·装　备·

超声波液位传感器录井现场应用拓展

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摘　要　结合多年录井现场生产实践,阐述了超声波液位传感器的 3 种新用法:一是在无法安装靶式流量传感器的井通过监测缓冲罐或高架槽液面高度变化情况完成出口流量监测;二是监测停开泵时循环管线内(缓冲罐或高架槽)液面的变化,补偿停开泵时总池体积波动值,确保接单根、泵冲不稳定等特殊工况下溢流、井漏监测更加灵敏;三是通过对安装脱气器处高架槽液面吃水深度的监测,解决高架槽上脱气器常抽钻井液的问题,在保障井控安全的基础上,为高效优质录井提供借鉴,并针对每种用法,阐述了该传感器的设置、标定以及实现相应数据检测的实现过程。实例分析表明,效果较好,特殊钻井工况下该传感器完全可以取代相应传感器。

关键词　录井　液位传感器　出口流量　补偿池体积　脱气　吃水深度

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0　引　言

在录井技术服务现场,通常采用超声波液位传感器来测定钻井工程循环系统中钻井液罐内的液面绝对深度[1-3],进而计算出罐内钻井液体积大小,从而达到监测溢流、井漏等井控险情的目的。笔者经过多年的录井实践,通过对超声波液位传感器的拓展应用,解决了录井现场部分传感器实际安装使用难题和录井过程中遇到的困难。本文探讨了该传感器除了测量钻井液池体积外的其他 3 种用途、使用方法及应用效果。

1　超声波液位传感器监测出口流量

出口流量参数是钻井时出口管线内钻井液流速、返出量的具体体现,是及时发现并预报井漏和溢流等井控险情的最直接依据[4-5],在大庆油田钻探市场,该参数测量主要通过在出口导管上安装靶式流量传感器来实现。但在哈萨克斯坦项目录井作业过程中,由于钻井队伍频繁替换,有的钻机无法安装靶式流量传感器,导致无法录取钻井液出口流量数据资料,严重影响录井工作,并给井控安全带来巨大隐患。现场选用超声波液位传感器来监测钻井液出口流量,可解决这一难题。

1.1　选用思路

目前,录井现场靶式流量计对钻井液出口流量的测量,大多是定性测量而非定量测量,主要反映钻井液流量变化的趋势。通过对现场钻井液循环系统分析认为,出口导管钻井液流量大小与缓冲罐或高架槽中钻井液体积的变化趋势是一致的。因此,可以通过使用超声波液位传感器监测缓冲罐或高架槽内液面高度,达到与靶式流量传感器监测钻井液出口流量相同的效果。

1.2　初始化设定和标定

1.2.1　安装

选择钻井液流速相对较小、液面平稳、底部无遮挡物的位置进行安装。安装传感器时应保证探头发射和接收超声波的一面与钻井液液面垂直,并固定牢靠。

1.2.2　初始化

超声波液位传感器在录井现场常用于钻井液罐池体积测量,而钻井液缓冲罐或高架槽比钻井液罐小了很多,为使得测量更加精确,其初始化设定需要做相应的更改。设定钻井液缓冲罐或高架槽深为 1 m,传感器测量盲区为 25 cm,则需要设置好最大

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检测距离(125 cm,传感器输出信号 4 mA)、最小检测距离(25 cm,传感器输出信号 20 mA),见图 1。

