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HEAVY FEEDSTOCK VISBREKING PROCESS.

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Annotation. Visbreaking, an important process in oil refining, plays a key role in improving the quality of fuel oil, reducing its viscosity and increasing the yield of lighter and more valuable products. This is achieved by medium thermal cracking, which breaks down large hydrocarbon molecules into smaller molecules, making it more liquid and easier to process. This article provides an in-depth analysis of the visbreaking process, its goals, comparison with other waste processing processes, existing technologies, operational control and environmental aspects.

Keywords: stable gasoline, liquefied, synthetic fuel, diesel fuel, associated gases, fractionation, condensation, cracking.

Аннотация. Висбрекинг, важный процесс в нефтепереработке, играет ключевую роль в улучшении качества мазута, снижая его вязкость и увеличивая выход более легких и ценных продуктов. Это достигается средним термическим крекингом, который расщепляет большие молекулы углеводородов на более мелкие молекулы, что делает его более жидким и легким для переработки. В данной статье представлен углубленный анализ процесса висбрекинга, его целей, сравнение с другими процессами переработки отходов, существующих технологий, оперативного контроля и экологических аспектов.

Ключевые слова: стабильный бензин, сжиженное, синтетическое топливо, дизельный топлива, попутные газы, фракционирование, конденсация, крекинг.

Annotatsiya. Neftni qayta ishlashdagi muhim jarayon bo‘lgan visbreking mazutning qovushqoqligini pasaytirish va yengil va qimmatbaho mahsulotlar chiqishini oshirishda muhim rol o‘ynaydi. Bu uglevodorodlarning katta molekulalarini kichikroq molekulalarga ajratadigan o‘rtacha termik kreking yordamida amalga oshiriladi, bu esa uni suyuqroq va qayta ishlash osonroq qiladi. Ushbu maqolada visbreking jarayoni, uning maqsadlari, chiqindilarni qayta ishlashning boshqa jarayonlari bilan taqqoslash, mavjud texnologiyalar, tezkor nazorat va ekologik jihatlar chuqur tahlil qilingan.

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Kalit so‘zlar: barqaror benzin, suyultirilgan, sintetik yoqilg‘i, dizel yoqilg‘isi, yo‘ldosh gazlar, fraksiyalash, kondensatsiya, kreking.

INTRODUCTION.

Visbreaking of heavy crude oil is a key process in modern oil refining, aimed at reducing viscosity and improving the performance properties of residual oil products. This process involves thermally treating heavy oil residues, such as tar and semi-tar, which results in the partial breakdown of high-molecular-weight hydrocarbons into lighter components. The primary goal of visbreaking is to produce fuel oil with reduced viscosity and to increase the yield of light petroleum products without significant coke formation.

The relevance of visbreaking stems from the need to efficiently utilize heavy crude oil and increase refining efficiency. Compared to other thermal processes, visbreaking is characterized by relatively mild operating conditions and lower capital costs. This makes it widely used in oil refineries to process residual feedstock and improve production efficiency.

In the processing of oil residues — semihudrons and tar — the target product is usually boiler fuel, obtained as a result of reducing the viscosity of the initial residue. This process of shallow decomposition of raw materials is called light cracking or visbreaking.

Visbreaking is thermal cracking for the poor. The visbreaking plant uses heavy residue from the vacuum distillation process, some of which is thermally cracked in it. The product can be divided into fractions again, which leads to a reduction in the volume of the residue. After that, a certain distillate petroleum product (diluent) is added to the residue for dilution, then the residue (pitch) of visbreaking becomes suitable for use as residual (boiler) fuel. The amount of distillate added for dilution is less than the amount of cracking products leaving the plant, so overall, the amount of residual fuel is reduced.

