channels with a length of 40 mm [25]. The experimental results showed that dispersing Al_2O_3 and SiO_2 nanoparticles in water significantly increased the overall heat transfer coefficient while thermal resistance of heat sink was decreased up to 10%. Also they numerically investigated corresponding configuration [26]. The results revealed that channel diameter, as well as heat sink height and number of channels in a heat sink have significant effects on the maximum temperature of heat sink [27]. Regarding numerical aspects, Scientifics demonstrated when the commonly used assumption of constant heat flux boundary condition is applicable in heat and fluid flow analysis in microfluidic systems [28]. Also a general Nusselt number correlation for fully developed laminar flow was developed as a function of two dimensionless parameters, namely, Biot number and relative conductivity, to take the conduction effects of the solid substrate on heat transfer into account.

1.3. Rheological Models

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 [29].

1.4. Fluid Mechanics

Fluid mechanics is the study of the forces involved in both still and flowing fluids [30]. Reynolds introduced a dimensionless number in order to compare fluid flow independent of which medium surrounded them and other variables. The Reynolds number is the ratio of inertial forces to viscous forces in fluid flow [31].

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
Crude oil	32

2.2. Preparing Nano-Sized Fe_2O_3

Ferric dioxide (Fe_2O_3) is a transition metal oxide that has long been known to be active for hydrocarbon decomposition and has more recently shown to display high reforming activity for various long-chain Hydrocarbons. Researches showed that Fe_2O_3 is highly active for reforming isooctane via partial oxidation. This process is exothermic (ΔH°= −582.2 kJ/mol) and in the presence of Fe_2O_3 proceeds to full conversion at 630°C and 1 atm.

2.3. Experimental Setup

The experimental setup includes mixing tank, adiabatic tube test section and electrical heater is used to survey the behavior of nano crude oil. At the beginning, the crude oil is mixed by ferric oxide nano particles in an ultrasonic (With 400Watt, for 3hour), then the nano crude oil is mixed in mixing tank, passing through an electrical heater to reach the desired temperature in range of, 30 C to 90 C and 25 C to 85 C.

3. Results and Discussion

3.1. The Investigation of Thermo-Kinetic Properties

Experiments are held to investigate the properties and behavior of nano oil comparing with simple oil. Thermo-physical properties like density, viscosity, thermal conductivity, thermal diffusivity with changes in temperature and amount of nano particle are surveyed. Figure 1 shows thermal conductivity meter.

Figure 1. *Thermal conductivity meter.*

3.2. The Effect of Temperature on Physical Properties and Dimensionless Groups

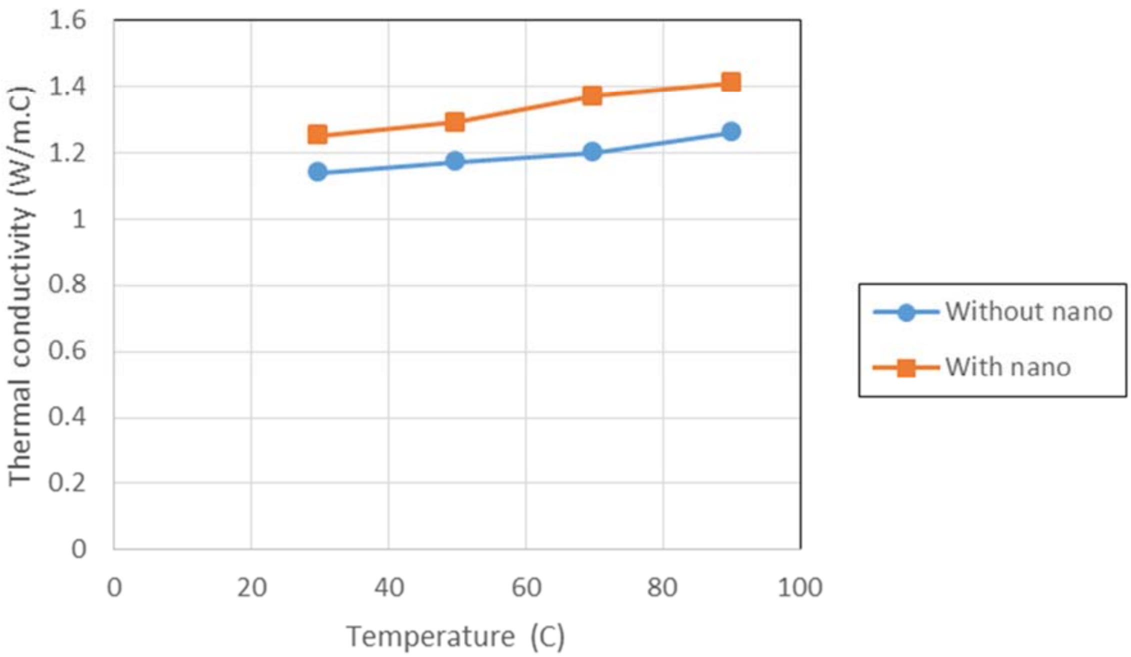

Figure 2. *The effect of temperature on thermal conductivity.*

The Figure 2 shows the effect of operaring temperature on the thermal conductivity. The effect of addition of 1% nano ferric oxide particle on the amount of thermal conductivity with temperature changing is shown in Figure 2. The operating temperature changes from 30 C to 90 C. The increase in values of temperature increases the values of thermal conductivity from 1.17 to 1.19 W/m.C since the increase in the kinetic energy of material, usaually. The increase in the amount of temperature shows the same increasing effect on the thermal conductivity of nano oil. The presence of nano ferric oxide as nano metal oxide and also the free electorns in metal particles incraeses the kinetic energy of nano oil. So, the incraesing trend is shown. Usage of nano particles increases about 11% of amount of thermal conductivity, averagely.

