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Strategies in Petrochemical Processes Part-I: Case of Peruvian Oil

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Abstract

The great importance of oil in today's world economy is based on their contribution the total energy supply. In 2020, the world consumed 91.3 million barrels of oil per day. Depending on the quality of the crude (chemical and physical properties), the different types of oil are commercialized around the world. For two decades ago, approximately, there are tendencies up to lower or free Sulphur fuels (content under 50 ppm) for vehicles in order to reduce the emissions generated. The sulfur content of crudes is important for the determination of commercial values. Peru exports most of their crude, due to this is too heavy in Sulphur content (2000-5000 ppm) for their refineries. Peru has undergone changes in the last three decades that increased the pressure about environmental issues. The Transport is considered one of the main causes of air pollution in several Peruvian cities. For this reason, it is imperative the development strategies in order to reduce the emissions of Sulphur compounds and/or improve the existent chemical processes of petrochemical industry. We present an alternative process design, corresponding to the Sulphur desorption unit for Peruvian crude oil, in order to minimize their content, previous to the distillation units.

Introduction

In 2020, the world consumed 91.3 million barrels of oil per day [1]. The great importance of oil in today's world economy is not only due to its considerable contribution to the total energy supply, but also to its function as a source of liquid energy and to the great diversity of uses it has as a raw material [2]. Depending on the quality of the crude (viscosity and degree of acidity), their different types are sold around the world. Most OECD countries are now at ultra-low Sulphur fuels (i.e. 10–15ppm Sulphur levels). Non-OECD countries, however, have varying standards in place, with many at 500ppm or above for automotive diesel fuels. These reasons make that Non-OECD countries aim their endeavors in order to move to cleaner fuel standards for health and climate reasons [3]. Peru for example, has two or more diesel sulfur grades on their market.

Over the past couple of decades, there has been a trend towards lower Sulphur automotive fuels and cleaner. Thus, there is demand by more efficient vehicles in their emission standards mainly. However, there are still countries and entire regions that use high Sulphur fuels, which negatively impact on public health (through fine particulate matter) and climate (black carbon emissions). Higher Sulphur fuels (in particular, diesel fuel) are still in use (above 50 ppm) [4]. Peru exports most of their crude, as this is too heavy for their refineries, and instead imports crude oil from Ecuador for refining (around 120 barrels per day) and some refined products to meet domestic consumption. Although the current standard specifies 5000ppm Sulphur, in reality the country is distributing 150ppm nationwide, with a target of 50ppm in the next years (the expected completion date of the new Talara's refinery). While Peru have high

Sulphur standards (2000-5000ppm), there is an opportunity to improve import standards for refined products. In March 2014, at the Latin America and Caribbean Environment Ministers Forum, a Decision on Air Pollution was adopted, which included improvement in fuel quality. Sulphur content of diesel should not exceed 50ppm. Taking into account the immense benefits that the liquid hydrocarbons can give to the subsector for Peru, the State has drawn up a course through the promulgation of a new regulatory framework, in order to ensure the continuity of the development of the industry. The Talara's refinery modernization project is being developed, which would help to mitigate the emissions of polluting products (such as Sulphur), allowing the processing of heavy and complex hydrocarbons (such as those produced in the Peruvian Amazonas region), and expanding the country's fuel refining capacity to enhance energy security [5].

