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鹿台山煤业15号煤层瓦斯 涌出量预测研究

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摘要: 鹿台山煤业2号煤层即将采完, 15号煤层作为接替煤层开发。现选用分源预测法对鹿台山煤业15号煤层的瓦斯涌出量进行预测, 得出15号煤层瓦斯含量梯度为 $(1.52\text{m}^3/\text{t})/100\text{m}$; 根据判定规则, 确定15号煤层瓦斯风化带高度为301.11m, 宽度为2150.79m; 最后采用分源预测法对15号煤层的瓦斯涌出量进行预测, 并分析矿井瓦斯涌出组成。研究结果显示, 煤层在达产状态下, 矿井的最大绝对瓦斯涌出量为 $42.39\text{m}^3/\text{min}$, 最大相对瓦斯涌出量为 $33.58\text{m}^3/\text{t}$, 确定鹿台山煤业属高瓦斯矿井。

关键词: 瓦斯涌出量 分源预测法 瓦斯含量 瓦斯风化带

Study on Gas Emission Prediction for No. 15 Coal Seam of Lutaishan Coal Industry

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Abstract: No. 2 coal seam of Lutaishan coal mine is about to be mined out, and No. 15 coal seam is developed as a replacement coal mine. The source prediction method is used to predict the gas emission volume of No. 15 Coal Seam in Lutaishan Coal Mine. The gradient of gas content in No. 15 Coal Seam is $(1.52\text{m}^3/\text{t})/100\text{m}$. According to the determination rules, the height of the gas-weathered zone in No. 15 Coal Seam is determined to be 301.11m, with a width of 2150.79m. Finally, the prediction results of gas emission volume in No. 15 Coal Seam are obtained by using the source prediction method and the composition of gas emission is analyzed. The research results show that under full production conditions, the maximum absolute gas emission from the coal mine is $42.39\text{m}^3/\text{min}$, and the maximum relative gas emission is $33.58\text{m}^3/\text{t}$, confirming that Lutai Mountain Coal Industry is classified as a high-gassy coal mine.

Keywords: Gas emission volume; source prediction method; gas content; gas-weathered zone

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神府区块深煤层定向井轨迹控制优化与应用

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摘要: 神府区块位于鄂尔多斯盆地东缘, 其主要烃源岩是本溪组的8+9#煤层, 此主力煤层也是后续重要的煤层气产量贡献来源。而神府区块在定向钻井过程中会受到地层自然降斜、丛式井井间防碰、井斜过大电测困难及排采下泵等要求的限制, 制约了神府区块深煤层的高效开发。为解决上述定向钻井施工过程中的问题, 从定向轨迹优化、预斜防碰设计和精细化定向管控措施入手, 开展了相关定向工艺技术研究, 形成了神府区块深煤层定向钻井关键技术。有效地减少了定向滑动段距离及耗时, 规避了井下轨迹防碰风险, 助力了神府区块深煤层钻井的提速提效。

关键词: 深煤层 定向钻井 轨迹优化 预斜防碰

Optimization and Application of Trajectory Control for Directional Wells in Deep Coal Seams in Shenfu Block

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Abstract: The Shenfu Block is located on the eastern edge of the Ordos Basin, and its main source rock is the No. 8 and No. 9 coal seams of the Benxi Formation. This main coal seam is also an important contributor to future coalbed methane production. However, during the directional drilling process in the Shenfu Block, there are limitations such as the natural inclination of the formation, collision prevention between cluster wells, difficulty in electrical logging due to excessive inclination, and pumping requirements, which restrict the efficient development of deep coal seams in the Shenfu Block. To solve the problems in the directional drilling construction process, relevant directional technology research has been carried out from the aspects of directional trajectory optimization, pre-inclined collision prevention design, and refined directional control measures, forming key technologies for deep coal seam directional drilling in the Shenfu Block. These technologies have effectively reduced the distance and time of directional sliding sections, avoided the risk of collision prevention in underground trajectory, accelerated the drilling speed, and improved the efficiency of deep coal seam drilling in Shenfu Block.

