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The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық рефератитвтік және ғылымиметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық рефератитвтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

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[1]Atyrau University of oil and gas named after Safi Utebayev, Atyrau, Kazakhstan;
[2]International Scientific and Educational Center «Astana», Astana, Kazakhstan;
[3]Atyrau University named after Kh.Dosmukhamedov, Atyrau, Kazakhstan;
[4]Ufa State Petroleum Technological University, Institute of Oil Refining and Petrochemistry Salavat, Bashkortostan.
*E-mail: nagima@inbox.ru

RESEARCH RESULTS OF RESIDUE FROM THE CATALYTIC CRACKING UNIT OF THE ATYRAU REFINERY AND RECOMENDATIONS FOR PITCH PRODUCTION

Karabassova Nagima — degree, Senior lecturer, Atyrau University of oil and gas named after S. Utebayev, Atyrau, Kazakhstan,
E-mail: nagima@inbox.ru, https://orcid.org/0000-0001-6121-1125;
Muldakhmetov Marat — Doctor of Chemical Sciences, professor, Academician, International Scientific and Educational Center «Astana», Almaty, Kazakhstan,
E-mail: muldakhmetov57@mail.ru, https://orcid.org/0000-0001-7471-1807;
Shambilova Gulbarshin — Doctor of Chemical Sciences, professor, Atyrau University named after Kh.Dosmukhamedov, Atyrau, Kazakhstan,
E-mail: shambilova_gulba@mail.ru, https://orcid.org/0000-0002-2733-986X;
Kanbetov Assylbek — Candidate of biological sciences, Associate professor, Atyrau University of oil and gas named after S. Utebayev, Atyrau, Kazakhstan,
E-mail: a.kanbetov@mail.ru, https://orcid.org/0000-0002-9990-0230;
Sharafutdinov Dan — student, Ufa State Petroleum Technological University. Institute of oil Refining and petrochemistry Salavat, Bashkortostan,
E-mail: dan.sharafutdinov@icloud.com, https://orcid.org/0009-0000-1399-070X.

Abstract. *Relevance.* The study is relevant due to the need to deepen oil refining and find efficient ways to utilize heavy petroleum residues at the Atyrau Oil Refinery, where their use as boiler fuel is becoming economically unviable due to excise duties and quality risks. *Objective.* The objective is a comprehensive study of catalytic cracking residue with the development of recommendations for petroleum pitch production. *Methods and methodology.* The research involved detailed analysis of the physicochemical properties of the feedstock, as well as its elemental and hydrocarbon group composition, using atomic emission spectroscopy and a "Gradient" chromatograph. The initial sample was distilled in a laboratory unit equipped with a packed column. Fractions obtained at different boiling ranges were subjected to pitching in a laboratory reactor fitted with a system for gas oil collection. Experiments were carried out on a pilot-scale pitching unit, while simulated distillation data for coking gas oil samples, obtained by gas chromatography, were further modeled using Aspen Hysys software. *Results and conclusions.* The results demonstrated that the cracking residue is characterized by high coking ability, a considerable content of aromatic hydrocarbons, and very low concentrations of metals, which makes it a valuable feedstock for producing high-quality carbon materials. Analysis of fractional composition and true boiling point curves confirmed that thermally processed products are lighter and more diverse than the original residue. The feasibility of petroleum pitch production by thermocondensation was confirmed, with yields ranging from 11.5% to 32.5% by mass. A conceptual process scheme was proposed to improve efficiency. Implementation of these recommendations will enable production of mesophase petroleum pitches for carbon–carbon composites, while increasing refining depth, improving profitability, reducing waste, and enhancing environmental performance.

Keywords: deep oil refining, catalytic cracking unit, cracking residue, pitch process, oil pitch, Atyrau Refinery

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[1]С.Өтебаев атындағы Атырау мұнай және газ университеті, Атырау, Қазақстан;

[2]«Астана» халықаралық ғылыми-білім беру орталығы, Астана, Қазақстан;

[3]Х.Досмұхамедов атындағы Атырау университеті, Атырау, Қазақстан;

[4]Уфа мемлекеттік мұнай технологиялық университеті, Мұнай өңдеу және мұнайхимиясы институты, Салават, Башқұртстан.