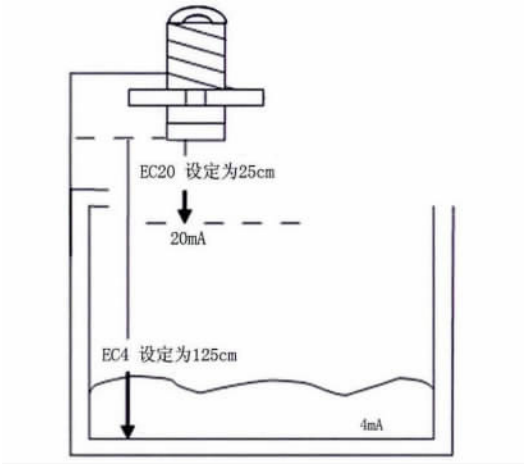


图 1　初始化示意

1.2.3　标定

完成初始化后,在软件界面将出口流量参数接入池体积 6 传感器通道,并用两点法标定该传感器零点和满度,完成工作曲线标定。

1.3　应用效果

现以哈萨克斯坦项目 Aktobe 区块的某井来说明应用超声波液位传感器和靶式流量传感器监测相对出口流量的效果对比。该井由长城钻探下属的中哈项目部某钻井队承钻,该队有条件安装靶式流量传感器。现场正常安装靶式流量传感器同时,在高架槽增加安装了超声波液位传感器进行测试对比。靶式流量传感器接入出口流量测量通道,测量参数为出口流量(靶式);高架槽处超声波液位传感器初始化后接入池体积 6 通道,测量参数同为出口流量(池体积 6)。图 2 是其正常钻进时的实时监测曲线,图中右侧栏红线是靶式流量传感器测得的出口流量值,黑线是高架槽超声波液位传感器测得的出口流量值。通过曲线分析可以看出,尽管两者实测值不相等,但其趋势变化是一致的。

图 3 和图 4 分别是该井在高架槽上使用超声波液位传感器进行起钻和下钻过程出口流量测量的录井曲线。按井控要求,起钻时,每 3～5 柱钻杆和每柱钻铤灌入钻井液一次;吊灌钻井液时,钻井液充满井筒后从出口导管流出,通过高架槽返回到起下钻计量罐,液位传感器监测到出峰(图 3 中"出口流量"),同时起下钻计量罐呈阶梯递减趋势(图 3 中"池体积 1");下钻时,随着每柱钻杆或钻铤的下入不断替换井筒内钻井液体积,井筒钻井液通过高架槽返出,液位传感器监测到钻井液返出情况(图 4 中"出口流量"),同时起下钻计量罐持续上涨(图 4 中"池体积 1")。