Peru has experienced major economic, social and institutional changes during the last 25 years ago approximately. These changes have brought with them both increased pressures on the environment and new approaches to environmental management. The regulatory framework now in place for managing air quality includes environmental quality standards (EQS), maximum permissible limits (MPLs), and instruments for restoring environmental quality such as action plans also. Studies conducted by the Peruvian Ministry of the Environment (2014) on morbidity and mortality attributable to air pollution in metropolitan Lima found 1 220 deaths that were likely attributable to PM pollution in the city, of which 468 were caused by respiratory and 165 by cardiovascular diseases. The economic cost of these and other health impacts analyzed in the study was USD 806 million, of which USD 802million corresponded to mortality. Transportation has been identified as one of the main causes of air quality problems, appearing as the first or second source of pollution in all 31 priority attention zones that have an action plan. Peru's vehicle fleet are old and poorly maintained. The country allows the importation of used vehicles, although restrictions have recently been imposed, including a five-year vehicle age limit. Vehicle emissions are controlled through MPLs, which have been in place since 2001 and regulate emissions of CO, NOx, SOx, HC, PM and other pollutants. The fuel now in use has a high Sulphur content, except in the following Peruvian regions: Lima, Arequipa, Cusco, Puno, Madre de Dios and the province of Callao, where there is a ban on the use and sale of diesel with more than 50 ppm of Sulphur [5]. Peru's emissions of greenhouse gases represent 0.3% of global emissions. Roughly half the country's emissions come from activities related to land use, changes in land use, and deforestation. The 2010 emissions inventory reports 124 109 Gg-CO_{2eq}, and the main sources as deforestation and degradation of tropical forests (35.1%), followed by the energy sector (32.7%), primarily through growth in the vehicle fleet, the agriculture sector (21%), waste (6.2%) and industrial processes (5.1%). Aggregate data on emissions of particulate material (PM) report a relatively stable trend over time, at roughly 75 000 tonnes per year [3]. Sulphur emissions have been decreasing slightly thanks to the use of low Sulphur-content fuels, mainly in Lima and other major Peruvian cities. Carbon monoxide emissions grew by an average of 2.42% per year, together with the vehicle fleet and emissions of nitrogen oxide from mobile sources. The Transport is considered one of the main causes of air pollution in several Peruvian cities. The fact is that Peru's vehicle fleet is old and receives little maintenance results in high emission levels. In 2004-2013, the vehicle fleet grew by 6.3% per year nationwide. Peru uses fuels with a high Sulphur content, particularly diesel. Law 28.694 (22 March 2006), banned the use and marketing of diesel fuel with a Sulphur content above 50 ppm. Diesel fuels with Sulphur content range 2000-5000 ppm are used. The incorporation of natural gas into the country's energy matrix has made a significant contribution to reducing and preventing pollution, and its use has been extended to power generation, manufacturing industry and transport. Roughly 8% of the vehicle fleet now runs on natural gas [5].

Peru has adopted the following standards on the key pollutants: particulate matter (PM), nitrogen dioxide (NO), Sulphur dioxide (SO_2), carbon monoxide (CO) and ozone (O_3). There are also quality standards for fuel-related pollutants: lead, benzene, hexane and hydrogen sulfide ($H_2S_{(g)}$). Peru's annual emissions standard for PM (50 μg/m^3) is above the annual average of 20μg/m^3 recommended by the World Health Organization (WHO, 2006). In the case of the daily standard for PM, the upper limit imposed in Peru is equivalent to 150 μg/m^3, three times the level recommended by WHO (50 μg/ m^3) as an average over 24 hours). In the case of nitrogen dioxide, WHO recommends averages of 40 μg/m^3 annually and 200 μg/m^3 per hour. In the case of Sulphur dioxide, Peru applies two daily average values, thus, does not adopt a standard applicable to SO_2 emissions averaged over a 10-minute period, as suggested by WHO to avoid serious effects. In the framework of environmental management in Peru, these maximum permissible limits applicable to atmospheric emissions are defined by the economic sector mainly, rather than by the technology employed [5].