Keywords: Deep coal seams; directional drilling; trajectory optimization; Pre-inclined collision prevention

煤层气井自循环平衡注水洗井工艺技术研究

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摘要: 煤粉沉积是制约煤层气连续稳定生产的重要因素, 目前煤层气行业普遍采用的方式是在作业过程中伴随油管下入注水管, 间歇性向井筒注入清水, 以提高产出水的携煤粉能力, 保障井的稳定运行。但随着洗井工艺技术不断地实践, 暴露出洗井工艺技术投入成本高、外来水储层配伍性差、工作不连续及井口窜气存在安全隐患等难题。论文针对目前煤层气生产过程中洗井工艺存在的问题, 通过技术攻关和现场试验, 对传统回注洗井工艺进行自主升级改造, 研究出一套自循环平衡洗井新工艺以及回注水与产出水平衡关系模型, 实现标准化应用, 保障煤层气井的排采连续与稳定。

关键词: 煤层气井 自循环 平衡注水 洗井工艺

Study on Well Washing Technology with Self-circulating Balanced Water Injection for Coalbed Methane Wells

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Abstract: Pulverized coal deposition is an important factor restricting the continuous and stable production of coalbed methane. At present, the common method adopted in the coalbed methane industry is to accompany the pipe string of water injection along with the tubing running during the operation, and intermittently inject clean water into the wellbore to improve the carrying capacity of produced water for pulverized coal and ensure the stable production of coalbed methane wells. However, with continuous practice, challenges have emerged with the well washing process and technology, including high investment cost, poor compatibility with external water reservoirs, discontinuous operation and potential safety hazards related to gas channeling at the wellhead. This paper addresses the the problems existing in the current well washing process in coalbed methane production. Through technical research and field experiments, the traditional re-injection well washing process has been independently upgraded and transformed. A new self-circulating balanced well washing process has been developed, along with the balance model between re-injection water and produced water, so as to achieve standardized application and ensure the continuous and stable drainage and production of coalbed methane wells.

Keywords: Coalbed methane wells; self-circulation; balanced water injection; well washing process

煤层气射流泵井排采后期降低能耗的探索

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摘要: 射流泵举升工艺是煤层气水平井重要的排采举升工艺, 但排采后期高能耗问题成为制约该工艺推广的关键。本文通过对沁水盆地南部马必东区块射流泵工艺应用现状进行分析, 主要针对排采后期低产液阶段因井下管柱或工具长期运行导致密封不严、进泵通道堵塞造成频率上升、地层出液量小导致供需不平衡等问题造成的高能耗现状展开研究。研究表明, 通过提高泵效与改变运行模式可明显降低能耗, 其中优化井下密封组件及泵筒结构可有效提高泵效, 低产液阶段“一拖多”运行模式可有效降低排采机组的用电量。

关键词: 射流泵 提高泵效 水平井 煤层气 沁水盆地

Exploration of Reducing Energy Consumption in Later Stage of Jet Pump Drainage for Coalbed Methane Wells

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Abstract: The jet pump lifting process is an important drainage and lifting technology for horizontal coalbed methane wells. However, the high energy consumption in the later stage of drainage has become a key factor restricting the promotion of this technology. This paper analyzes the application status of the jet pump technology in the Mabidong Block in the southern Qinshui Basin. It mainly focuses on the high energy consumption situation in the low liquid production stage in the later stage of drainage, which is caused by problems such as poor sealing of downhole tubing strings or tools due to long-term operation, blockage of the pump inlet channel leading to increased frequency, and small liquid output from the formation resulting in an imbalance between supply and demand. The research shows that energy consumption can be significantly reduced by improving pump efficiency and changing the operation mode. Specifically, optimizing the underground sealing components and pump barrel structure can effectively enhance pump efficiency. The “one-driving-multiple” operation mode in the low liquid production stage can effectively reduce the electricity consumption of the drainage unit.

