

CHINA COALBED METHANE

(Bimonthly)

Vol.21 No.3 June.2024

3

2024

主管单位：国家矿山安全监察局

主办单位：煤炭信息研究院

中联煤层气有限责任公司

编辑出版：《中国煤层气》编辑部

主 编：张 勇

副 主 编：朱光辉 刘文革 李忠城

印 刷：北京华联印刷有限公司

定 价：18 元

发 行：《中国煤层气》编辑部

(100029 北京市朝阳区

芍药居 35 号)

国际标准连续出版物号：ISSN 1672-3074

国内统一连续出版物号：CN 11-5011/TD

广告发布登记：京朝市监广登字 20190010 号

电 话：(010) 84657948 (投稿)

(010) 84657905 (征订)

传 真：(010) 84657941

http://www.iiem.ac.cn

Email: cbmc@iiem.ac.cn

中国煤层气

ZHONGGUO MEICENGQI

2004 年创刊 (双月刊)

第 21 卷第 3 期 2024 年 6 月

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目次

2024年第3期

宁夏韦州矿区煤层气压裂智能微地震地面监测技术应用研究	
..... 谭浩 张广兵 孙佳 于洋 荆锐英 杨彦成	(3)
新疆尼勒克煤田深部煤层气大规模改造工艺试验 王壁鸿 (8)
煤层气井煤粉产出规律特征及主控因素研究	..... 赵泽 孔鹏 张浩亮 徐勇 王雷雷 (12)
煤层气L型水平井潜油隔膜泵配套工艺技术研究	..... 薛志亮 (16)
煤层气直井储层堵塞原因分析及解堵措施应用	
..... 郭晶 张建国 贾慧敏 王琪 何珊 范秀波	(20)
煤层气井电潜螺杆泵故障识别与治理对策	..... 李玲玉 刘昌平 王岩 刘斌 雷兴龙 李泽州 (25)
基于测井参数的煤储层含气量预测方法研究	..... 白云思雨 谢非 王赐勋 (29)
多元逐步回归分析法在煤层含气量预测中的应用——以胡家河井田4号煤层为例	
..... 惠鹏 郭燕珩 陈小军	(33)
冀中坳陷大城凸起深部煤层气井垢形成机理及防垢方法	..... 姜燕 张利文 张嘉友 于根喜 (38)
煤系气分层合采工艺技术研究	..... 刘凯 余焱群 刘印华 王云飞 吴建军 李焕文 (43)

Main Contents

Vol. 21 No. 3

Application Research on Intelligent Microseismic Ground Monitoring Technology for Coalbed Methane Fracturing in Weizhou Mining Area of Ningxia	..... TAN Hao <i>et al.</i> (3)
Large-Scale Transformation Process Experiment of Deep Coalbed Methane in Nileke Coalfield of Xinjiang	..... WANG Bihong (8)
Research on Characteristics and Main Control Factors of Coal Powder Production in Coalbed Methane Wells	..... ZHAO Ze <i>et al.</i> (12)
Research on Application Technology of Submersible Diaphragm Pump in Coalbed Methane L-shaped Horizontal Wells	..... XUE Zhiliang (16)
Analysis of Reservoir Plugging Causes in Coalbed Methane Vertical Wells and Application of Unplugging Measures	..... GUO Jing <i>et al.</i> (20)
Fault Identification and Treatment Strategies for Electric Submersible Screw Pumps in Coalbed Methane Wells	..... LI Lingyu <i>et al.</i> (25)
Research on Gas Content Prediction Method for Coal Reservoirs based on Logging Parameters	..... BAIYUN Siyu <i>et al.</i> (29)
Application of Multiple Stepwise Regression Analysis in Gas Content Prediction of Coal Seams —A Case Study of the No. 4 Coal Seam in Hujiahe Minefield	..... HUI Peng <i>et al.</i> (33)
Scale Formation Mechanism and Anti-scale Method of Deep Coalbed Methane Wells in Dacheng Uplift of Jizhong Depression	..... JIANG Yan <i>et al.</i> (38)
Research on Layered Co-Mining Technology for Coal Series with Multiple Gas Layers LIU Kai <i>et al.</i> (43)