*E-mail: nagima@inbox.ru

АТЫРАУ МҰНАЙ ӨҢДЕУ ЗАУЫТЫНЫҢ КАТАЛИТИКАЛЫҚ КРЕКИНГ ҚОНДЫРҒЫСЫНЫҢ ҚАЛДЫҒЫН ЗЕРТТЕУ НӘТИЖЕЛЕРІ ЖӘНЕ ПЕК ӨНДІРУ БОЙЫНША ҰСЫНЫСТАРДЫ БЕРУ

Қарабасова Нағима — магистр, аға оқытушы, С.Өтебаев атындағы Атырау мұнай және газ университеті, Атырау, Қазақстан,
E-mail: nagima@inbox.ru, https://orcid.org/0000-0001-6121-1125;
Мулдахметов Марат — химия ғылымдарының докторы, профессор, академик, «Астана» халықаралық ғылыми-білім беру орталығы, Астана, Қазақстан,
E-mail: muldakhmetov57@mail.ru, https://orcid.org/0000-0001-7471-1807;
Шамбилова Гүлбаршын — химия ғылымдарының докторы, профессор, Х.Досмұхамедов атындағы Атырау университеті, Атырау, Қазақстан,
E-mail: shambilova_gulba@mail.ru, https://orcid.org/0000-0002-2733-986X;
Канбетов Асылбек — биология ғылымдарының кандидаты, қауымдастырылған профессор, С.Өтебаев атындағы Атырау мұнай және газ университеті, Атырау, Қазақстан,
E-mail: a.kanbetov@mail.ru, https://orcid.org/0000-0002-9990-0230;
Шарафутдинов Дан — магистрант, Уфа мемлекеттік мұнай технологиялық университеті, мұнай өңдеу және мұнайхимиясы институты, Салават, Башқұртстан,
E-mail: dan.sh@mail.ru, https://orcid.org/0009-0000-1399-070X.

Аннотация. *Өзектілігі.* Жұмыстың өзектілігі мұнайды терең өңдеу деңгейін арттыру және ауыр мұнай қалдықтарын тиімді кәдеге жарату жолдарын іздеу қажеттілігімен байланысты, өйткені оларды Атырау мұнай өңдеу зауыты жағдайында қазандық отынының құрамына қосу акциздердің жоғары болуы мен өнім сапасының төмендеу қаупіне байланысты экономикалық тұрғыдан тиімсіз болып отыр. *Мақсаты.* Негізгі мақсат – қолданыстағы каталитикалық крекинг қондырғысынан алынатын крекинг-қалдықты кешенді зерттеу және мұнай пектерін өндіру бойынша ұсыныстар әзірлеу. *Әдістері және әдіснамасы.* Жұмыс барысында шикізаттың физика-химиялық қасиеттеріне, элементтік және топтық көмірсутектік құрамына атомдық-эмиссиялық спектрометр және «Градиент» хроматографы арқылы жан-жақты талдау жүргізілді. Бастапқы үлгінің айдау процесі насадкалы колоннасы бар зертханалық қондырғыда орындалды. Крекинг-қалдықтың әртүрлі фракцияларын пектеу газойльді жинауға арналған шығару жүйесімен жабдықталған зертханалық реакторда жүзеге асырылды. Тәжірибелер пектеудің пилоттық зертханалық қондырғысында жүргізілді. Әртүрлі шикізат түрлері үшін газдық хроматография әдісімен алынған пектеу газойльдерінің имитациялық айдау деректері Aspen Hysys бағдарламасы көмегімен болжанды. *Нәтижелер мен қорытындылар.* Зерттеу нәтижесінде крекинг-қалдықтың жоғары кокстену қабілетімен, ароматты көмірсутектердің едәуір мөлшерімен және металдардың өте төмен құрамымен сипатталатыны анықталды, бұл оны жоғары сапалы көміртекті материалдар алуға құнды шикізат етеді. Фракциялық құрам мен нақты қайнау температураларының қисықтарын талдау пектеу өнімдерінің бастапқы крекинг-қалдықпен салыстырғанда жеңілірек және құрамы әртүрлі екенін көрсетті, бұл ауыр фракцияларды термиялық өңдеудің тиімділігін дәлелдейді. Эксперименттік түрде қалдықтың әртүрлі фракцияларын термоконденсациялау арқылы мұнай пегін алу мүмкіндігі расталды, бұл ретте мақсатты өнімнің шығымы процесс параметрлеріне байланысты массаның 11,5%-дан 32,5%-ға дейін өзгеретіні

анықталды. Алынған нәтижелер негізінде вакуумдық айдау блогы мен мерзімді пектеу реакторларын қамтитын технологиялық сұлба ұсынылды. Ұсынылған шешімдерді қолдану зауытта көміртек–көміртек композициялық материалдар өндіруге арналған инновациялық мезофазалық пектер өндірісін жолға қоюға, мұнайды өңдеу тереңдігін және жалпы рентабельділікті арттыруға, өндірістік қалдықтарды азайтуға және технологиялық процестердің экологиялық көрсеткіштерін жақсартуға мүмкіндік береді.

