ДОНСКОЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

УПРАВЛЕНИЕ ЦИФРОВЫХ ОБРАЗОВАТЕЛЬНЫХ ТЕХНОЛОГИЙ

Кафедра «Иностранный язык в сфере технических наук и технологий»

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Аннотация

Методические указания содержат профессионально – ориентированные тексты на английском языке для студентов, обучающихся по направлению 18.03.01 «Химическая технология», а также упражнения, способствующие развитию навыков чтения, перевода и устной речи.

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Unit 1
Text A. Crude Oil

Task 1. Read the following words and try to remember them:

adulteration – примешивание
carbon number – число углеродных атомов
compound – *хим*. соединение
gravity - плотность
jet fuel – реактивное топливо, авиакеросин, авиатопливо
lubricating stock – смазочный материал
occur – происходить, случаться
refinery – нефтеперерабатывающий завод
reforming – реформинг, крекинг лигроина
residuum – мазут, осадок
rough index – приближенный показатель
still – перегонный аппарат, ректификационная колонна
stock – дистиллят, перерабатываемое сырье
tar – смола, битум, сланцевая нефть
yield – производить, давать выход, выход (продукта)

Task 2. Read the text

Crude oil is a complex mixture consisting of up to 200 or more different organic compounds, mostly hydrocarbons. Different crudes contain different combinations and concentrations of these various compounds. The API (American petroleum institute) gravity of a particular crude is merely a measure of its specific gravity, or density. The higher the API number, expressed as degrees API, the less dense (lighter, thinner) the crude. Conversely, the lower the degrees API, the more dense (heavier, thicker) the crude. Crude from different fields and from different formations within a field can be similar in composition or be significantly different. In addition to API grade and hydrocarbons, crude is characterized for other unwanted elements like sulfur, which is regulated and needs to be removed.

Crude oil API gravities typically range from 7 to 52 corresponding to about 970 kg/m3 to 750 kg/m3, but most fall in the 20 to 45 API gravity range. Although light crude (i.e., 40-45-degree

API) is good, lighter crude (i.e., 46-degree API and above) is not necessarily better for a typical refinery. Looking at the chemical composition of crude, as the crude gets lighter than 40-45 degrees API, it contains shorter molecules, or less of the desired compounds useful as high-octane gasoline and diesel fuel, the production of which most refiners try to maximize. Likewise, as crude gets heavier than 35 degrees API, it contains longer and bigger molecules that are not useful as high-octane gasoline and diesel fuel without further processing.

For crude that have undergone detailed physical and chemical property analysis, the API gravity can be used as a rough index of the quality of the crude of similar composition as they naturally occur (that is, without adulteration, mixing, blending, etc.). When crude of different type and quality are mixed, or when different petroleum components are mixed, API gravity cannot be used meaningfully for anything other than a measure of the density of the fluid.

For example, consider a barrel of tar that is dissolved in 3 barrels of naphtha (lighter fluid) to produce 4 barrels of a 40-degree API mixture. When this 4-barrel mixture is fed to a distillation column at the inlet to a refinery, one barrel of tar plus 3 barrels of lighter fluid is all that will come out of the still. On the other hand, 4 barrels of a naturally occurring 40-degree API South Louisiana Sweet crude, when fed to the distillation column at the refinery, could come out of the still as 1.4 barrels of gasoline and naphtha, 0.6 barrels of kerosene (jet fuel), 0.7 barrels of diesel fuel, 0.5 barrels of heavy distillate, 0.3 barrels of lubricating stock, and 0.5 barrels of residuum (tar).

The chemical composition is generalized by the carbon number which is the number of carbon atoms in each molecule. The medium blend is desired because it has the composition that will yield the highest output of high-octane gasoline and diesel fuel in the cracking refinery. Though the heavy stock and the light stock could be mixed to produce a blend with the same API gravity as the medium stock, the composition of the blend would be far different from the medium stock. Heavy crude can be processed in a refinery by cracking and reforming that reduces the carbon number to increase the high value fuel yield.

Task 3. Find Russian equivalents for the following English words and word collocations:
blend, sulphur; chemical composition; barrel; heavy distillate; hydrocarbon; cracking; specific gravity; detailed analysis, distillation column, high-octane gasoline, range, maximize, specific gravity, naturally occurring.

углеводород, удельная плотность, дистилляционная колонна, диапазон значений, природного происхождения, удельная плотность, химический состав, максимально увеличить, сера, высокооктановый бензин, подробный анализ, баррель, смесь, тяжелый дистиллят, крекинг.

Task 4. Say if the following sentences are true or false. Correct the false ones.

1. Crude oil consists of hydrocarbons only.
2. The lower the API number, the lighter the crude oil.
3. Most refiners try to maximize high-octane gasoline and diesel fuel.
4. The API gravity can be used as a rough index of the quality of the crude of similar composition as they naturally occur.
5. The highest output of high-octane gasoline and diesel fuel can be obtained from light crude.
6. Reducing the carbon number increases the high value fuel yield.
7. The heavy stock and the light stock can be mixed to produce a blend with the same API gravity.
8. Crude oil API gravities usually range from 20 to 45 degrees.
9. As crude gets heavier than 35 degrees API, it contains shorter and smaller molecules.
10. Crude oil is characterized for such important element as sulphur which should be added if necessary.

Task 5. Read the text again and get ready to answer the questions:

1. What does crude oil consist of?
2. What is API?
3. What is API gravity for light crude?

4. Why is crude with 46-degree API and above not so good?
5. When does crude oil contain longer and bigger molecules?
6. What does the carbon number represent?
7. Why is medium blend desired?
8. What kind of crude contains longer and bigger molecules?
9. Can we mix the heavy stock and the light stock? What is the result?
10. What can be obtained if 4 barrels of a naturally occurring 40-degree API crude is fed to the distillation column?

Task 6. Match the terms and their definitions

1) hydrocarbons	a) a unit of volume, almost always used for crude oil and petroleum products
2) chemical composition	b) processing technique by which the molecular structure of a hydrocarbon is rearranged to alter its properties
3) oil field	c) a mixture of two or more things
4) API gravity	d) any substance that can provide heat and produce energy when it is burned.
5) barrel	e) complex mixture containing many different hydrocarbon compounds
6) blend	f) the process whereby complex organic molecules are broken down into simpler molecules
7) crude oil	g) a commonly used index of the density of a crude oil or refined products
8) cracking	h) a piece of land beneath which fossil fuels (oil) can be extracted for economic value
9) fuel	i) molecules of carbon and hydrogen in various combinations
10) reforming	j) arrangement, ratio, and type of atoms in molecules of chemical substances

Task 7. Discuss with your groupmates the main characteristics of crude oil: composition, physical and chemical properties, application.

Text B. Natural Gas

Task 8. Read the following words and remember them:

condensate well – конденсатная скважина
diluent – разбавляющий, разжижающий
enhance – улучшить, усилить
pipeline quality natural gas – газ, соответствующий требованиям транспортирования по трубопроводу
raw – сырой, необработанный
recovery – добыча (газа)
restriction- ограничение
well – скважина
wellhead - устье скважины
Wobbe index – показатель Уобба (теплотворной способности топлива)

Task 9. Guess the meaning of the following words and word collocations or look them up in a dictionary:

ethane, propane, butane, pentanes, hydrogen sulfide, carbon dioxide, helium, nitrogen, iso-butane, gasoline, pipeline, mixture, separate, hydrocarbon condensate, by-products, raw materials, associated gas.

Task 10. Read the text and try to understand it.

The natural gas used by consumers is composed almost entirely of methane.
However, natural gas found at the wellhead, although still composed primarily of methane, is by no means as pure. Raw natural gas comes from three types of wells: oil wells, gas wells, and condensate wells. Natural gas that comes from oil wells is typically termed 'associated gas'. This gas can exist separate from oil in the formation (free gas), or dissolved in the crude oil (dissolved gas). Natural gas from gas and condensate wells, in which there is little or no crude oil, is termed 'non-associated gas'. Gas wells typically produce raw natural gas by itself, while condensate wells produce free natural gas along with a semi-liquid hydrocarbon condensate.

Whatever the source of the natural gas, once separated from crude oil (if present) it commonly exists in mixtures with other hydrocarbons; principally ethane, propane, butane, and pentanes. In addition, raw natural gas contains water vapor, hydrogen sulfide (H2S), carbon dioxide, helium, nitrogen, and other compounds.

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as 'pipeline quality' dry natural gas. Major transportation pipelines usually impose restrictions on the makeup of the natural gas that is allowed into the pipeline and measure energy content in kJ/kg (also called calorific value or Wobbe index).

While the ethane, propane, butane, and pentanes must be removed from natural gas, this does not mean that they are all 'waste products’. In fact, associated hydrocarbons, known as 'natural gas liquids' (NGL) can be very valuable by-products of natural gas processing. NGL include ethane, propane, butane, iso-butane, and natural gasoline.

These NGLs are sold separately and have a variety of different uses; raw materials for oil refineries or petrochemical plants, as sources of energy, and for enhancing oil recovery in oil wells. Condensates are also useful as diluent for heavy crude.

Task 11. Answer the following questions:

1. What is natural gas used by consumers composed of?
2. What types of wells does raw natural gas come from?
3. What is called 'associated gas'?
4. What kind of gas is called free gas?
5. What does raw natural gas contain?
6. What hydrocarbons exist in mixture with natural gas?
7. What does natural gas processing consist of?
8. What does natural gas liquids comprise?
9. Why are NGLs sold separately?
10. What restrictions do major transportation pipelines impose?

Task 12. Complete the following sentences according to the text

1. Condensate wells produce free natural gas along with …
2. Natural gas separated from crude oil commonly exists in mixtures with other hydrocarbons: …
3. Major transportation pipelines usually … on the makeup of the natural gas.
4. kJ/kg is also called …or Wobbe index.
5. Ethane, propane, butane, and pentanes … from natural gas.
6. Associated hydrocarbons are known as …
7. NGLs can be very valuable … of natural gas processing.
8. Condensates can be used … for heavy crude.

Task 13. Make up phrases by matching the words in the two columns the way they are used in the texts A and B:

1. crude	a. fuel
2. natural	b. property
3. transportation	c. plant
4. diesel	d. number
5. distillation	e. gas
6. chemical	f. vapor
7. heavy	g. pipelines
8. petrochemical	h. products
9. water	i. in composition
10. waste	j. column
11. carbon	k. oil
12. similar	l. distillate

Task 14. Discuss the following topics with your groupmates:

1. Means of extraction of natural gas.
2. Natural gas processing.
3. Natural gas transportation.

Unit 2

Text A. Composition of hydrocarbons

Task 1. Read the following words and remember them:

approximate – приблизительный, близкий
asphalt – нефтяной/асфальтовый битум
branched chain – разветвленная цепь
clay – глина, глинистые минералы
constituent – компонент, составная часть
crack - расщеплять, крекировать
generic – обобщенный, базовый
impurity – примесь
refine – очищать, перерабатывать
saturated rings – насыщенные кольца
solids – твердая фаза
sour crude – высокосернистая сырая нефть
sweet crude – низкосернистая нефть
w/w (weight in weight) – весовое соотношение

Task 2. Guess the meaning of the following words or look them up in a dictionary:

sulphur, vanadium, nickel, zinc, chromium, sodium, inorganic material, iso-paraffins, naphthenes, cycloparaffins, pentane isomer, aromatics, octane, alkanes, petrol, nonane, hexadecane, diesel fuel, olefinic hydrocarbons, paraffin wax, pentane isomers, kerosene, cycloalkanes.