宁夏韦州矿区煤层气压裂智能微地震地面监测技术应用研究

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摘要: 对韦州矿区煤层气压裂直井实施智能微地震地面监测, 布设高精度检波器40台, 采用STA/LTA方法进行有效事件检测, 利用REAL方法对拾取事件进行定位, 压裂段累计识别有效微地震事件53件次, 推断压裂施工最大平均影响半径178m, 裂缝组合以近水平为主, 最大延伸缝长约210m, 最大延伸缝宽约10m, 最大延伸缝高约6m, 地应力方向以NNW-SSE为主, 与推测主应力方向一致。监测结果表明, 在厚覆盖层区域开展煤层气压裂微地震地面监测具有一定的适用性。

关键词: 煤层气 智能微地震 地面监测 压裂裂缝 压裂效果

Application Research on Intelligent Microseismic Ground Monitoring Technology for Coalbed Methane Fracturing in Weizhou Mining Area of Ningxia

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Abstract: Intelligent microseismic ground monitoring is implemented for coalbed methane fracturing vertical well in Weizhou Mining Area. With the wellhead as the center, 40 high-precision geophones are installed. Effective event detection is performed using the STA/LTA method. The REAL method is used for locof picking events. A total of 53 effective microseismic events are identified in the fracturing section. It is inferred that the maximum average influence radius of fracturing construction is 178m. The crack combinations are primarily near-horizontal, with the maximum fracture length extending about 210m, the maximum fracture width approximately 10 meters, and the maximum fracture height around 6 m. The primary direction of in-situ stress is NNW-SSE, consistent with the inferred principal stress direction. The monitoring results show that the coalbed methane fracturing microseismic ground monitoring in the area with thick cover has certain applicability.

Keywords: Coalbed methane; intelligent microseismic; ground monitoring; fracturing crack; fracturing effect

基金项目 宁夏回族自治区自然科学基金项目(2023AAC03782); 宁夏非常规天然气勘查开发团队(2022BSB03105)。

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新疆尼勒克煤田深部煤层气 大规模改造工艺试验

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摘要: 本文主要围绕新疆尼勒克煤田深部煤层气的开发, 详细阐述了大规模改造工艺试验的全过程。此次工艺试验是新疆首次进行煤层气大规模改造工艺试验, 通过对压裂工艺的深入研究和不断优化, 初步形成适宜于新疆深部煤层气的储层改造技术。

关键词: 深部煤层气 大规模 压裂工艺

Large-Scale Transformation Process Experiment of Deep Coalbed Methane in Nileke Coalfield of Xinjiang

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Abstract: This article mainly focuses on the development of deep coalbed methane in the Nileke Coalfield of Xinjiang, and elaborates in detail on the entire process of large-scale transformation process experiment. This is the first large-scale coalbed methane transformation process experiment conducted in Xinjiang. Through in-depth research and continuous optimization of fracturing technology, a reservoir transformation technology suitable for deep coalbed methane in Xinjiang has been developed.

Keywords: Deep coalbed methane; large scale; fracturing technology

1 新疆尼勒克煤田深部煤层气资源特征

项目现已实施完成 HCS-3 参数井 + 生产井的钻井与压裂工作, 井深 1608m, 按设计预期钻进至有利储层, 分别为侏罗系八道湾组 A1、A2、A3 煤层。

1.1 储层地质条件

尼勒克煤田深部煤层埋深较大, 部分区域煤层埋深达到了 2000m, 地质构造复杂, 存在断层、褶皱等多种地质现象。HCS-3 井构造位于于尼勒县胡

吉尔台南部勘查区胡吉尔台向斜 (W2) 南翼。胡吉尔台向斜 (W2) 位于评价区中部, 轴面直立, 走向东西, 贯穿全区, 长约 15km, 控制程度为基本查明。

