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# ОПТИМИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ ПОДГОТОВКИ НЕФТИ И ГАЗА ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ПРОЦЕССА

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*. Был разработан новый газовый фильтр-сепаратор для повышения эффективности очистки природного газа, извлекаемого вместе с сырой нефтью в полевых условиях. Традиционные методы очистки газа часто не соответствуют нормативным требованиям по удалению легких жидких углеводородов (C5+), что приводит к значительным потерям нефти, ухудшению качества газа и увеличению выбросов в окружающую среду. Предлагаемая конструкция включает сужающиеся коалесцирующие фильтры, которые способствуют слиянию капель и увеличению их осаждаемости в соответствии с законом Стокса.*

*Инновационные особенности сепаратора включают входное отверстие, подключенное тангенциально для оптимизации динамики потока, сужающиеся фильтры для эффективного разделения, резервуар для сбора жидкости и систему дренажа для удаления собранных углеводородов. Эти компоненты работают синергетически, повышая эффективность разделения при сохранении надежности работы и пропускной способности. Полевые испытания подтвердили эффективность сепаратора в значительном снижении содержания C5+, обеспечивая улучшенную чистоту газа и соответствие промышленным стандартам.*

*Использование этой технологии в полевых условиях снижает негативное воздействие на окружающую среду за счет минимизации сжигания газа и восстановления цен-*

*ных углеводородов для альтернативного использования. Способность сепаратора повышать добычу нефти и качество газа, одновременно сокращая выбросы в окружающую среду, подчеркивает его потенциал как революционного решения для операций по добыче нефти и газа. Эта инновация соответствует требованиям отрасли к устойчивым и эффективным методам управления углеводородами.*

***КЛЮЧЕВЫЕ СЛОВА:*** *месторождение, технологический узел, сепаратор, фильтр, обеднённый газ, нефть, легкие жидкие углеводороды, вода и др.*

# ТЕХНОЛОГИЯЛЫҚ ҮДЕРІСТЕРДІ ОҢТАЙЛАНДЫРУ: МҰНАЙ МЕН ГАЗДЫ ДАЙЫНДАУ ҮШІН ҮДЕРІСТІҢ ТИІМДІЛІГІН АРТТЫРУ

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*. Мұнаймен бірге өндірілген табиғи газды дала жағдайында тазарту тиімділігін арттыру үшін жаңа газды сүзгі-сепаратор жасалды. Кәдімгі газ тазарту әдістері жеңіл сұйық көмірсутектерді (С5+) жою бойынша нормативтік талаптарға жиі сәйкес келмейді, бұл мұнайдың айтарлықтай жоғалуына, газ сапасының нашарлауына және қоршаған ортаға шығарылатын эмиссиялардың артуына әкеледі. Ұсынылған конструкция сұйықтық тамшыларының бірігуіне ықпал ететін, олардың тұндырылу тиімділігін Стокс заңына сәйкес арттыратын тарылатын коалесценциялық сүзгілерді қамтиды.*

*Сепаратордың инновациялық ерекшеліктеріне ағын динамикасын оңтайландыру үшін тангенциалды қосылған кіріс, тиімді бөлуге арналған тарылатын сүзгілер, сұйықтықты жинауға арналған жинағыш және жиналған көмірсутектерді жоюға арналған дренаж жүйесі кіреді. Бұл компоненттер бөлу тиімділігін арттыру үшін синергетикалық жұмыс істейді және жұмыс сенімділігі мен өткізу қабілетін сақтайды. Дала сынақтары сепаратордың С5+ құрамын айтарлықтай төмендетуде, газ тазалығын жақсартуда және өнеркәсіптік стандарттарға сәйкестігін қамтамасыз етуде тиімділігін растады.*

*Бұл технологияны дала жағдайында пайдалану газды жағуды азайту және балама мақсаттар үшін құнды көмірсутектерді қалпына келтіру арқылы қоршаған ортаға әсерді азайтады. Сепаратордың мұнай өндіру мен газ сапасын жақсарта отырып, қоршаған ортаға шығарылатын эмиссияларды азайту мүмкіндігі оны мұнай мен газ өндіру операциялары үшін төңкерістік шешім ретінде көрсетеді. Бұл инновация көмірсутектерді басқарудағы тұрақты және тиімді тәжірибеге саланың сұранысына жауап береді.*

***ТҮЙІН СӨЗДЕР:*** *кен орны, технологиялық түйін, сепаратор, фильтр, жеңіл газ, мұнай, жеңіл сұйық көмірсутектер, су және т.б.*

# OPTIMIZATION OF TECHNOLOGICAL PROCESSES OF OIL AND GAS PREPARATION TO ENHANCE OPERATIONAL EFFICIENCY

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*A novel gas filter separator has been developed to enhance the purification of natural gas extracted alongside crude oil under field conditions. Conventional gas purification methods frequently fail to achieve regulatory standards for the removal of light liquid hydrocarbons (C5+), resulting in substantial oil losses, compromised gas quality, and increased environmental emissions. The proposed design integrates narrowing coalescer filters that facilitate droplet coalescence, promoting sedimentation efficiency in accordance with Stokes' law.*

