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# 贵州六盘水煤层气井产气下降 阶段负压排采技术研究

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**摘要:** 目前排水降压采气是煤层气井开采的主要方式, 开采过程中会达到产气下降阶段, 常出现自然产量不断降低成为低产低效井。为治理该类煤层气井, 需要促进煤层气的解吸、扩散和渗流, 煤层气负压排采技术多次取得很好的增产效果, 根据煤层负压排采技术增产因素可以逐步完善该技术的理论基础, 负压排采技术在增大生产压差的同时, 可能会产生煤储层解堵、促进井间干扰以及增加渗透率等效果, 能最大限度降低废弃压力, 提高煤层气的最终采收率。研究认为六盘水大河区块煤层气井产气量下降阶段使用负压排采技术是可行的。

**关键词:** 煤层气 负压排采 增产 可行性

## Study on Negative Pressure Drainage Technology for Declining Gas Production Stage of Coalbed Methane Wells in Liupanshui of Guizhou

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**Abstract:** Currently, gas recovery by water drainage is the main method for coalbed methane well production, During the extraction process, gas production will enter a declining stage, often leading to the continuous decrease of natural production and becoming low-production and low-efficiency wells. To manage such wells, it is necessary to promote the desorption, diffusion and seepage of coalbed methane, and the negative pressure drainage technology for coalbed methane has achieved a good effect in increasing production many times. By studying the factors contributing to production increase using negative pressure drainage technology of coal seam, the theoretical basis of this technology can be progressively improved. Negative pressure drainage technology may produce the effects of coal reservoir plugging removal, promoting inter-well interference and increasing permeability while increasing the production pressure difference. This can minimize abandoned pressure and improve the final recovery rate of coalbed methane. The study concludes that using negative pressure drainage technology during the declining gas production stage of coalbed methane wells in Dahe Block of Liupanshui is feasible.

**Keywords:** Coalbed methane; negative pressure drainage; increasing production; feasibility

# 煤层气长水平段水平井钻完井技术探索

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**摘要:** 煤层气长水平段水平井技术是深部低渗透煤储层高效开发一种重要手段, 然而由于其水平段长、水垂比大等因素使得在钻进和完井过程中存在井眼轨迹控制难度大、滑动钻进托压、岩屑床清除和完井管串下入困难、易发生漏失等技术难题。为此, 渤海钻探工程技术研究院从井眼轨迹优化设计、随钻轨迹控制、漏点检测、井眼延伸辅助工具配套和完井技术配套等方面开展研究, 形成了煤层气长水平段水平井钻完井技术, 并在山西沁水盆地 ZP4-76-32L 等 2 口成功应用, 创造国内煤层气 2001m 单支最长水平段、最大水垂比 3.67 的记录。

**关键词:** 沁水盆地 煤层气 长水平段 井眼延伸

## Exploration of Drilling and Completion Technology for Long Horizontal Wells in Coalbed Methane

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**Abstract:** The long horizontal section horizontal well technology for coalbed methane is an important means of efficient development in deep low-permeability coal reservoirs. However, due to factors such as the length of the horizontal section and the large water-to-vertical ratio, there are technical difficulties in controlling wellbore trajectory, sliding drilling support pressure, rock debris bed removal, and completion pipe string insertion during drilling and completion, as well as the risk of leakage. To address these issues, the CNPC Bohai Drilling Engineering Company Limited has conducted research on the optimization design of wellbore trajectory, control of drilling trajectory, matching of wellbore extension auxiliary tools and completion technology, and has formed the drilling and completion technology for long horizontal sections of coalbed methane. It has been successfully applied in two wells, including ZP4-76-32L in the Qinshui Basin of Shanxi, creating a record for the longest horizontal section of a single 2001m coalbed methane branch and a maximum water-to-vertical ratio of 3.67 in China.