Keywords: Jet pump; pump efficiency improvement; horizontal well; coalbed methane; Qinshui Basin

煤层气 L 型水平井低液面问题 现场处置研究

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摘要: 低液面现象是指煤层气 L 型水平井停井后气量下降、流压下降、液面降至 0 的一种特殊现象。对多口煤层气 L 型水平井出现的低液面现象进行分析, 认为 L 型水平井出现低液面问题的主要原因是井下气水存在一定的推动作用, 其本质原因是由于泵挂位置过高、地层压力过低且无法快速恢复。针对问题出现时管柱位置的不同, 现场研究形成了三类处置方案, 一是注水恢复地层压力, 二是井筒放空提高排水效率, 三是对井筒实施负压排水, 大幅提高了该问题的解决效率。

关键词: 煤层气 L 型水平井 低液面

Research on Field Disposal of Low Liquid Level Issue in L-shaped Coalbed Methane Horizontal Well

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Abstract: The low liquid level phenomenon refers to a special situation where, after the shutdown of an L-shaped coalbed methane horizontal well, the gas volume decreases, the flowing pressure drops and the liquid level falls to 0 meters. An analysis of the low liquid level phenomenon in multiple L-shaped coalbed methane horizontal wells suggests that the main reason for this issue in L-shaped horizontal wells is the certain driving effect of gas and water underground. The fundamental cause is due to the excessive depth of the pump hanging position, the excessively low formation pressure, and the inability to restore quickly. In response to the different positions of the tubing when the problem occurs, three types of disposal plans have been formed through field research. The first is to inject water to restore formation pressure, the second is to empty the wellbore to improve the water drainage efficiency, and the third is to implement negative pressure drainage of the wellbore. These measures have significantly improved the efficiency of solving this issue.

Keywords: Coalbed methane; L-shaped horizontal well; low liquid level

L 型水平井是目前煤层气开发应用的主力井型之一, 沁水盆地南部煤层气开发实践表明, 该井型

具有控制面积大、单井产量高、采气速度快等优点, 具有大规模应用的前景。郑庄区块目前投产 L

井下定向地质勘探孔“一孔多用” 技术在主焦煤矿的成功应用

李仁杰

(河南省瓦斯治理研究院有限公司, 河南 450000)

摘要: 目前定向钻进技术已广泛应用在煤矿瓦斯治理、探放水和地质勘探等方面, 但施工成本高, 钻孔复合作用欠缺成为共性问题。本文重点讲述安阳主焦煤矿 2301 工作面定向地质勘探孔的钻进工艺, 不仅探清断层和煤层赋存条件, 钻孔后期又可作为探放水孔和顶板高位抽放孔重复使用, 旨在说明定向钻进技术“一孔多用”的复合功能和优越性, 望为进一步发挥定向钻进技术的优势提供借鉴。

关键词: 定向钻进技术 一孔多用 地质勘探 效果分析 分支 设计

Successful Application of “One Hole for Multiple Uses” Technology for Underground Directional Geological Exploration Drilling in Zhujiao Coal Mine

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(Henan Gas Control Research Institute Co., Ltd., Henan 450000)

Abstract: Directional drilling technology has been widely used in coal mine methane control, water exploration and drainage, and geological exploration. However, the high construction cost and lack of compound functions for drilling boreholes have become common problems. This paper focuses on the drilling process of directional geological exploration boreholes in the 2301 Working Face of Zhujiao Coal Mine in Anyang. The borehole not only figures out the fault and coal seam occurrence conditions but also allows the holes to be reused as water exploration and drainage boreholes and high-position gas extraction boreholes in the roof after drilling. The aim is to demonstrate the composite functions and advantages of “one hole for multiple uses” directional drilling technology and to provide a reference for further leveraging the advantages of directional drilling technology.