Task 3. Read the text and try to understand it

Crude oil is a mixture of hydrocarbon compounds (95 - 99 % w/w) of different chemical composition and molecular structures with some impurities. Most of these impurities, such as sulphur, nitrogen, vanadium and nickel are chemically bound to the hydrocarbon structures. Others, such as sand/clay, water and water-soluble salts of zinc, chromium and sodium are present as inorganic material.

The hydrocarbons in crude oil are a mixture of three chemical groups: paraffins (straight and branched chains are called normal- and iso-paraffins), naphthenes (saturated rings or cycloparaffins) and aromatics (one or more unsaturated rings). The most used rough distinction between crude oil types is sweet or sour. Sweet crude is normally low in sulphur and lightly paraffinic. Sour crude is usually high in sulphur and heavily naphthenic.

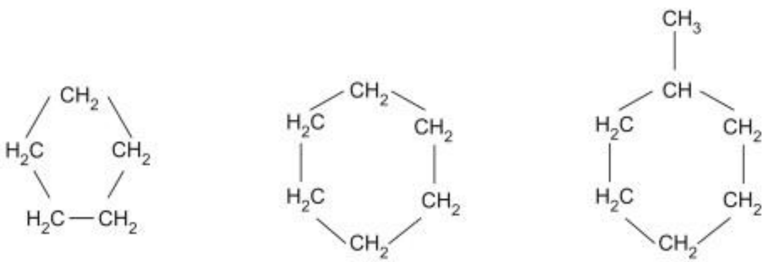
The paraffin hydrocarbon component of crude oil has the generic formula CnH2n+2, and may comprise gases, liquids, or solids depending on their molecular weight (or the value of *n*). The simplest example of this group is methane, CH4, the chief constituent of natural gas. It has a boiling point of 164 °C and a melting point of 183 °C. Propane and butane, C3H8, and C4H10, both are gases under ordinary conditions, but with boiling points of 42 and 1 °C, respectively, are relatively easily liquefied. Butane and the higher (larger carbon number) members of this series occur not only in the straight chain form, referred to as the normal or *"n"* form, but also in various branched chain structures of the same molecular formula but with different physical and chemical properties.

Pentane isomers, C5H12, have boiling points in the range of normal ambient conditions, and represent the approximate borderline between gases and liquids in the paraffin series.

Normal octane, C8H18, with a melting point of 57 °C and boiling point of 126 °C, occurs near the upper end of the liquid paraffinic constituents of gasoline.

The alkanes, also known as paraffins, are saturated hydrocarbons with straight or branched chains. They generally have from 5 to 40 carbon atoms per molecule. The alkanes from pentane (C5H12) to octane (C8H18) are refined into gasoline (petrol), the ones from nonane (C9H20) to hexadecane (C16H34) into diesel fuel and kerosene (primary component of many types of jet fuel), and the ones from hexadecane upwards into fuel oil and lubricating oil. At the heavier end of the range, paraffin wax is an alkane with approximately 25 carbon atoms, while asphalt has 35 and up, although these are usually cracked by modern refineries into more valuable products. Any shorter hydrocarbons are considered natural gas or natural gas liquids.

Naphthenes. Saturated hydrocarbons also occur in petroleum in cyclic form, and will have generic molecular formulas of the form CnH2n (if monocyclic). These cycloparaffins are referred to as *naphthenes* in the petroleum industry and occur primarily as five, six, and seven-membered rings, with and without alkyl substituents. They also occasionally occur as various combinations of two of these ring systems linked or fused together. Examples of naphthenes are cyclopentane, cyclohexane, and methylcyclohexane.



Cyclopentane (C_5H_{10}) **Cyclohexane** (C_6H_{12}) **Methylcyclohexane** (C_7H_{14})

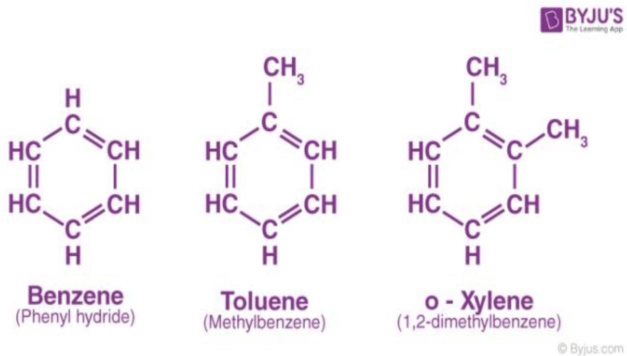
The cycloalkanes, also known as naphthenes, are saturated hydrocarbons which have one or more carbon rings to which hydrogen atoms are attached according to the formula CnH2n.

Naphthenes are desirable FCC feedstocks because they produce high-octane gasoline. The gasoline derived from the cracking of naphthenes has more aromatics and is heavier than the gasoline produced from the cracking of paraffins.

The boiling point and densities of naphthenes are higher than those of alkanes having the same number of carbon atoms. Naphthenes commonly present in crude oil are rings with five or six carbon atoms. These rings usually have alkyl substituents attached to them. Mutli-ring naphthenes are present in the heavier parts of the crude oil.

Aromatic hydrocarbons are "unsaturated hydrocarbons which have one or more planar six-carbon rings called benzene rings, to which hydrogen atoms are attached". occur to a varying extent and have a higher ratio of carbon to hydrogen than any of the commonly occurring paraffins or naphthenes. Many aromatic hydrocarbons contain a benzene ring (also referred to as an aromatic ring).

The benzene ring is stabilized by resonance and the pi electrons are delocalized in the ring structure. A few examples of aromatic hydrocarbons are provided below. It can be observed that all these compounds contain a benzene ring.



The aromatic hydrocarbons which do not contain a benzene ring are commonly referred to as heteroarenes. All of these heteroarenes obey Huckel's rule (total number of pi electrons in a monocyclic ring = 4n + 2 where n is any positive integer or zero).

The aromatic content of crude oils can vary widely. The density (or °API) of a crude oil is an indicator of the aromatic content. While the bulk of the hydrocarbon content of crude oils is represented by the paraffins, naphthenes, and aromatics, small percentages of several other types of compounds are also present. Olefinic hydrocarbons, unsaturated chain compounds having a carbon–carbon double bond and a type formula CnH2n, also occur in natural petroleum but only to a very small extent since they are relatively unstable.

The composition of the crude is the most important parameter in establishing the range and quality of products that may be produced from a refinery. The impurities of the crude, which usually make up 1 - 5 % of the total, are also very important in establishing the value of the crude and the difficulties in converting it into marketable products. The most important impurity of crude oil is sulphur, which is present largely in the form of organic compounds such as mercaptans and sulphides. Crudes containing more than 0.5 % w/w S are commonly referred to as 'sour' and the others as being 'sweet'. In general, the sulphur content increases in the higher boiling fractions.

Task 4. Find English equivalents for the following words and word combinations:

углеводородное соединение, химический состав, химически связаны с, молекулярный вес, относительно легко сжижается, структуры с разветвленными цепями, обычные условия внешней среды, в пределах, пограничное состояние, смазочное масло, ценные продукты, насыщенные углеводороды, содержание ароматических соединений, часто встречающийся/ распространенный, углерод-углеродная двойная связь, товарные продукты

Task 5. Read the text again and answer the questions:

1. What impurities does crude oil possess?
2. What chemical groups represent hydrocarbons in crude oil?
3. What do physical and chemical properties of butane depend on?
4. What is the common difference between aromatic hydrocarbons and paraffins or naphthenes?
5. What does the composition of the crude influence on?
6. What is the most important impurity of crude oil?
7. How does sulphur influence the properties and quality of crude oil?
8. Do naphthenes occur with or without alkyl substituents?
9. Why are the impurities of the crude very important?
10. What kind of organic compounds does sulphur represent?
11. How many carbon atoms does paraffin wax have?

Task 6. Match the beginning and the ending of the sentences

1) Most of such impurities as sulphur, nitrogen, vanadium and nickel are	a) saturated hydrocarbons with straight or branched chains.
2) The hydrocarbons in crude oil	b) as 'sour' and the others as being 'sweet'.

3) The paraffin hydrocarbon component of crude oil	c) a higher ratio of carbon to hydrogen than any of the commonly occurring paraffins or naphthenes.
4) The alkanes are	d) in establishing the range and quality of products that may be produced from a refinery.
5) Naphthenes occur primarily	e) may comprise gases, liquids, or solids.
6) Aromatic hydrocarbons occur to a varying extent and have	f) but with boiling points of 42 and 1 °C, respectively, are relatively easily liquefied.
7) The bulk of the hydrocarbon content of crude oils is	g) chemically bound to the hydrocarbon structures.
8) The composition of the crude is the most important parameter	h) are a mixture of three chemical groups.
9) Crudes containing more than 0.5 % w/w S are commonly referred to	i) as five, six, and seven-membered rings.
10) Propane and butane are gases under ordinary conditions	j) represented by the paraffins, naphthenes, and aromatics.

Task 7. Guess the kind of a hydrocarbon according to the description

1. Its melting point is 57 °C and boiling point is 126 °C.
2. Its number of carbon atoms is 35 and more.
3. It occurs not only in the straight chain form but also in various branched chain structures.
4. It has a boiling point of 164 °C and a melting point of 183 °C.
5. They generally have from 5 to 40 carbon atoms per molecule.
6. It has approximately 25 carbon atoms.
7. It has a boiling point of 42 °C.
8. It has a carbon–carbon double bond.

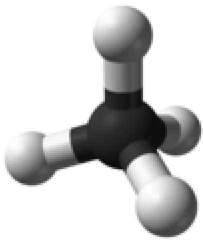
Text B Gaseous Hydrocarbons

Task 8. Read the following words and remember them:

abundantly – в изобилии, богато
by-product – побочный/сопутствующий продукт
carbon black – чистый углерод, углеродная сажа
colliery – каменноугольная копь
constituent – элемент, составляющая
explosive – взрывной, воспламеняющийся
gasoline – бензин
greenhouse gases – газы, вызывающие парниковый эффект
potent – мощный, сильнодействующий
reinforcing agent – упрочняющий наполнитель
volatility – испаряемость, летучесть

Task 9. Read the text and try to understand it

Methane



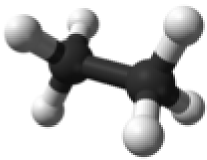
is colourless, odourless gas that occurs abundantly in nature and as a product of certain human activities. Methane is the simplest member of the paraffin series of hydrocarbons and is among the most potent of the greenhouse gases. Its chemical formula is CH_4.