**Keywords:** Qinshui Basin; coalbed methane; long horizontal section; wellbore extension

根据全国第四轮煤层气资源评价结果, 我国埋深 2000m 以内的煤层气资源量为  $29.82 \times 10^{12} \text{ m}^3$ , 其中埋深 1000 ~ 2000m 的深层煤层气资源量为  $18.71 \times 10^{12} \text{ m}^3$ , 占比达 62.7%。经过三个五年计

**基金项目** 中国石油集团油田技术服务有限公司科学研究与技术开发项目“钻完井复杂防治技术研究”(2023T-001-002)。

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# 煤层气井受钻井压裂影响因素研究

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**摘要:** 煤层气是在煤热演化的过程中形成并赋存在煤层中的一种优质新型清洁能源, 在我国煤层气资源极其丰富, 开采前景十分广阔。煤层气的开采不仅能降低矿井的灾害程度, 还能减少温室气体的排放, 助力实现“碳达峰, 碳中和”目标。煤层气的完井方式通常采用压裂完井, 随着煤层气生产区块进入大规模开发阶段, 部分井受到邻井钻井压裂影响, 导致气量下降。本文通过对区块受钻井压裂影响井的数据进行分析处理, 收集井间距、受钻井压裂影响前正常气量等数据, 并进行分析对比, 发现新井150m范围内更容易受到钻井影响, 新井150m~300m范围更易受到钻井压裂的影响。并为后期新投井的钻井压裂提供指导。

**关键词:** 煤层气 钻井影响 压裂影响

## Research on Influencing Factors of Coalbed Methane Wells by Drilling and Fracturing Operations

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**Abstract:** Coalbed methane is a high-quality new clean energy formed in the process of coal thermal evolution and deposited in coal seams. China possesses extremely rich coalbed methane resources with vast extraction potential. Extracting coalbed methane can not only reduce mine disasters, but also reduce greenhouse gas emissions, helping to achieve the goal of “carbon peak, carbon neutrality”. Coalbed methane wells are usually completed using fracturing techniques. As coalbed methane production blocks enter the large-scale development stage, some wells are affected by the drilling and fracturing of adjacent wells, resulting in a decrease in gas production. This study analyzes and processes the data from wells affected by drilling and fracturing, and collects data such as well spacing and normal gas production volume before drilling and fracturing impacts for analysis and comparison. It is found that the new wells are more likely to be affected by drilling within 150m, and are more susceptible to fracturing impacts within 150 ~ 300m, which could guide the drilling and fracturing operation in newly planned wells.

**Keywords:** Coalbed Methane; drilling impact; fracturing impact

# 深部煤储层游离气含量计算方法研究

## ——以鄂尔多斯盆地L区为例

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**摘要:** 文章根据深部煤储层特点, 游离气含量由总含气量与吸附气含量获得。其中总含气量由煤层工业组分拟合法获得, 煤储层的吸附气以物理吸附为主, 主要吸附在煤储层的孔隙表面上, 因为分形几何公式中的分形维数可以表达孔隙的复杂程度, 所以煤层气吸附气含量和分形维数存在一定的相关性, 分形维数越高, 甲烷吸附量越多, 煤储层的吸附气含量越大。根据这一特性构建起L区8+9号煤层吸附气含量模型。最终根据深部煤储层特点获得游离气含量拟合模型, 该研究成果为鄂尔多斯盆地L地区8+9号煤层的游离气含量预测提供一种有效手段。

**关键词:** 8+9号煤层 游离气 分形维数 吸附气含量

## Study on Calculation Method of Free Gas Content in Deep Coal Reservoirs —A Case Study of L Area, Ordos Basin

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**Abstract:** Based on the characteristics of deep coal reservoirs, the free gas content is derived from the total gas content and the adsorbed gas content. The total gas content is obtained using the industrial component analogy method for coal seams, while the adsorbed gas in coal reservoirs primarily involves physical adsorption, mainly occurring on the surface of coal reservoir pores. Since the fractal dimension in the fractal geometry formula can express the complexity of pores, there is a certain correlation between the adsorbed gas content of coalbed methane and the fractal dimension. A higher fractal dimension indicates a greater methane adsorption capacity and higher adsorbed gas content in the coal reservoir. According to this characteristic, the adsorbed gas content model for 8+9 Coal Seams in the L Area is established. Ultimately, a fitting model for free gas content is developed based on the characteristics of deep coal reservoirs. This research provides an effective method for predicting the free gas content in the 8+9 Coal Seams of the L Area in the Ordos Basin.