Түйін сөздер: мұнайды терең өңдеу, каталитикалық крекинг қондырғысы, крекинг-қалдық, пектеу, мұнай пегі, Атырау мұнай өңдеу зауыты

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[1]Атырауский университет нефти и газа имени С.Утебаева, Атырау, Казахстан;
[2]Международный научно-технический центр «Астана», Астана, Казахстан;
[3]Атырауский университет имени Х.Досмухамедова, Атырау, Казахстан;
[4]Уфимский государственный нефтяной технический университет, Институт нефтепереработки и нефтехимии, Салават, Башкортостан.
*E-mail: nagima@inbox.ru

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ОСТАТКА УСТАНОВКИ КАТАЛИТИЧЕСКОГО КРЕКИНГА АТЫРАУСКОГО НЕФТЕПЕРЕРАБАТЫВАЮЩЕГО ЗАВОДА И ВЫДАЧА РЕКОМЕНДАЦИЙ ПО ПРОИЗВОДСТВУ ПЕКОВ

Карабасова Нагима — магистр, старший преподаватель, Атырауский университет нефти и газа имени С.Утебаева, Атырау, Казахстан,
E-mail: nagima@inbox.ru, https://orcid.org/0000-0003-1763-722X;
Мулдахметов Марат — доктор химических наук, профессор, академик, Международный научно-технический центр «Астана», Астана, Казахстан,
E-mail: muldakhmetov57@mail.ru, https://orcid.org/0000-0001-7471-1807;
Шамбилова Гүлбаршын — доктор химических наук, Атырауский университет имени Х.Досмухамедова, Атырау, Казахстан,
E-mail: shambilova_gulba@mail.ru, https://orcid.org/0000-0002-2733-986X;
Канбетов Асылбек — кандидат биологических наук, ассоциированный профессор, Атырауский университет нефти и газа имени С.Утебаева, Атырау, Казахстан,
E-mail: a.kanbetov@mail.ru, https://orcid.org/0000-0002-9990-0230;
Шарафутдинов Дан — магистрант, Уфимский государственный нефтяной технический университет, Институт нефтепереработки и нефтехимии, Салават, Башкортостан,
E-mail: dan.sh@mail.ru, https://orcid.org/0009-0000-1399-070X.

Аннотация. *Актуальность*. Актуальность работы обусловлена необходимостью повышения глубины переработки нефти и поиска эффективных путей утилизации тяжелых нефтяных остатков в условиях Атырауского нефтеперерабатывающего завода. Вовлечение таких остатков в состав котельного топлива становится экономически невыгодным из-за акцизов и рисков ухудшения качества продукции, что требует разработки более рациональных направлений их переработки. *Цель*. Провести комплексное исследование крекинг-остатка действующей установки каталитического крекинга и разработать рекомендации по его использованию для производства нефтяных пеков. *Методы*. В ходе работы проведен детальный анализ физико-химических свойств сырья, его элементного и группового углеводородного состава с использованием атомно-эмиссионного спектрометра и хроматографа «Градиент». Разгонка исходного образца выполнена на лабораторной установке с насадочной колонной. Пекование фракций различной глубины отбора крекинг-остатка осуществлено в лабораторном реакторе, снабженном отводом для сбора газойля. Эксперименты проводились на пилотной лабораторной установке пекования. Данные по имитированной дистилляции образцов газойля пекования, полученные методом газовой хроматографии для разных видов сырья, были спрогнозированы с помощью программы Aspen HYSYS. *Результаты и выводы*. Установлено, что крекинг-остаток характеризуется высокой коксуемостью, значительным содержанием ароматических углеводородов и крайне низким содержанием металлов, что делает его ценным сырьем для получения высококачественных углеродных материалов. Анализ фракционного состава и кривых истинных температур кипения показал, что продукты пекования обладают более легким и разнообразным компонентным составом по сравнению с исходным крекинг-остатком, что подтверждает эффективность термической переработки тяжелых фракций. Экспериментально подтверждена возможность получения нефтяного пека методом термоконденсации различных фракций остатка, при этом выход целевого продукта составил от 11,5 до 32,5 масс.% в зависимости от параметров процесса. На основании полученных данных разработана и предложена принципиальная технологическая схема установки, включающая блоки вакуумной разгонки и реакторы периодического пекования. Применение данных рекомендаций позволит заводу наладить производство инновационных мезофазных пеков для создания углерод-углеродных композиционных материалов, повысить общую рентабельность и глубину переработки нефти, сократить объем производственных отходов и улучшить экологические показатели технологических процессов.

Ключевые слова: глубокая переработка нефти, установка каталитического крекинга, крекинг-остаток, пекование, нефтяной пек, Атырауский нефтеперерабатывающий завод

Introduction. In the modern world of oil refining, in-depth oil refining does not lose its relevance and is of great interest to meet the growing demand for motor fuels (Karabassova et al., 2025)

In this regard, catalytic cracking is crucial for the production of the high-octane component of gasoline with an octane rating of 85-93 using the research method from low-value heavy raw materials **(**Oloruntoba et al., 2022), At the same time, a significant amount of valuable liquefied gases is formed, which are raw materials for subsequent production of high–octane gasoline components of isomeric structure: alkylate and methyl tert-butyl ether, as well as raw materials for petrochemical industries (Emberru et al., 2024). The light gas oil produced in the process is usually used as a component of diesel fuel, and heavy gas oil with a high content of polycyclic aromatics is used as a raw material for the production of carbon black or high–quality electrode coke (for example, needle coke) **(**Tanimu et al., 2025).