1.2 煤层物性

煤层渗透率较低, 平均渗透率小, 孔隙度较小, 给煤层气的运移和产出带来困难。

1.3 煤层含气量

具有较高的煤层含气量, 局部区域 A2 煤层含气量约 $5 \sim 10 \text{m}^3/\text{t}$, 但分布不均。

煤层气井煤粉产出规律特征及 主控因素研究

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摘要: 针对沁水盆地柿庄南区块煤层气井产粉严重的问题, 连续采集20口煤层气井煤粉溶液样品, 在实验室测试获取了煤粉浓度、煤粉粒径、煤粉形态和主要成分等煤粉产出特征。通过系统研究煤粉产出特征的影响因素, 发现煤粉浓度和煤体结构的相关系数 R^2 为0.707, 具有较强的相关性; 水平井的煤粉浓度平均值为2.85g/L, 定向井的煤粉浓度平均值为0.36g/L, 相差了8倍; 煤体结构是煤粉产出的主控地质因素, 井型是主控工程因素。研究成果为柿庄南区块煤层气产粉规律研究和控粉措施提供了实验数据和理论指导。

关键词: 产粉特征 煤体结构 主控因素 柿庄南区块

Research on Characteristics and Main Control Factors of Coal Powder Production in Coalbed Methane Wells

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Abstract: To address the serious problem of coal powder production in the Shizhuang South Block of the Qinshui Basin, coal powder solution samples were continuously collected from 20 coalbed methane wells. The coal powder production characteristics, such as concentration, particle size, morphology, and main components, are obtained through laboratory testing. Through systematic research on the influencing factors of coal powder production characteristics, it is found that the correlation coefficient R^2 between coal powder concentration and coal body structure is 0.707, indicating a strong correlation; The average concentration of coal powder in horizontal wells is 2.85g/L, while the average concentration of coal powder in directional wells is 0.36g/L, indicating a difference of 8 times. The coal body structure is the main geological factor controlling the production of coal powder, and the well type is the main engineering factor. The research results provide experimental data and theoretical guidance for studying the coal powder production laws and controlling measures in the coalbed methane wells of Shizhuang South Block.

Keywords: Coal powder production characteristics; coal body structure; main controlling factors; Shizhuang South Block

煤层气 L 型水平井潜油隔膜泵 配套工艺技术研究

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摘要: 煤层气 L 型水平井占比的提高使得无杆举升工艺愈发受到重视, 潜油隔膜泵液固两相适应性好、井下通过性好, 具备在 L 型水平井中推广的潜力。沁南某气田在 2019 年引入后, 针对在试验过程中出现的气锁故障, 研制了三相气液分离装置 + 解气锁接头 + 沉砂装置的多重防砂除气工艺, 搭配自循环回注水等配套工艺, 经现场试验, 成功解决了气锁问题, 初步建立了潜油隔膜泵排水采气工艺体系, 适合于在中低产水量的煤层气 L 型水平井推广应用。

关键词: 煤层气 潜油隔膜泵 水平井 防砂除气

Research on Application Technology of Submersible Diaphragm Pump in Coalbed Methane L-shaped Horizontal Wells

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Abstract: As the the proportion of L-shaped horizontal wells in coalbed methane fields increases, the rodless lifting technology has been paid more attention to. With good adaptability to liquid-solid phases and excellent underground passability, the submersible diaphragm pump shows potential for widespread application in L-shaped horizontal wells. After being introduced in a certain gas field in Southern Qinshui Basin in 2019, issues such as the airlock faults were found in the process of testing, a multi-sand control and degassing technology were developed, incorporating a three-phase gas-liquid separation unit, a gas release lock joint and a sand settling unit, matching the supporting technology, such as self-circulating water re-injection. The field test successfully resolves the issue of the airlock, leading to the initial establishment of a drainage and gas recovery system using a submersible diaphragm pump. This system is suitable for the promotion and application of L-type horizontal wells with medium and low water production.