**Keywords:** No. 8, 9 Coal Seams; free gas; fractal dimension; adsorbed gas content

# 煤层气井排采制度定量优化方法

## ——以潘庄煤层气井为例

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**摘要:** 以潘庄煤层气井为例, 根据煤层气井的开发特征, 制订了“522”排采制度优化思路; 利用分类和大数据统计的方法, 从检泵周期和产气量两个维度对不同井型不同煤层的煤层气井进行了排采制度优化, 得到煤层气井不同排采阶段排采工作制度定量优化的一种方法。这为煤层气井排采制度的定量优化提供了思路和借鉴, 尤其对目前排采经验相对较少的深部煤层气的开采有着很重要的参考价值。

**关键词:** 煤层气 排采制度 定量 优化

## Quantitative Optimization Method for Drainage System of Coalbed Methane Wells

### —Taking Panzhuang Coalbed Methane Well as an Example

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**Abstract:** Taking the coalbed methane wells in Panzhuang as an example, and based on the development characteristics of coalbed methane wells, a “522” optimization strategy for the drainage system is proposed. By using classification and big data statistics methods, the drainage system of coalbed methane wells in different types and coal seams is optimized from two dimensions: pump inspection cycle and gas production rate. This study presents a quantitative optimization method for the drainage system of coalbed methane wells at different drainage stages. The findings provide valuable insights and references for the quantitative optimization of coalbed methane drainage system, especially for the extraction of deep coalbed methane with relatively limited extraction experience.

**Keywords:** Coalbed methane; drainage system; quantification; optimization

# 煤层气 L 型水平井电潜螺杆泵井 清防砂工艺技术创新及应用

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**摘要:** 套管完井压裂投产的煤层气 L 型水平井出砂严重, 倒置式电潜螺杆泵举升工艺受压裂砂影响故障频繁, 影响了连续稳定排采, 因此确定了倒置式电潜螺杆泵排采过程中由于压裂砂导致的故障点, 并针对性创新应用了井筒内、导流罩及泵内清砂工艺技术, 同时优化防砂管柱设计, 确保了连续稳定排采。

**关键词:** 煤层气 L 型水平井 电潜螺杆泵 清防砂工艺 连续稳定 排采

## Technological Innovation and Application of Sand Cleaning and Control Process for Coalbed Methane L-type Horizontal Well with Electric Submersible Screw Pumps

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**Abstract:** Coalbed methane L-type horizontal wells, which are completed and fractured using casing, often face severe sand production. The inverted electric submersible screw pump lifting process is frequently affected by fracturing sand, leading to frequent failures and disrupting continuous and stable drainage. This study identifies the fault points caused by fracturing sand in the process of discharge and production by the electric submersible screw pump and innovatively applies sand cleaning techniques inside the wellbore, flow guide covers, and within the pump. Additionally, the sand control tubing design was optimized, ensuring continuous and stable drainage.

**Keywords:** Coalbed methane L-type horizontal well; electric submersible screw pump; sand cleaning and control process; continuous and stable drainage.