Methane is lighter than air having a specific gravity of 0.554. It is only slightly soluble in water. It burns readily in air, forming carbon dioxide and water vapour; the flame is pale, slightly luminous, and very hot. The boiling point of methane is −162 °C (−259.6 °F) and the melting point is −182.5 °C (−296.5 °F). Methane in general is very stable, but mixtures of methane and air, with the methane content between 5 and 14 percent by volume, are explosive.

Explosions of such mixtures have been frequent in coal mines and collieries and have been the cause of many mine disasters.

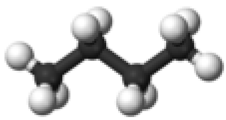
Methane is an important source of hydrogen and some organic chemicals. Methane reacts with steam at high temperatures to yield carbon monoxide and hydrogen; the latter is used in the manufacture of ammonia for fertilizers and explosives. Other valuable chemicals derived from methane include methanol, chlorophorm, carbon tetrachloride and nitromethane. The incomplete combustion of methane yields carbon black, which is widely used as a reinforcing agent in rubber used for automobile tires.

Ethane



is a colourless, odourless, gaseous hydrocarbon (compound of hydrogen and carbon), belonging to the paraffin series; its chemical formula is C_2H_6. Ethane is structurally the simplest hydrocarbon that contains a single carbon–carbon bond. The second most important constituent of natural gas, it also occurs dissolved in petroleum oils and as a by-product of oil refinery operations and of the carbonization of coal. The industrial importance of ethane is based upon the ease with which it may be converted to ethylene (C_2H_4) and hydrogen by pyrolysis, or cracking, when passed through hot tubes.

Butane



is either of two colourless, odourless, gaseous hydrocarbon (compound of carbon and hydrogen), members of the series of paraffinic hydrocarbons. Their chemical formula is C_4H_{10}. The compound in which the carbon atoms are linked in a straight chain is denoted normal butane, or *n*-butane; the branched-chain form is isobutane.

Both compounds occur in natural gas and in crude oil and are formed in large quantities in the refining of petroleum to produce gasoline.

The butanes present in natural gas can be separated from the large quantities of lower-boiling gaseous constituents, such as methane and ethane, by absorption in a light oil. The butanes thus obtained can be stripped from the absorbent along with propane and marketed as liquefied petroleum gas (LPG), or they can be separated from the propane and then from each other by fractional distillation: *n*-butane boils at -0.5° C (31.1° F); isobutane boils at -11.7° C (10.9° F). Butanes formed by catalytic cracking and other refinery processes are also recovered by absorption into a light oil.

Commercially, *n*-butane can be added to gasoline to increase its volatility. Transformed to isobutane in a refinery process known as isomerization, it can be reacted with certain other hydrocarbons such as butylene to form valuable high-octane constituents of gasoline.

Propane

is a colourless, easily liquefied, gaseous hydrocarbon (compound of carbon and hydrogen), is the third member of the paraffin series following methane and ethane. The chemical formula for propane is C_3H_8. It is separated in large quantities from natural gas, light crude oil, and oil-refinery gases and is commercially available as liquefied propane or as a major constituent of liquefied petroleum gas (LPG).

As with ethane and other paraffin hydrocarbons, propane is an important raw material for the ethylene petrochemical industry. The decomposition of propane in hot tubes to form ethylene also yields another important product, propylene. From propylene such organic chemicals as acetone and propylene glycol are derived. The oxidation of propane to such compounds of carbon, hydrogen, and oxygen as acetaldehyde is also of commercial interest.

Although a gas at ordinary atmospheric pressure, propane has a boiling point of -42.1° C (−43.8° F) and thus is readily liquefied under elevated pressures. It therefore is transported and handled as a liquid in cylinders and tanks. In this form, alone or mixed with liquid butane, it has great importance as a fuel for domestic and industrial uses and for internal-combustion engines.

Task 10. Find English equivalents for the following words and word combinations:

бесцветный, без запаха, определенная деятельность человека, удельная плотность, двуокись углерода, водяной пар, органические вещества (химикаты), неполное сгорание, природный газ, сжиженный нефтяной газ, абсорбирующее вещество, атмосферное давление, легко сжижается при повышенном давлении, топливо для использования в домашних условиях и промышленности, двигатель внутреннего сгорания, нефтеперерабатывающее производство.

Task 11. Write out from the text the names of the following chemicals and chemical processes and read them aloud:

кислород, метан, этан, бутан, пропан, парафиновый углеводород, водород, углерод, моноксид углерода, аммиак, метанол, хлороформ, тетрахлорметан, нитрометан, резина, масло на нефтяной основе, коксование, этилен, пиролиз, крекинг, парафиновые углеводороды, изобутан, фракционированная перегонка, каталитический крекинг, изомеризация, пропилен, пропиленгликоль, ацетон, уксусный альдегид (ацетальдегид).

Task 12. Read the text again and answer the questions:

1. Is methane soluble in water?
2. What does methane produce while burning?
3. What valuable chemicals are derived from methane?
4. What does the incomplete combustion of methane yield? Where is it used?

5. Which chemicals can be obtained from ethane? What kind of techniques are used?
6. What is the difference between *n*-butane and isobutane?
7. Where do *n*-butane and isobutane occur and where are they formed in large quantities?
8. What are the boiling points of *n*-butane and isobutane?
9. Can butanes be recovered into a light oil? If yes, which method is used?
10. Which gas is a major constituent of liquefied petroleum gas (LPG)?
11. What product does the decomposition of propane yield?
12. What chemicals are derived from propylene?
13. Where is liquefied propane used as a fuel?

Task 13. Match the names of chemicals (1-8) and their definitions (a-h):

1. propane	a. Its mixtures with air are very explosive.
2. ethane	b. It can be derived from methane.
3. methane	c. It can be added to gasoline to increase its volatility.
4. hydrogen	d. Organic chemicals such as acetone and propylene glycol are derived from it.
5. carbon tetrachloride	e. It is the second most important constituent of natural gas.
6. *n*-butane	f. It is obtained as a result of the oxidation of propane.
7. propylene	g. Its chemical formula is C_3H_8.
8. acetaldehyde	h. It is used in the manufacture of ammonia for fertilizers and explosives.

Task 14. Tell if the following sentences are true or false. Correct the false ones.

1. Methane is one of the main reasons for greenhouse effect.
2. Mixtures of methane and air, with the methane content between 0.554 and 1 percent by volume, are explosive.

3. Methane reacts with steam at low temperatures to yield carbon monoxide and hydrogen.
4. The incomplete combustion of methane yields coal.
5. Ethane is the most complex hydrocarbon in structure.
6. Methane and ethane are higher-boiling gaseous constituents than the butanes.
7. *N*-butane can be transformed to isobutane.
8. Propylene can be obtained by the method of decomposition of ethylene.
9. Propane cannot be liquefied at all.

Task 15. Tell about some of the chemicals mentioned in the text, describe their most important properties and applications.

Unit 3. Text Compression

Среди основных этапов научно-информационной деятельности важное место занимает аналитико-синтетическая переработка поступающей информации на родном и иностранных языках, включающая перевод с одного языка на другой, обзоры, аннотирование, реферирование и т.д.

Реферат (Review) — это сжатое, краткое изложение текста с основными фактическими данными, выводами и рекомендациями. По полноте изложения содержания печатного текста рефераты принято делить на рефераты-резюме и рефераты-конспекты.

Требования к составлению реферата:

1. Реферат строится на основе ключевых фрагментов, выделенных из текста.
2. Реферат должен быть написан литературным языком с использованием научной терминологии, принятой в научной литературе по той или иной отрасли науки и техники.

3. Реферат должен объективно и точно отражать содержание первоисточника; нельзя вносить какие-либо изменения или дополнения по существу реферируемой работы.

4. Не следует в реферате излагать собственную точку зрения или критические замечания.

Структура реферата:

1) Выходные данные источника: фамилия и инициалы автора, заглавие, издательство, место, год издания (для журнала — название и номер).

2) Главная мысль, идея реферируемого материала.

3) Изложение содержания: реферируемый материал излагается в последовательности, в которой он приводится в тексте.

4) Выводы автора или результаты исследований.

Порядок работы над рефератом:

1. Просмотреть текст с целью ознакомления с его содержанием.

2. Ознакомиться с графической частью (чертежами, схемами, таблицами
и т.п.) с целью уточнения содержания текста при чтении.

3. Выделить абзацы текста, содержащие основную информацию, подтверждающую, раскрывающую и уточняющую заглавие текста.

4. Опустить второстепенную информацию.

5. Повторно прочитать выделенные абзацы.

6. Преобразовать сложные синтаксические конструкции в более простые.

8. Обобщить отдельные сведения в единый связный текст.

9. Записать полученную сокращенную информацию по указанной выше схеме.

Аннотация (Abstract / Summary) — это краткая характеристика текста с изложением наиболее важных положений.

Основным отличием аннотации от реферата является то, что реферат дает представление о содержании оригинала, а аннотация — только о его тематике. Аннотация перечисляет, называет проблемы оригинала, но не раскрывает их.

По целевому назначению и содержанию аннотации подразделяются на справочные и рекомендательные (или информационные и описательные), специализированные и общие.

Требования к составлению аннотации:

1. При составлении аннотации следует избегать сложных конструкций и предложений.
2. Аннотацию необходимо составлять, сохраняя логическую структуру текста.
3. Для обобщения информации рекомендуется использовать специальные обороты и фразы-клише, приведенные ниже.
4. Названия фирм, компаний следует давать в их оригинальном написании; аббревиатуры и различные сокращения необходимо использовать в соответствии с общепринятыми в справочной литературе.

Структура аннотации:

1) Выходные данные источника: фамилия и инициалы автора, заглавие, издательство, место, год издания (для журнала — название и номер).
2) Введение общей темы.
3) Предельно краткое изложение основных вопросов, рассматриваемых в тексте.
4) Общие выводы или заключения автора статьи, эмоционально-оценочное отношение составителя аннотации к аннотируемому тексту.

