

石油背压式液动冲击器的室内试验研究^{*}

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摘 要 随着油气田勘探开发向纵深发展, 钻遇的硬地层越来越多, 地层的岩石可钻性级值及硬度增高。冲击旋转钻井技术这一被认为是破碎坚硬岩石最有效的方法目前在石油钻井界得到了普遍重视。冲击旋转钻进是冲击式钻进和旋转钻进相结合的一种钻进方法, 在钻遇坚硬地层时, 以其钻速快、钻井成本低、岩屑大、钻压低和井斜程度轻等优点受到油气田的普遍欢迎。文章通过对背压式液动冲击器进行室内试验研究, 得出了各种冲击参数(冲击频率、振动幅值、冲击力大小)对其使用性能的影响; 为科学调整和设计背压式冲击器提供了一定的依据, 同时也为背压式冲击器的现场试验及应用奠定了基础。

主题词 石油 天然气 冲旋钻井技术 液动冲击器

背压式液动冲击器的工作原理

本冲击器为无簧式双阀双作用液动冲击器, 结构简单、调试方便, 运动件少, 工作可靠。主要有上阀机构、冲锤机构、冲击能量及旋转扭矩传递机构以及附属机构四部分组成(见图1)。由示意图可见, 冲击器的上阀及冲击锤具有类似的形状。其特点是上端比下端具有较小的直径, 以保证在运行过程中, 下端有效承受液压的面积大于上端, 进而实现二者的往复运动。这就是它的基本工作原理。本冲击器在启动前由于重力的关系上阀及冲击锤均处于最下部位位置。钻井液从外壳上方进入上阀下部的通孔和上阀—冲击器之间的间隙而进入冲击锤的内孔道, 液流到达铁砧及下接头时, 由于下接头内设有节流环, 因而液流在冲击锤下端形成较高的液压。虽然上阀及冲击锤系统上下端是一个连通器, 但由于其下端的有效承压面积大于上端, 因而液流迫使上阀—冲锤迅速上行。上阀先期上行到活阀的上死点。应当指出, 通过精确的计算, 上阀上行(回程)必须超前于冲击锤的上行(回程)过程。当冲击锤上行到与上阀接触后, 液流在阀—锤之间被截断并产生水击, 冲击锤在阀—冲锤系统的重量、高压液流和反弹惯性力的联合作用下迫使冲击锤对铁砧实现冲击并完成冲击锤的工作行程。由于上阀的行程设计比冲击锤

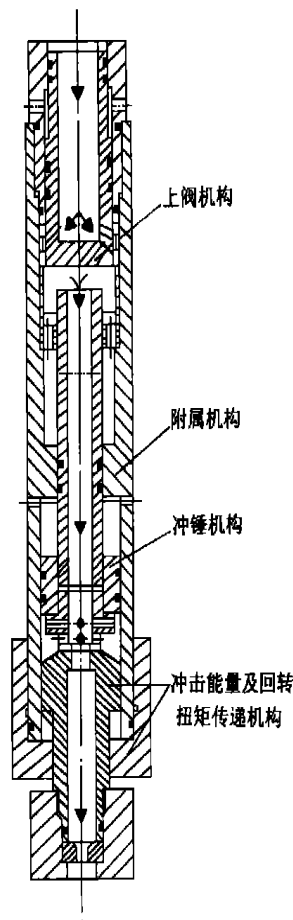


图1 背压式液动冲击器结构示意图

^{*} 本文系中国石油天然气集团公司“九五”科技攻关项目。

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短,在冲击锤到达下死点前上阀与冲击锤被迫脱离而产生间隙,所以上阀也达到了其下死点,这样冲击器各运动部件又恢复到开始前的各相对位置,于是第二次工作循环又开始了。冲击锤重复上述过程,周而复始,对铁砧产生周期性冲击作用,铁砧将冲击动载传递给井底的钻头,进而达到冲旋破岩的效果。