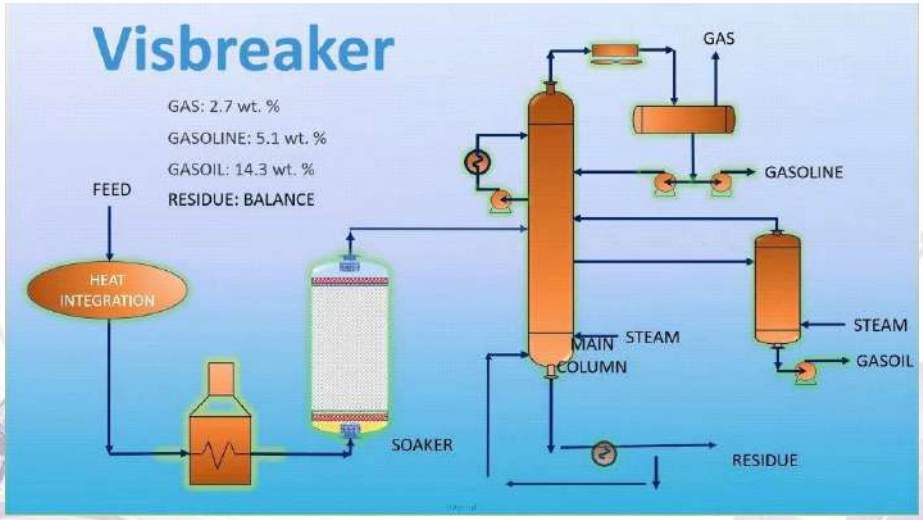


Fig. 1. The visbreaking process.

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Objectives of visbreaking and comparison with other cleaning processes.

The main purpose of visbreaking is to reduce the viscosity of heavy fuel oils, such as vacuum residues and bitumen, making them easier to process and utilize. These heavy oils are characterized by high viscosity, high density and high sulfur content, which makes them difficult to use directly. By breaking down large hydrocarbon molecules into smaller ones, visbreaking achieves a "viscosity reduction" effect and increases the value of heavy fuel.

In particular, the goals of visbreaking include:

Decrease in viscosity: This is the most important goal. Reducing the viscosity of heavy oil facilitates its transportation, storage and subsequent processing.

Increasing the yield of light oils: Visbreaking allows for the production of some light petroleum products such as gasoline and diesel, thereby increasing the overall yield of light oils in the refinery. Improved product properties: The oil remaining after visbreaking can be used as a raw material for the production of fuel oil or asphalt, having improved properties such as reducing sulfur content and increasing stability.

Visbreaking has its own unique features compared to other cleaning methods:

Catalytic cracking: Catalytic cracking uses catalysts to facilitate the reaction at lower temperatures, producing light petroleum products such as gasoline and diesel. Visbreaking is based on high-temperature thermal cracking with relatively harsh reaction conditions. Catalytic cracking focuses more on the production of light oil products with high added value, while visbreaking emphasizes reducing viscosity and increasing the value of using heavy oil.

Delayed coking: Delayed coking is mainly used for processing heavy raw materials such as vacuum residue to produce coke and a small amount of light oil. Visbreaking is aimed at reducing the viscosity and increasing the value of heavy oil and does not aim to produce coke. Delayed coking is a deep cracking process that produces coke as a fuel or industrial raw material, whereas visbreaking is a soft cracking process mainly aimed at reducing viscosity.

Hydrocracking: Hydrocracking uses catalysts in the presence of hydrogen to crack heavy oil into lighter products. Hydrocracking has milder reaction conditions, but requires high hydrogen pressure and expensive catalysts. Visbreaking does not require hydrogen and has relatively simple reaction conditions.

Are there any established visbreaking technologies? Currently, the most widely used visbreaking technologies in the industry include:

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Visbreaking furnace: This is the most traditional visbreaking process. The starting oil is subjected to thermal cracking in a furnace to produce a lighter oil and a residual oil with a reduced viscosity. The visbreaking furnace is simple, but the furnace efficiency is low and the energy consumption is high.

Settling tank visbreak: The reaction takes place in a settling tank with a longer residence time, which is suitable for processing high-viscosity raw materials. The visbreak in the sump is easy to operate, but the reaction rate is slow and the production efficiency is low.