Список выражений, рекомендуемых для написания реферата и аннотации:

1. The article (text) is entitled ... The article is head-lined ...	Статья озаглавлена ...
2. The author of the article is ... The article is written by ...	Автор статьи — ... Статья написана ...
3. It is (was) published in ...	Она (была) опубликована в ...
4. The main idea of the article is ... The subject of information is ... The article deals with ... The text is about ... The article is devoted to ... The article touches upon ... The article describes ...	Основная идея статьи ... Тема сообщения ... Статья рассматривает ... В тексте сообщается о ... Статья посвящена ... Статья затрагивает ... Статья описывает ...
5. The author reports (states, stresses, thinks) ... It is pointed out that... It is stressed that ... It is shown that... The problems of ... are considered Special attention is given to ... An important information is given on..	Автор сообщает (заявляет, подчеркивает, думает) ... Указывается, что ... Подчеркивается, что ... Показано, что ... Рассматриваются проблемы ... Особое внимание уделяется ... Предоставляется важная информация о ...
5. The conclusion is made that ... Conclusions are drawn ... The author comes to the conclusion that ...	Делается вывод о ... Делаются выводы ... Автор приходит к выводу, что...
6. The article is of importance (interest) to ...	Статья важна (представляет интерес) для …

Task 1. Read the text and write an abstract using the recommended expressions

From carbon black to PVC

Before oil and gas were freely available, people made everyday things from natural materials. Clothes were made from cotton, wool, and leather. Containers, for example bottles and cups, were made from metal, glass, and clay (soft earth that becomes hard when cooked). Paints and cosmetics were made from plants and minerals.

One example of a natural product is carbon black. It's a colouring used in ink for writing and drawing and for paint. It is made by burning wood, oil, or other natural materials. It was discovered in prehistoric times, and it's commonly used today.

The first petrochemical factory was built in 1872, and it made carbon black from natural gas. Carbon black wasn't a new product, but using a factory was a new way of making it. It became possible to make large amounts of it cheaply because natural gas was plentiful and inexpensive. At that time, carbon black was used to make ink, paint, and crayons. It is now used mostly to make car tyres.

In the early 1900s, the petrochemical business began to grow. There were a lot of oil refineries, and they created chemical by-products. Oil companies wanted to find ways to use these chemicals.

Soon scientists and engineers learned to change the hydrocarbon molecules in coal, petroleum, and refinery by-products. From the 1920s to the 1940s, familiar man-made products like nylon, polystyrene, and polyvinyl chloride (PVC) were developed. Synthetic dyes, paints, and medicines were invented.

Today, petrochemical products are everywhere. They are very useful, but they also have some problems. People throw away a lot of plastic products because they are inexpensive. One problem with plastics is that generally they do not rot or break up like natural materials. Plastic bags are already polluting oceans and killing wildlife. They cannot easily be remelted and reused. Scientists and petrochemical manufacturers continue their work to develop safe and useful products.

Unit 4

Text A. Petroleum Refineries

Task 1 Write down and try to remember the following words and expressions:

atmospheric residue – остаток атмосферной перегонки, мазут
conversion unit – установка по переработке
cut - фракция, содержание воды/газа в нефти
downstream process – процесс переработки нефти и газа
feed (fed, fed) – подавать, вводить
feedstock – исходное сырье
fraction – компонент нефти, продукт перегонки
hydroskimming – первичная переработка (гидрооблагораживание)
oblige - обязывать
product slate – ассортимент продукции
refinery – нефтеперерабатывающий завод
reform – облагораживать, улучшать качество
sequence – последовательность
steam cracker – паровая крекинг-установка
vacuum gasoil – вакуумный газойль
vacuum residue – остатки вакуумной перегонки, вакуумный мазут

Task 2 Read the text.

Petroleum refineries are complex plants, where the combination and sequence of processes are usually very specific to the characteristics of the raw materials (crude oil) and the products to be produced. In a refinery, portions of the outputs from some processes are fed back into the same process, fed to new processes, fed back to a previous process or blended with other outputs to form finished products. All refineries are different regarding their configuration, process integration, feedstock, feedstock flexibility, products, product mix, unit size and design and control systems. In addition, differences in owner's strategy, market situation, location and age of the refinery, historic development, available infrastructure and environmental regulation are amongst other reasons for the wide variety in refinery concepts, designs and modes of operation.

The production of a large number of fuels is by far the most important function of refineries and will generally determine the overall configuration and operation. Nevertheless, some refineries can produce valuable non-fuel products such as feedstocks for the chemical and petrochemical industries. Examples are mixed naphtha feed for a steam cracker, recovered propylene, butylenes for polymer applications and aromatics manufacture. Other speciality products from a refinery include bitumen, lubricating oils, waxes and coke.

Refining crude oil into usable petroleum products can be separated into two phases and a number of supporting operations. The **first phase** is desalting of crude oil and the subsequent distillation into its various components or "fractions". A further distillation of the lighter components and naphtha is carried out to recover methane and ethane for use as refinery fuel, LPG (propane and butane), gasoline blending components and petrochemical feedstocks. This light product separation is done in every refinery.

The **second phase** is made up of three different types of "downstream" processes: combining, breaking and reshaping fractions. These processes change the molecular structure of hydrocarbon molecules either by breaking them into smaller molecules, joining them to form larger molecules, or reshaping them into higher quality molecules. The goal of those processes is to convert some of the distillation fractions into marketable petroleum products through any combination of downstream processes. Those processes define the various refinery types, of which the simplest is the 'Hydroskimming', which merely desulphurises and catalytically reforms selected cuts from the distillation unit. The amounts of the various products obtained are determined almost entirely by the crude composition. If the product mix no longer matches the market requirements, conversion units have to be added to restore the balance.

The market demand has for many years obliged refineries to convert heavier fractions to lighter fractions with a higher value. These refineries separate the atmospheric residue into vacuum gasoil and vacuum residue fractions by distillation under high vacuum, and then feed one or both of these cuts to the appropriate conversion units. Thus, by inclusion of conversion units, the product slate can be altered to suit market requirements irrespective of the crude type. The number and the possible combinations of conversion units are large.

Task 3. Find English equivalents for the following collocations:

рыночный спрос; соответствовать требованиям рынка (2); независимо от типа сырой нефти; обессерить/десульфурировать; восстановить баланс; можно разделить на две фазы; режим работы; возможные сочетания; состоять из; последующая дистилляция; изменить молекулярное строение; формирование продуктов перегонки.

Task 4. Find 10-12 international words in the text above and translate them.

Task 5. Make up phrases by matching the words in the two columns the way they are used in the text:

1. product	a. refineries
2. historic	b. materials
3. control	c. structure
4. petroleum	d. development
5. petrochemical	e. unit
6. steam	f. demand
7. supporting	g. oils
8. downstream	h. residue
9. market	i. industry
10. atmospheric	j. systems
11. lubricating	k. mix
12. distillation	l. processes
13. molecular	m. operations
14. raw	n. cracker

Task 6. Answer the questions:

1) What do the combination and sequence of processes at the refinery depend on?
2) What determines the overall configuration and operation of the refinery?
3) What are the reasons for designs and modes of operation?
4) What is the first phase of refining crude oil?
5) What processes is the second phase made up of?
6) How do the processes of the second phase change the molecular structure of hydrocarbon molecules?
7) Why can the product slate be altered?

8) How do refineries separate the atmospheric residue into vacuum gasoil and vacuum residue fractions?
9) What non-fuel products do some refineries produce?
10. What determines the amounts of the various products obtained?

Task 7. Complete the sentences with the words and word combinations below:

can produce, breaking, have to be added, is carried out, selected, lighter fractions, regarding, to convert

1. The refineries are different … their configuration, process integration, feedstock, feedstock flexibility, products, product mix, unit size and design and control systems.
2. Some refineries … valuable non-fuel products.
3. Distillation of the lighter components and naphtha … to recover methane and ethane for use as refinery fuel.
4. The goal of downstream processes is … some of the distillation fractions into marketable petroleum products.
5. Hydroskimming desulphurises and catalytically reforms … cuts from the distillation unit.
6. Conversion units … to restore the balance if the product mix no longer matches the market requirements.
7. Refineries have to convert heavier fractions to … with a higher value.
8. The types of "downstream" processes are combining, … and reshaping fractions.

Task 8. Write an abstract of the text using the recommended expressions in Unit 3.

Text B. Atmospheric and Vacuum Distillation

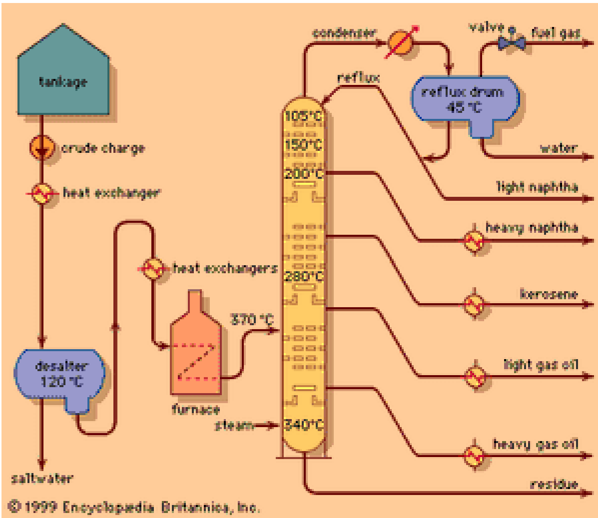
Task 9. Read the following words and try to remember them:

coking – закоксовывание
draw – погон, фракция
flashed vapour – выделяемый пар
fractionation tray – тарелка ректификационной колонны
hydrotreatment – гидроочистка

reflux drum – рефлексная емкость, сборник возврата
side stream – боковая фракция
steam ejector – пароструйный насос
strip – отделять, отгонять
stripping steam – технологический/отгоночный пар
stripping tower – колонна для отгона легких фракций, отпарная колонна
treater – технологическая установка, колонна

Task 10. Read the text and try to understand it.

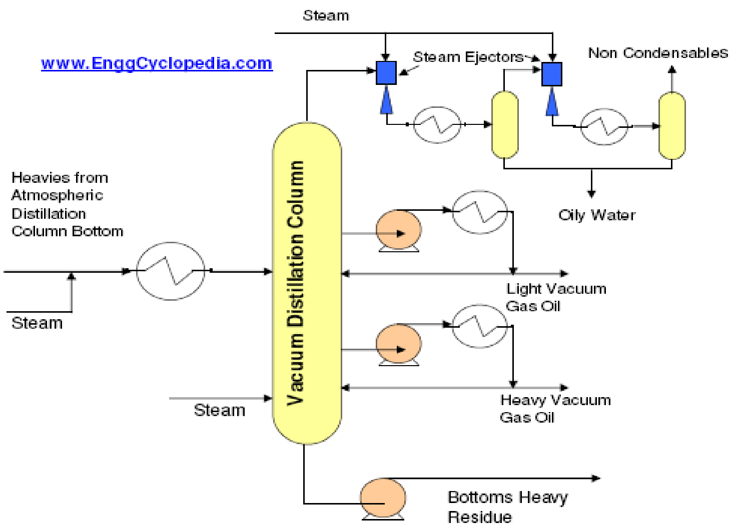
These are two primary distillations preceded by crude oil desalting and they are the first and fundamental separation processes in a refinery.



The CDU is the first important processing step in a refinery. Crude oil is heated to elevated temperatures and then generally subjected to distillation under atmospheric pressure (or slighly higher) separating the various fractions according to their boiling range. Heavier fractions from the bottom of the CDU, which do not vaporise in this column, can be further separated later by vacuum distillation.