*The separator's innovative features include a tangentially connected inlet for optimized flow dynamics, narrowing filters for efficient separation, a liquid collection sump, and a drainage system for the removal of collected hydrocarbons. These components work synergistically to enhance separation performance while maintaining operational reliability and throughput capacity. Field testing demonstrated the separator's efficacy in significantly reducing C5+ content, achieving improved gas purity and compliance with industrial standards.*

*The deployment of this technology in field conditions mitigates environmental impacts by minimizing gas flaring and recovering valuable hydrocarbons for alternative applications. The separator's ability to enhance oil recovery and gas quality while reducing environmental emissions underscores its potential as a transformative solution for oil and gas production operations. This innovation aligns with industry demands for sustainable and efficient practices in the management of hydrocarbons.*

***KEYWORDS:*** *Field, Technological node, Separator, Filter, Lean gas, Oil, Light liquid hydrocarbon, Water, etc.*

**Introduction.** Natural gas flaring during oil production results in significant environmental and economic losses. Annually, approximately 140 billion cubic meters of natural gas are burned globally, releasing over 106 million tons of CO2 (GGFR World Bank indicators). Crude oil extracted from fields consists of hydrocarbons in solid, liquid, and gaseous forms. To transform crude oil into a marketable product and ensure efficient transportation, impurities such as water, gases, and mechanical particulates must be removed. Existing methods for gas purification, including physical, chemical, and thermal processes, face limitations in achieving regulatory standards, particularly for removing light liquid hydrocarbons (C5+). This inadequacy highlights the need for innovative solutions.

**Technological Development.** To address these challenges, a new gas filter separator was developed, aimed at purifying natural gas separated from crude oil in field conditions. The design employs narrowing coalescer filters, which function by reducing the distance between liquid droplets, promoting coalescence through intermolecular attraction. The resulting larger droplets enhance the rate of sedimentation, as described by Stokes' formula. The separator's components include:

1. **Body:** Diameter 3-4 times larger than the inlet line.
2. **Inlet Line:** Connected tangentially to the body.
3. **Narrowing:** Coalescer Filters: Installed on the inlet line.
4. **Collector:** Connects technological lines at the inlet.
5. **Sump:** Collects the separated liquid phase.
6. **Drainage Line:** Removes collected liquids.

**Process Mechanism.** Natural gas enters the narrowing filter, where the distance between droplets decreases, promoting coalescence. Larger droplets settle more rapidly in the separator, enhancing gas purification. The system minimizes resistance and ensures reliability by incorporating multiple technological lines to accommodate increased droplet sizes without compromising capacity.

A filter separator with a new design has been developed to separate oil produced from wells at the final stage of production from gas contained in it and achieve existing norms for purification. The function of the developed filter separator is based on the principle of coalescence of small-sized droplets which make up the liquid phase system. The coalescence is achieved by reducing the distance between droplets during the movement of multiphase mixture in the filter. By using filters, the gas separated from oil in the initial stages of the process is obtained at a higher level of purity in the final stage separator. With the effect of the filter, it is possible to prevent oil and gas losses in the field by increasing the efficiency of separation in the technological process.

Every year, including in 2023, on average, 140 billion cubic meters of natural gas were burned and as a result more than 106 million tons of CO2 gas was released during the process of oil production in the world. (GGFR World Bank indicators)

It is known that the composition of crude oil extracted from fields mainly consists of various hydrocarbon compounds in solid, liquid and gaseous form. In order to transform crude oil into a commodity and ensure its efficient transportation, it is required to remove water, gases and other mechanical impurities from oil. At the initial stage, gas purification from produced oil is carried out by various physical, chemical and thermal methods in separators installed in the field [2,3]. By using the aforementioned procedures, it is extremely difficult or almost impossible to fully purify the gas extracted from oil from different light liquid hydrocarbons (C5+) to the level required by the existing regulations.

The presence of light liquid hydrocarbons in the lean gas separated from oil causes certain complications in the following processes, including large oil losses. Thus, the light liquid hydrocarbons remaining in the gas are transferred to consumers together with natural gas. In this case, oil losses occur in the production process, and at the same time, the quality indicators of the purchased commodity gas decrease. Due to the utilization of this gas in industrial and domestic settings, greater quantities of harmful emissions are discharged into the atmosphere than initially anticipated.

