

Characterization of Heavy Crude Oil Through Physical And Chemical Properties

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Abstract- Heavy crude oil is termed as dead oil, which has a high density and viscosity compared to light and medium crude oil. In this research article, the heavy crude oil is characterized by using its physical and chemical properties. The physical properties of heavy crude oil are density, specific gravity, °API and viscosity. The chemical properties discussed are the actual composition of the heavy crude oil and their separation techniques. Heavy crude oil composition contains a large amount of asphaltene and resins compared to saturate and aromatics. Due to this high amount of asphaltene and resins, the light and middle distillates are obtained in smaller quantity. In the meanwhile, heavy crude oil can produce great amount of bottom or heavy distillates. In oil field, understanding the major properties of the heavy crude will help in their better recovery and refining practices.

Keywords- Density, °API, Asphaltene, Resins, Viscosity, Saturate and Aromatic

I. INTRODUCTION

The crude oil is one of the important sources of energy in the World-Wide. Due to the increasing demand in the fuel energy and population, the light and medium crude oil production leads to well depletion [11]. The heavy crude oil can take part in the supply of fuel energy to avoid the rapid depletion of light crude oil wells. Moreover, heavy crude oil can be obtained from shallow reservoirs when compared to light crude oil produced from deep reservoirs [6]. The heavy crude oil contributes about 15% in the total World oil reserves. The recovery of heavy crude oil has been increased in considerable amount in recent years due to the rise in crude oil price per barrel [4].

The crude oil is classified mainly into light, medium, heavy and extra-heavy based on the °API. The heavy crude oil is varied into sweet and sour heavy crude oil depending upon the sulphur content present [2]. The heavy crude oil have a high specific gravity and low °API indication to the high viscosity, low emulsification and high adhesion on nature. Properties of a crude oil are a key parameter to identify the suitable recovery method, production processes, transport facilities and refining equipments [1].

The physical properties of heavy crude oil are density, specific gravity, °API, and viscosity. The chemical properties of heavy crude oil are the composition of heavy crude oil such as asphaltene, resin, aromatics and saturate and water content [7]. Heavy crude oil contains asphaltene and resin content in the chief composition. In this research article, the heavy crude oil was collected from a specific area and characterized by means of the physical and chemical properties [5].

II. MATERIALS AND METHODS

A. Materials Required

The heavy crude oil was collected from a Gujarat heavy crude oil field for the research purpose. The chemicals such as toluene, n-heptane and n-hexane were brought from a chemical company.

B. Methodology

The physical and chemical properties of heavy crude oil are characterized by the simple methods adopted and are discussed further. In the chemical characterization, the asphaltene, resin, aromatics and saturate content are determined by solvent separation process. The water content or moisture content in the heavy crude oil is determined by using the Dean and Stark apparatus.

C. Physical Characterization of Heavy Crude Oil

Density

Density is one of the foremost parameter in the Heavy crude oil characterization and classifications from other crude oil. Density is defined as the ratio of mass to volume [7]. The heavy crude oil of 5ml was taken in the weighed glass plate and the weight of the 5ml crude oil is noted. The density of heavy crude oil was calculated from the formula:

Density = (Mass of the heavy oil) / (Vol. of the heavy oil taken)

Where,

Density is measured in kg/m^3 .

Mass of the heavy oil is measured in kg.

Vol. of the heavy oil is measured in m^3 .

Specific Gravity

Specific gravity is another important factor to identify the heavy crude oil and to calculate the °API. Specific gravity is the ratio of density of heavy crude oil to the standard density of water [7]. Specific gravity has no units.

Specific Gravity = (Density of the heavy oil) / (Density of the water)

°API

°API stands for the American Petroleum Institute. °API helps in differentiating the various crude oil under one roof. The general classification of Crude oil based on °API was tabulated below.

Table 1. Classification of crude oil

Sl.No.	Type of Crude oil	°API
1.	Light Crude oil	$\geq 31^\circ$
2.	Medium Crude oil	22° to 31°
3.	Heavy Crude oil	10° to 22°
4.	Extra-Heavy Crude oil	$\leq 10^\circ$

The °API can be calculated using the values of specific gravity obtained for the heavy crude oil. The formula for the evaluation of °API was given below.

$$^\circ\text{API} = (141.5 / \text{Specific Gravity of heavy oil at } 60^\circ\text{F}) - 131.5$$

Viscosity

Viscosity is referred to the measure of resistance to the heavy crude oil flow [7]. Viscosity of the heavy crude oil is very high compared to light and medium crude oil due to the higher concentration of asphaltene and resin content. The viscosity of heavy crude oil is greatly affected by the heat and dilution. Addition of heat and chemical such as toluene and heptanes make the flow of heavy crude oil in a better way.

D. Chemical Characterization of Heavy Crude Oil

Determination of Asphaltene, Resin, Aromatics and Saturates Content

The composition of the heavy crude oil consists of asphaltene, resins, aromatics and saturates. The dominant constituents are asphaltene and resin which is responsible for

the physical characteristics of the heavy crude oil namely viscosity [7].

Determination of the major composition of heavy crude oil was carried out by the solvent separation process. Initially, the asphaltene was precipitated and leave the resin, aromatics and saturate. The resin, aromatics and saturates were passed through the clay column which retains the resin and allows the aromatics and saturate to pass through.

The procedure for asphaltene determination is the 20 g of heavy crude oil was taken and 40 times the n-heptane was added to the heavy crude oil. For the time period of two days, the mixture is twice shaken in a day. After two days, the mixture was filtered and the asphaltene precipitated was moisture dried. For more accurate results, 1 g of asphaltene after filtration was dissolved in 100 ml of toluene. Then the precipitate is filtered and left for evaporation. The asphaltene content was calculated using the formula:

$$\text{Asphaltene content} = (\text{Wt. of dried asphaltene} / \text{Vol. of crude oil}) \times 100$$

Where,

Asphaltene content is measured in g/ml.