Sulphur

Sulphur is a reactive, nonmetallic element naturally found in nature in a free or combined state. In its combined form, this element is naturally present in sulfide ores of metals such as iron, zinc, copper, and lead. It is also a constituent of natural gas and refinery gas streams, in the form of hydrogen sulfide. The most important use of Sulphur is for sulfuric acid production. Sulphur is also used for the rubber vulcanization, in production of pharmaceutical, in additive in high pressure lubricants, in blends used for road construction, as raw material of precursors of corrosion inhibitors, in polymeric compounds [6-7]. Sulphur in crude oils is mainly present in the form of organosulfur compounds. Among the most important compounds are the thiols (mercaptans). Hydrogen sulfide is the important inorganic sulfur compound (corrosive nature) found in crude oil. Most sulfur compounds can be removed from petroleum streams through hydrotreatment processes. Determination of the Sulphur content in crudes is important, because depending of the content of this element will indicate the type of treatment required for the distillates. In order to determine the Sulphur content, a weighed crude sample (or fraction) is burned in an air stream. All Sulphur compounds are oxidized to sulfur dioxide, which is further oxidized to sulfur trioxide and finally titrated with a standard alkali. The sulfur content of crudes is important for the determination of commercial values. Sour crudes (like Peruvian case) contain a high percentage of hydrogen sulfide. Progressively stronger regulations over gasoline and diesel sulfur specifications obligate industrialized countries to reduce the corresponding emissions from transportation engines. It is requested the introduction of sulfur-free fuels (i.e., sulfur < 10 ppm) to meet the ultra-low vehicle emission specifications [6-7].

Oil in Latin America

Historically, Latin America has been a net exporter of oil. However, has an incidence comparatively reduced in the operation of the world hydrocarbon market: 10% of total reserves, 8.3% of consumption, 14% of production. The occidental world market is dominated by two types of companies:

1. Transnational companies trained in intensive countries in energy consumption (Europe and USA)
2. State companies, established in the main countries in oil producer's development

Among the Latin-American stages in industry are:

I. Development led by multinational companies

II. Greater State control, formation of state companies

III. Structural reforms: liberalization and removal of barriers to private investment

The actual context of oil in Latin America is based on the Internationalization of oil companies in the region since the mid-1990s.

Characteristics of the Industry

Upstream: exploration and exploitation.

Downstream: refining, distribution, wholesale and retail.

The downstream segment of the oil industry in Peru there is a high industrial concentration in the refining and wholesale marketing stages of liquid fuels.

Refining

Refining is a process "Multiproduct"; whose production depends on the type of crude oil used. The design of refineries depends on the crude to use and the characteristics of the market. The structure of Peruvian market is constituted by a Duopoly structure, with two vertically integrated companies in the downstream of the industry as they are: PetroPeru, and Repsol.

The Demand

Among the factors that affect the demand for derivatives can be mentioned:

Level of economic activity

Prices

Availability of energy sources alternatives

Substitution processes associated with the change in the energy matrix

The replacement of diesel and residuals by gas natural (in power generation).

The displacement of kerosene and gasoline by LPG

Official projections indicated that the demand for liquid fuels grow at a rate of 1.7% annual average in the period 2007-2017, mainly due to a higher consumption of natural gas (that contain hydrocarbons liquids also). The organizational structure adopted by the oil industry in Peru (refining and marketing companies), suggests that there is no reason to expect a spontaneous evolution towards more markets competitive, even in a context of change of energy matrix [8,9]. Among the factors that affect the prices can be mentioned:

International price of oil.

Conditions of competition in the Internal market.

