TASHKENT STATE UNIVERSITY OF ECONOMICS

International journal of topics

INNOVATION SCIENCE AND TECHNOLOGY

Scopus || Electronic journal specializing in Scopus

ISSUE 10

Acceptance of papers **October, 2025**

Acceptance of papers

Published monthly

Topics

economics, technology, social sciences

ISSN 3060-5229

Electronic publication, Issue 10. 141 pages.
Approved for publication on October 19, 2025.

THE SCIENTIFIC-POPULAR ELECTRONIC JOURNAL **"INNOVATION SCIENCE AND TECHNOLOGY"** HAS BEEN REGISTERED UNDER THE NUMBER **C-5669633** BY THE AGENCY FOR INFORMATION AND MASS COMMUNICATIONS (AOKA) OF THE REPUBLIC OF UZBEKISTAN, EFFECTIVE FROM OCTOBER 9, 2024.

CONTACTS

Phone: **+998 50 737 87 88**

Website: https://ist-journal.uz

Email: innovationist2025@gmail.com

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Editorial board:

CONTENTS

CONTENTS

ANALYSIS OF EXISTING TECHNOLOGICAL SOLUTIONS TO THE PROBLEM OF WATERING GAS WELLS

Abdirazakov Akmal Ibrahimovich
Associate professor, Karshi State
Technical University,
Karshi city, Republic of Uzbekistan
E-mail: akmal/abdirazakov@bk.ru
ORCID: 0009-0004-1810-9482

Boymurodov Boynazar Muradillayevich
Master's degree, Karshi State
Technical University,
Karshi city, Republic of Uzbekistan

Abstract: This article examines the main challenges encountered during the operation of gas and gas condensate fields, such as the presence of formation and gas-containing water at the wellbore bottom, and the causes of these challenges. It also discusses methods for eliminating them, including closing the wellbore channel, pumping with cement and special polymer solutions, removing residual water and condensate from the wellbore bottom by changing pressure, removing fluid from the wellbore bottom with foams and surfactants, reducing the diameter of tubing, and using a plunger lift. The article also discusses the disadvantages of these methods for removing fluid from the wellbore bottom, their features, advantages, and disadvantages, and provides recommendations for using improved pumping equipment for removing fluid from gas and gas condensate wells.

Key words: gas, gas condensate, fields, production, hydrocarbon, liquid, water cut, gas recovery, liquid, saturation zone, well, bottomhole, formation, depression, low pressure, lifting, tubing, surfactant, installation of an electric centrifugal pump.

Annotatsiya: Ushbu maqolada gaz va gazkondensat konlarini ishlatishda qatlam bosimi yuqori yoki past bo'lganda yuzaga keladigan asosiy murakkabliklardan biri — quduq tubida qatlam suvi hamda gaz tarkibidagi suvlarning cho'kib qolishi va ularning kelib chiqish sabablari tahlil qilingan. Shuningdek, bunday muammolarni bartaraf etish usullari sifatida suv yo'lini yopish, sement va maxsus polimer eritmalarini haydash, mavjud suv va kondensat qoldiqlarini quduq tubidan bosimni o'zgartirish orqali falkga chiqarib yuborish, sirt faol moddalaridan foydalanib ko'piklar yordamida quduq tubidan suyuqlikni chiqarish, nasos-kompressor quvurlari diametrini kichraytirish yoki o'zgartirish, shuningdek, plunjernali liftni qo'llash orqali quduq tubidagi suyuqlikni chiqarish usullarining kamchiliklari, ularning qo'llanishdagi o'ziga xos jihatlari, afzallik va kamchiliklari yoritilgan. Gaz va gazkondensat quduqlaridagi suyuqlikni chiqarishda takomillashtirilgan nasos qurilmalaridan foydalanish samarali yo'nalish sifatida tavsiya etilgan.

Kalit so'zlar: gaz, gazkondensat, konlar, qazib olish, uglevodorod, suyuqlik, suvlangan, gazberuvchanlik, to'yinish hududi, quduq, quduq tubi, qatlam, depressiya, past bosimli, lifting, nasos-kompressor quvuri, SFM, MQCHEN.