One of the ways to process heavy residues from catalytic cracking is to produce high-quality mesophase oil pitches from it. The field of application of oil pitches is quite extensive however the most promising application is the production of carbon-carbon composite materials based on them. Depending on their properties, they can be used in automotive, energy and other industries. Therefore, it is possible to establish the production of oil pitches from heavy oil residues, both from the point of view of obtaining innovative materials and for the purpose of deepening oil refining **(**Eremenko et al., 2025).

Petroleum pitches are technologically advanced materials required in modern industry due to their unique physicochemical properties (Kumari et al., 2023). These materials are characterized by high thermal stability and mechanical strength, as well as good thermal and electrical conductivity, which makes them востребованными in many critical applications **(**Mingzhi Wang et al., 2025).

Compared to isotropic pitches, anisotropic pitches have a more ordered structure, enabling them to exhibit superior technical characteristics. Such materials open new opportunities for their use in high-tech manufacturing (Yinda Wang et al., 2025).

A key area of application for anisotropic pitches is the production of carbon fibers. Carbon fiber and composite materials based on it are unique products used across various industries, including nuclear, chemical, aerospace, electrical engineering, metallurgy, and mechanical engineering (Kovalev et al., 2025a), Demand for these materials is constantly growing, and their applications are expanding - from electric heating elements to the production of space rocket components. Due to their non-toxicity and the ability of carbon to integrate into the human body, carbon fiber-based endoprostheses are widely used in medicine (Kovalev et al., 2025b).

Another important application of anisotropic pitches is the production of needle coke, which is used in the manufacture of graphite electrodes for steelmaking in electric arc furnaces, as well as for producing synthetic graphite used as anode material in lithium-ion batteries for electric vehicles (Nevedrov et al., 2024).

The production of anisotropic pitches from coal tar causes significant environmental harm. Moreover, coal tar contains a large amount of carcinogenic substances, particularly polycyclic aromatic hydrocarbons, which pose serious risks to human health (Lia et al., 2020).

A more environmentally friendly and cost-effective raw material for producing anisotropic petroleum pitches can be residual petroleum fractions generated during oil refining and petrochemical processes - namely, heavy residues from catalytic cracking and heavy pyrolysis tar. These fractions are produced in substantial quantities but are not efficiently utilized (Kugatov et al. 2021; Dong Huang et al. 2021). Thus, the paper (He Liu et al. 2022) describes methods for producing high-quality needle coke from catalytic cracking unit residue. The characteristics of needle coke production arise from the carbonization process and the carbon mesophase theory (Guangxue Zhou et al. 2021)

Thus, the production of anisotropic petroleum pitches in Kazakhstan is highly relevant, given the extensive raw material base resulting from the high production capacities of oil refining and petrochemical enterprises. However, industrial-scale production of such pitches is currently absent. Therefore, an important task is the development of technologies for processing secondary heavy petroleum residues to produce pitches (Rujun Zha et al. 2025).

Materials and methods of research. In 2018, the Atyrau Oil Refinery commissioned a catalytic cracking unit for heavy oil residues (RFCC), the purpose of which is to convert fuel oil, vacuum gas oil, and heavy coking gas oil into high-value-added products, which include gasoline of various brands, jet fuels, diesel fuels, and liquefied petroleum gas (Danbay et al. 2021). The uniqueness of this installation lies in the fact that two regenerators are used in this process. This makes it possible to significantly reduce unit operating costs and increase the efficiency of the raw material processing process at this unit (Bukanova et al. 2021).

The catalytic cracking unit produces a product called cracking residue, which is removed from the cubic part of the main fractionation column C-0201 (Figure 1).