Wt. of dried asphaltene is measured in g.

Vol. of crude oil is measured in ml.

Resin content was evaluated by adding equal amount of benzene and acetone to the clay column. The separated resin was calculated in the same way as asphaltene content. The aromatics and saturates were subtracted from the total composition to the asphaltene and resin content.

Water/ Moisture Content Determination

The water content in the heavy crude oil was determined using the Dean and Stark apparatus. The heavy crude oil and toluene was taken in equal volume and placed in the round bottom, where the apparatus to be connected. The mixture is heated to vaporize toluene and the toluene has the ability to take water along with in the vaporization stage. The experiment was stopped, when the added amount of toluene was collected. The water content was calculated from the formula:

$$\text{Water content} = (\text{Vol. of water} / \text{Wt. of the crude oil}) \times 100$$

III. RESULT AND DISCUSSION

A. Physical Characterization of Heavy Crude Oil

Density, Specific Gravity, °API and viscosity of the heavy crude oil was determined by the straightforward method. The Physical Characterization of heavy crude oil is clearly tabulated below in table 2. Viscosity of heavy crude oil will be in the range of 10^3 to 10^4 [2]. Heavy crude oil will float in the water due to the high density and specific gravity of water, which are 1000 kg/m^3 and 1.00.

Table 2. Physical Characterization of heavy crude oil [2, 3, 8, 10]

PHYSICAL CHARACTERIZATION OF HEAVY CRUDE OIL				
	Density (kg/m ³)	Specific Gravity	°API	Viscosity (cP)
Heavy Crude oil	952.3	0.9532	16.93°	1000 - 10000

The density is a temperature dependent parameter. The heavy crude oil is heated to different temperatures and tabulated below in table 3. The tabulation shows that the density of the heavy crude oil decreases with the increase in temperature. The change in temperature will also affect the viscosity of heavy crude oil in the same way as density change [1].

Table 3. Change in density of the heavy crude oil and water with respect to temperature [3]

Sl.No.	Temperature (°C)	Density of heavy crude oil (kg/m ³)	Density of water (kg/m ³)
1.	30	952.3	995.7
2.	40	947.41	992.2
3.	50	945.07	988.0
4.	60	937.791	983.2
5.	70	930.121	977.7
6.	80	928.32	971.8
7.	90	912.99	965.323
8.	100	864.44	958.36

The standard density change of water with the different temperature was plotted along with the density of heavy crude oil in the fig. 1. The increase in the temperature has decreased the density of heavy crude oil which is compared with the change in density of water. This clearly shows the obtained value of density was decreased with the increase in temperature. The decreased in density of heavy crude oil will eventually improve the flow of heavy crude oil and in turn reduces the viscosity of crude oil [1].

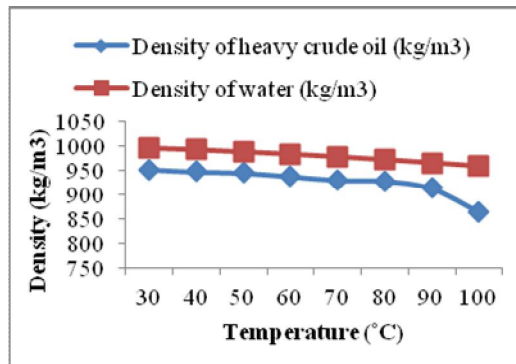


Fig. 1. Change in density of the heavy crude oil and water with respect to temperature

B. Chemical Characterization of Heavy Crude Oil

The Chemical Characterization of heavy crude oil was explained with the composition of asphaltene, resins, aromatics and saturates along with the water content. In general, the heavy crude oil contains a high amount of Sulphur, Nitrogen and Oxygen content [5]. The asphaltene is composed of a heterogeneous polycondensed aromatic rings and cyclic naphthenes along with atoms of Sulphur, Nitrogen and Oxygen. Resin is a dark coloured liquid, which is a high density resin fraction. Aromatics are a six-member chain compound such as benzene, toluene and xylene. Saturates is a low-molecular compound, which is either linear or branched chain compounds [5].

Table 4. Chemical Characterization of heavy crude oil [2, 3, 8, 10]

Composition of heavy crude oil (W/V %)			Water / Moisture content (%)
Asphaltene	Resin	Aromatics and Saturates	
25	30	45	43

The water content present in the heavy crude oil was found to be 43% by using Dean and Stark apparatus. The water content in the heavy crude oil will be removed in the initial refining stages of crude oil.

IV. CONCLUSION

The Physical and Chemical Characterization of heavy crude oil was determined. The density and viscosity of the heavy crude oil is inversely proportional to the °API. When the °API decreases, then there is an increase in the density, specific gravity and viscosity and vice-versa.

Density of heavy crude oil is greatly decreased by the heat effects. The high viscous behaviour is also changed by

the heating conditions. Thermal recovery of heavy crude oil is carried out due to the fact that the two or more parameter will be reduced namely density, viscosity, specific gravity and heavy compounds.

The heavy crude oil analyzed is black or dark brown in colour. The odour of the heavy crude oil is pungent smell due to the presence of Nitrogen and Sulphur. Heavy crude oil found to contain high amount of asphaltene and resin than aromatics and saturates. Due to the low amount of aromatics and saturates, the high value products such as LPG, gasoline, kerosene and diesel will be produced in low quantity compared to the low value products namely lubricating oil, fuel oil, gas oil and residuum.

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