Keywords: Directional drilling technique; one hole for multiple uses; geological exploration; effect analysis; branch; design

1 工作面地质概况

主焦煤矿为煤与瓦斯突出矿井, 主采二₁煤层。

1303 工作面平均煤厚 5.1m, 煤层平均倾角 8°, 煤层瓦斯含量 6.74m³/t, 压力 0.29MPa, 煤的坚固性系数 f 值为 0.24 ~ 0.32, 煤的破坏类型为 II ~ III 类, 煤

基于机器学习方法预测煤矿 瓦斯浓度的研究

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摘要: 采用人工神经网络 (ANN) 和长短时记忆网络 (LSTM) 预测了准东煤田某煤矿工作面的瓦斯浓度, 结果表明, 在一个隐含层的 ANN 模型中, 神经元数量为 32 时, 预测瓦斯浓度均方误差 (MSE) 最低为 0.5, 当隐含层为两个, 神经元数量分别为 3 和 10 时, 预测瓦斯浓度 MSE 最低为 0.03, 即最优 ANN 模型为 5-3-10-1。在一个隐含层的 LSTM 模型中, 神经元数量为 35 时, 预测瓦斯浓度 MSE 最低为 0.02, 当隐含层为两个, 神经元数量分别为 10 和 11 时, 预测瓦斯浓度 MSE 最低为 0.008, 即最优 LSTM 模型为 5-10-11-1。

关键词: 长短时记忆网络 人工神经网络 瓦斯 浓度 预测

Research on Predicting Coal Mine Gas Concentration Based on Machine Learning Methods

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Abstract: Artificial Neural Network (ANN) and Long Short Term Memory Network (LSTM) are used to predict the gas concentration in a coal mine's working face in Zhundong Coalfield. The results show that in an ANN model with one hidden layer, when the number of neurons is 32, the minimum mean square error (MSE) for predicting gas concentration is 0.5. When there are two hidden layers with 3 and 10 neurons respectively, the minimum MSE for predicting gas concentration is 0.03, indicating that the optimal ANN model is 5-3-10-1. In an LSTM model with a hidden layer, when the number of neurons is 35, the minimum MSE for predicting gas concentration is 0.02. When there are two hidden layers with 10 and 11 neurons respectively, the minimum MSE for predicting gas concentration is 0.008, indicating that the optimal LSTM model is 5-10-11-1.

Keywords: Long short-term memory network; artificial neural network; gas; concentration; prediction

基于多重分形理论的瓦斯异常区 煤层孔隙非均质性研究

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摘要: 为了探究引起瓦斯异常的微观孔隙结构因素, 运用高压压汞实验对比研究了瓦斯异常区与正常区煤样孔隙发育特征, 引入多重分形理论定量表征了孔隙非均质性, 并分析了孔隙结构及其非均质性对瓦斯赋存与异常的控制作用。结果表明煤样孔隙结构具有多重分形性质, 异常区煤样各尺度孔隙分布均匀, 非均质性较低而连通性较强。具有类似微观结构的煤层为有利于瓦斯聚集赋存, 但墨水瓶形孔制约了瓦斯逸散, 形成局部高压瓦斯区, 易引起瓦斯异常。

关键词: 孔隙结构 非均质性 多重分形 瓦斯异常 开滦矿区

Research on Pore Heterogeneity of Coal Seam in Gas Anomalous Areas Based on Multifractal Theory

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Abstract: To explore the effect of microscopic pore structure on gas anomalies, the pore characteristics of coal samples from gas anomalous and normal areas are compared by using high-pressure mercury intrusion experiments. The multifractal theory is introduced to quantitatively characterize the pore heterogeneity and the control effects of pore structure and its heterogeneity on gas occurrence and anomaly are analyzed. The results show the pore structure of coal samples has multifractal properties, and the pore distribution is uniform in the samples from anomalous areas, with low heterogeneity and strong connectivity. The coal seams with similar micro-structure are favorable for gas accumulation and occurrence, but the ink-bottle pores restrict the gas diffusion, forming local high-pressure gas zones, which are prone to cause gas anomalies.