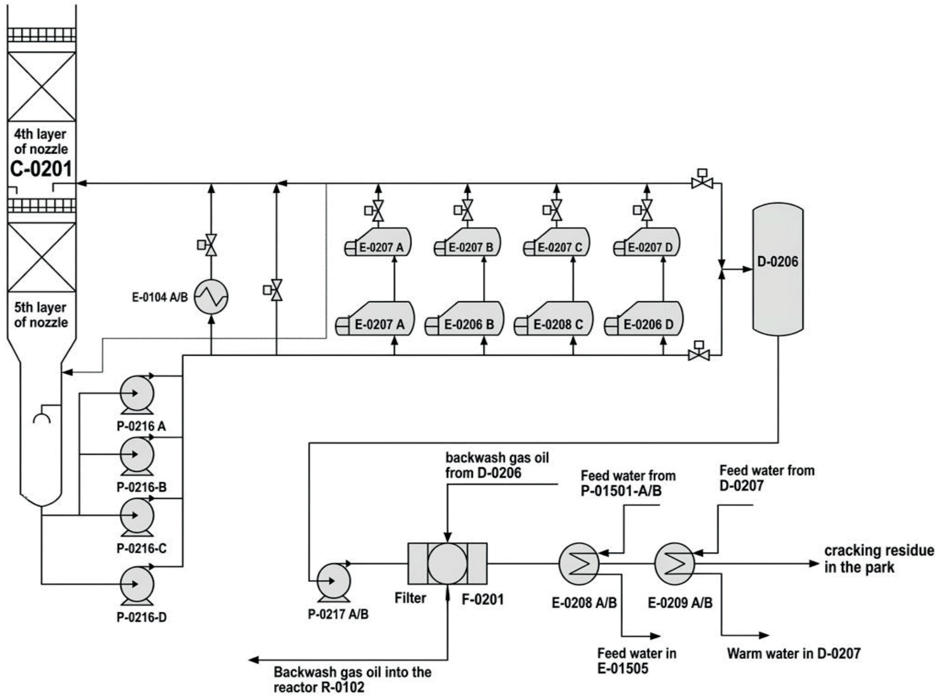

Figure 1. Block for obtaining cracking residue for the catalytic cracking unit.

To date, the cracking residue is fully involved in the preparation of commercial fuel oil of the M-100 brand. When the cracking residue is involved in fuel oil, there is a significant risk of deterioration in the quality characteristics of marketable products. One of the reasons is the non-use of the filter No. F-0201, designed to clean the cracking residue from mechanical impurities, including catalyst dust. But this filter has not been functioning since the start-up of the catalytic cracking unit (Technological regulations, 2024)

According to factory data, cracking residue is produced in the amount of 13.5 tons/hour or 326 tons per day (Table 1).

Table 1. Material balance of catalytic cracking unit.

Name	Yield	
	wt.%	t/year
Input:		
Feed of catalytic cracking unit	100,0	2431000
Total	100,0	2431000
Output		
Fuel gas	5,3	128843
Light gas oil	12,4	301444
Liquefied gas	18,1	440011
Stabilized gasoline	52,8	1283568
Heavy gas oil	2,9	70499
Cracking residue	4,4	106964
Acid gas in amine solution	0,9	21879
Losses	3,2	77792
Total	100,0	2431000

In order to study possible options for processing heavy oil residues, a cracking residue selected from a catalytic cracking unit was used as a raw material. Its physico-chemical characteristics were determined, as shown in table 2.

Table 2. Physico-chemical characteristics of cracking residue.

№	Parameter, unit of measurement	Value
1	Density at 20 °C, kg/m³	952,6
2	Distillation characteristics: initial boiling point, °C	269
	Distillate yield at temperature, %	
	350 °C	4,3
	360 °C	5,2
	400 °C	29,9
	440 °C	57,1
	480 °C	73,1
3	Water content, wt.%	0,03
4	Chloride salts content, mg/dm³	8,25
5	Kinematic viscosity at 100 °C, mm²/s	10,850
6	Flash point (open cup), °C	216

7	Mechanical impurities, wt.%	5,40
8	Conradson carbon residue, wt.%	6,34
9	Ash content, wt.%	0,044
10	Sulfur content, wt.%	0,481

As can be seen from the presented data, the raw material is a heavy, highly viscous, low-volatile product with a moderate sulfur content and a low proportion of water and salts. High coking capacity and mechanical impurities indicate the need for further processing or purification when used in technological processes.

The group hydrocarbon composition of the feedstock, which was determined using the Gradient-M chromatograph, is shown in table 3. It is characterized by a high content of paraffin-naphthenic hydrocarbons (66.8% by weight). At the same time, the presence of a significant proportion of aromatic hydrocarbons (24.6% by weight) was detected. These components provide high coking ability, contribute to the formation of a condensed aromatic structure, and increase the yield of pitches and carbonaceous residues needed in the production of carbon black. Resinous-asphaltene substances (8.6% by weight) additionally increase the propensity of raw materials to thermocondensation and the formation of a carbon phase, which has a positive effect on both the properties of oil pitches and the output of carbon black.

Table 3. Hydrocarbon group composition of the feedstock.

№	Component name	Content, wt.%
1	paraffinic–naphthenic hydrocarbons	66,8
2	light aromatic hydrocarbons	4,0
3	medium aromatic hydrocarbons	1,6
4	heavy aromatic hydrocarbons	19,0
5	resins I	1,1
6	resins II	4,9
7	asphaltenes	2,6

The elemental composition of the cracking residue was studied by inductively coupled plasma atomic emission spectrometry (ICP-AES) according to ST RK ASTM D 5185-2013 (Table 4).

