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Research Article

Parametric Study of Basic Items in the Desulfurization Process; Evaluation of Uncertainty Data

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Abstract: The subject of this experimental report is the application of nano particles in petroleum refinement. Sulfur removal from petroleum using mixed bed which contains nano molybdenum oxide and nano cobalt oxide, each of them in 50 volume percentage, is considered in this study. The properties related to the process characterization which is defined as X factor and pressure drop, are evaluated experimentally. Catalyst diameter, bed diameter, bed height, temperature and pressure, superficial velocity is changed and the effect of these on the value of X factor is obtained to present the optimum operational and geometrical parameters.
Keywords: operating and geometric condition; desulphurization; efficiency; novel method.

INTRODUCTION

The environmental issues include societal demands that liquid hydrocarbon fuels be clean and less polluting [1-4]. The emergence of new refining processes and the increasing use of new forms of energy production, e.g., fuel cells, exemplify operational issues. Together, these trends are driving the need for deep desulfurization of diesel and jet fuels. In the past two decades petroleum refining has changed extensively and the fortunes of hydro treating, in particular, have witnessed a sea change [5]. Hydro-treaters now occupy a central role in modern refineries and more than 50% of all refinery streams now pass through hydro-treaters for conversion, finishing, and pre-treatment purposes [6, 7]. Hydro-desulfurization is the largest application of catalytic technology in terms of the volume of material processed. On the basis of usage volume, HDS catalysts are ranked third behind catalysts used for automobile emission control and FCC. Commercial hydro treating catalysts are, typically, Zn, Co or Mo. For example, Mo, known for its high hydrogenation activities, is preferred as a promoter when feed stocks containing high amounts of nitrogen and aromatics need to be processed.

It seems, nano particles such as metal oxides can promote the heating and cooling process [8, 9]. For example, the nano substances like; metal oxides can enhanced the thermal stability of some of materials [10].

Today, about 90 percent of vehicular fuel needs are met by oil. 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. 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. 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.

In its strictest sense, petroleum includes only crude oil, but in common usage it includes all liquid, gaseous, and solid hydrocarbons. 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. 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.

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. 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. 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 bitumens.

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. The exact molecular composition varies widely from formation to formation but the proportion of chemical elements varies over fairly narrow limits as follows. Distillation, the process by which oil is heated and separated in different components, is the first stage in refining. Crude oil is any naturally-occurring flammable mixture of hydrocarbons found in geologic formations, such as rock strata. Most petroleum is a fossil fuel, formed from the action of intense pressure and heat on buried dead zooplankton and algae. Technically, the term petroleum only refers to crude oil, but sometimes it is applied to describe any solid, liquid or gaseous hydrocarbons. Petroleum consists primarily of paraffins and naphthenes, with a smaller amount of aromatics and asphaltics. The exact chemical composition is a sort of fingerprint for the source of the petroleum.

In this work, Carbon nano catalyst is applied for sweetening process of two samples of oil which contain H2S contaminant. So, the operating and geometrical parameters are evaluated in this paper. In addition, economic investigation is discussed in this study to clear more uncertain aspects. Therefore, the gained results can be interesting for related industries and can be applicable in process optimization.

MATERIALS AND METHODS

The sour oil feed tank is equipment with an agitator to provide homogenous feed flow and prevent sedimentation.

Oil flow rate is adjusted by a valve and flow meter in line of oil movement. After passing the filter the oil flows through a pump to reach the required pressure of feed.

The oil flows from the top of vessel to down through the distributor on the catalytic packed bed contains nano carbon tubes.

Packed bed contains layers equipped with nano carbon particles on their surfaces. Figure 1 shows a schematic of this layered packed bed. Temperature in bed is provided by an electrical heater which is around the vessel and process pressure by pump. A digital recorder saves temperature trough the bed and pressure difference of top and bottom of the bed.

Product sample is analyzed to obtain the amount of sulfur.