背压式冲击器的室内实验

(1)测试原理。

为保证冲击器在具有最佳工作状态时准确反映其性能,在对冲击器性能测试中,采用压力传感器作为机—电信号转换元件,采集冲击锤打击铁砧子的冲击力,再计算冲击器的输出能量——冲击能量以及其它相应的冲击参数^[2]。力传感器在冲击力的作用下,通过应变仪和数字分析仪可直接反映冲击锤打击铁砧子时的冲击力值。

据动量原理

$$mv = F t$$

(1)

得出:

$$F = \frac{mv}{t}$$

(2)

式中: F 为冲击力, N ; m 为冲锤质量, kg ; v 为冲击速度, m/s ; t 为冲击时间, t 。

式(2)反映了运动速度与力之间的关系,引申到冲击器的测试中,即当冲锤的质量一定及冲击铁砧子时间相等时,冲击力与相应的击砧速度对应,据此可计算出在液力作用下锤的冲击能量。

(2)测试系统。

根据测试原理,建立了如图 2 所示的自动检测系统简图,该测试系统主要有显示器、分析仪、应变仪、传感器等组成。

(3)测试结果。

第 阶段实验:本阶段采用冲击器的上阀结构如图 3 所示(其测试结果详图见袁光杰,冲旋钻井技术研究硕士学位论文,西南石油学院石油工程学院, 2001 年)。

第 阶段实验:本阶段采用冲击器的上阀结构如图 4 所示(其测试结果详图见袁光杰,冲旋钻井技术研究硕士学位论文,西南石油学院石油工程学院, 2001 年)。

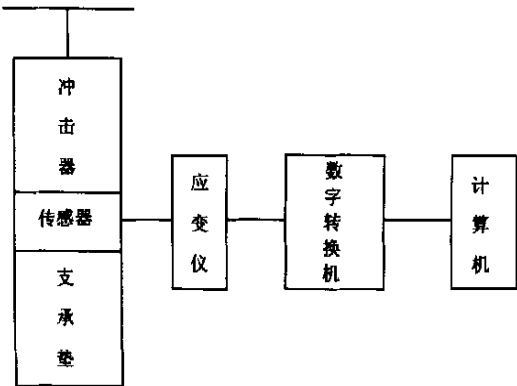


图 2 测试系统简图

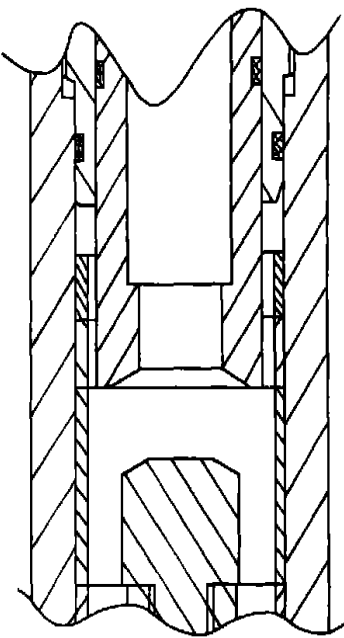


图 3 下出口式上阀

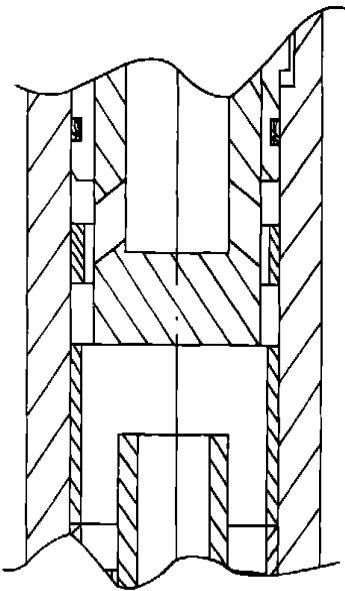


图 4 侧出口式上阀

试验结果分析

(1)泵压和排量的增加,都会使冲击器的冲击频

率和冲击力有所增大,因此在现场应用时,可通过调节泵压和排量在一定范围内改变冲击器的冲击参数以满足钻不同地层的需要。

(2)由图3、图4及相应的实验结果可以看出,冲击器的上阀和冲击锤的形状对冲击器的冲击频率有很大影响,且试验表明上阀和冲击锤的形状设计成流动阻力较小的形状,会有效地使冲击器的冲击频率降低到所需范围。