Table 4. Elemental composition of the feedstock.

Element Name	Mean Value, ppm	Standard Deviation, ppm	Standard Deviation, %
Silver	0.057	0.011	18.7
Aluminum	0.013	0.003	26.1
Boron	<0.001	0.014	29.2
Barium	0.007	0.003	46.5
Calcium	0.007	0.004	2.32
Cadmium	0.004	0.001	30.8
Chromium	0.004	0.002	642
Copper	0.132	0.011	8.24

Iron	0.011	0.005	49.1
Potassium	0.055	0.100	181
Lithium	<0.001	0.028	21.6
Magnesium	<0.006	0.002	35.5
Manganese	<0.002	0.000	2.54
Molybdenum	<0.027	0.013	152
Sodium	<0.003	0.009	2.09
Nickel	0.117	0.020	17.1
Phosphorus	0.077	0.062	80.0
Lead	0.123	0.006	4.56
Silicon	<0.002	0.146	76.7
Tin	<0.002	0.003	3.71
Titanium	<0.003	0.001	43.0
Vanadium	<0.003	0.004	161
Zinc	<0.003	0.000	4.40

As can be seen from the presented data, the cracking residue is characterized by a very low content of most metals. Only Cu, Ni, and Pb have been precisely identified — the rest are at the level of trace amounts or below the detection limit.

The initial cracking residue of the Atyrau Refinery's catalytic cracking was distilled using a laboratory installation with a packed column (Figure 2)

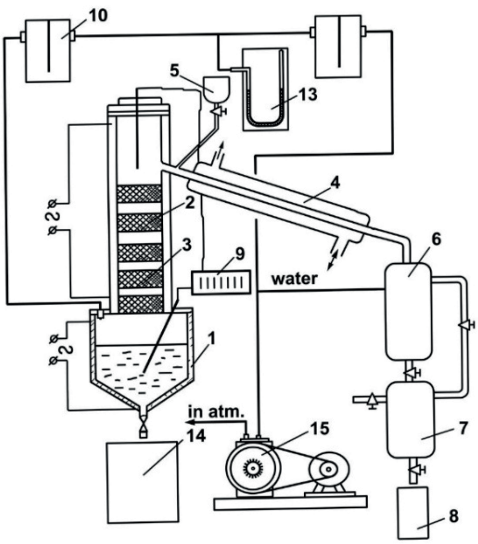

Figure 2. Schematic diagram of a laboratory setup for vacuum distillation of cracking residue. 1 - cube; 2 - distillation column; 3 - spiral packing; 4 - water condenser; 5 - funnel for washing the system; 6 - upper receiver; 7 - lower receiver; 8 - distillate flask; 9 - potentiometer; 10 - Tishchenko flasks; 11 - thermocouple; 13 - mercury vacuum gauge; 14 - porcelain beaker; 15 - vacuum pump

The data obtained is presented in table 5.

Table 5. Fractionation of the initial cracking residue in a packed column.

Top column temperature, °C	Distillate yield, wt.%
266	0,000
300	1,807
350	4,706
400	7,500
450	41,875

The resulting fractions of the cracking residue were used as the raw material of the pitch process.

The pitching of fractions with different sampling depths of the catalytic cracking residue was carried out on a laboratory reactor equipped with a branch for collecting gas oil. The reactor diagram is shown in figure 3.

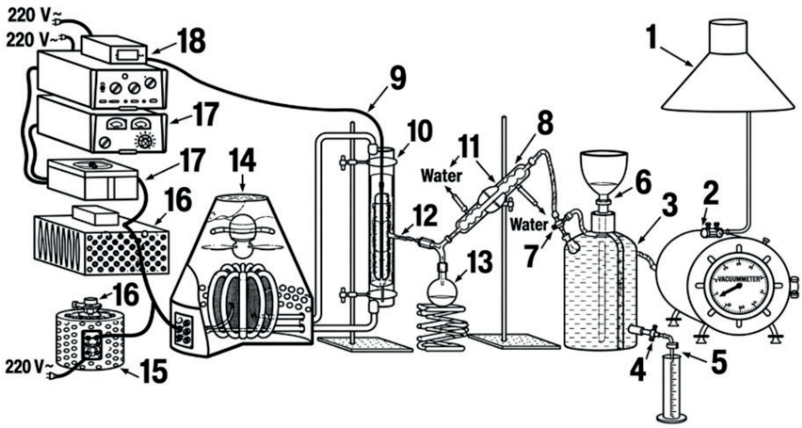

Figure 3. Schematic diagram of the laboratory setup for the sintering process.
1 – hood; 2 – gas clock; 3 – gas meter; 4 – graduated cylinder; 5, 6, 7 – three-way valves; 8 – water cooler; 9 – thermocouple; 10 – furnace; 11 – reactor; 12 – allonge; 13 – gas oil receiver; 14 – fan; 15 – transformer; 16 – latrine vacuum transformer; 17 – high precision temperature controller; 18 – indicator.