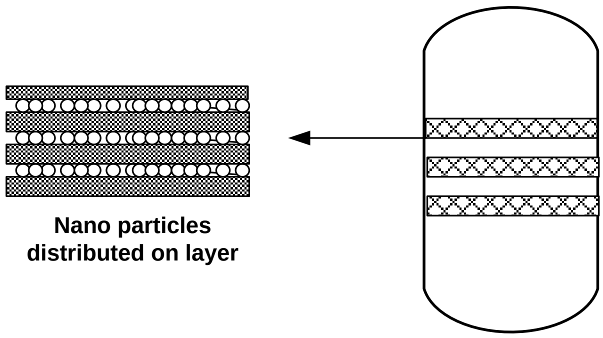

Fig-1: A schematic of layered packed bed

RESULTS AND DISCUSSIONS

To evaluate the effect of important operation and manufacturing parameters on the performance of the sweetening process, experiments are held. The quality performance of the process is reported as the one mines the ratio of outlet sulfur concentration to the inlet sulfur concentration, X=1-C/C0. The amount of 0.6 ppm sulfur in outlet petroleum is desirable according to the standards.

Operation parameters

Sulfur removal from oil by catalytic bed happens chemically and physically. Appropriate reaction temperature and pressure fasts the process which is selected due to the species and safety parameters. On the other hand, physical mass transfer and the mass transfer coefficient is also related the operation temperature and pressure.

Mass transfer phenomenon from oil phase on solid phase is dependent on the equilibrium conditions. Operation pressure and temperature affects the equilibrium state. Deviation from equilibrium condition results the adsorption mass transfer. So, in this part these majors are considered.

Finding the appropriate pressure and temperature is done by measuring the amount of X factor in low temperature values of 30, 35, 40, 45 and 50 C and suggested pressure values of 1, 1.5, 1.7 and 2 atm. legally, the higher pressure and lower temperature helps adsorption from oil to solid surface. Figure 2 shows the results of finding the appropriate operation conditions.

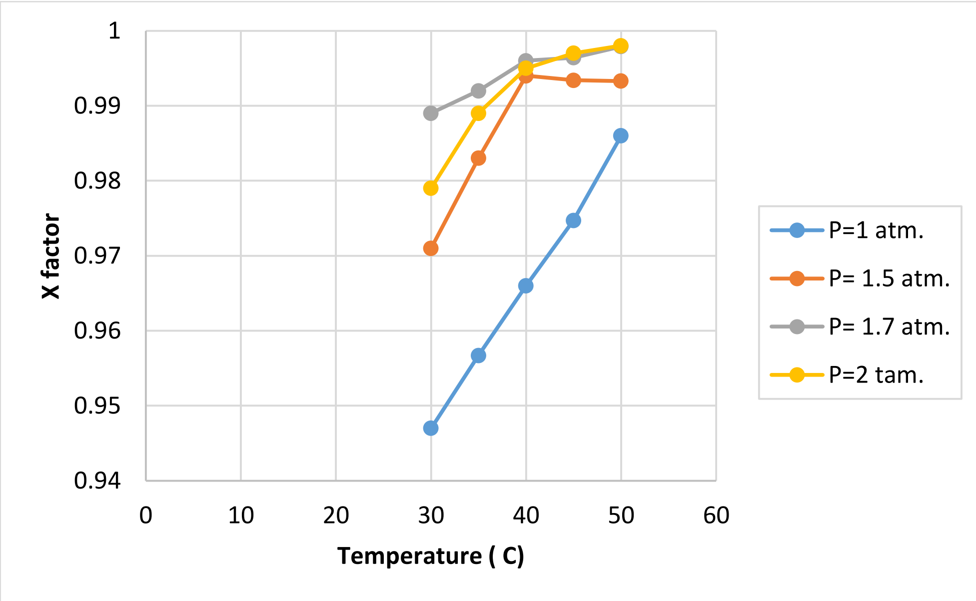

Fig-2: Values of X factor versus operation conditions

The increase in temperature decreases the value of sulfure in the outlet stream so increases the value of X factor at all amounts of pressures. The trend of changes in amounts of X factor is different for 1 atm from the other values of pressure. It seems that at 1 atm, the best temperature which helps the adsorption process is 50 C with value of 0.986 for X factor. However, the incraese trend of X factor from 30 C to 40 C of operation tempertaure changes to decrease trend with slight slop from 40 C to 50 C at pressure of 1.5 atm. So, the best values of temperature for 1.5 atm, 1.7 atm and 2 atm are 40 C, 50 C and 50 C, respectively. The realted values of X factor are 0.9940, 0.9979 and 0.998, respectively. Also, the values of X factor at 30, 35 and 40 C and 1.7 atm are higher than those are obtained at 2 atm and the same temperatures.