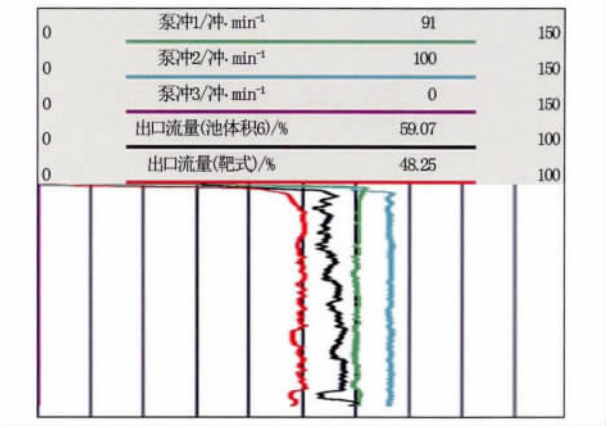


图 2　正常钻进两种传感器检测出口流量曲线对比

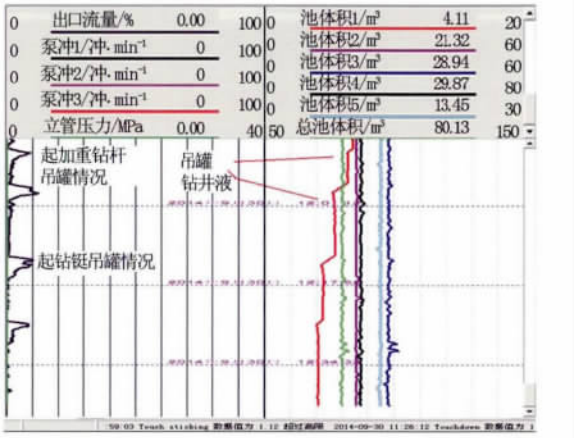


图 3　Aktobe 区块的某井起钻过程中监测曲线

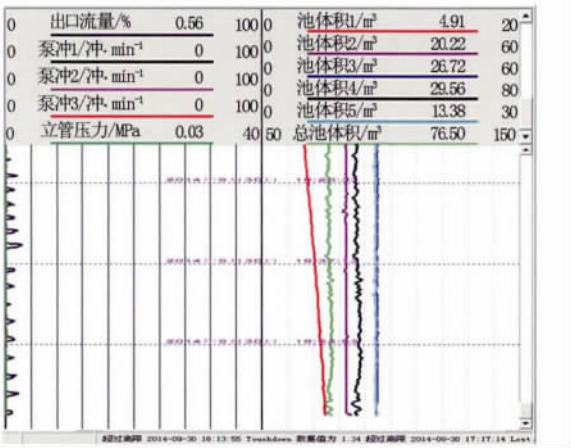


图 4　Aktobe 区块的某井下钻过程中监测曲线

通过以上分析可知,使用超声波液位传感器监测钻井液出口流量,其响应特征与靶式流量传感器相似,能够完成不同工况下的钻井液流量监测任务。

因此，可以使用超声波液位传感器替代靶式流量传感器监测钻井液出口流量。

2 停开泵时对总池体积的补偿

在录井过程中，通常都会遇到这样的问题：在接单根时，停泵后总池体积在一段时间内逐渐上涨，开泵后又逐渐降低，数分钟之后才趋于平稳。这主要是由于钻井循环系统中，循环管线（包括高架槽或钻井液缓冲罐）内钻井液体积无法得到监测，即未纳入钻井液总池体积计算的缘故。开泵时，对循环管线来讲是个充填钻井液的过程，因而钻井液总池体积将逐渐降低；停泵时，则是循环管线释放钻井液的过程。如果在这个过程中出现井漏或溢流，往往难以发现。为解决这个问题，现场将液位传感器当作流量传感器用的同时，还将该通道信号设定为“补偿池体积”，用来补偿停开泵过程中钻井液总池体积的损失。现以 Wellstar 综合录井仪器为例介绍。

2.1 设置方法

①设置好出口流量，确定采集通道号。例如设置出口流量通道号为“10”。②选用备用池体积 6 作为补偿池体积，将通道号也设定为“10”，使得其数值与出口流量值一样。③根据现场循环管线长度以及钻井液缓冲罐容积，预估停开泵钻井液充满循环管线值，或通过实际钻进过程观察，得出每次停开泵时总池体积变化的经验值。例如根据实时数据观察，某井钻井液总池体积通常停开泵时变化量约为 3 m^3，若将20 mA电流值设定为3 m^3，4 mA电流值设定为 0，则可用两点法标定该补偿体积。④将补偿池体积 6 计入总池体积。

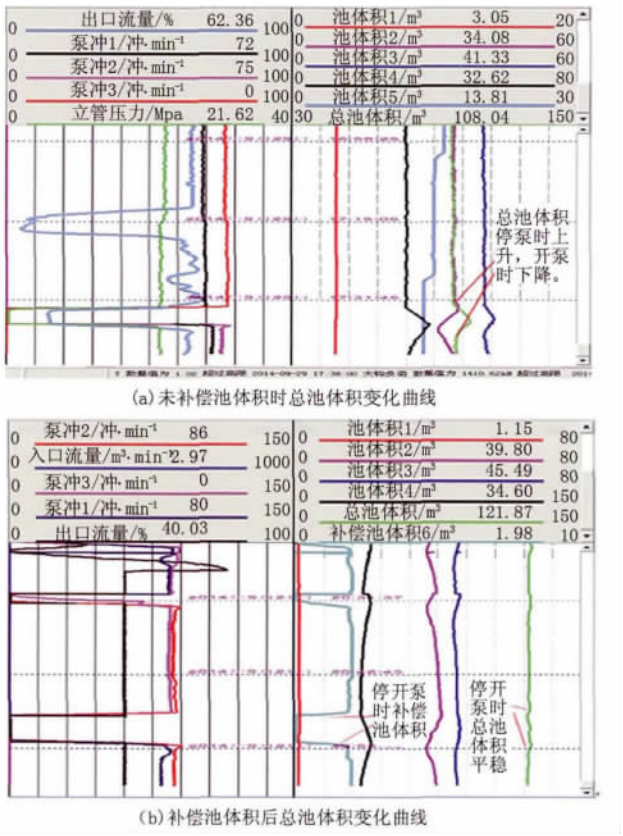
2.2 应用效果

以某井实际钻井情况为例，在未设置补偿池体积时，停开泵时钻井液总池体积曲线波动较大，变化量在 2～3 m^3 之间（图 5a）；设置补偿池体积后，在停开泵时钻井液总池体积基本稳定，曲线呈直线形态（图 5b），更加有利于对此时钻井液池体积增减量的判断。

因此，设定补偿体积，考虑停开泵过程中存在于循环管线内的钻井液，对接单根、泵冲数不稳等特殊工况下溢流、井漏等工程异常监测更加灵敏，对保障井控安全具有良好的促进作用。

3 脱气器工作状态的监测

很多钻井队在钻井液出口并没有设置钻井液缓冲罐，脱气器只能安装在高架槽上。通常高架槽钻井液流量较急，脱气器安装条件并不理想，现场往往在高架槽尾部设置挡板，使高架槽快速蓄满钻井液，以达到脱气器工作要求。与此同时，井队方场地工需要通过撤掉挡板来清理沉砂。但底部沉砂量不一样或者每次活动挡板位置不同时，钻井液液面将有变化，轻则因液面太低造成脱气效率低下[6-7]，重则因气路管线抽入钻井液导致色谱分析仪损坏。