Coil Visbreaking: This process uses rapid heating and rapid cooling to control the degree of reaction and reduce the occurrence of adverse reactions. Coil visbreaking can increase the yield of light oil, but it has high equipment requirements.

In addition, some new visbreaking technologies are being studied and developed, such as fluidized bed visbreaking and catalytic visbreaking. These new technologies are aimed at improving reaction efficiency, reducing energy consumption and reducing pollutant emissions, and are the future direction of visbreaking technology development.

How can I control the parameters of the visbreaking installation? Managing the operation of a visbreaking installation is crucial and includes, in particular, the following:

Reaction temperature: The reaction temperature is a key factor influencing the degree of cracking. Too high or too low a temperature will affect the quality and yield of the product. To achieve the best viscosity reduction effect, the reaction temperature must be precisely controlled according to the nature of the feedstock and technological requirements.

Reaction pressure: The reaction pressure has a definite effect on the cracking reaction. As a rule, a lower pressure is used. Reducing the reaction pressure can reduce the occurrence of adverse reactions and increase the yield of light oil.

Time of stay: The residence time determines the degree of reaction and should be adjusted depending on the nature of the raw materials and technological requirements. Too long a residence time will lead to excessive cracking and the formation of too much gas and coke; too short a residence time will lead to a poor viscosity reduction effect.

Consumption of raw materials: The consumption of raw materials must be adjusted to the reaction temperature, pressure and residence time to ensure stable operation of the plant and product quality.

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Recycling rate: The recycling ratio refers to the ratio of recycled oil to fresh raw materials. Regulation of the recirculation coefficient allows you to control the reaction depth and product properties.

In addition to the above parameters, in order to ensure stable operation of the plant and product quality, it is also necessary to monitor the combustion efficiency in the furnace, the state of liquid flow in the reactor, etc.

Pollutants and their processing in the visbreaking process. The visbreaking process forms certain pollutants, mainly:

Exhaust gases: mainly hydrocarbon gases, sulfides, nitrogen oxides and others that need to be purified. Combustion or reduction of hydrocarbon gases; sulfides can be removed using desulfurization devices; nitrogen oxides can be recycled using selective catalytic regeneration (SCR) or selective non-catalytic regeneration (SNCR) and other technologies.

Waste water: They mainly contain pollutants such as petroleum and phenols, which must be degreased and biologically treated. Oil can be removed using oil separators or flotation plants; phenols can be treated by biodegradation or adsorption.

Solid waste: They mainly include coke, waste, etc., which must be used or disposed of safely. Coke can be used as fuel or for the production of electrode materials; waste can be incinerated or buried in a landfill.

In order to meet the requirements of environmental protection, appropriate measures must be taken to clean up various pollutants, such as exhaust gas treatment, wastewater treatment and integrated solid waste management. Visbreaking, as an important method of processing heavy fuel oil, plays an important role in increasing the yield of light oil and increasing the efficiency of the product. Due to the continuous optimization of technological processes, operational control and enhanced environmental management, the vibration stand will play an even more important role in the future oil refining industry. In the context of increasing environmental protection requirements and changing energy structure, vibration stand technology will evolve towards high efficiency, energy conservation and environmental protection, contributing to the sustainable development of the oil refining industry.

The most common method of deepening oil refining is vacuum distillation of fuel oil and separate processing of vacuum gas oil (by catalytic and hydrocracking) and tar. The resulting tar, especially in the process of deep vacuum distillation, cannot be directly used as boiler fuel due to its high viscosity. To obtain commercial boiler fuel from such tar without processing them, a large consumption of distillate diluents is required, which practically negates the deepening of oil refining achieved by vacuum distillation. The simplest method

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of shallow tar processing is visbreaking in order to reduce viscosity, which reduces diluent consumption by 20-25% by weight, as well as the total amount of boiler fuel. Usually, the raw material for visbreaking is tar, but it is also possible to process heavy oils, fuel oil, and even asphalt from de-asphalting processes. Visbreaking is carried out under less harsh conditions than thermal cracking, due to the fact that, firstly, heavier and therefore easier to crack raw materials are processed; secondly, the permissible cracking depth is limited by the onset of coke formation (temperature 440 - 500^{0}C, pressure 1.4 - 3.5 MPa).