Atmospheric distillation involves the heating, vaporisation, fractionation, condensation, and cooling of feedstocks. The desalted crude oil is heated to about 300 - 400 .C and fed to a vertical distillation column at atmospheric pressure where most of the feed is vaporised and separated into its various fractions by condensing on 30 to 50 fractionation trays, each corresponding to a different condensation temperature. The lighter fractions condense and are collected towards the top of the column. The overhead hydrocarbon vapours are condensed and accumulated in the overhead reflux drum of the main fractionator. In this drum sour water, light fractions and stripping steam are separated from the hydrocarbon liquid. The overhead hydrocarbon liquid, the so-called naphtha minus stream, is commonly fed directly to the downstream naphtha treater. Within each atmospheric distillation tower, a number of side-streams of low-boiling point components are removed from different trays in the tower. These low-boiling point mixtures are in equilibrium with heavier components which must be removed. The side-streams are each sent to a different small stripping tower containing four to ten trays with steam injected under the bottom tray. The steam strips the light-end components from the heavier components and both the steam and light-ends are fed back to the atmospheric distillation tower above the corresponding side-stream draw tray. Most of these fractions generated in the atmospheric distillation column can be sold as finished products after a hydrotreatment, or blended with products from downstream processes.

Vacuum distillation.



Atmospheric residue is heated up to 400 °C, partially vaporised (30 - 70 % by weight) and flashed into the base of the vacuum column at a pressure between 40 and 100 mbar. The vacuum inside the fractionator is maintained with steam ejectors, vacuum pumps, barometric condensers or surface condensers. The injection of superheated steam at the base of the vacuum fractionator column further reduces the partial pressure of the hydrocarbons in the tower, facilitating vaporisation and separation. The unvaporised part of the feed forms the bottom product and its temperature is controlled at about 355°C to minimise coking. The flashed vapour rising through the column is contacted with wash oil (vacuum distillate) to wash out entrained liquid, coke and metals. The washed vapour is condensed in two or three main spray sections. In the lower sections of the column the heavy vacuum distillate and optional medium vacuum gasoil are condensed. In the upper section of the vacuum column the light vacuum distillate is condensed. Light (non-condensable) components and steam from the top of the column are condensed and accumulated in an overhead drum for separating the light noncondensables, the heavier condensed gasoil and the water phase. The most important operational aspect of a vacuum unit is the quality of the heavy vacuum gasoil, especially when this is fed to a hydrocracker unit.

Task 11. Guess the meaning of the word combinations or look them up in a dictionary:

crude oil desalting; processing step; boiling range; condensation temperature; overhead hydrocarbon vapours; low-boiling point components; blended with products; superheated steam; light-end components; bottom product; washed vapour; light noncondensables; main fractionators; are in equilibrium; atmospheric residue; wash oil.

Task 12. Match the words in Column A with the synonyms in Column B.

Column A	Column B
1. step	a. form
2. involve	b. constituent
3. corresponding	c. different
4. commonly	d. fluid
5. component	e. include

6. generate	f. vapour
7. blend	g. usually
8. various	h. stage
9. liquid	i. installation
10. a number of	j. appropriate
11. steam	k. decrease
12. unit	l. mix
13. reduce	m. an array of

Task 13. Answer the questions on the text:

1. What are fundamental separation processes in a refinery?
2. What does atmospheric distillation involve?
3. How many fractionation trays are there in a vertical distillation column?
4. What is the pressure in a vacuum column?
5. What is done to minimize coking?
6. What is condensed in the lower sections of the vacuum column?
7. Which process can be used for heavier fractions from the bottom of the CDU?
8. Where are the overhead hydrocarbon vapors condensed and accumulated?
9. How is the feed separated into its various fractions in a vertical distillation column?
10. What happens in the overhead reflux drum of the main fractionator?

Task 14. Match the beginning and the ending of the sentences

1) Crude oil is heated to elevated temperatures and then subjected to distillation	a) are separated from the hydrocarbon liquid in the overhead reflux drum.
2) Heavier fractions which do not vaporize in the CDU	b) be sold as finished products after a hydrotreatment.
3) The lighter fractions condense and are collected	c) the atmospheric distillation tower.
4) Sour water, light fractions and stripping steam	d) in the lower sections of the column.
5) The steam strips the light-end components from the	e) can be further separated later by vacuum distillation.

6) Both the steam and light-ends are fed back to	f) heavier components.
7) Most of the fractions generated in the atmospheric distillation column can	g) under atmospheric pressure.
8) The heavy vacuum distillate and optional medium vacuum gasoil are condensed	h) towards the top of the column.

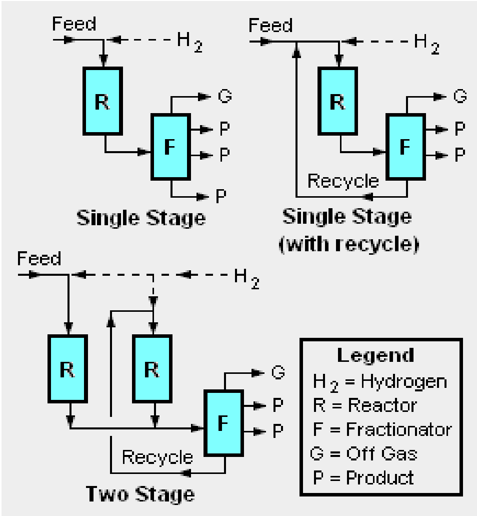
Task 15. Tell about the two primary distillation processes: atmospheric and vacuum.

Unit 5
Text A. Hydrocracking

Task1. Write down the words and remember them:

deasphalted oil – деасфальтизат
dewaxing- удаление парафина
feed – исходный продукт
fixed-bed reactor – реактор с неподвижным слоем катализатора
foul – отравлять (катализатор)
hydroconversion – гидропереработка
once-through – однократный
process stream – технологический поток
smoke point – высота некоптящего пламени
sour water – серосодержащая вода
suppress – подавлять
two-fold – двойной, двоякий

Task 2. Read the text:



It is one of the most versatile of all refining processes, capable of converting any fraction from atmospheric gasoils to residual (deasphalted) oil into products with a lower molecular weight than the feed. The hydrocracking reactions occur under high hydrogen partial pressure in the presence of a catalyst with a two-fold function, hydro-genation and cracking. Hydrocracking may also be used for the cracking of superior fuels and the production of lubricants. The type of catalyst maximises the production of naphtha, mid-distillates or lub production. The presence of hydrogen suppresses the formation of heavy residual material and increases the yield of gasoline by reacting with the cracked products, giving net products, which are a mixture of pure paraffins, naphthenes and aromatics. Hydrocracking produce mid-distillates with outstanding burning and cold flow properties as follows:

- Kerosene with low freezing points and high smoke points.
- Diesel fuels with low pour points and high cetane numbers.
- Heavy naphthas with a high content of single-ring hydrocarbons.
- Light naphthas with a high isoparaffin content.
- Heavy products that are hydrogen-rich for feed FCC units, ethylene plants (LVOC), or lub oil dewaxing and finishing facilities.

When hydrocracking is applied to heavy residues, a pretreat-ment is needed to remove high metal content before the hydrocracking reaction is produced. Residue hydro-conversion is type of hydrocracking applied to convert low-value vacuum residue and other heavy residue streams to lighter low-boiling hydrocarbons by reacting them with hydrogen.

The main feed stream to a hydrocracker is the heavy vacuum distillate stream from the High Vacuum unit. Those feedstocks are fractions very difficult to crack and cannot be cracked effectively in catalytic cracking units. Other process streams such as heavy cycle oil from the catcracker unit, heavy gasoils from the coker or visbreaker unit, extracts from lube oil units, mid-distillates, residual fuel oils and reduced crudes may be blended to the main heavy vacuum distillate stream. The main products are LPG, gasoline, jet fuel and diesel fuel, all practically sulphur-free. The production of methane and ethane is very low, normally less than 1 %.

Hydrocracking normally use a fixed-bed catalytic reactor with cracking occurring under substantial pressure (35 to 200 kg/cm2) in the presence of hydrogen at temperatures between 280 and 475 .C. This process also breaks the heavy, sulphur-nitrogen- and oxygen bearing hydrocarbons and releases these impurities to where they could potentially foul the catalyst. For this reason, the feedstock is often first hydrotreated and dewatered to remove impurities (H_2S, NH_3, H_2O) before being sent to the hydrocracker. If the hydrocracking feedstocks are first hydrotreated to remove impurities, sour water and sour gas streams will contain relatively low levels of hydrogen sulphide and ammonia in the fractionator.

Depending on the products desired and the size of the unit, hydrocracking is conducted in either single-stage or multi-stage reactor processes. Hydrocrackers can be classified in three categories, single-stage once-through, single-stage recycle and two-stage recycle

Task 3. Find Russian equivalents for the following words and word expressions:

hydrocracking reactions; under high hydrogen partial pressure; hydrogenation; cracked products; lub production; mid-distillates; burning and cold flow properties; pretreatment; heavy naphtha; light naphtha; heavy cycle oil; hydro-conversion; catalyst; low pour point.

Task 4. Answer the questions:

1. What kind of process is hydrocracking?
2. What is the influence of a catalyst?

3. Why is the yield of gasoline increased?
4. What is residue hydro-conversion? Where is it applied?
5. Why is the feedstock first hydrotreated and dewatered?
6. What kind of reactor can be used and what does it depend on?
7. How can hydrocrackers be classified?
8. What mid-distillates does hydrocracking produce? What are their properties?
9. Why is a pretreatment needed when hydrocracking is applied to heavy residues?
10. What kind of process streams can be blended to the main heavy vacuum distillate stream?

Task 5. Complete the sentences with the words and word combinations below:

low freezing, molecular weight, depending on, hydrocarbons, catalytic cracking, low pour points, superior fuels, gasoline

1. Products with a lower … than the feed are obtained in hydrocracking.
2. Hydrocracking may be used for the cracking of … and the production of lubricants.
3. Kerosene possesses such properties as … points and high smoke points.
4. Diesel fuels have such features as … and high cetane numbers.
5. The presence of hydrogen increases the yield of … by reacting with the cracked products.
6. Heavy vacuum distillates are very difficult to crack and cannot be cracked effectively in … units.
7. Hydrocracking is conducted in either single-stage or multi-stage reactor processes … the products desired and the size of the unit.
8. Hydrocracking with a fixed-bed catalytic reactor also breaks the heavy, sulphur-nitrogen- and oxygen bearing …

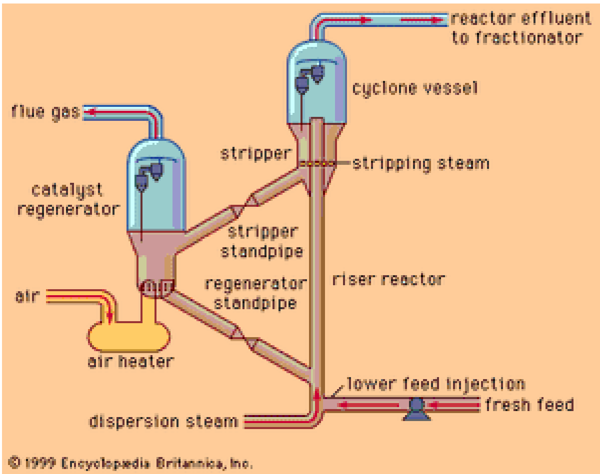
Text B. Catalytic Cracking

Task 6. Read the following words and try to remember them:

alkylation –алкилирование
atomise – распылять, измельчать

etherification – эфиризация
fluid catalytic cracking (FCC) – крекинг с флюидизированным катализатором
fluidised – псевдоожиженный
intimately – тщательно
olefinic – олефиновый
residue catalytic cracking (RCC) – каткрекинг осадка
riser reactor – лифт-реактор
silica alumina – алюмосиликат
visbroken – с пониженной вязкостью
w/w – weight in weight – массовая доля

Task 7. Read the text and try to understand it.