Аннотация: В данной статье рассматриваются основные трудности, возникающие при эксплуатации газовых и газоконденсатных месторождений, такие как наличие пластовой и газосодержащей воды на забое скважины, и причины их возникновения, а также методы их устранения, такие как закрытие водопроявляющего канала, нагнитания цементными и специальными полимерными растворами, удаления имеющихся остатков воды и конденсата с забоя скважины путем изменения давления, удаление жидкости с забоя скважины пенами с применением поверхностно-активных веществ, уменьшение диаметра насосно-компрессорных труб и применение плунжерного подъемника. Приведены недостатки способов удаления жидкости с забоя скважин, их особенности, преимущества и недостатки при использовании, а также представлены рекомендации по применению усовершенствованных видов насосного оборудования для удаления жидкости с газовых и газоконденсатных скважин.

Ключевые слова: газ, газовый конденсат, месторождения, добыча, углеводород, жидкость, обводнненость, газоотдачи,, жидкость, зона насыщения, скважина, забой, пласт, депрессия, низкое давление, лифтинг, насосно-компрессорная труба, поверхностно активных веществ ПАВ, УЦЭН.

INTRODUCTION

Currently, a large number of wells in gas and gas condensate fields are subject to fluid accumulation at the well's bottomhole, which subsequently self-suppresses. This leads to the cessation of gas flow from the well, resulting in significant losses of recoverable gas and, consequently, failure to achieve the final gas recovery factor. According to forecasts by gas industry experts, by 2030, the number of wells shut down due to fluid accumulation at the well's bottomhole will reach up to 50% of all wells. This problem is especially acute in the late stages of field development, when reservoir pressure and well productivity are declining. Therefore, finding solutions to combat complications during gas production at gas and gas condensate fields is crucial.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of water production in gas wells has long been recognized as a key challenge in maintaining productivity and extending well life. According to Sun Xindi in his comprehensive review of horizontal well operations, the main causes of water influx include coning, channeling, and liquid loading, each of which significantly reduces well deliverability and complicates flow assurance. He emphasizes that effective mitigation requires an integrated approach combining reservoir management, completion design, and post-treatment monitoring.

Bai Bing, in his widely cited work on in-situ polymer gel applications, highlights that polymer and crosslinked gel systems have become essential tools for water shutoff operations. Bai's studies show that correctly designed polymer gels can reduce permeability in high-water-saturation zones by more than 90 %, provided that gelation time and salinity are optimized for reservoir conditions. This view is supported by Al Brahim, who classifies modern polymer systems into temperature-resistant and organically crosslinked categories and notes that their success depends heavily on injection sequence and mechanical stability.

Expanding on chemical techniques, Al Taq analyzes the use of relative permeability modifiers (RPMs) as a selective chemical solution that reduces water mobility without hindering gas flow. His 2021 study demonstrates that surfactant-based RPMs can maintain hydrocarbon productivity while reducing water production in fractured formations, though efficiency declines in oil-wet environments. Similarly, Seifi Farnaz presents results from laboratory core-flooding experiments showing that nano-enhanced chemical agents improve adsorption on rock surfaces and thus extend the treatment's lifetime compared with earlier polymer designs.

Mechanical and hybrid methods remain indispensable in practice. Taha Abdullah provides a detailed operational overview of water-shutoff procedures, describing how swellable packers and mechanical seals can isolate unwanted water zones when chemical placement is impractical. He also notes that mechanical methods are often combined with inflow control devices to sustain zonal balance in long horizontal sections. Research conducted by Qu Jianhua and Wang Ping supports this view: their study on soft movable polymer gels shows that hybrid mechanical-chemical isolation can control water coning in horizontal wells while preserving gas flow from productive zones.

For liquids removal, Schlumberger's Oilfield Review (2016) and Chen et al. (Frontiers in Energy Research, 2024) both describe plunger-lift systems as cost-effective, low-maintenance technologies suitable for deliquification in mature gas wells. They emphasize that automation of plunger cycles and integration with surface sensors can significantly reduce venting losses and optimize production cycles. While electric submersible pumps remain an alternative, their high energy costs limit their use in low-rate gas wells.