Studies have shown that as the duration (i.e., deepening) of cracking increases, the viscosity of the cracking residue initially decreases intensively, reaches a minimum, and then increases. The extreme nature of the change in the dependence of the viscosity of the residue on the cracking depth can be explained as follows. In the feedstock (tar), the main carrier of viscosity is sodium asphaltenes of a "loose" structure. The subsequent increase in the viscosity of the cracking residue is explained by the formation of compaction products - carbenes and carbides, which are also viscosity carriers. It is believed that a more intensive decrease in the viscosity of the cracking residue is facilitated by an increase in temperature with a corresponding reduction in the duration of visbreaking. This fact indicates that the temperature and duration of visbreaking are not completely interchangeable. This conclusion also follows from the data that the activation energy for the decay reaction is significantly higher than the condensation reaction. Therefore, there cannot be a complete analogy in the material balance and especially in the composition of products between different types of visbreaking processes. In recent years, two main directions have been identified in the development of visbreaking in our country and abroad. The first is "furnace" (or visbreaking in a furnace with a coking section), in which a high temperature (480 - 500^{0}C) is combined with a short residence time (1.5 - 2 min.).

The second direction is visbreaking with an external reaction chamber, which, in turn, may differ in the method of feeding raw materials to the reactor for upstream and downstream visbreaking.

In the second type of visbreaking, the required degree of conversion is achieved with a milder temperature regime (430-450^{0}C) and a long residence time (10 - 15 min.). Low-temperature visbreaking with a reaction chamber is more economical, since with the same degree of conversion, the thermal load on the furnace is lower. However, with "furnace" cracking, a more stable cracking residue is obtained with a lower yield of gas and gasoline, but with an increased yield of gas oil fractions. In recent years, there has been a steady tendency to increase the weight of visbreaking raw materials due to an increase in the depth of extraction of heavy oils with a high content of asphalt - resinous substances of

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increased viscosity and coking ability, which significantly complicates their processing. The domestic visbreaking plants in operation differ somewhat among themselves, since they were built either according to a standard design, or by reconstructing AT or thermal cracking plants. They differ in the number and type of furnaces, columns, and the presence or absence of an external reaction chamber. Material balance visbreaking visbreaking with vacuum distillation gas 3.7 3.0 stabilization head 2.5 gasoline 12.0 2.5 8.5 visbreaking residue 81.3 – light vacuum gas oil – 6.0 heavy vacuum gas oil – 20.0 vacuum visbreaking residue – 59.5 losses 0.5 0.5 flow diagram residual raw materials (tar) are pumped through heat exchangers, where it is heated by the heat of the waste products to The temperature is 3000C and enters the heating and reaction coils of parallel furnaces.

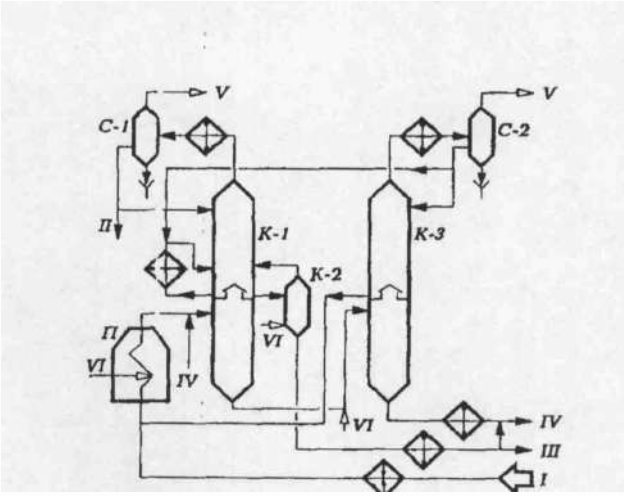


Figure 2 - Schematic diagram of a tar visbreaking installation. I - raw materials; II - gasoline for stabilization; III - kerosene - gas oil fraction (200 - 350 0C); IV - visbreaking residue; V - HFC gases; VI - water vapor.