(3)冲击锤和上阀的行程以及两者之比对冲击器的冲击参数有一定的影响,即:冲击锤行程增大,冲击频率降低;在合理范围内,即为冲程的0.6~0.4倍时,上阀行程增大,冲击频率和冲击力也增大,但超出合理范围反而会减小。

(4)通过综合比较可以看出上阀行程为冲程的0.5倍左右时,冲击器的各项参数达到最佳状态,同时也可以看出,冲程对冲击频率的影响范围在30 Hz内。

(5)纵观各实验数据图,可以明显看出在每一个冲击周期中,应力波形图都连续出现两次波峰,其中前一个较大,后一个较小。根据冲击破碎岩石理论可知,在冲击锤与铁砧子撞击时,入射应力波在撞击界面处发生反射,反射后的冲击波到达冲击锤自由端,再次发生反射后重新到达冲击锤的撞击端实现对砧子的第二次冲击,但由于波在传递过程有能量损耗,故冲击应力较第一次弱一些。表现在波形图上,就是在一个冲击周期中连续出现两次波峰,其中第一次的较大一些,第二次的较小一些。

(6)在室内实验过程中,同时也采用了改变喷嘴直径,冲击锤重量和上阀重量等方法来测量实验数据,实验结果表明它们都在一定程度上对冲击器的工作性能有影响,且测出的结果与计算机模拟的结果相一致。

(7)大量的实验数据表明,冲击锤行程和上阀行程都有一个变化范围,太大或太小都不好。对于背压式液动双作用冲击器来讲,冲击锤行程 $S = 25 \sim 65$ mm,上阀行程 $S_1 = 10 \sim 30$ mm,冲击锤与上阀之间的间隙 $S = 10 \sim 30$ mm时,冲击器能发挥出最好的冲击性能。同时,在今后做实验时,要考虑到冲击器的剧烈振动程度,采取一定的减震措施。

结 论

(1)背压式冲击器是一种性能稳定,工作可靠,结构简单易于石油钻井现场使用的液动冲击器。

(2)通过实验本文对冲击器的冲击参数进行了定性和定量的描述,对今后冲击器的改进和现场应用有一定的指导意义。

参 考 文 献

- 1 王人杰,蒋荣庆.液动冲击旋转钻探.北京:地质出版社,1988
- 2 王克雄等.液动冲击器测试系统的研究.石油大学学报,1995

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气体加速泵排水采气新工艺在西南地区首获成功

中国石油西南油气田分公司蜀南气矿首次运用气体加速泵排水采气新工艺,在宋家场构造现场实施获得成功。这项从美国引进的新工艺技术成功运用打破了老井挖潜“六大工艺”一统西南老气田的局面,为后期气田的生存与发展注入了新的活力和希望。目前,实施该项新工艺的宋1井日增产天然气5000 m³以上,效果明显,达到了设计要求。

气体加速泵是将气体喷射原理与气举紧密结合,将原连续气举底部工作阀换为具有喷射原理的加速器,利用地面注入气的高压动能,通过加速器的喷射作用提高排水采气效果。针对气田全面进入开采后期,储采比低,老井挖潜难度逐年加大的局面,蜀南气矿运用新工艺有效地降低了注入气量,有效改善了过去因气举气源紧张而经常停举的状况,有利于气井后期的连续稳定生产。电潜泵、机抽、喷射泵是气田后期挖潜有力手段,但一次性投资大,需要高压电作动力,工艺复杂、管理困难、成本较高。而该新工艺不需起上油管作业,较常规气举相比,在投资上仅增加气体加速泵所需较少设备费,在操作上与常规气举无异,有较好的推广应用前景。

(陈文彬 谢飞 供稿)