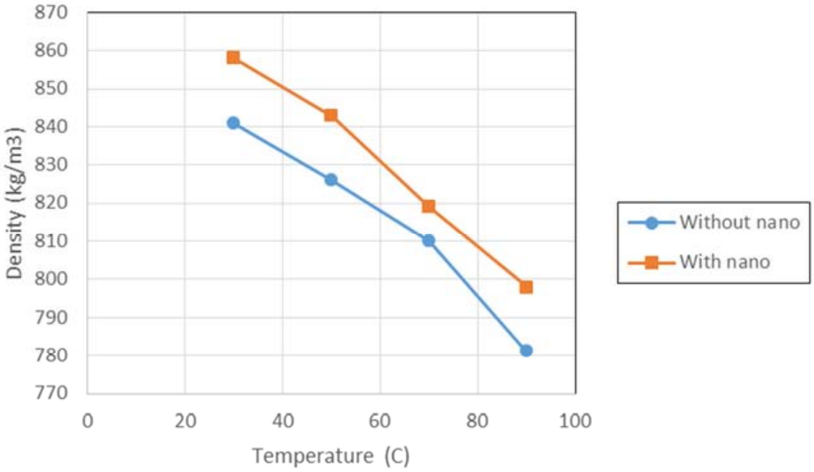

Figure 3. Density versus temperature.

The effect of nano ferric oxide addition on the amount of density is shown in Figure 3. The incraese in temperature decreases the density value since the constant mass and the the volume increase, usually. The changes in temperature values from 30 C to 90 C decreases the amount of density from 840 to 780 (kg/ m3) for simple oil. The effect of temperature increase on the density value is the same and the decraese in the amount of density of nano oil is seen from 859 to 799 kg/m^3. Clearly, the addition of nano metal oxide incraeses the mass value and the volume value of oil, so increases the density value. Average increase in the amount of density by addition of 1% of nano ferric oxide is about 1.8%.

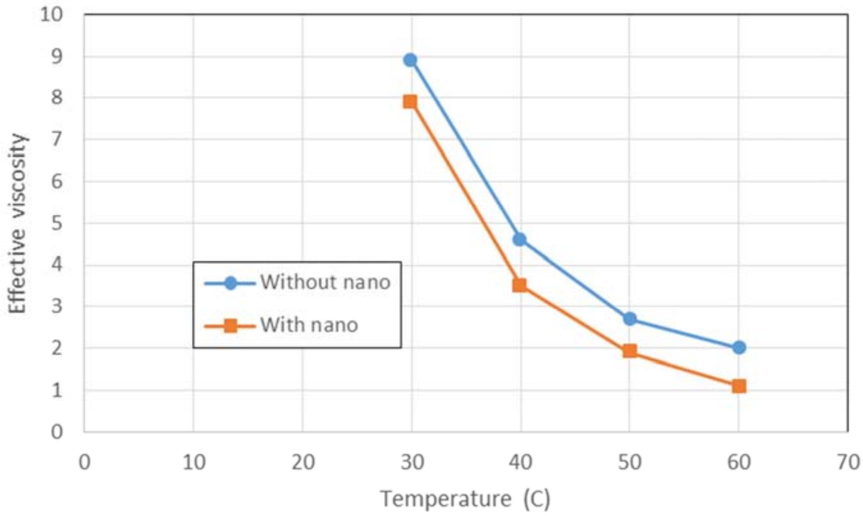

Figure 4. Effective viscosity versus temperature.

The values of effective viscosity versus temperature for both nano and simple oil is shown in Figure 4. The incraese in the value of tempertaure decreases the value of effective viscosity. The effective viscosity is defined as the absolute viscosity at the present temperature. This ratio decreases by the increase in temperature for both simple and nano oil. The effective viscosity decreases from 8 to 1 for nanooil and decraeses from 9 to 2 for simple oil. The addition of nano ferric oxide decreases the value of effective viscosity about the 27%, averagely than the simple oil. The increase in temperature shows the same decraese in the value of effective viscosity for simple oil and nano oil.

4. Conclusions

The 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 (ranges from 30-70 C, 25-85 C, 30-90 C) in a tube section is investigated, experimentally. Results show the average increase in the amount of density by addition of 1% of nano ferric oxide is about 1.8%.

The addition of nano ferric oxide decreases the value of effective viscosity about the 27%, averagely than the simple oil. The increase in temperature shows the same decraese in the value of effective viscosity for simple oil and nano oil.

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