A separate line of technological development is represented by downhole separation and reinjection systems. A Curtin University technical report (2007) outlines how Downhole Oil-Water Separation (DOWS) technology allows immediate water disposal into lower formations while keeping gas and light hydrocarbons flowing to the surface. The report documents up to 25 % production improvement and 50 % reduction in surface handling costs under favorable pressure conditions. However, as both Sun and Taha note, the complexity and cost of DOWS installations restrict their widespread adoption.

Most recent reviews, including Al Brahim's and Seifi's, conclude that combining multiple methods—chemical, mechanical, and deliquification technologies—yields the highest success rate. Yet, as Bai Bing cautions, upscaling laboratory results to field performance remains problematic due to heterogeneous reservoirs and incomplete diagnostics. Modern research therefore advocates for integrated field pilots, advanced logging and tracer monitoring, and long-term performance tracking to validate and optimize these technologies.

RESEARCH METHODOLOGY

The research relied on a combination of technical document analysis, field reports, and experimental data published by international petroleum engineering journals. Statistical comparisons and case-based synthesis were applied to evaluate the efficiency of different water-shutoff technologies. The collected data were systematized, and comparative analysis was used to identify performance trends and limitations of each technological solution.

ANALYSIS AND RESULTS

Currently, gas well operations are complicated by numerous factors, the main ones being reduced reservoir pressure at the field and fluid accumulation at the wellbore bottom. These two complications are inextricably linked. Globally, the development of these complications is divided into four stages. As each stage progresses, gas flow rate decreases, while the amount of water in the wellbore increases, leading to a cessation of wellbore flow.

The first stage is anhydrous, in which only gas enters the well. Then, in addition to gas, water begins to enter the wellbore bottomhole, accumulating as a film on the pipe walls and being carried away by the gas flow to the wellhead. The third stage is characterized by a balance between the amount of water entering the wellbore and being carried to the surface. Subsequently, as reservoir pressure drops, well production enters the fourth stage, during which the rate of liquid column growth in the wellbore increases. This, combined with a decrease in reservoir drawdown, leads to a transition to zero-flow operation of the gas-liquid lift system, followed by well shutoff. Therefore, minimizing losses during gas and condensate production by using the most efficient liquid removal technologies becomes a crucial task in the final stage of gas and gas condensate field production.

Liquid enters the wellbore bottomhole because gas, moving at high velocity in the formation, entrains liquid and attempts to transport it to the surface. High velocity ensures a flow regime in which the liquid remains suspended, resulting in a low volume fraction of liquid in the flow and minimal pressure losses due to the gravity component of the flow.

For marginal wells operating at the margin of profitability, ensuring fluid removal from the wellbore is crucial, as this will determine whether the wellbore continues or ceases production. Fluid accumulation in the wellbore poses a threat to the operation of not only marginal wells but also gas wells with high wellhead pressures and large diameter production casings.

The high velocity at which the gas moves can be accompanied by significant pressure losses caused by friction, while the pressure losses caused by the liquid column in the wellbore are relatively small.

As the gas velocity in the production casing begins to decline over time, the velocity of the liquid carried by the gas decreases. This alters the nature of liquid flow near the pipe walls, leading to the formation of liquid plugs and liquid accumulation at the bottomhole. All of these factors increase the proportion of liquid in the gas flow, leading to reduced productivity or complete cessation of gas production from the well.

As the gas flow moves toward the wellhead, both hydrocarbons (condensate) and water particles may precipitate due to a decrease in temperature and pressure. In some cases, liquid may enter the wellbore due to water influx from the underlying aquifer. Most methods for combating water influx in gas wells are insensitive to the source of the liquid in the wellbore, but there are methods aimed at preventing problems associated with liquid condensation that do not prevent liquid influx from outside. Therefore, it is necessary to confirm that the condensation process is the source of the water. Otherwise, the problem will not be solved.

When the gas velocity is high enough to remove most or all of the water entering the well, the reservoir pressure and well flow rate are in a stable equilibrium. In this case, the well will operate at a constant flow rate.