L 型水平井因井眼稳定、可改造、低成本、产量高的优势, 已成为煤层气田开发布井的主要井型。该类型水平井由直井段、造斜段和水平段组成, 井眼轨迹沿着煤层或煤层附近水平方向钻进一

定长度, 整个井眼为单一井眼轨迹, 无其它分支, 整个井身结构呈“L”型的单支水平井。且根据完井方式, 该类型水平井井底至井口的钻完井井身结构有两种, 一种是可压裂改造的套管完井井身结

# 马必东区块煤层气井螺杆泵排采制约因素分析及治理措施研究

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**摘要:** 螺杆泵因具备排液量大、泵效高、设备占地面积小且易于装备等优点, 主要在高产液量的合采井、水平井中应用, 但在生产过程中随着排采程度累加后地层返液量减少, 泵充盈度不够, 泵效变低, 造成螺杆泵运行过程中长期处于高温积碳状态发生烧泵。文章以马必东区块煤层气采气区为研究区, 通过建立螺杆泵排采水产出、过滤、返注的循环装置, 结合螺杆泵排采运行阶段特点, 制定合理的运行模式, 避免烧泵、卡泵等故障发生, 保障螺杆泵的平稳运行, 提高排采时率, 对提高单井产能具有一定的积极作用。

**关键词:** 马必东区块 螺杆泵 故障频发 注水循环 提高排采时率

## Analysis of Restricting Factors and Research on Treatment Measures for Screw Pump Drainage of Coalbed Methane Well in Mabidong Block

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**Abstract:** Due to the advantages of large liquid discharge, high pump efficiency, small equipment footprint, and easy installation, screw pump is mainly used in high-yield liquid co-production wells and horizontal wells. However, in the production process, as the accumulation of drainage degree, the return liquid from the formation decreases, the pump filling degree is not enough, and pump efficiency becomes low, resulting in long-term high-temperature carbon accumulation during the operation of the screw pump and causing the burning burnout. The paper takes the coalbed methane production area of Mabidong Block as the research area to solve these problems by establishing a screw pump drainage system incorporating water extraction, filtration and reinjection cycle, and combining with the characteristics of the screw pump operation stages, a suitable operating mode is developed to avoid the occurrence of pump burnout and stuck, ensure the smooth operation of the screw pump, and improve the drainage time rate, thereby enhancing the production capacity of individual wells.

**Keywords:** Mabidong Block; screw pump; frequent failures; water reinjection cycle; increase drainage time rate

# 临兴区块煤层气井负压排采 增压入干技术研究

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**摘要:** 针对临兴区块煤层气储层压力低、井场汇压高, 气井产气无法入干的问题, 提出了负压排采增压入干工艺措施。建立了空气干燥基、平衡水和饱和水煤样的解吸模型, 得到煤层气负压解吸规律, 设计了井场井组负压排采增压外输工艺流程方案, 通过智能控制系统, 根据井口压力传感器数值, 动态调节气井产气外输路线; 建立了负压排采时机选择模型, 根据等温吸附实验数据, 推算出临兴区块负压排采时机。

**关键词:** 煤层气开发 负压排采技术 增压输送 解吸模型

## Research on Negative Pressure Production and Pressure Boosting Technology for Coalbed Methane Wells in Linxing Block

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**Abstract:** To address the issues of low reservoir pressure and high collection pressure at the well site in the Linxing Block, which prevent coalbed wells from delivering gas to the main pipeline, a negative pressure production and pressure boosting process has been proposed. A desorption model for coal samples based on air drying, equilibrium water, and saturated water is established, revealing the negative pressure desorption patterns of coalbed methane. A process flow scheme for negative pressure production and pressure boosting for well groups at the well site has been designed, which uses an intelligent control system to dynamically adjust the gas export routes of the wells based on the readings of wellhead pressure sensors. A model for selecting the timing of negative pressure production has been established, and based on isothermal adsorption experimental data, the timing for negative pressure production in the LX Block has been determined.