Results. The experimental data obtained on pitching fractions of different sampling depths of heavy oil residue of the Atyrau Refinery are presented in table 6.

Table 6. Results of experiments on the coking of fractions with different depths of heavy catalytic cracking gas oil withdrawal from the Atyrau Oil Refinery.

Fraction	Isothermal holding time at 430 °C, min	Coke/semi-coke yield on feed, wt.%	Gas oil yield on feed, wt.%	Gas oil density, kg/m³
450 ^{0}C – final boiling point	200	23,4	58,2	952,2
450 ^{0}C– final boiling point	60	32,5	61,2	–
350 ^{0}C– final boiling point	245	11,5	79,7	961,9

300 ^{0}C – final boiling point	180	17,5	75,9	965,2
400 ^{0}C –final boiling point	45	19,3	74,6	967,7

Data on the simulated distillation of pitch gas oil samples performed by gas chromatography for different types of raw materials are presented in table 7.

Table 7. Results of simulated distillation (gas chromatography) of coking gas oil samples.

Distillate yield, wt.%	Temperature for the specified feed fraction, °C			
	300 ^{0}C – final boiling point	350 ^{0}C – final boiling point	400 ^{0}C – final boiling point	450 ^{0}C – final boiling point
0,0	54,25	53,82	74,57	74,19
0,5	65,88	76,32	86,25	87,49
5,0	180,80	198,34	198,74	186,47
10,0	263,98	290,14	248,63	235,39
15,0	324,51	351,77	308,36	252,45
20,0	363,10	380,35	360,28	290,16
25,0	383,74	395,93	385,58	330,36
30,0	397,55	406,22	399,75	367,28
35,0	407,37	414,36	409,26	394,05
40,0	415,57	422,16	417,35	410,41
45,0	422,92	429,30	423,55	421,28
50,0	430,14	437,42	429,93	428,74
55,0	439,25	446,40	437,42	435,90
60,0	448,61	456,92	445,08	443,50
65,0	459,89	468,40	453,44	450,80
70,0	474,41	484,87	462,92	459,12
75,0	505,68	–	474,50	467,81
80,0	–	–	491,31	478,66
85,0	–	–	–	496,61

As a result of processing experimental data on vacuum distillation of the cracking residue and simulated distillation of pitch gas oil samples at Aspen Hysys, a series of TBP (True Boiling Points) curves was obtained, shown in figure 4.

The figure below shows the curves of true boiling points characterizing the fractional composition of various petroleum products: the cracking residue of the Atyrau Refinery catalytic cracking and various fractions of pitch gas oil (300 ^{0}C – f.b.p., 350 ^{0}C – f.b.p., 400 ^{0}C – f.b.p., 450 ^{0}C – f.b.p.).

The graph illustrates the dependence of the total distillate yield on the heating temperature. All the presented samples demonstrate a regular increase in the yield of light and medium fractions with increasing temperature, however, the nature of the curves varies significantly depending on the type of raw material.

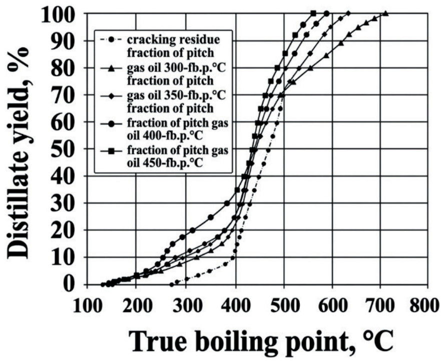

Figure 4. Integral curves of true boiling points for the initial cracking residue and pitch gas oil samples.

A comparison of the TBP curves allows us to conclude about the different volatility and component composition of the materials under study. The cracking residue is a more homogeneous heavy raw material in composition, while pitch gas oils contain a significant proportion of low-boiling components, which determines their technological properties during further processing.

The result of the TBP determination is presented in Table 8.

Table 8. Results of determining the true boiling point (TBP) of catalytic cracking residue and coking gas oil samples.