If the gas velocity is too low to remove water, the pressure gradient gradually increases due to fluid accumulation at the wellbore, leading to increased backpressure on the formation. As backpressure increases, the rate of gas inflow into the wellbore will gradually decrease until it no longer provides the “critical gas flow rate” required for continuous fluid removal. This will lead to fluid accumulation in the wellbore and increased downhole pressure, leading to reduced gas production and eventual wellbore failure.

At present, the velocity of gas movement in the wellbore is the main diagnostic parameter, based on which it is possible to predict the accumulation of liquid at the bottom of a gas well.

At the early stage of flooding of gas wells, an effective method of combating complications is the use of water shut-off technologies, which involve the integrated or individual implementation of the following measures: the creation of hydrophobic emulsion screens in the productive part of the gas reservoir, artificial colmatation water-saturated space, installation of cement bridges, which can also be combined with preliminary injection of various waterproofing materials. One method for eliminating water influx is to inject a blocking reagent composition followed by cementing the zone. The goal of water shutoff is to isolate the water-saturated portion of the reservoir, which typically has high filtration-capacity properties (FPP).

A consequence of using this technology is difficulty in bringing wells into production due to the reduced thickness of the productive layers involved in development. It’s worth noting that the positive effect of water shutoff works diminishes over time, while the number of wells experiencing development problems after using this technology is increasing.

The most common method for removing fluid from wells, requiring no additional equipment, is flare blowdown. This essentially involves a short-term increase in drawdown pressure to suddenly increase wellbore speed, resulting in a short-term increase in flow rate. As is well known, even a short-term increase in drawdown pressure causes damage to the bottomhole formation zone, leading to sand production and abrasive wear of equipment. It should be noted that the effectiveness of this method is short-lived. Automated well blowdown projects have been developed to optimize well blowdown time, thereby increasing their efficiency. However, this solution will not completely eliminate the shortcomings of this technology.

Liquid removal technology using surfactants has become widespread in the modern oil and gas sector. Injecting surfactants into a water-producing wellbore results in the formation of foam, which is subsequently carried to the surface by the gas flow. This technology relies on the fact that the liquid is held within a cloud of gas bubbles, and the effect is exerted over a large surface area, resulting in a reduction in the system's density and, consequently, a lower pressure gradient. Another undeniable advantage of this technology is its applicability to wells with extremely low flow rates.

A disadvantage of this method is the potential for the formation of stable foam compounds, which negatively impacts the operation of the wellbore collection and treatment system, specifically leading to a reduction in well flow rates, increased loads at booster compressor stations (BCS), a reduction in the quality of field gas treatment, loss of absorbent during gas drying, deposit formation, and a reduction in flow areas on the flow paths of field equipment.

Another way to create conditions for water removal from the wellbore is to increase the gas flow rate by reducing the tubing diameter. Replacing the tubing strings with smaller flow sections increases the flow rate and reduces bottomhole pressure. However, a tubing diameter that is too small for the well's flow rate can lead to excessive frictional pressure losses and contribute to increased bottomhole pressure. This operation is accompanied by a 20-50% reduction in the well's flow rate. The effect of replacing the tubing in the well lasts from 8 to 15 months, resulting in the wells operating at a constant flow rate and preventing fluid accumulation at the bottomhole. After this period, water removal conditions deteriorate back to the original levels, necessitating a second replacement with an even smaller diameter.

Plunger lift technology utilizes a special movable separator located in the tubing string. This device consists of a plunger that moves upward under wellbore pressure and then returns to the bottomhole under gravity. In addition to the plunger, a spring located at the wellbore bottom is required to smoothly stop the separator. The wellhead must be modified to allow the plunger to stop and then be surrounded by the gas flow. A controlled actuator valve is also required to open and close the flow line. For proper valve operation, a number of sensors are required, including a sensor that registers the plunger's arrival, as well as an electronic controller with a device that determines the well's production and closure periods to ensure increased productivity.