Keywords: Coalbed methane; submersible diaphragm pump; horizontal well; sand control and degassing

1 潜油隔膜泵举升工艺介绍

潜油隔膜泵举升工艺由地面部分、连接部分和

井下部分组成, 地面部分主要是控制柜、接线盒, 连接部分由小扁电缆和动力电缆组成, 井下部分是潜油隔膜泵, 其中地面部分和连接部分与常见的潜

煤层气直井储层堵塞原因分析及 解堵措施应用

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摘要: 针对煤层气直井储层堵塞后气量难以恢复的问题, 开展了储层堵塞原因及恢复措施的研究。通过对煤层气直井储层堵塞成因及生产特征分析, 将储层堵塞分为三种类型: 层间干扰型、排采不连续型、井间干扰型, 针对不同原因导致的储层堵塞在进行压裂车解堵时应根据各自的是适应性进行选井和施工, 同时尽可能增大措施规模和排量, 提高措施见效率和单井产气量。本文提供的压裂车解堵技术, 能够有效解决储层堵塞问题, 提高储层堵塞井单井产气量。

关键词: 储层堵塞 压裂车解堵 层间干扰 排采不连续 井间干扰

Analysis of Reservoir Plugging Causes in Coalbed Methane Vertical Wells and Application of Unplugging Measures

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Abstract: Addressing the challenge of difficult gas production recovery following the reservoir plugging in coalbed methane vertical wells, this study investigates the causes of reservoir plugging and the unplugging measures. By analyzing the causes of reservoir plugging in coalbed methane vertical wells and their production characteristics, three types of blockage were identified: interlayer interference, discontinuous drainage and inter-well interference. For the reservoir plugging caused by different reasons, it is crucial to select wells and conduct operations based on the specific applicability when performing unplugging using fracturing trucks. At the same time, the injection water volume and the discharge rate should be maximized to improve the effectiveness of the measure and the gas production of individual wells. The fracturing truck unplugging technology put forward by this paper can effectively resolve the issue of reservoir plugging and improve the gas production of reservoir-plugging wells.

Keywords: Reservoir plugging; unplugging using fracturing truck; inter-layer interference; discontinuous drainage; inter-well interference

由于煤储层具有机械强度低、脆而软、低压、非均质性强等特点, 煤层气井在生产过程中由于受

层间干扰、排采不连续等原因造成储层堵塞, 进而影响裂缝导流能力和煤层气的解吸渗流, 导致产

煤层气井电潜螺杆泵故障识别与治理对策

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摘要: L型套管压裂水平井在低渗或深部煤层气田开发上具有很大的技术优势, 电潜螺杆泵举升工艺为水平井排采的重要方式之一, 具有排量大, 设备占地面积小, 调参方便, 自动化程度高等技术优势。通过现场 270 余口井的排采实践, 发现该类泵型存在卡泵、烧泵等 5 类故障, 分析总结了各类故障发生前后的生产特征及原因, 提出 4 类针对性预防及后期治理对策, 研究结果为电潜螺杆泵在沁水煤层气田的稳定排采奠定了基础, 同时也为其他煤层气区块的开发提供了借鉴经验。

关键词: 煤层气井 电潜螺杆泵 故障识别及诊断 治理对策

Fault Identification and Treatment Strategies for Electric Submersible Screw Pumps in Coalbed Methane Wells

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Abstract: L-type casing fractured horizontal wells have great technical advantages in the development of low-permeability or deep coalbed methane fields. As one of the important methods for horizontal well drainage and production, the electric submersible screw pump lifting process has technological advantages such as large displacement, small equipment footprint, convenient parameter adjustment, and a high degree of automation. Based on drainage and production practice from over 270 wells on site, it is identified that this type of pump has 5 types of faults such as pump jamming and pump burning. The production characteristics and causes before and after each type of fault are analyzed and summarized, and 4 targeted prevention and later treatment measures are proposed. The research results lay the foundation for stable drainage and production of electric submersible screw pumps in the Qinshui coalbed methane field, and also provide a reference for the development of other coalbed methane blocks.