(a) 未补偿池体积时总池体积变化曲线

(b) 补偿池体积后总池体积变化曲线

图 5 补偿池体积前后对比

经过反复摸索，现场通过在高架槽上安装超声波液位传感器来监测高架槽液面，根据所测数值大小判断脱气器吃水深度，很好地解决了这一难题。现以大庆录井在哈萨克项目某井现场数据来说明其判断效果。

图 6 为某井采用超声波液位传感器监测出口流量的录井图。

在图中 A 点时，钻井液出口流量稳定在 60%左右，调整脱气器吃水深度到最佳工作状态，此时背景气如 A 1 处所示；在 B 点时，泵冲不变，钻井液出口流量迅速降低，甚至接近于零，此时场地工拿掉高架槽挡板亦无法脱气，对应气测曲线在一个管路延时后降低如 B 1 处所示；之后，活动钻具，钻井液液面

不稳,脱气器吃水深度不稳定;在 C 点时,挡板底部积满沉砂,钻井液液面迅速上升至 65%,技术人员判断钻井液液面超过脱气器吃水深度高限将抽入钻井液,需要立即采取措施加以控制。通过反复观察,得出该井钻井液出口流量与脱气器吃水深度关系见表 1。

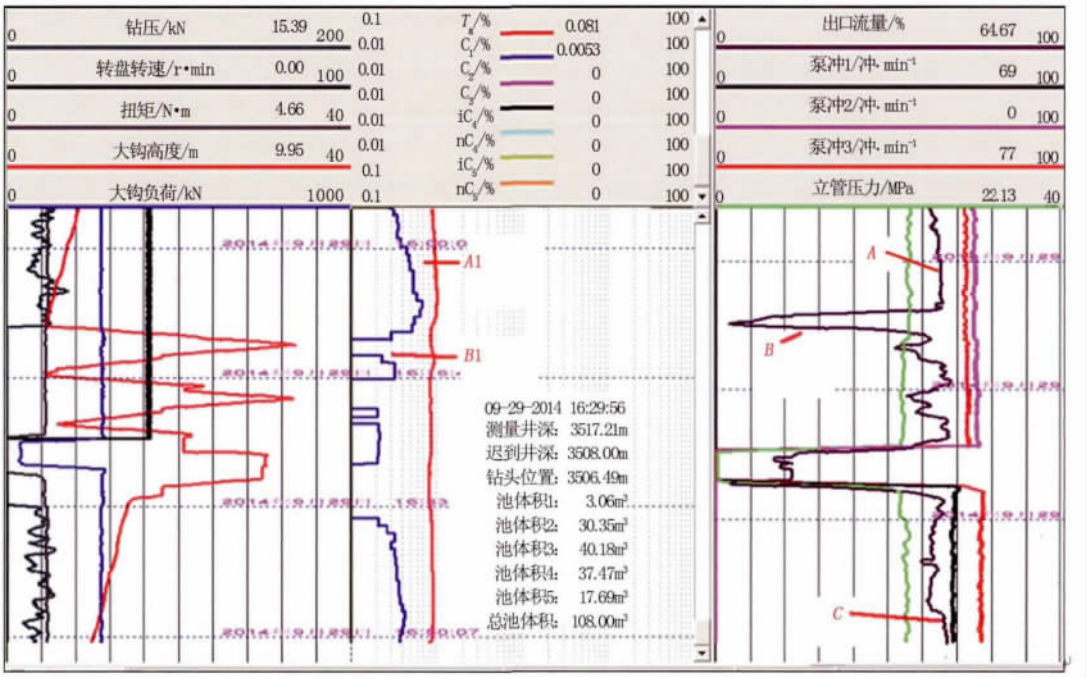


图 6　某井超声波液位传感器监测脱气器工作状态

表 1　钻井液出口流量与脱气器吃水深度关系

出口流量	脱气器工作状态
≤54%	不能脱气
54%～64%	正常
≥64%	极易抽吸钻井液

在钻井液液面波动较为频繁的录井条件下,可以使用液位传感器监测液面变化情况,并设定报警,提示仪器操作员调整脱气器位置,最大程度地避免录井仪气路抽入钻井液,从而保障气体检测分析系统安全和录井资料质量。