Mass transfer driving force

Sulfur initial concentration in the oil stream affects the amount of outlet sulfur from the bed. So, experiments are held in a catalytic bed contains 50 nm in diameter nano catalyst with 5 cm height and 2 cm bed diameter. Initial sulfur concentration in feed oil varies in value of 30, 45, 50, 55 and 65 ppm. At each experimental run, the used catalytic bed is replaced by a fresh catalytic bed. Figure 3 shows the changes in the amount of X factor versus the initial sulfur content. Although the increase in the amount of initial concentration increases the initial concentration driving force between oil and nano catalyst, the bed adsorption capacity is limited and the sulfur removal is disturbed at high initial sulfur in the inlet oil. So, the increase in the amount of inlet sulfur decreases the amount of X factor. However, totally the all amounts of X factor are higher than 0.97 in all experiments. The changes in the amount of initial concentration from 30 ppm to 50 ppm and from 30 ppm to 65 ppm decrease the amount of X factor just 0.07% and about 1.7%, respectively. The sudden decrease in the amount of X factor after 50 ppm shows the determined adsorption capacity for the used catalytic bed.

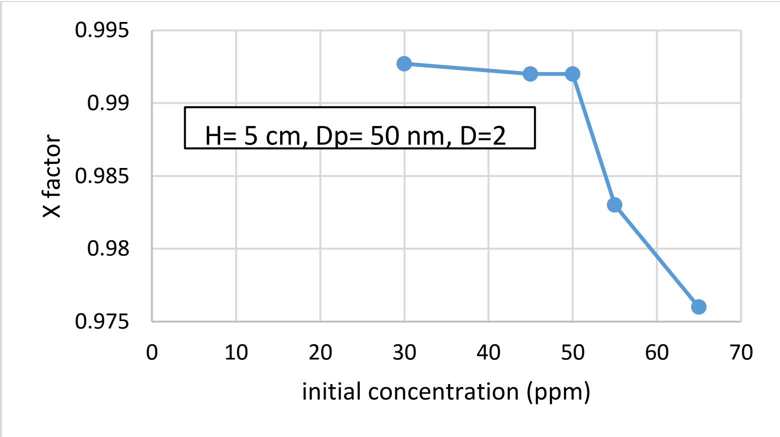

Fig-3: X factor versus the initial concentration

UNCERTAINTY

The accuracy of calculation are reported here as uncertainty. The comparison between calculated variable and experimental ones obtains the error values. Table 1 shows the uncertainty values of the effect of initial concentration, pressure drop, characteristic length, reactor diameter, superficial velocity on the conversion factor. The last column of table 1 shows the uncertainty of prediction of pressure drop versus height of bed.

Table1: Uncertainty values of calculated conversion factor

C_0	E_{C0}	Δp	$E_{\Delta p}$	l_c=H/D	E_{lc}	D	E_D	Us	E_{Us}	H	E_H
30	0.0011	40	-0.011	1.5	0.001	2	0.001	0.14	-0.001	1	0.0001
45	-0.001	50	-0.01	2	-0.011	2.5	-0.011	0.2	-0.01	2	-0.00001
50	-0.0011	60	0.012	2.5	0.01	3	-0.0012	0.38	0.011	3	0.00012
55	0.012	80	-0.013	3	-0.012	4	0.0001	0.59	0.012	4	-0.000011
65	-0.013			3.5	0.001					5	-0.000001
										6	0.000012

CONCLUSIONS

Nano catalytic reactor includes mixed metallic oxide characteristics are evaluated in oil sweetening process experimentally, in this study. Optimum operation temperature and pressure, bed length and bed diameter, oil flow rate, catalyst diameter and sulfur initial concentration are analyzed by value of X factor and selected. The higher value of conversion factor, X factor, considering the cost is the purpose of the experiments.

Low temperature range 30, 35, 40, 45 and 50 C at low pressure range of 1, 1.5, 1.7 and 2 atm are applied and 35 C and 1.7 atm is proposed as the best value of operation conditions.

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