Catalytic cracking is the most widely used conversion process for upgrading heavier hydrocarbons into more valuable lower boiling hydrocarbons. It uses heat and a catalyst to break larger hydrocarbon molecules into smaller, lighter molecules. Unlike the hydrocracker process, no hydrogen is used and consequently, limited desulphurisation takes place. Compared to other heavy oil catalytic conversion processes the FCC process is superior in being able to handle larger quantities of metals, sulphur and asphaltenes. One drawback is the minimal flexibility in changing the product yields.

Normally the main feed stream to a catalytic cracking unit (catcracker) is the heavy vacuum distillate stream from the vacuum distillation unit. Other process streams may be blended into the catcracker feed such as heavy gasoil from the atmospheric distillation unit, coker or visbroken gasoil, deasphalted oil and extracts from lub oil units and sometimes a small quantity of atmospheric residue. Those streams may be hydrotreated to make them suitable for the catcracker. Compared to other conversion processes the catalytic cracker process is characterised by a relatively high yield of good quality gasoline and relatively high quantities of C3 and C4. Both products are highly olefinic and therefore ideal feed streams for the alkylation, etherification and petrochemical industries. One drawback of the FCC process is the very low quality of the mid-distillate products in terms of sulphur, olefins, aromatics and cetane index.

The *residue catalytic cracking (RCC)* unit is a catcracker unit used to upgrade heavier fractions such as atmospheric residue. The majority of products need further treatment prior to storage.

A number of different catalytic cracking designs are currently in use in the world, including fixed-bed reactors, moving-bed reactors, fluidized-bed reactors and once-through units. The fluidized- and moving-bed reactors are by far the most prevalent in world refineries.

Fluid catalytic cracking (FCC)

Fluid catalytic cracking units are by far the most common cat-cracking units. The FCC unit consists of three distinct sections, the reactor-regenerator section including air blower and waste heat boiler, the main fractionator section including wet gas compressor and the unsaturated gas plant section. In the FCC process, oil and oil vapour preheated to 250 to 425°C is contacted with hot catalyst (zeolite) at about 680 - 730°C in the riser reactor. To enhance vaporisation and subsequent cracking, the feed is atomised with steam. The cracking process takes place at temperatures between 500 and 540°C and a pressure of 1.5 - 2.0 bar. Most catalysts used in catalytic cracking are zeolites (some 15% w/w) supported by amorphous synthetic silica alumina with metals. The catalyst is in a fine, granular form which mixes intimately with the vaporised feed. The fluidised catalyst and the reacted hydrocarbon vapour separate mechanically in a (two-stage) cyclone system and any oil remaining on the catalyst is removed by steam stripping.

Task 8. Find English equivalents for the following word expressions:

псевдоожиженный катализатор; отгонка водяным паром; циклонная установка; реактор с подвижным катализатором; усилить парообразование; крекирование происходит; высококачественный бензин; реактор с псевдоожиженным слоем; высокая производительность; небольшое количество остатков атмосферной перегонки.

Task 9. Answer the questions:

1. What is catalytic cracking used for?
2. Why does limited desulphurisation take place?
3. What is the main feed stream to a catalytic cracking unit?
4. What other process streams may be blended into the catcracker feed?
5. What is the catalytic cracker process characterized by?
6. What is the drawback of the FCC process?
7. What is a residue catalytic cracking unit used to?
8. What sections does the FCC unit consist of?
9. Why is the feed atomized with steam
10. What form does catalyst have in FCC?

Task 10. Make up phrases by matching the words in the two columns the way they are used in the text:

1, process	a. feed
2. heavy	b. industries
3. hydrocarbon	c. reactor
4. catalytic	d. blower
5. jet	e. stripping
6. vaporised	f. residues
7. steam	g. process
8. petrochemical	h. index
9. to enhance	i. stream
10. air	j. fuel
11. cetane	k. molecules
12. mid-distillate	l. vaporisation

Task 11. Write an abstract of the texts (Hydrocracking and Catalytic cracking) using the recommended expressions in Unit 3.

Unit 6

Text A. Catalytic Reforming

Task 1. Read the following words and try to remember them:

carbon laydown – отложение углерода
catalyst bed – слой катализатора
catalyst collection vessel – сборник катализатора
cyclization reaction – реакция замыкания цикла
enhancer – усилитель (реакции)
foster – способствовать
promoter – ускоритель
regeneration tower - регенерационная колонна
rhenium – рений
semi-regenerative – с периодической регенерацией
straight-run gasoline – бензин прямой перегонки
tin - олово

Task 2. Read the following text:

This process upgrades naphtha (light distillates) into aromatic-rich streams that can be used for octane enhancers for gasoline blending or as a petrochemical feedstock. Originally the process was developed in the 1950s to upgrade low-octane, straight-run gasoline to high-octane liquid. This process converts naphthenes into corresponding aromatics and isomerizes paraffinic structures to isomeric forms. The naphtha charge is a varying mixture of C6–C11 paraffins, naphthenes, and aromatics. In a catalytic reformer, aromatic compounds pass through the system unchanged, while naphthalenes react selectively to form aromatics.

In the reformer, multiple reactions occur simultaneously. This process is endothermic and is subject to carbon laydown; thus, refiners must regenerate reforming catalysts. Several catalyst-regenerating approaches are possible. Semi-regenerative processes use moving-bed catalyst reactors. The catalyst bed reactors are placed side-by-side, and hydrogen is used to lift and convey the catalyst to the next bed, except for the last bed where it is regenerated. Other reforming designs use a continuous moving bed to continuously regenerate a portion of the catalyst. The reactors are stacked on top of each other, and gravity moves the catalyst through the bed. From the last reactor, the catalyst is lifted by nitrogen or hydrogen to a catalyst collection vessel. The catalyst is regenerated in a regeneration tower and returned to process.

In the catalytic reforming process, the feed is pumped to operating pressure and mixed with a hydrogen-rich gas before heating to reaction temperatures. The net hydrogen produced is a by-product of the dehydrogenation and cyclization reactions.
In the late 1960s, it was discovered that adding certain promoters such as rhenium, germanium, or tin to the platinum-containing catalyst would reduce cracking and coke formation. The resulting bi-metallic and tri-metallic catalysts facilitate a lower operating pressure without fostering hydrocracking conditions. Earlier reforming pressures ranged around 3.45 MPa; with improved catalyst systems, such operations now use operating pressures of 1.2-2.6 MPa. Advances in continuous catalyst design permit using operating pressures as low as 0.345 MPa.

Operating temperatures are also critical. The listed reactions are endothermic. The best yields occur along isothermal reaction zones, but are difficult to achieve. Instead, the reaction beds are separated into a number of adiabatic zones operating at 260-540 °C with heaters between stages to supply the necessary energy to promote heat of reaction and hold the overall train near or at a constant temperature.

Three or four zones are commonly used to achieve high-octane products.

Task 3. Find English equivalents for the following word expressions: улучшать состояние; смешение бензинов; нефтехимическое сырье; ароматические нефтепродукты; установка реформинга; очистительная установка; процессы с периодической регенерацией; рабочее давление; побочный продукт процесса дегидрогенизации; было обнаружено; усовершенствованная каталитическая система; повышать теплоту реакции

Text B. Bitumen

Task 4. Read the following words and try to remember them:

air rate – расход воздуха
bitumen blowing unit (BBU) – установка окисления битума
blowing – нагнетание воздуха
gravel – гравий
penetration – степень твердости битуминозных материалов, проникновение
to raise steam – поднимать пар
residence time – время пребывания
to sparge – впрыскивать, орошать
quenching – резкое охлаждение

Task 5. Read the text:

Bitumen is a residue derived from certain crude oils after vacuum distillation has removed waxy distillates. Bitumen is normally mixed with other components (e.g. gravel) to produce asphalt that is used in road paving, roof coating and pipe sealing or coating. Bitumen production only appears in some refineries. There are also some refineries that specialize in producing those components.

The desired properties of bitumen may be achieved either by adjusting distillation conditions or by "blowing". In the latter process, air is blown into hot bitumen causing dehydrogenation and polymerisation reactions and giving a harder product with higher viscosity, higher softening point and a reduced 'penetration' (The penetration, often used as the main criterion, refers to the depth of penetration by a standard needle in a bitumen sample at standard conditions.). The properties of the blown bitumen are determined by the residence time in the oxidation vessel, the air rate and the liquid temperature. If any of these parameters is increased, the penetration is reduced and the softening temperature is raised.

In most applications the hydrocarbon feed stream to a bitumen blowing unit (BBU) is the bottom residue stream from a vacuum unit and in some instances the residue (extract) from a deasphalting unit.

Normally, a number of different grades of bitumen are produced in campaigns and these are further modified by blending with other high-boiling components such as vacuum residue, heavy gas oil or synthetic polymers. In this way a single blowing unit is able to cater for a wide range of bitumen grades for various applications.

The BBU will either operate on a continuous basis or in batch mode depending on the quality of the vacuum residue feedstock and the required bitumen product specification. Continuous processes are more spread in refineries.

A typical continuously operated BBU receives its hot feed directly from the vacuum distillation unit. Where the bitumen feed is received from storage, an additional fired heater may be required to preheat the feed to a temperature of about 200 - 250°C, but can be up to 550 .C. With a batch-operated BBU, a feed buffer vessel is usually included to store the hot feed stream from the vacuum unit.

The residue feedstream is pumped into the top of the oxidation vessel. Operating pressure in the top of the oxidation vessel is normally around 1 bar and in the bottom around 2 bars, depending on the height of the vessel. As air is sparged into the base of the vessel, oxidation of the residue takes place, resulting in heat. The temperature in the oxidation vessel, which determines to a certain extent the bitumen grade, is normally controlled between 260 – 300 °C. Different options are applied, taking in colder feed to the oxidation vessel, recirculation of cooled bitumen product from the bitumen rundown cooler, and in older units even direct water quenching is applied. The blown bitumen is removed from the bottom of the oxidation vessel and cooled by raising steam before being sent to storage.