Visbreaking products are removed from the furnaces at a temperature of 500^0C and cooled by quenching (visbreaking of the residue) to a temperature of 430^0C and sent to the lower ьsection of the distillation column K1. A combined-cycle gas mixture is discharged from the top of this column, which, after cooling and condensing in refrigerating condensers, enters the C1 gas separator, where it is divided into gas, water and a gasoline fraction. Part of the gasoline is used to irrigate the top of K1, and the balance amount is directed to stabilization.

A fraction of light gas oil (200 - 3500C) is removed from the battery K1 through the steam column K2 and, after cooling in refrigerators, is sent to mix with the visbreaking residue or removed from the installation. A part of the light gas oil is used to create an intermediate circulating irrigation of the K1 column. Cubic liquid from K1 flows by gravity into column K3. By reducing the pressure from 0.4 to 0.1 - 0.05 MPa and supplying water vapor to the flow from K1 to K3, light fractions are steamed. The combined-cycle gas mixture discharged from the top of K3 enters the gas separator C2 after cooling and condensationThe gases

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from it are directed to the nozzles of the furnaces, and the light phlegm returns to column K1. Heavy phlegm is discharged from the K3 battery, which mixes with the initial tar sent to the furnace. The remaining visbreaking from the bottom of K3 is removed from the installation after cooling in heat exchangers and refrigerators. To prevent coking of the reaction coils of the furnaces (volumetric floor flame), they provide for the supply of a turbulator - water vapor in the area where the flow temperature reaches 430 - 450^{0}C. Vacuum distillation visbreaking at a number of refineries (Omsk and Novo-Ufimskoye), through the reconstruction of thermal cracking plants, the technology of a combined process of tar visbreaking and vacuum distillation of cracking residue into light and heavy vacuum gas oil and heavy visbreaking residue has been developed and mastered. The target product of the process is heavy vacuum gas oil, characterized by a high density (940-990 kg/m3), containing 20-40% polycyclic hydrocarbons, which can be used as a raw material for producing high-index thermal gas oil or electronic coke, as well as as a raw material for catalytic or hydrocracking and thermal cracking processes, both without and with preliminary hydrotreating. Light vacuum gas oil is mainly used as a diluent of heavy tar. The heavy visbreaking residue contains concentrated polycyclic aromatic hydrocarbons, resins, and asphaltenes.

CONCLUSION.

Thus, the visbreaking process is one of the most efficient and cost-effective methods for shallow processing of heavy oil residues. The main objective of this process is to reduce the viscosity of tar and other heavy oil fractions, which reduces the consumption of diluents and increases the yield of light petroleum products. Visbreaking is carried out under relatively mild thermal cracking conditions and is characterized by lower coke formation compared to other deep processing processes.

The analysis showed that the efficiency of the process depends on the correct choice of technological parameters: temperature, pressure, residence time of raw materials and the recirculation coefficient. The optimal combination of high temperature and short reaction time contributes to a maximum reduction in the viscosity of the residue and an increase in the stability of the products obtained. At the same time, excessive deepening of the process leads to the formation of carbenes and carbides, which cause an increase in viscosity and coking of equipment.

Modern visbreaking technologies are constantly being improved. Along with traditional furnace installations, installations with reaction chambers are becoming more widely used, providing a more economical mode of operation and improving product quality. In addition, much attention is paid to the

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environmental safety of the process, including the treatment of gas emissions, wastewater and solid waste treatment.

Consequently, visbreaking occupies an important place in the modern oil refining industry, ensuring an increase in the depth of oil refining, the rational use of heavy raw materials and the improvement of the technical and economic performance of refineries. In the future, further development of visbreaking technologies will be aimed at improving energy efficiency, reducing environmental stress and increasing the yield of valuable petroleum products.

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