**Keywords:** Coalbed methane development; negative pressure extraction technology; pressure boosting and transportation; desorption model

# 光纤长期监测技术在煤层气开发中的应用

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**摘要:** 煤层气储层动态监测受井筒条件限制, 煤层动态监测效率低, 监测资料少, 无法准确分析各层段的开发情况, 制约了煤层气开发动态矛盾分析和调整方案的制定。分布式光纤测井在华北某煤层气田开展了实际应用, 在正常生产条件下实时反映了各层段的产气动态、环空液面变化, 并反映了管柱在生产中发生的异常, 起到了异常预警作用。本文从煤层气开发特点角度分析了煤层气开发监测需求和光纤监测的适用性, 并通过实际案例展示了分布式光纤在煤层气井动态监测中能发挥的作用和效果, 在一定程度上解决了煤层气多层开采监测难题。

**关键词:** 分布式光纤 煤层气 产出剖面 长期监测

## Application of Long-term Fiber Optic Monitoring Technology in Coalbed Methane Development

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**Abstract:** The dynamic monitoring of coalbed methane reservoirs is limited by wellbore conditions, resulting in low monitoring efficiency and insufficient data, making it difficult to accurately analyze the development status of each layer. This limitation hinders the analysis of dynamic issues and the formulation of adjustment plans for coalbed methane development. Distributed fiber optic logging has been practically applied in a certain coalbed methane field in North China. It reflects the gas production dynamics of each layer in real-time under normal production conditions, monitors the changes in annular fluid level, and detects anomalies in the tubing during production, providing early warning of these anomalies. This paper analyzes the monitoring needs of coalbed methane development and the applicability of fiber optic monitoring from the perspective of coalbed methane development characteristics. Through actual case studies, it demonstrates the role and effectiveness of distributed fiber optics in the dynamic monitoring of coalbed methane wells, to some extent resolving the challenges of multilayer coalbed methane extraction monitoring.

**Keywords:** Distributed fiber optics; coalbed methane; production profile; long-term monitoring

# 利用旋转阀式蓄热氧化工艺实现 减排温室气体技术探讨

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**摘要:** 煤矿瓦斯综合利用是煤矿甲烷减排的主要途径。由煤矿抽采泵站抽采出的瓦斯经过瓦斯掺混装置与空气(或乏风)进行均匀混配,混配后的浓度小于 1.2%,经旋转阀式蓄热氧化装置进行无焰氧化,氧化后产生的热通过余热锅炉系统、发电系统,进行煤矿瓦斯综合利用。通过旋转阀式蓄热氧化工艺对煤矿瓦斯甲烷浓度不超过 8% 加以利用,助力煤矿实现温室气体减排。

**关键词:** 无焰氧化 低浓度风排瓦斯 旋转式蓄热氧化 CCER

## Discussion on Technology of Reducing Greenhouse Gas Emissions by using Rotary Valve Regenerative Oxidation Process

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**Abstract:** The comprehensive utilization of coal mine gas is the main way to reduce methane emissions in coal mines. The gas extracted by the coal mine pumping station is evenly mixed with air (or ventilation air methane) through the gas distribution system, resulting in a mixture with a methane concentration of less than 1.2%. This mixture undergoes flameless oxidation in a rotary valve regenerative oxidation device, and the heat generated from the oxidation is utilized in the comprehensive utilization of coal mine methane through systems such as the waste heat boiler and power generation system. The methane concentration of coal mine methane through the rotary valve regenerative oxidation process is not more than 8%. This technology helps coal mines reduce greenhouse gas emissions.

**Keywords:** Flameless oxidation; low-concentration ventilation air methane; rotary regenerative oxidation; China Certified Emission Reduction (CCER)

### 1 旋转式蓄热氧化装置在煤矿温室气体减排适用条件

2024 年发布《温室气体自愿减排项目方法学 煤矿低浓度瓦斯和风排瓦斯利用(征求意见稿)》

中关于国家核证自愿减排量对 CCER (China Certified Emission Reduction) 给出了明确的定义并对煤矿瓦斯减排技术也给出了具体的两种适用条件:一种是利用收集的风排瓦斯,通过无焰氧化分解销毁,或分解销毁后产生的热能用于发电;另一种是