In order to purify the gas at the level of the current requirements, lean gas separated from the oil should be transported to gas processing plant, where it is processed and adapted to the requirements of the standards intended for domestic use. Because oil fields are often far from gas processing plants and wells tend to produce less as they age, in most situations, it's generally seen as inefficient to transport gas over long distances for processing. Therefore, it is either used for internal demand or flared in the field. About 300 billion $m^3$ of natural gas are wasted or burnt in flares annually for a variety of reasons that oil producers have disclosed during the production process. Such emissions seriously harm the environment.

The presented topic shows that there is a serious and urgent problem in oil production, and it creates the need to conduct research to eliminate it.

Based on the above, a new innovative and improved gas filter separator has been developed for the purification of natural gas separated from oil in technological processes

in field conditions from water, light liquid hydrocarbons and mechanical mixtures. The goal of the project is to boost separation process efficiency and enhance the separators utilized in the technical hubs of the oil and gas production and transportation network.

The main idea of the work presented is that, in order to improve the effectiveness of the separators used in the field for the purification of oil and gas, newly created diffuser narrowing filters [1] are employed in the separator. On the separator's intake line are the filter elements that are employed in the device. Narrowing filters work by shortening the distance between the liquid droplets in natural gas, which causes the droplets to mix and separate from the gas phase more quickly.

The main operation scheme of the gas filter separator is given in the following figure [*figure 1*].

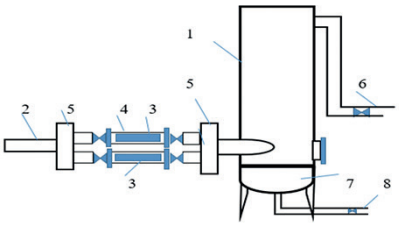
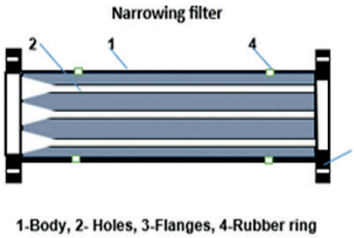



**Figure-1**




**Fiqure-2**

The provided gas filter-separator (*Figure 1*) consists of a body (1) whose diameter is 3-4 times larger than the diameter of the inlet line, an inlet line (2) connected tangentially from the lower part to the body, narrowing coalescer-filters placed on the inlet line (3), the collector (5) where the technological lines are connected at the inlet, the device where filter elements are placed on the inlet line and connected to the line with flanges (4), the outlet line (6) connected from the upper side to the body, a special sump (7) installed in the lower part of the body and designed for collecting the separated liquid phase, and eventually a drainage line (8) intended for removing the liquid collected at the bottom of the separator.

The narrowing filter device mounted on the inlet line (*figure 2*) consists of a cylindrical body (1) whose size matches the inlet line's diameter and a number of holes (2) that are opened on the filter sized at 1/10 of the inlet line's diameter.

A flange (3) connects the filter to the pipe, and a sealing rubber ring is inserted into the body's opening channel (4) to hold the filter in place.

The steps below are followed in order to complete the procedure and obtain the desired technical outcome: The natural gas enters the narrowing filter placed in this line before to the separator while it is flowing via the input line. The flow of gas travels toward the center of the hole as it passes through the diffuser section at the opening in the filter. At this time, the distance between the liquid droplets begins to decrease, and the moving liquid droplets come closer to each other and merge. Due to the intermolecular attraction of the liquid phase droplets, coalescence occurs, and as a result, the size of the droplets that make up the liquid phase in the gas increases. According to the well-known Stokes formula, the increase in the size of liquid droplets contained in natural gas intensifies their deposition in the separator.

$$[v=(g\ (\rho_s-\rho_f)d^2/18\mu]$$

As can be seen from the formula, the rate of deposition of droplets (v) depends on the diameter of the droplet (d), and if the diameter of the droplet increases in the process, the rate of deposition will be increased by the square of the diameter.

The effectiveness of the gas purification process in the separator is increased by increasing the intensity of the settling of liquid droplets included in the natural gas. In order to ensure process reliability and prevent the possibility of additional resistance in the filter due to the process's increased droplet size and consequent reduction in the separator's output capacity, two or more technological lines are installed on the collector.

The aforementioned separator is deemed very suitable for usage in the technical hub meant for oil and gas processing in the field. By using this separator, it is possible to purify the gas produced together with oil from the wells to a higher level. By purifying the light liquid hydrocarbons (C5+) contained in the gas separated from oil, a large amount of oil losses in the production process and damage to the environment when it is used as a combustion product are prevented, and at the same time, the quality indicators of natural gas are increased. The light liquid hydrocarbons separated in the process can be used for other purposes and higher efficiency can be gained in the production process.

**Conclusion.** The newly developed filter separator represents a significant advancement in oil and gas processing technology. By enhancing separation efficiency and meeting regulatory standards, it minimizes environmental impact, reduces economic losses, and improves the quality of both oil and gas products. The presented technology is particularly suitable for use in field conditions, addressing pressing challenges in oil production while paving the way for more sustainable practices.

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