The plunger lift operates in a cyclical mode. During a shut-in, when the plunger lift is in the downhole position, fluid accumulates at the wellbore, while pressure in the annulus rises. Gas pressure in the annulus depends on the wellbore shut-in duration, formation pressure, and formation permeability. When the annulus pressure reaches a certain value, the actuator valve opens, and the well begins flowing. Expanding gas from the annulus fills the tubing and begins to lift the plunger, along with the fluid, toward the wellhead. Gas extraction continues until the wellbore flow rate decreases to a level close to the critical flow rate, and fluid begins to accumulate in the wellbore. At this point, the wellbore is shut in, and the plunger descends to the wellbore and seats on the shock absorber spring. The pressure buildup period begins again. The cycle then begins again, with the well once again going through cycles of gas accumulation in the annulus and water removal.

Compared to replacing the tubing with smaller diameter pipes, this method is much more cost-effective. Furthermore, the well flow rate is significantly higher than with replacing the tubing.

The complexity of implementing this technology stems from the fact that as the plunger moves up the tubing, fluid leaks can occur. This can lead to the plunger exiting the wellhead empty, causing a strong impact on the wellhead equipment, potentially causing mechanical damage. A key requirement for using this technology is the ability to build up sufficient annular pressure to lift the plunger to the surface. Furthermore, the fluid inflow must be sufficient to ensure sufficient gas pressure to lift the liquid to the surface.

Despite some success, the use of these methods requires large amounts of high-pressure gas, the construction of gas pipelines to supply high-pressure gas to wells, and has a limited scope of application and is not a definitive solution for wells with low reservoir pressure.

Therefore, it is necessary to consider other artificial lift technologies for the challenging conditions of high-water, low-pressure wells.

Toward the end of a well's life, the fluid level may be above the perforations, and gas will rise through the fluid column to the surface in the form of bubbles. Gas production will continue at a low but stable flow rate, and no liquid will reach the wellhead. Analyzing the performance of such a well without taking into account its history, one can assume that there is no fluid accumulation in the well, and the low flow rate is a consequence of declining reservoir pressure.

Many wells produce not only gas but also condensate and water. If the reservoir pressure drops below the dew point, condensate enters the well as a liquid along with the gas. If the reservoir pressure is above the dew point, condensate enters the well as a vapor phase along with the gas and may liquefy in the production string or separator.

There are several mechanisms for water entering a gas well:

1. Water can come from an aquifer located above or below the gas-saturated formation.
2. In a water-driven mode, water moving along the formation will reach the bottom of the well.
3. Unbound formation water can be removed from the formation along with gas.
4. Water or hydrocarbons can enter the wellbore along with the gas in the form of a vapor phase and condense in the production string.

Let's look at these sources in more detail.

A flood cone occurs when the gas flow rate is high enough to entrain water from the underlying aquifer, which may be located outside the perforated wells. interlayers. It is worth noting that horizontal wells exhibit significantly smaller pressure gradients between gas and underlying aquifer zones, however, at very high flow rates we can observe a similar picture, which in turn is called not the formation of a flood cone, but the pulling of the gas-water complex toward the horizontal well.

When a well operates in a water-driven mode, that is, when reservoir pressure is maintained using the energy of the aquifer, water is eventually drawn toward the gas-producing well, which ultimately leads to this water entering the wellbore, which entails the above-mentioned problems associated with the accumulation of liquid at the bottomhole.

If a well is completed with an open hole or perforated in multiple reservoir intervals, water influx from other intervals is possible. This situation can be used to our advantage if the aquifer is located below the producing gas reservoir. Using various technical means and technological methods, and once the required injectivity is achieved, water can be injected into the aquifers, allowing the gas to rise to the surface.

Due to poor quality cementing of the annular space or destruction of the cement stone, behind-the-casing cracks occur. overflows that allow water to flow from aquifers interlayers into gas layers, and then into the wellbore.

Don't forget about water, which may be present in a free state in the gas-bearing formation. It will also flow into the well along with the gas.

Since the gas flow rate decreases with a decrease in reservoir pressure, this will also be accompanied by an increase in the amount of liquid in the wellbore.