Keywords: Pore structure; heterogeneity; multifractal analysis; gas anomaly; Kailuan Coalfield

1 样品与方法

1.1 实验样品

实验样品采自开滦矿区钱家营矿的主采煤层, 其中 YC-1 和 YC-2 煤样采自瓦斯异常区域 (表 1)。

实验煤样主要为肥煤和焦煤, $R_{o,max}$ 介于 1.29 ~ 1.33, 显微组分以镜质组为主。工业分析表明水分含量较低, 灰分和挥发分含量较高。与原生结构煤相比, 瓦斯异常区煤样发生了不同程度变形, 产生

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基于瓦斯地质单元划分的瓦斯赋存 规律与瓦斯治理策略

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摘要: 搞清井田瓦斯赋存规律是瓦斯治理的基础, 瓦斯地质单元的划分是研究煤层瓦斯地质规律的基础。以永夏煤田新桥煤矿为例, 分析了矿井地质构造与瓦斯分布特征, 将井田划分为4个瓦斯地质单元; 分别讨论了4个瓦斯地质单元内煤层埋深、顶板岩性和煤厚等对瓦斯赋存的影响, 研究表明: 在构造影响区以外, 煤层埋藏深度是影响区内瓦斯赋存状态的主要控制因素, 并进行了二2煤层瓦斯含量预测。依据矿井瓦斯地质单元及其瓦斯地质规律, 制订了新桥煤矿瓦斯精准防治策略。

关键词: 瓦斯赋存 瓦斯地质单元 低瓦斯矿井 精准防治

Gas Occurrence Law and Control Strategies Based on Gas-geology Unit Division

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Abstract: Understanding the gas occurrence law in the mining field is the basis of gas control, and the division of gas-geology units is the basis of studying the geology law of coal seam. Taking Xinqiao Coal Mine in Yongxia Coalfield as an example, the geological structure and gas distribution characteristics of the coal mine are analyzed. The mining field is divided into four gas-geology units. The effects of coal seam burial depth, roof lithology, and coal thickness on gas occurrence in four gas-geology units are discussed respectively. The results show that outside the tectonic influence zone, the burial depth of the coal seam is the main controlling factor affecting the gas occurrence state in the area, and the gas content of II2 Coal Seam is predicted. According to the gas-geology units and their gas geological laws, the gas precise prevention and control strategy for Xinqiao Coal Mine is developed.

Keywords: Gas occurrence; gas-geology unit; low gas mine; precise prevention and control

中浅层煤层气开发关键技术及 进一步发展方向

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摘要: 为系统梳理中浅层煤层气开发关键技术, 明确下步攻关方向, 文章基于沁水盆地开发实践, 从储层评价及井位部署技术、钻完井技术、储层改造技术、排水采气技术及低压集输技术等 5 方面总结了中浅层煤层气开发的关键技术, 提出了下步攻关方向, 同时明确了煤层气企业开展技术攻关的保障体系建设路径, 为中浅层煤层气开展系统技术攻关指明了方向。

关键词: 中浅层煤层气 关键技术 攻关方向 保障体系

Key Technologies and Future Development Direction of Mid-shallow Coalbed Methane

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Abstract: In order to systematically summarize the key technologies for the development of mid-shallow coalbed methane and clarify the future research direction, the paper, based on the development practice of Qinshui Basin, summarizes the key technologies for mid-shallow coalbed methane development from five aspects, including reservoir evaluation and well location deployment technology, drilling and completion technology, reservoir reconstruction technology, water drainage and gas production technology and low-pressure gathering and transportation technology. It also puts forward the future research directions, and outlines the construction path of the support system for technical research for coalbed methane enterprises, providing a clear direction for the systematic technical research on mid-shallow coalbed methane development.

Keywords: Mid-shallow coalbed methane; key technologies; research direction; support system

我国煤层气资源量丰富, 埋深 2000m 以浅煤层气地质资源量为 $30.5 \times 10^{12} \text{ m}^3$, 而埋深 2000m 以深的深部煤层气资源虽尚未进行过系统评价, 但初步估算资源量为 $40.71 \times 10^{12} \text{ m}^3$ 。近十年来, 围绕中浅层煤层气高效开发, 以提高单井产量和实现老井长期稳产为目标, 在储层评价及井位部署设计、钻完井技术、储层改造技术、排水采气技术及

低压集输技术等五方面开展关键技术攻关, 实现单井产量大幅提高, 支撑煤层气产量快速上升。

1 中浅层煤层气开发关键技术体系

1.1 储层评价及井位部署技术

在煤层气开发初期, 认为“有煤就有气”, 没有认识到煤储层的非均质性, 导致开发工艺规模推