Task 6. Find English equivalents for the following word expressions:

реакции дегидрогенизации и полимеризации; вязкость; точка размягчения; образец битума; аппарат окисления; глубина проникновения стандартной иглы; установка деасфальтизации; разные сорта битума; тяжелый газойль; непрерывный процесс, в определенной степени, оксидированный битум

Task 7. Answer the questions:

1. What is bitumen?
2. How can the desired properties of bitumen be achieved?
3. What are the hydrocarbon feed stream to a bitumen blowing unit?
4. How can different grades of bitumen be modified?
5. Where may an additional fired heater be required? What for?
6. What is the temperature in the oxidation vessel?

Supplementary Reading

Text 1. Fluid Coking Process

Fluidized bed coking is a petroleum refining process in which heavy petroleum feeds, typically the non-distillable residues (resids) from fractionation, are converted to lighter, more useful liquid products by thermal decomposition (coking) at elevated reaction temperatures, typically about 480 to 590°C, (about 900 to 1100°F). The process is carried out in a unit with a large reactor vessel containing hot coke particles which are maintained in the fluidized condition at the required reaction temperature with steam injected at the bottom of the vessel with the average direction of movement of the coke particles being downwards through the bed. The heavy oil feed is heated to a pumpable temperature, mixed with atomizing steam, and fed through multiple feed nozzles arranged at several successive levels in the reactor, usually referred to as "rings" since they are arranged around the periphery of the reactor at different, vertically spaced intervals in the upper part of the reactor. Steam is injected into a stripper section at the bottom of the reactor and passes upwards through the coke particles in the stripper as they descend from the main part of the reactor above and promotes fluidization of the particles in the bed. The feed liquid coats a portion of the coke particles in the fluidized bed and subsequently decomposes into layers of solid coke and lighter products which evolve as gas or vaporized liquid. The light hydrocarbon products of the coking (thermal cracking) reactions vaporize, mix with the fluidizing steam and pass upwardly through the fluidized bed into a dilute phase zone above the dense fluidized bed of coke particles. This mixture of vaporized hydrocarbon products formed in the coking reactions continues to flow upwardly through the dilute phase with the steam at superficial velocities of about 1 to 2 metres per second (about 3 to 6 feet per second), entraining some fine solid particles of coke. Most of the entrained solids are separated from the gas phase by centrifugal force in one or more cyclone separators, and are returned to the dense fluidized bed by gravity through the cyclone diplegs. The mixture of steam and hydrocarbon vapors from the reactor is subsequently discharged from the cyclone gas outlets into a scrubber section in a plenum located above the reaction section and separated from it by a partition. It is quenched in the scrubber section by contact with liquid descending over scrubber sheds in a scrubber section. A pumparound loop circulates condensed liquid to an external cooler and back to the top row of scrubber section to provide cooling for the quench and condensation of the heaviest fraction of the liquid product. This heavy fraction is typically recycled to extinction by feeding back to the fluidized bed reaction zone.

The solid coke from the reactor, consisting mainly of carbon with lesser amounts of hydrogen, sulfur, nitrogen, and traces of vanadium, nickel, iron, and other elements derived from the feed, passes through the stripper and out of the reactor vessel to a burner where it is partly burned in a fluidized bed with air to raise its temperature from about 480 to 700°C (about 900° to 13G0°F), after which the hot coke particles are recirculated to the fluidized bed reaction zone to provide the heat for the coking reactions and to act as nuclei for the coke formation.

The Flexicoking™ process, also developed by Exxon Research and Engineering Company, is, in fact, a fluid coking process that is operated in a unit including a reactor and burner, often referred to as a heater in this variant of the process, as described above but also including a gasifier for gasifying the coke product by reaction with an air/steam mixture to form a low heating value fuel gas. The heater, in this case, is operated with an oxygen depleted environment. The gasifier product gas, containing entrained coke particles, is returned to the heater to provide a portion of the reactor heat requirement. A return stream of coke sent from the gasifier to the heater provides the remainder of the heat requirement. Hot coke gas leaving the heater is used to generate high-pressure steam before being processed for cleanup. The coke product is continuously removed from the reactor. In view of the similarity between the Flexicoking process and the fluid coking process, the term "fluid coking" is used in this specification to refer to and comprehend both fluid coking and Flexicoking except when a differentiation is required.

The dense fluid bed behaves generally as a well-mixed reactor. However, computational fluid dynamics model simulations and tracer studies have shown that significant amounts of coke particles coated in heavy petroleum feed can rapidly bypass the reaction section and descend into the stopper section at the bottom of the reactor while still coated with a film of liquid which is then largely lost as a source of potential liquid product.

Effective mixing of the injected heavy oil feed with the coke particles is vital to reactor operability and liquid yield. A major concern in the process is the formation of liquid-rich agglomerates of coke solids held together by a sticky, adherent liquid film on the coke particles. These agglomerates, with particle sizes substantially larger than average bulk solids, suffer from increased heat and mass transfer limitations and reduce liquid yields. If the liquid were spread more evenly over the coke particles, creating thinner films, the heat and mass transfer limitations could be reduced and subsequently liquid yields would increase. In addition, when the liquid to solid ratio of the agglomerates is reduced, the agglomerates are weaker and more likely to break up so that the steam requirements associated with attrition of the agglomerates might be reduced. The excess steam can be removed from the process to reduce sour water make, or be reemployed in the reactor in an alternative way such as additional feed nozzle atomization.

In order to prolong the average residence time of the wetted coke particles in the reactor, one method of operation is to inject the heavy oil feed through the injection nozzles in the upper part of the reactor but to use the lower rings solely for the injection of steam. More feed injected higher in the bed increases the residence time between the feed zone and stripper, affording more time for the liquid film to dry reducing the fouling in the stripper region.

A typical commercial unit with an average feed rate per nozzle of about 230 mVday (about 1450 sbpd) might have, for example, 96 feed nozzles distributed between 6 feed rings. Rings 1 and 2 at the two highest levels in the reactor might have 20 feed nozzles each, Ring 3 immediately below Ring 2 might have 19 nozzles. Ring 4 might have 16, Ring 5 might have 14 and Ring 6 might have 7. Rings 5 and 6, however, might not be used for feed injection but, instead, could be purged with steam to prevent plugging. Each pair of feed rings (1&2, 3&4, 5&6) could be connected to a separate feed header line which can be varied separately, but typically all feed header lines would be controlled to the same pressure which, in a typical commercial unit, might be in the range of about 1000 to 2000 kPag (for example, from about 1500 tol700 kPag), equivalent to about 145 to 290 psig (for example, from about 220 to 245 psig). The superficial upward velocity in the reactor might range from about 60 cm/sec at the level of the lowest ring (Ring 6), increasing to about 1 m/sec at the level of the highest ring (Ring 1). The average gas to liquid ratio (GLR or steam-to-oil) ratio at which the nozzles are all operated (for nozzles feeding oil) might typically be 0.86 %w/w (the GLR is reported as (mass flow rate steam)/(mass flow rate oil) 100%). [0009] Studies have shown that increasing the gas to liquid ratio (GLR) in the feed nozzle enhances the dispersion of the liquid onto the particles. If this approach is used, the overall steam usage increases, which is not attractive because of restrictions on the processing of sour water from the unit and reduced feed throughput due to reactor top bed velocity restrictions. The objective therefore is to improve feed dispersion and liquid yield without increasing the overall steam usage. The majority of these studies were performed at one fluidization velocity, which was fairly low; on the order of 15 cm/sec (about 0.5 ft/s). More recently, tests have reported the benefits of increasing the fluidization velocities in the region of a feed nozzle: increasing the fluidization velocity to 90 cm/sec (about 3 ft/sec) provides similar benefits as increasing GLR to a feed nozzle. Other reports demonstrated a negligible improvement in jet bed interaction when the gas/liquid ratio was increased from 1.5 %w/w to 2.7 %w/w with a fluidized bed operated at about 40 cm/sec (about 1.3 ft/s). Increasing the fluidization velocity from 15 cm to about 75 cm/sec (about 0.5 ft/sec to 2.5 ft/sec) resulted in a significant improvement in jet bed interaction when using a poorly performing feed nozzle. When comparing a nozzle operating with and without atomization, significant differences were observed at the lower superficial gas velocity, and only a slight decrease in performance was observed at a higher fluidization velocity when the atomization gas was removed.

Text 2. Alkylation

Another method to convert light olefins into gasoline blending stocks is alkylation. In this process, light olefins – propylene, butylene, and amylenes with isobutene – are reacted in the presence of strong acids to form branched chain hydrocarbons. These branched hydrocarbons, often referred to as alkylate, have a high-octane value; thus, it is an excellent contributor to the octane pool.

Alkylation traditionally combines isobutane with propylene and butylene using an acid catalyst, either hydrofluoric (HF) acid or sulfuric acid. The reaction is favored by high temperatures, but competing reactions among the olefins to give polymers prevent high-quality yields. Thus, alkylation is usually done at low temperatures to deter polymerization reactions. Temperatures for HF acid-catalyzed reactions are approximately 40 °C, and for sulfuric acid they are approximately 10 °C. Notably, some acid loss occurs with this process. Approximately 1–1.2 lb of HF acid/bbl of alkylate is consumed, while 25–30 lb of sulfuric acid/bbl of alkylate is consumed. The alkylation feed should be dried and desulfurized to minimize acid loss. Since the sulfuric-acid-catalyzed reactions are carried out below normal atmospheric temperatures, refrigeration facilities are included.

Let us consider one example where dry liquid feed containing olefins and isobutane is charged to a combined reactor–settler. The reactor uses the principle of a differential gravity head to circulate through a cooler before contacting a highly dispersed hydrocarbon feed in the reactor pipe. The hydrocarbon phase, generated in the settler, is sent to a fractionator, which separates LPG-quality propane, isobutane recycle, *n*-butane, and alkylate products. A small amount of dissolved catalyst is also removed from the propane product by a small stripper tower.

Environmental and safety concerns on acid-based processes are promoting research and development efforts on solid-acid alkylation processes. Liquid catalysts pose possible risks to the environment, employees, and the general public from accidental atmospheric releases. Also, these acid catalysts must be regenerated—another reliability and safety issue. Thus, research efforts are directed at investigating other methodologies to produce high-octane alkylation gasoline component streams.

Text 3. Nanotechnology in Oil and Gas Industry

Nanotechnology is the technology of nanoscopic materials with size in the scale which help in enhancing the performance of processes. This technology is relatively a recent development in scientific research and is constantly adding to technological advancement since inception. Fascinating developments which may not have been achieved without nanotechnology have been made. The technology has no limitation as to which field it can be applied. As a result, its applications in the oil and gas are enormous ranging from exploration, reservoir drilling, completion, production processing and refining for enhanced oil recovery, increasing the performance of equipment and improving reservoir production. So at this point, one of the ways that has been found to increase productivity and enhance performance in the oil and gas industry is nanocoating.