Tax policy

Commercial policy

Stabilization mechanisms

Oil and Gas in Peru

The use of bitumen or asphalt dates from the time of the first inhabitants of the banks of the Euphrates River, where this material was used to caulk their boats or canoes. There are mentions of use at the time of the Babylonian culture. From time immemorial, tar was extracted in various places in Peru (e.g. at north of the Chira River). During the colonial period (XVI-XIX centuries), the exploitation of tar was active. The use of oil in the La Brea (actually in the northern of Peru) area had a significant development in the first half of the XIX century. In 1823, before any other country in Hispano-America, the first oil drilling was made in the North of Peru (Piura). The desire to extract oil on a certain scale arose soon as the use of kerosene was known in Peru (1861), in order to be used in lighting. In 1863 was exploited oil in Piura presenting a gravity of 0.919-0.925, revealing a high percentage of kerosene (70%). In 1866, one million gallons of kerosene was consumed in Peru. In 1892 the production of oil amounted to 20000 tons approximately [10]. Oil refining properly began in Peru with the commissioning of the Talara refinery in 1917 with a production capacity of 10,000 barrels of crude oil per day. Over time, the Talara refinery went through various stages of growth and modernization. During the first years of XX century, the legislative history of hydrocarbons in Peru was dealt with the existent mining regulations, which was issued on January 2, 1922 under the Law No. 4452. It was not until March 12, 1952 with a new normative was promulgated the new Petroleum Law No. 11780 setting of terms for exploitation concessions (term under Law No. 4452 undefined). In 1979 oil production increased substantially. Later, the fall of economic activity reduced the oil production until 1991 (Persian Gulf War). During the 1990s, oil production continued to decline, but was slightly offset by the start of Natural Gas Liquids production in 1997, which increased significantly with the start of the Camisea Project (2004). The development of this Project changed the country's primary energy matrix. At 2015, the crude oil production in Peru stands at 59,000 barrels per day. However, the condensates and Natural Gas Liquids (NGL) produced by the Camisea lots has allowed liquid hydrocarbons to increase, reaching a daily average of up to 173,000 barrels per day (2014).

The Oil & Gas sector in Peru has gone through a transformation, from an industry in decline to a major contributor to the economic growth in Peru. Historically, Peru became an importer in the late 1980s and early 1990s. Peru is not an oil-producing country. The maximum production was reached in the 1980s and barely exceeded 200 thousand barrels per day. Nowadays, it is found that the external dependence on crude oil associated with the gap between production and national demand, which is increasing. From 1990 to 1997, investment in the sector increased from $20 million to $4.3 billion. Areas under operation hiked from 1 million to 23 million hectares in the same period. In 2016, the Peruvian proven oil reserves are 683 million barrels (ranking 42nd in the world).

The current production and consumption approximately at that year are 141 and 246 million barrels per year respectively. Peru has proven oil reserves for 25 years approximately, below the world average, 40 years. In reality, the problem of long-term supply of oil requires real oil production; in other words, the important thing is to know the percentage of the resources and reserves that the oil industry will be able to extract to cover demand in the coming years. Between 2010 and 2016, the production of conventional crude oil has been reduced almost by 20 million barrels per year [11]. While national crude production has inexorably reduced, the demand for petroleum derivatives is increasing at a worrying rate. The demand for diesel and LPG exceeds 65% of the total consumption of petroleum derivatives. The Peru's energy dependence on external fossil resources is accentuated by the increase in consumption, due in turn to the increase of number of new automobiles mainly, and also by the reduction in annual crude oil production. In 2012, Peru ranked 98th out of 147 countries in a survey done by Fraser Institute, which focused on the attractiveness for global oil & gas investment. In 2014, it ranked 79th out of 156 countries; in 2015, 89th out of 126; in 2016 it ranked 64th out of 96 countries, and in 2017 it ranked 58th out of 97 countries. According to Peru's Central Bank, 7.1% of the investments to be made in 2019-2020 will be related to oil & gas activities [12]. Among the future challenges of Peruvian industry is the promulgation of a new regulatory framework, in order to ensure the continuity of the development of the industry [5].

Energy in Peru

Modernization of the energy sector has a significant influence on local and global pollutant emissions. The importance of natural gas is reflected in statistics on international trade in energy sources. Crude oil imports declined, while imports of oil derivatives increased in response to the requirement to use low-Sulphur fuels imposed by the environmental authorities in the peruvian regions. Peru's energy needs increased in the average growth of 6.4% per year, while the demand for crude oil, excluding derivative products, increased by 3.8% per year on average, which was less than the growth of the economy overall. The transformation of Peru's energy matrix has had positive effects on local pollution. Thanks to the greater availability of gas, thermal electricity generation has not been carbon-based, which has enabled the industry to cease using industrial oils. In that sense, Peru aspires to be recognized internationally as a country characterized by having a highly competitive energy sector, contributing significantly to the reduction of poverty, satisfying the needs of the population, but preserving the environment.