4　结束语

出口流量监测、补偿池体积监测和脱气器液面吃水深度监测 3 个方面的应用实例,只是超声波液位传感器在现场录井技术服务过程中拓展使用的一部分,其他用途尚有待生产中进一步发掘。据某研究机构调查显示,截至 2013 年底,国内从事录井技术服务的企业超过 70 家,录井队伍总量超过 2000 支。在录井新技术日趋发展的今天,竞争也愈演愈烈,因而立足于录井基础工作,充分挖掘现有设备的使用潜力,不断创新工作方法,对于高效优质录井无疑将起到更大促进作用。

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group in Dabei area of Tarim basin, belongs to ultra-deep high pressure gas reservoirs, generally is high-pressure, low porosity, low permeability and fractured sandstone reservoirs. Geological conditions, drilling technology and other influence factors bring difficulties to gas reservoir interpretation and evaluation. Through generalizing and analyzing oil production test data of 22 wells and gas logging hydrocarbon gas components and derived parameters of 30 layers in Dabei area, gas logging hydrocarbon gas components and derived parameters were collectively named as gas logging data volume, the performance characteristics and regularity of gas logging data volume in gas reservoirs were summarized, in view of the problem that gas logging data volume and oil production test conclusions are inconsistent in individual wells during statistically analyzing, the concept of non-standard gas logging data volume was put forward, the divided method of the ratio of total hydrocarbon to methane was adopted, gas logging data volume of the corresponding interval was divided into non-standard gas logging data volume and standard gas logging data volume according to the ratios, after getting rid of the non-standard gas logging data, gas logging standard chart and gas reservoir interpretation criteria were set up for Cretaceous system in Dabei area, the results showed this chart and criteria tallied with practice, the results of on-site interpretation and evaluation were good, they lay the foundations for field interpretation and evaluation of gas reservoirs in Dabei area.

Key words: gas logging well, fractured gas reservoir, gas logging component, derived parameter, gas logging interpretation chart

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Development and application of high-precision intelligent partition gas chromatograph. Zheng Zhoujun, Yu Wencheng, Liang Dongquan, Qiu Tianmin, Zhang Dongfang and Fu Yiming. ***Mud Logging Engineering*****, 2015,26(1): 49-52**

By using the newly designed FID micro-current amplifier and electronic pressure controllor (EPC), the high-precision detection and stream pressure control were realized for partition gas chromatograph, its minimum volume fraction of gas detection is 1×10^{-6} $C_1 - C_5$ online detection performance, which expands the scope of chromatograph application, making it possible to combine with quantitative degassing technology. Digitization and real-time feedback of EPC high precision pressure control technology greatly improve the stability of partition gas chromatograph. With the new electric control and human-computer interaction system, the intelligent applications of the partition gas chromatograph were realized, and the function components within the instrument are of the modular integration were convenient for on-site maintenance. A new generation of high-precision intelligent partition gas chromatograph may provide more accurate and reliable first-hand gas logging data for the interpretation and evaluation of oil and gas reservoirs.

Key words: high precision, pressure controller, chromatograph, quantitative degassing, modularization

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A new digital imaging system of CIS cutting logging. Teng Gongsheng, Zhang Guoliang, Chen Shuqiu and Shao Jiajia. ***Mud Logging Engineering*****, 2015,26(1):53-57**

Cutting imaging logging technique in China already has more than ten years of experimental application process, but the skills and capabilities remain at a similar level of digital photography, the key technology is failed to make a breakthrough and cannot meet the needs of geological applications on cutting logging. By four years of joint research, Image Information Research Institute of Sichuan University and Daqing Oilfield developed a new CIS cutting digital image acquisition and analysis system. By using the new architecture design, dual CMOS camera joint acquisition, adaptive white balance, stand-alone intelligent monitoring, three-dimensional coordinate mapping and other new techniques, the hardware of the system achieved cutting high-fidelity and high-definition imaging, thus meeting the geological demands of macroscopic observation and microscopic analysis of cutting logging. Software system has created a series of key techniques of image processing, such as extended depth of field, target segmentation and extraction, cutting intelligent identification, thus fundamentally expanding the variety of geological analysis and application of cutting image and promoting cutting logging development to the direction of automation, informatization and refinement. The results have been widely used in 11 key exploration wells, which plays an important role in the process of oil and gas exploration, has been highly evaluated by the construction parties of Daqing Oilfield and Jilin Oilfield, and has higher application prospects.