Distillate yield, wt.%	Top column temperature for the specified sample, °C				
	Initial catalytic cracking residue	Coking gas oil of residue fraction			
		300 ^{0}C – final boiling point	350 ^{0}C – final boiling point	400 ^{0}C – final boiling point	450 ^{0}C – final boiling point
0,0	266,5	126,2	136,1	145,3	137,4
1,0	276,8	138,2	151,5	156,5	148,8
2,0	296,1	161,2	178,9	178,5	169,5
3,5	321,1	195,7	215,0	211,0	196,5
5,0	342,9	224,6	245,1	233,1	214,8
7,5	375,1	259,4	283,7	254,8	237,9
10,0	392,1	289,9	316,6	274,2	248,5
12,5	397,3	320,3	347,4	304,2	256,0
15,0	401,1	344,6	368,9	333,2	268,8
17,5	405,2	362,7	381,9	358,8	288,4
20,0	409,1	374,4	389,7	373,3	309,1
25,0	417,8	393,9	404,1	394,4	349,8
30,0	427,0	404,7	413,5	407,1	382,2
35,0	436,6	412,4	419,6	415,4	402,6
40,0	446,6	419,3	426,0	420,7	416,2

45,0	456,7	426,3	432,7	426,7	425,4
50,0	466,5	433,9	440,4	432,8	432,8
55,0	474,8	443,4	450,0	439,4	439,0
60,0	482,2	451,4	461,4	446,8	445,1
65,0	489,6	466,1	475,3	455,7	452,0
70,0	497,2	488,2	491,5	467,0	460,3
75,0	505,6	519,3	509,5	482,0	470,9
80,0	515,5	554,4	529,8	499,3	485,3
85,0	528,5	589,7	552,3	518,0	501,3
90,0	541,3	622,3	573,9	537,4	516,7
92,5	551,5	638,6	585,3	544,5	526,5
95,0	564,0	658,7	598,2	557,1	539,1
96,5	573,1	672,9	607,4	567,8	547,8
98,0	583,5	689,1	618,0	580,2	557,3
99,0	591,2	701,2	626,0	588,2	560,0
100,0	599,6	714,4	634,9	588,2	560,0

Based on the presented results, the following schematic diagram of a pitch production unit (Figure 5) is proposed, designed for processing heavy cracking residue from catalytic cracking.

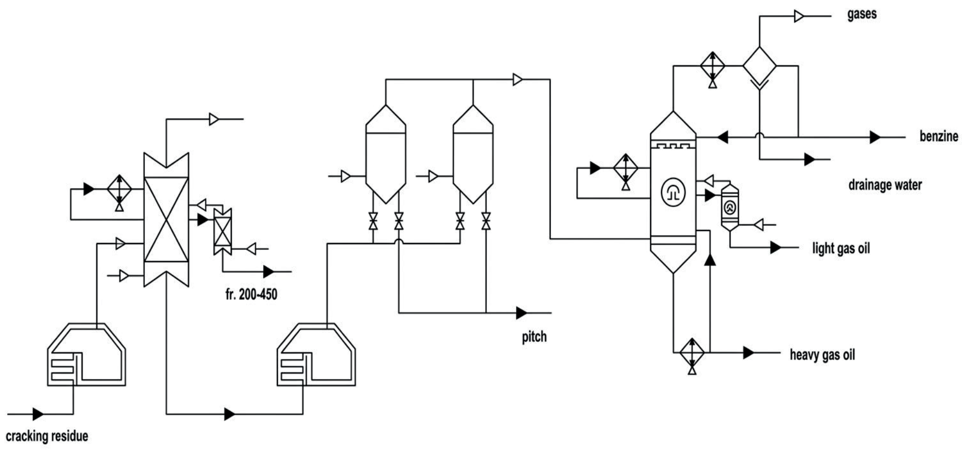

Figure 5. Schematic diagram of the pitch production plant at the Atyrau Oil Refinery.

The unit consists of a vacuum distillation unit for cracking residue, two parallel periodic pitch reactors, and an atmospheric distillation unit for light pitch products. Additionally, we can get gas, gasoline, light and heavy gas oil.

This unit is designed to process the heavy cracking residue of a catalytic cracking unit in order to produce pitch, as well as gases, gasoline, light and heavy gas oils.

The use of this unit at oil refineries helps to increase the depth of processing and economic efficiency of production.

Conclusions. In conclusion, it was found that the cracking residue of the Atyrau Refinery's catalytic cracking unit is characterized as a heavy hydrocarbon feedstock with pronounced composition features. The analysis of physico-chemical, elemental and group hydrocarbon parameters showed a high coking capacity of the product (6.34%) and a significant content of aromatic hydrocarbons (24.6%). The results obtained indicate the expediency of its use as a promising raw material for the production of carbon-containing materials.

Based on the experimental results, a basic technological scheme of an oil pitch production unit has been developed, including a vacuum distillation unit, batch pitch reactors, and units for the disposal of light products. The implementation of the proposed scheme will increase the depth of oil refining at the Atyrau refinery, increase the yield of gasoline and gas oil fractions; organize the production of commercial oil pitch as an independent product with high added value; reduce waste and improve environmental performance of production.

The results obtained confirm the technological and economic feasibility of involving the cracking residues of catalytic cracking in the process of pitch production and open up prospects for further research in the field of optimizing pitching parameters and improving the properties of final carbon materials.

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