Main investment projects

Firstly, the Petroperu (National Oil Company) is not only undergoing works to keep the Northern Peruvian Pipeline operating, but has also stated that, in the short term, it would finish the design and cost studies to begin the modernization of their pipeline. This project is crucial, due to the importance of the pipeline for northeast of Peru. The main downstream project constitutes the Modernization of Talara's Refinery, with a budget of US$5 billion, and 73% advancement as of the first quarter of 2019. Once completed, refining capacity will increase from 65,000 to 95,000 barrels per day. In addition, the refinery would be able to produce low sulfur fuels, as required by Peruvian regulations. The modernization of the main refineries in the country (Talara and La Pampilla) will increase the production capacity. The investment and work involved in the sector contributed to the recovery and the positive evolution of the hydrocarbon national production. An emblematic example of this growth is the Camisea project. This project contributed to putting Peru on the map of natural gas producers. The hydrocarbon investment for years 2019-2020 is estimated at approximately US$1.4 billion and the growth of the sector is estimated to be 3% for 2019, after difficult years marked by low oil prices. The provision set forth in the energy planning for the country through 2025 expects an increase in the consumption of liquid hydrocarbons from 209,000 to 285,000 barrels per day or, another scenario, from 212,000 to 339,000 barrels per day, stressing the necessity of new infrastructure. Therefore, the optimization projects of the Talara and La Pampilla re fineries will gain special importance in order to reach those expectations. The energy projects come along with the need to adopt preventive and corrective measures to reduce the impact on the environment of the operations, as well as continue to increase efforts to reduce greenhouse gas emissions generated by oil & gas, and electricity industries [5,12].

Camisea Project

The Camisea project and their surroundings can assure to supply to even more gas-to-power projects, especially in the southern regions. The fuel of Camisea (Natural Gas) has contributed greatly to Peru's development, providing a steady and increasing energy flow. Camisea's estimated hydrocarbon reserves are around 13 million cubic feet of natural gas and 660 million of liquid (NGL) barrels. It is estimated that these reserves will reduce the cost of electricity and national fuel. The impact on savings in power generation were estimated around of US$22.4 billion during its first 10 years (the project began operating in 2004). Undoubtedly, it has changed the Peruvian energy matrix dramatically, constituting the support for energy and infrastructure projects development for the mid-term. Nowadays, the consumption of liquid fuels has been reduced, in order to introduce different energy sources, such as LPG (Liquefied Petroleum Gas) and VNG (Vehicle Natural Gas). In the future, Peru intends to generate a matrix based not only on petroleum, but equally on renewable energy and natural gas. The development of natural gas and condensates from the Camisea project have created a new strategic option for the energy sector in Peru. Such development has contributed to increase the reserves and hydrocarbon production and, therefore, the supply and demand patterns of such an energetic matrix [5,12].

Influence and Economic Impact and Environmental in the Country

Economic impacts

The globalization of the oil market has determined the short-term dynamics of international oil prices. Peru has not been oblivious to the effects of these events that affected the world economy in the 21st century. Peru is a net importer of derived hydrocarbons of oil and depends on the fluctuations of the world market which are reflected in the international price. In addition, this price is influenced by geopolitical, technological and speculative aspects. The demand describes characteristics associated with the consumer decision of economic agents. The supply is divided into the upstream and downstream segments. The activities included in upstream are the exploration of new reserves, exploitation of oil and/or natural gas (NG) and the transport of hydrocarbons. The downstream segment includes everything from the refining or fractionation of the hydrocarbon and its transformation into different fuels, the transportation and storage of the fuels, to the wholesale and retail marketing. The crescent importance of liquid hydrocarbons (oil and its derivatives, natural gas liquids.) in the Peruvian economy can be understood fundamentally by the impact of this subsector on the main economic indicators associated with the country's growth and development [5,12].