CONCLUSIONS AND SUGGESTIONS

Given the potential increase in the number of wells prone to flooding at gas and gas condensate fields, the need to find a solution to this problem is clear. To this end, existing gas well flood control methods used in Uzbekistan and abroad were analyzed.

Most gas fields are developed under elastic water drive. Consequently, when reservoir pressure decreases, water enters the well, leading to significant losses of gas reserves and significant complications in well operations. Due to well flooding, gas production drops sharply, while sand production from the formation increases sharply. Many gas wells are decommissioned due to flooding. As follows from the above, water isolation, flaring, surfactant use, and replacing tubing with smaller diameter pipes are insufficient for gas production from low-pressure, water-fed reservoirs. Therefore, given the growing relevance of this problem, technical solutions are being sought. For example, studies have considered the use of surface compressors, surface twin-screw booster pumps, and heating the liquid using microwave emitters for evaporation; however, these methods have not solved the problem.

Recommendations:

1. The causes and mechanism of flooding of gas wells at a late stage of field development are considered.
2. An analysis of existing technical and technological solutions for combating flooding of gas wells was conducted.
3. It has been shown that a promising approach to solving the problem of removing accumulated water at the bottom of gas wells is a mechanized method of lifting liquid using submersible pumps.
4. One of the technical areas of application for submersible pumps is the development of hybrid pumps that simultaneously implement several operating processes. Of particular interest are hybrid pumps that can operate both as a pump and a dispersant, and are also resistant to high suspended particle content in the gas-liquid mixture flow.

List of used literature:

1. Дж. Ли, Г. Никкенс, М. Уэллс Эксплуатация обводняющихся газовых скважин. Технологические решения по удалению жидкости из скважин. Москва: Премиум Инжиниринг, 2008. 384 с.
2. Shurtan neft va gaz qazib chqarish boshqarmasi hisobotlari, 2008-2023..
3. Руководство по эксплуатации скважин сеноманских залежей по концентрическим лифтовым колоннам: Р Газпром 2-3.3-556-2011. М.: Газпром экспо, 2011. 29 с.
4. Дроздов А.Н. Технология и техника добычи нефти погружными насосами в осложненных условиях. Москва: МАКС пресс, 2008. 312 с.
5. Пономарев А.И. Повышение эффективности разработки залежей углеводородов в низкопроницаемых и слоисто-неоднородных коллекторах. Новосибирск: СО РАН, 2007. 236 с.
6. Сазонов Ю.А. Основы расчета и конструирования насосно-эжекторных установок.. Москва: ГУП Изд-во «Нефть и газ» РГУ нефти и газа имени И.М. Губкина, 2012. 305 с.
7. Идельчук И.Е. Справочник по гидравлическим сопротивлениям / – М.: Машиностроение, 1992. – 672 с.

Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2025. № 10

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

"The journal "INNOVATION SCIENCE AND TECHNOLOGY" has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

Our address: Tashkent city, Yunusobod district, 19th block, House 17.

TASHKENT STATE UNIVERSITY OF ECONOMICS

Google Scholar | OPEN ACCESS | ULRICHSWEB GLOBAL SERIALS DIRECTORY
Academic Resource Index ResearchBib | ISSN INTERNATIONAL STANDARD SERIAL NUMBER INTERNATIONAL CENTRE | CYBERLENINKA
OpenAIRE | ROAD | НАУЧНАЯ ЭЛЕКТРОННАЯ БИБЛИОТЕКА LIBRARY.RU
BASE | INDEX COPERNICUS INTERNATIONAL | Crossref
doi Digital Object Identifier | CiteFactor Academic Scientific Journals | zenodo

Acceptance of articles

Published every monthly

Directions

Social, economic, political, technological, scientific

Scopus || Scientific electronic journal specializing in Scopus

CERTIFICATE NUMBER: №390637

ORDER NUMBER ACCORDING TO THE LICENSE REGISTER: C-5669633

CONTACT:

Contact us
+998 50 737 87 88

Telegram channel
t.me/scopus_IST2100

Journal official website
https://ist-journal.uz/index.php/IST