Nanocoating is simply coating a material with a nanoscaled material for desirable performance of a system or process. This is achieved in several ways. As an example, Dr. Hung-Jue Sue of Texas A&M University presented a paper at the April 2014 oil and gas conference about his research into anti-corrosion epoxy coating. He iterated that the presentation is one of his research papers to self-assemble nanoclay which has been shown to give impressive performance against metal corrosion since it is one of the major concerns in the oil and gas industry. This problem is basic and should be properly addressed in order not to interrupt production and eventually high cost of repairing. Nanocoating stands as a durable corrective measure for several existing challenges in the oil and gas industry. It helps to prevent drilling equipment from wearing and provides desirable resistance against insulation and corrosion for pipelines and chemical plants. Nanocoating is more environmental friendly and efficient than anti-corrosion paints and other conventional coating methods used in the oil and gas industry. Various reasons account for covering substrates such as underwater pipeline systems, vessels, reactors, and pipe joints but not limited to these. Knowing that nanocoating is anti-static and water resistant, it is widely useful for underwater systems which answer the question of its effectiveness with fluids. It protects color fading. It can also be used to take off dirt particles in pipes since it is a strong dirt repellant. The mode of operation in industries particularly the oil and gas industries subject equipment to severe conditions which are detrimental to the productivity of the industry. However, it should be noted that such severe conditions cannot be averted as exploration, drilling, processing and production are very tedious tasks in the industry. You can imagine the stress pipes and vessels will be subjected to having to transport crude oil from beneath the earth surface for further processing and eventually to end users. There are problems arising along the line which may not be prevented but can be combated. To increase productivity at low cost, the industry wants equipment with high durability and efficiency so as not to be faced with the problem of having to change equipment from time to time, particularly the underground equipment. Nanotechnology has found a gap to bridge in the oil and gas industry. One of such is the special types of nanocoating to protect against yield threatening problems such as corrosion. Nano-structured coating is experiencing growth in the oil and gas industry over the traditional coating as they offer significantly improved performance and ultimately cost effective. Today, properties such as corrosion resistance, abrasive resistance, strength, hardness, friction coefficient, local wear resistance, stress corrosion cracking, electrical resistance, solid solubility, hydrogen solubility, permeability, thermal stability and malleability which are potential solutions to problems in the oil and gas industry have been greatly improved with nanocoating. There are basically a number of ways to achieve this painting of nanosized particles comprising some sort of mineral or chemicals on surfaces. Depending on the particular property to improve, nanocoating can be used to achieve a number of dependable results. Anti-corrosion coating, lubricant coating, thermal coating and anti-fouling coating are the different types of nanocoating that exist.

Lubricant nanocoating. Apart from the fact that the metal parts of machinery make dreadful and unpleasant sounds when they slide against each other they also damage the machinery and eventually flaws its efficiency. This is essentially the benefit of lubricant coating in the oil industry. Lubricant nanocoating is more efficient compared to the conventional lubricants. They keep the machinery at top-notch performance based on the lubrication they provide. This ultimately increases the life span of the machinery.

Thermal nanocoating. Geothermal conditions that could melt the metal of the drills and other equipment used in the extraction process from the earth in the oil industry are being guided against by thermal nanocoating. Most of the time, these equipment have to work to very deep levels of the earth surface for very long period of time in order to get the oil to the surface. As a result, thermal nanocoating helps to provide the equipment with required protection and defense to withstand the heat and very high pressures at those levels.

Anti-fouling nanocoating. It should be noted that pipes, machineries, equipment or facility made of metal and sited underwater have bacteria and plants cling unto the metal surface. The continuous accumulation of these bacteria and plants over time is very disadvantageous to the performance of the machinery.

Additional Information

The main oil refinery processes are presented below.

Vacuum Distillation Unit (VDU) Process

• Process Objective:
– To recover valuable gas oils from reduced crude via vacuum distillation.
• Primary Process Technique:
– Reduce the hydrocarbon partial pressure via vacuum and stripping steam.
• Process steps:
– Heat the reduced crude to the desired temperature using fired heaters
– Flash the reduced crude in the vacuum distillation column
– Utilize pumparound cooling loops to create internal liquid reflux
– Product draws are top, sides, and bottom

Delayed Coking Process

• Process Objective:
– To convert low value resid to valuable products (naphtha and diesel) and coker gas oil.
• Primary Process Technique:
– Thermocracking increases H/C ratio by carbon rejection in a semi-batch process.
• Process steps:
– Preheat resid feed and provide primary condensing of coke drum vapors by introducing the feed to the bottom of the main fractionator
– Heat the coke drum feed by fired heaters
– Flash superheated feed in a large coke drum where the coke remains and vapors leave the top and goes back to the fractionator

– Off-line coke drum is drilled and the petroleum coke is removed via hydrojetting

Fluidic Coking Process

• Process Objective:
– To convert low value resid to valuable products (naphtha and diesel) and coker gas oil.
• Primary Process Technique:
– Thermocracking increases H/C ratio by carbon rejection in a continuous process.
• Process steps:
– Preheat resid feed, scrub coke particles, and provide primary condensing of reactor vapors by introducing the feed to the scrubber
– Resid is atomized into a fluid coke bed and thermocracking occurs on the particle surface
– Coke particles leaving the reactor are steam stripped to remove remaining liquid hydrocarbons
– Substoichiometric air is introduced to burner to burn some of the coke and provide the necessary heat for the reactor
– Reactor vapors leave the scrubber and go to the fractionator

Fluidic Catalytic Cracking (FCC) Process

• Process Objective:
– To convert low value gas oils to valuable products (naphtha and diesel) and slurry oil.
• Primary Process Technique:
– Catalytic cracking increases H/C ratio by carbon rejection in a continuous process.
• Process steps:
– Gas oil feed is dispersed into the bottom of the riser using steam
– Thermal cracking occurs on the surface of the catalyst
– Disengaging drum separates spent catalyst from product vapors
– Steam strips residue hydrocarbons from spent catalyst
– Air burns away the carbon film from the catalyst in either a "partial-burn" or "full-burn" mode of operation
– Regenerated catalyst enters bottom of riser-reactor

HF Alkylation Process

• Process Objective:
– To combine light olefins (propylene and butylene) with isobutane to form a high octane gasoline (alkylate).

• Primary Process Technique:
– Alkylation occurs in the presence of a highly acidic catalyst (hydroflouric acid or sulfuric acid).
• Process steps:
– Olefins from FCC are combined with IsoButane and fed to the HF Reactor where alkylation occurs
– Acid settler separates the free HF from the hydrocarbons and recycles the acid back to the reactor
– A portion of the HF is regenerated to remove acid oils formed by feed contaminants or hydrocarbon polymerization
– Hydrocarbons from settler go to the DeIsobutanizer for fractionating the propane and isobutane from the n-butane and alkylate
– Propane is then fractionated from the isobutane; propane as a product and the isobutane to be recycled to the reactor
– N-Butane and alkylate are deflourinated in a bed of solid adsorbent and fractionated as separate products

Hydrotreating Process
• Process Objective:
– To remove contaminants (sulfur, nitrogen, metals) and saturate olefins andaromatics to produce a clean product for further processing or finished product sales.
• Primary Process Technique:
– Hydrogenation occurs in a fixed catalyst bed to improve H/C ratios and to remove sulfur, nitrogen, and metals.
• Process steps:
– Feed is preheated using the reactor effluent
– Hydrogen is combined with the feed and heated to the desired hydrotreating temperature using a fired heater
– Feed and hydrogen pass downward in a hydrogenation reactor packed with various types of catalyst depending upon reactions desired
– Reactor effluent is cooled and enter the high pressure separator which separates the liquid hydrocarbon from the hydrogen/hydrogen sulfide/ammonia gas
– Acid gases are absorbed from the hydrogen in the amine absorber
– Hydrogen, minus purges, is recycled with make-up hydrogen
– Further separation of LPG gases occurs in the low pressure separator prior to sending the hydrocarbon liquids to fractionation.

Hydrocracking Process

• Process Objective:
– To remove feed contaminants (nitrogen, sulfur, metals) and to convert low value gas oils to valuable products (naphtha, middle distillates, and ultra-clean lube base stocks).
• Primary Process Technique:
– Hydrogenation occurs in fixed hydrotreating catalyst beds to improve H/C ratios and to remove sulfur, nitrogen, and metals. This is followed by one or more reactors with fixed hydrocracking catalyst beds to dealkylate aromatic rings, open naphthene rings, and hydrocrack paraffin chains.
• Process steps:
– Preheated feed is mixed with hot hydrogen and passes through a multi-bed reactor with interstage hydrogen quenches for hydrotreating
– Hydrotreated feed is mixed with additional hot hydrogen and passes through a multi-bed reactor with quenches for first pass hydrocracking
– Reactor effluents are combined and pass through high and low pressure separators and are fed to the fractionator where valuable products are drawn from the top, sides, and bottom
– Fractionator bottoms may be recycled to a second pass hydrocracker for additional conversion all the way up to full conversion.

Catalytic Reforming Process

• Process Objective:
– To convert low-octane naphtha into a high-octane reformate for gasoline blending and/or to provide aromatics (benzene, toluene, and xylene) for petrochemical plants.
Reforming also produces high purity hydrogen for hydrotreating processes.
• Primary Process Technique:
– Reforming reactions occur in chloride promoted fixed catalyst beds; or continuous catalyst regeneration (CCR) beds where the catalyst is transferred from one stage to another, through a catalyst regenerator and back again. Desired reactions include: dehydrogenation of naphthenes to form aromatics; isomerization of naphthenes; dehydrocyclization of paraffins to form aromatics; and isomerization of paraffins. Hydrocracking of paraffins is undesirable due to increased light-ends make.
• Process steps:

– Naphtha feed and recycle hydrogen are mixed, heated and sent through successive
reactor beds
– Each pass requires heat input to drive the reactions
– Final pass effluent is separated with the hydrogen being recycled or purged for hydrotreating
– Reformate product can be further processed to separate aromatic components or be used for gasoline blending

Isomerization Process
• Process Objective:
– To convert low-octane n-paraffins to high-octane iso-paraffins.
• Primary Process Technique:
– Isomerization occurs in a chloride promoted fixed bed reactor where n-paraffins are converted to iso-paraffins. The catalyst is sensitive to incoming contaminants (sulfur and water).
• Process steps:
– Desulfurized feed and hydrogen are dried in fixed beds of solid des-sicant prior to mixing together
– The mixed feed is heated and passes through a hydrogenation reac-tor to saturate olefins to paraffins and saturate benzene
– The hydrogenation effluent is cooled and passes through a isomeri-zation reactor
– The final effluent is cooled and separated as hydrogen and LPGs which typically go to fuel gas, and isomerate product for gasoline blending

References

1. https://www.newworldencyclopedia.org/entry/Paraffin

2. https://www.sciencedirect.com/topics/engineering/naphthenes

3. https://byjus.com/chemistry/aromatic-hydrocarbons/

4. https://patents.google.com/patent/WO2016171890A1/en