Keywords: Coalbed methane well; electric submersible screw pumps; fault identification and diagnostic; treatment strategies

近年来, 煤层气井开发逐步由直井、定向井、裸眼井向 L 型套管压裂水平井井型转变, 套管压

基于测井参数的煤储层含气量 预测方法研究

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摘要: 煤层气含气量测定通常受人为因素影响较大, 且测定成本高时间长, 而测井数据连续且易获取, 通过与含气量建立线性关系, 确定利用补偿中子、密度、自然伽马、电阻率、声波时差和深度这六种参数用来建立煤层含气量预测模型。采用多元线性回归、BP神经网络、随机森林这三种方法构建煤储层含气量预测模型。随后利用构建的模型进行盲井检验, 结果表明以上三种预测模型均能较好预测煤层含气量, 而随机森林模型在此区块预测效果最好。

关键词: 煤层 煤层气 多元线性回归 BP神经网络 随机森林 含气量

Research on Gas Content Prediction Method for Coal Reservoirs based on Logging Parameters

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Abstract: The determination of coalbed methane gas content is often significantly affected by human factors, and the measurement cost is high and the time is long. However, the logging data is continuous and easy to obtain. Through the establishment of a linear relationship with the gas content, six parameters of compensation neutron, density, natural gamma, resistivity, sonic time difference and depth are identified and used to establish the prediction model for the gas content of the coal seam. Three methods, multiple linear regression, BP neural network and random forest, are used to construct a prediction model for coal reservoir gas content. Subsequently, the constructed model is used to test the blind well, and the results show that the above three prediction models can effectively predict the gas content in the coal seam, with the random forest model showing the best prediction effect in this Block.

Keywords: Coal seam; coalbed methane; multiple linear regression; BP neural network; random forest; gas content

多元逐步回归分析法在煤层 含气量预测中的应用

——以胡家河井田4号煤层为例

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摘要: 煤层含气量是煤层气选区评价的重要指标, 也是煤层气储量计算的重要参数。本文以胡家河井田4号煤层为例, 依据井田煤层气井钻孔测试资料, 通过进行单因素分析从诸多影响含气量因素中筛选出主控因素, 优选运用多元逐步回归法结合主控因素建立了4号煤层含气量的预测模型, 结果表明, 胡家河4号煤层含气量主导收到煤层埋深和煤层厚度的影响, 经计算其预测值与实测值基本相符, 为研究区煤层气资源评价和开发选区提供了重要的指导。

关键词: 煤层含气量 单因素分析 多元逐步回归分析 预测模型 胡家河井田

Application of Multiple Stepwise Regression Analysis in Gas Content Prediction of Coal Seams —A Case Study of the No. 4 Coal Seam in Hujiahe Minefield

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Abstract: The gas content of the coal seam is an important indicator for the evaluation of coalbed methane area selection, and is also a crucial parameter for the calculation of coalbed methane reserves. This paper takes the No. 4 Coal Seam of Hujiahe Minefield as a case study, utilizes the borehole test data of coalbed methane wells, and identifies the main control factors from many factors affecting gas content through a single factor analysis. By using the multivariate stepwise regression method combined with the main control factors, a prediction model for the coal gas content of the No. 4 Coal Seam is established. The results show that the gas content of Hujiahe No. 4 Coal Seam is primarily influenced by the coal seam depth and thickness. After calculating, the predicted values are consistent with the measured values, which provides important guidance for the evaluation and development of coalbed methane resources in the study area.