I. Macroeconomics Impacts

The importance of the hydrocarbon sector in the Peruvian economy can be appreciated through its participation in four fundamental economic variables: Gross Domestic Product (GDP), Gross Value Added (GVA), Investments and Trade Balance of Hydrocarbons.

A. Gross Domestic Product

According to data from the National Institute of Statistics and Informatics (INEI), the participation of the hydrocarbon sector (oil and gas extraction and refining) within the total GDP reached 3.6% in 2014.

B. Gross Value Added

In 2014, the weight of the hydrocarbon sector in the Peruvian economy amounted to 3.9% driven by the exploitation of hydrocarbons in the national territory.

C. Investments

Peru's economic growth in the period 2005-2013 was due, to a large extent, to the expansion of the country's productive capacity generated by investment. They reached their peak in 2012 with US $ 1,880 million. At the macroeconomic level, this represented 4.8% of private investment.

D. External sector

The hydrocarbon balance has been in deficit in the last two decades. At 2014 values, the deficit reduction in the GLP Balance amounts to US $ 11,258 million.

II. Microeconomic Impacts

Economic Impact on the Public Sector

In the fiscal context, the hydrocarbon sector contributes to Peruvian society through the payment of taxes, royalties for license contracts and contributions for service contracts. Royalties are partially distributed by oil canon and over-canon. The fiscal contribution of the hydrocarbon sector to Peruvian society went from US $ 662 million in 2005 to more than US $ 2009 million in 2014 [5,12].

Environmental Impact

Through Law No. 29852, the Hydrocarbons Energy Security System and the Social Energy Inclusion Fund (FISE) were created. One of the purposes of the FISE is to promote these energy sources, mainly NG and LPG, so that greenhouse gas emissions such as carbon dioxide (CO_2) are mitigated. The greatest mitigation of tons of CO_2 emitted would have been obtained in the Peruvian central and southern regions (29% and 47%, respectively). The incidence of total mitigation of CO_2 emissions has reached 39% for extreme poor households and 32% for non extreme poor households [5].

Aspects of Industrialization of Crude Oil

Crude oils can be classified in Paraffinic, Naphthenic and Asphaltic depending on the relative ratio of the hydrocarbon classes that predominates in their mixture. Crude oils differ appreciably in their properties according to origin and the ratio of the different components in the mixture. Lighter crudes generally yield more valuable light and middle distillates, which are sold at higher prices. Crudes containing a high percent of impurities, such as sulfur compounds, are less desirable than low-sulfur crudes because of their corrosivity and the extra treatment cost. Oil and natural gas (NG) are a mixture of organic compounds of carbon and hydrogen in liquid (oil) and gaseous (NG) states, which are formed in underground deposits of sedimentary rock mixed with other elements. Natural gas liquids (NGL) contain butane and propane mainly, although also can contain ethane or pentane. The refining of NGL allows to obtain value-added products and multiple derivatives. These derivatives are used in almost all economic sectors, although mainly in industry (petrochemical, electrical, manufacturing, etc.), transportation, food cooking and heating. The crude oil must be subjected to a series of processes in order to convert it into the hundreds of products that are derived from it. Together, these processes comprise one of the most complicated phases: the refining. The basic processing units in the refining industry for the manufacture of fuel products include: 1) crude oil distillation, 2) catalytic reforming, 3) catalytic disintegration, 4) catalytic hydrolysis, 5) alkylation, 6) pyrolysis, 7) hydrotreatment and 8) gas concentration [6]. In the following paragraphs we described the Hydrotreatment process.