Key words: cutting imaging, high fidelity, high definition, extended depth of field, target segmentation and extraction, intelligent identification, geological application

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Mud logging site application development for ultrasonic liquid level sensor. Liu Bin. ***Mud Logging Engineering*****, 2015, 26(1): 58-61**

Combined with many years of mud logging field production practice, the paper described three new usages for ultrasonic liquid level sensor: the first is on the wells that the target type flow sensor can't be installed, the outlet flow detection was completed by monitoring the changes of the liquid level in buffer tank or overhead tank; the second is monito-

ring the level changes within the circulation pipe line (buffer tank or overhead tank) during pump stopping and starting to compensate the undulating quantity of total pit volume during pump stopping and starting, and ensure to monitor overflow, lost circulation more sensitively in the special conditions of single pipe connection and instable pump stroke; the third is to solve the problem of the degasser on overhead tank often extracting drilling fluid by monitoring the level draft of overhead tank where degasser is installed. Based on well control safety, they provide reference for efficient mud logging, and for each method, the author set forth the realizing process of sensor setting, calibration and the corresponding data detection. Example analysis showed the results were good, ultrasonic liquid level sensor can replace the corresponding sensors in special drilling conditions.

Key words: mud logging, liquid level sensor, outlet flow, compensation pit volume, degasification, draft

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Optimized configuration of data acquisition for Advantage Ⅱ mud logging unit under gas drilling condition. Hu Zongmin. ***Mud Logging Engineering*****,** 2015, 26(1): 62-65

Because the imported new mud logging units such as ALS, Advantage Ⅱ can not directly collect, store and display the increased mud logging parameters under gas drilling conditions, it needs to be optimized in the configurations of its hardware and software. The optimized configuration for hardware mainly increases isolation barrier module of the sensor signal acquisition in the original acquisition system, and adjusts its wiring. The optimized configuration for software mainly performs channel assignment, field definitions, and unit adjustment to the increased sensor parameters in configuration files of acquisition, transmission and display software. After optimizing the configurations, Advantage Ⅱ mud logging unit is able to adapt to the data acquisition requirements under the condition of gas drilling, thus reversing a trend that the imported mud logging unit cannot be used under the condition of gas drilling.

Key words: gas drilling, Advantage Ⅱ mud logging unit, isolation barrier, configuration file, optimized configuration

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Remote identification technology for cuttings. Fu Yubao. ***Mud Logging Engineering*****,** 2015,26(1): 66-69

Remote mud logging platform, which was self-developed by Greatwall Mud Logging Company, uses wireless broadband networking technology to quickly transmit cutting images to the base, logs on to the network and controls cutting image acquisition system to take photos in real-time, thus making full use of the technical superiorities of the base experts and avoiding errors to occur at the important Geo-Logging operation parts of on-site complex lithology identification and key horizon determination. Experts at the base can use remote mud logging platform to analyze, describe and name cutting images through observation of on-site cutting images and control of on-site image acquisition instrument to shoot the scenes, realizing a remote cutting identification and guidance of horizon determination. The change of identifying and naming cutting from the wellsite to base experts improved the accuracy and timeliness of cutting identification, avoided the errors in horizon determination and cutting identification, was both in favor of management decision-making and improvement of the efficiency of mud logging operations.

Key words: cutting logging, cutting image acquisition, image analysis, cutting remote identification, horizon determination, expert decision

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APP system design and application for mud logging real-time data. Huo Chang, Wang Jin, Li Peng and Yang Peng. ***Mud Logging Engineering*****,** 2015, 26(1): 70-72

In the current remote logging construction, the network technology was combined with mobile devices, mud logging real-time data APP system was developed based on the existing comprehensive mud logging technology and network equipment. The system includes 3 parts of mobile device APP, mobile network and field comprehensive mud logging unit server, it utilizes the mobility, convenience and timeliness of mobile devices to get wellsite real-time data at all times and all places, real-time provides technical experts with true, complete and comprehensive firsthand field mud logging data, thereby effectively avoiding the risk of drilling site operations. The system has the functions of checking mud logging real-time data, real-time monitoring, single well information inquiry, and wellsite satellite map, instant messaging and two-dimensional code application, the compatibility and scalability are good. The practice of several wells proved the experts of mud logging companies can timely follow the changes in each parameter at different places via mobile device clients and communicate with field technicians, thus guiding field mud logging operations and avoiding operation risk.

Key words: remote mud logging, Android, mobile data, APP, two-dimensional code

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