Keywords: Gas content of coal seam; single factor analysis; multiple stepwise regression analysis; predictive model; Hujiahe field

冀中拗陷大城凸起深部煤层气井垢 形成机理及防垢方法

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摘要: 为解决大城深部煤层气井因井筒结垢严重导致检泵周期较短问题, 研究基于煤层气井水质和结垢物成分分析。结果显示, 深部煤层气井地层水中富含 HCO_3^- 离子, 易产生碳酸盐垢的金属阳离子; 结垢物主要成分为 FeCO_3 、铁氧化物以及少量的 CaCO_3 、 MgCO_3 等; 指出压力、流速是影响煤层气井结垢主要因素; 提出煤层井结垢机理为排采诱导流体压力降低导致二氧化碳从水中大量析出所致, 而铁氧化物主要由 HCO_3^- 离子对金属 Fe 腐蚀产生。针对大城煤层气井结垢机理和地质特点, 提出了内衬油管和定期加药综合治理防垢方法, 为深部煤层气高效稳定开发提供了重要支撑。

关键词: 大城 深层 煤层气 结垢 机理 防垢

Scale Formation Mechanism and Anti-scale Method of Deep Coalbed Methane Wells in Dacheng Uplift of Jizhong Depression

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Abstract: To address the issue of short pump maintenance cycles caused by serious shaft scaling in coalbed methane wells of Dacheng, a study is conducted based on the analysis of the produced water quality and scaling composition in coalbed methane wells. The results indicate that the formation water in deep coalbed methane wells is rich in HCO_3^- ions, which are easy to form carbonate scales with metal cations. The main components of the scale are FeCO_3 , iron oxide and small amounts of CaCO_3 , MgCO_3 , etc. It is identified that pressure and flow rate are the primary factors influencing scaling in coalbed methane wells. The scaling mechanism is attributed to the decrease of fluid pressure induced by drainage, leading to the precipitation of large amounts of CO_2 from the water, while iron oxides are primarily produced by the corrosion of metal Fe by HCO_3^- ions. Based on the scaling mechanism and geological characteristics of coalbed methane wells in Dacheng, a comprehensive treatment method of lining oil pipes and regular dosing is proposed to prevent scaling, which has been preliminarily validated. This provides crucial support for the efficient and stable development of deep coalbed methane reservoirs.

Keywords: Dacheng; deep layer; coalbed methane; scaling; mechanism; scale prevention

煤系气分层合采工艺技术研究

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摘要: 针对煤系地层气各层压力体系不同、储层差异性大, 常规采气工艺适应性差的问题, 提出煤系多气分层合采工艺, 进一步提升煤系地层气开发效益。根据研究区煤系气叠置类型, 立足“三抽”设备基础, 设计了基于空心抽油杆柱的三气合采工艺管柱, 实现了“机抽+自喷”组合的同井筒分压分采工艺技术, 为煤系地层气煤系气不同压力系统储层同井筒立体开发提供技术参考。

关键词: 煤系地层气 多气合采工艺 同井筒体系 分层合采

Research on Layered Co-Mining Technology for Coal Series with Multiple Gas Layers

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Abstract: Addressing the problems of different pressure systems and great reservoir difference of coal-bearing gas strata, and the poor adaptability of conventional gas production technology, a multi-layer and co-production technology of coal-series gas is put forward to further improve the development benefit of coal-bearing strata gas. According to the superposition type of coal-bearing gas in the study area and utilizing the foundation of “three-pumping” equipment, a three-gas co-production technology pipe string based on the hollow sucker rod string is designed. The technology of pressure-divided and separate production in the same shaft with a “three-pumping + self-injection carrying liquid” combination is realized, which provides a technical reference for the three-dimensional development of coal-bearing strata gas reservoirs with different pressure systems in the same shaft.

Keywords: Coal-bearing strata gas; multi-gas combined production technology; same wellbore system; separate and combined mining