Hydrotreatment Processes

The main objective of hydrotreating is to convert selectively one substance to another desirable one or to remove from the system one or more unwanted substances included in the raw material. Feeds to hydrotreatment units could be any petroleum fraction, from naphtha to crude residues. The hydrogen sulfide is produced, as also the corresponding hydrocarbons are released. Hydrogen sulfide compounds, ammonia and water are removed from the hydrotreated liquid product by exhaustion in the stabilizer section of the unit. The Hydrogen sulfide is then absorbed in a suitable absorbent and recovered as sulfur. The applications of hydrotreating are numerous: 1) naphtha pretreatment for catalytic reforming units; 2) desulfurization of distillate fuels; 3) improvement of the burning quality of jet fuel, kerosene and diesel fuel; 4) improvement of color, odor and storage stability of various fuels and petroleum products; 5) pretreatment of raw material for catalytic disintegration by elimination of metals, sulfur and nitrogen, and reduction of polycyclic aromatic compounds; 6) improvement of the quality of lubricating oils; 7) purification of light aromatic by-products of pyrolysis operations, and 8) reduction of the sulfur content of residual fuel oils [6-7]. Detailing the desulfurization process:

Desulfurization Processes

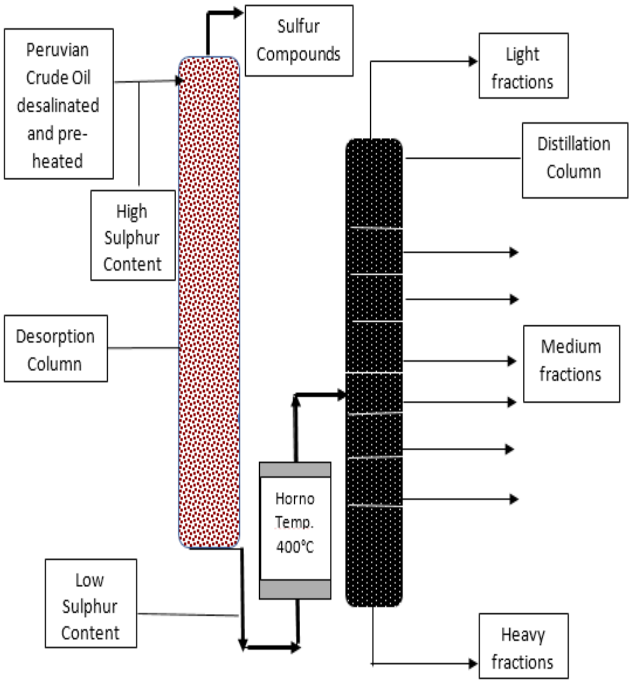
By this chemical process reduced crudes with especially high sulfur contents (on the order of 4% or more) can be brought to levels on the order of 1% by evaporation in vacuo.

Hydrogen sulfide is removed from the gaseous products by selective absorption in liquid solutions (usually organic amines). The H2S released from the solution rich in it is converted by further processing to elemental Sulfur or H_2SO_4 [6-7].

Proposal of the design of desorption Sulphur system

We proposed an alternative chemical process design in order to optimize the sweeting of the crude with high sulfur content (of the order of 5000 ppm approximately), in which there would have a desorption Sulphur system (containing one or more packed columns) after the step corresponding to the desalinization of crude. The range of temperatures of this desorption system would be 90-120°C (194-248°F) approximately, take in consideration that many organic sulfur compounds are not thermally stable at temperatures higher than this range values, but also that the solubility of these compounds increases with the temperature. For this reason, would be necessary a step of pre-heating, previous to the desorption process mentioned recently. Those Sulphur compounds desorbed could be cooled, and subsequently addressed to the Sulphur recovery unit. With this process unit is expected that the majority of Sulphur organic compounds are retired of oil crude, before the corresponding refining hydrocarbons steps.

Figure 1. Basic scheme of the design of Sulphur desorption unit before the refining hydrocarbons steps.



Final Remarks

Sulphur contained in crude oil and processed by petrochemical industry can be represent a seriously environmental problem. For this reason, is critical develop strategies in order to reduce the emissions of Sulphur compounds and/or improve the existent processes of this industry, in order to recovery this element. It has presented a design of the Sulphur desorption unit for Peruvian crude oil, previous to the heating and distillation units, in order to minimize their content. More in depth studies are necessary, in order to detail the process unit mentioned above, as also the process conditions for its corresponding implementation.

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