Blast-furance slag ,High temperature ,Crack ,Mechanism

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APPLICATION OF SLIMHOLE DRILLING AND TUBINGLESS COMPLETION IN THE GAS FIELD HOUWUJIAHU*

Liu Yanxue (Northeast Petroleum Bureau of CNSPC). *NATURAL GAS IND.* v. 22 ,no. 4. pp. 45 ~ 47 ,7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:There will be no obvious profit from shallow gas if the regular way is adopted in drilling and completion work. In order to reduce the exploitationcost ,slimhole drilling and tubingless completion ,in which oil tubing was used as production casing for cementing and perforation completion and afterwards was never used again during the production ,was applied in the Gas Field Houwujiahu for the first time by Northeast Petroleum Administration (NEPA) .During the whole process of operation ,such problems were extremely complicated as rigs selection ,well control and completion and so on. At the same time ,many techniques are discussed here such as the selection of rigs ,well construction ,well control and gas well testing etc. .It is also analyzed the reason that the rate of penetration (ROP) is low. Thus ,it is put forward some methods of improving the ROP with the optimum PDC bits and drilling parameters. Meanwhile ,it is evaluated on the economical benefit from the application of this technique.

SUBJECT HEADINGS: Shallow gas , Rig , Slimhole drilling , Tubingless completion , Evaluation , Shongliao Basin

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STUDY ON A NEW TYPE DRILLING FLUIDS WITH WHITE OIL LUBRICANT HML-1 *

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ABSTRACT:A lubricant is one kind of important chemical additives in drilling fluids ,whose functions are to improve the lubricity of drilling fluids ,to ease the friction between the well wall and the drilling tools (or casing) ,and to weaken the rotation torque of strings and resistance during the round trip so as to lessen the danger of drilling pipe sticking. According to the shortcomings in using the white oil lubricant in drilling fluids at present ,another new type white oil lubricant is put forward to be studied on. The ingredients of this lubricant is finely chosen in a special way through perpendicular experiments. After experiments in labs and on fields ,this lubricant is eventually proved to be excellent with good properties of fine lubricity , compatibility with drilling fluids and being poisonless (little bad effects on the environment) .

SUBJECT HEADINGS: White oil , Drilling fluid , Lubricant , Additive , Antisticking , Environmental protection

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EXPERIMENTAL RESEARCH ON BACK-PRESSURED HYDRAULIC IMPACTOR

Yuan Guangjie (Mechanical Engineering Institute of Shanghai Jiaotong University) and Chen Ping and Huang Wanzhi (Southwest Petroleum Institute). *NATURAL GAS IND.* v. 22 ,no. 4. pp. 50 ~ 52 ,7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:Along with the deep-going expansion of oil and gas exploration and development ,more and more hard strata have been drilled and the drillability extrema and hardnesses of the strata are increased. The percussive-rotary drilling technology being the most efficient way to break up the hard rocks has been highly thought of by oil-drilling circles commonly at present. The percussive-rotary drilling technology is a combinative method of both percussive drilling and rotary drilling. In the process of drilling hard strata ,this technology is of many advantages ,such as high drilling rate ,low drilling cost ,large drilling cuttings ,low WOB and small deviation angles ,etc. and it has been widely adopted in many oil and gas fields. In the paper , through the experimental research on back-pressured hydraulic

impactor,the influence of various parameters (impact frequency ,vibration amplitude and the magnitude of impact force) on its utilized performance is discussed ,which provides a certain basis for scientifically adjusting and designing the back-pressured impactor and lays the foundation for its on-the-spot experiment and application.

SUBJECT HEADINGS : Petroleum , Natural gas , Percussive-rotary drilling technology ,Hydraulic impactor

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EFFECT ANALYSIS OF DAMPER AND A NOVEL VIBRATION ABSORBER

Wang Chaojin (Southwest Petroleum Institute) .
NA TUR. GAS IND. v. 22 ,no. 4. pp. 53 ~ 56 ,7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:The downhole dampers in light of the vibration isolation principle to reduce the vibration of drilling string have been commonly used for controlling the longitudinal vibration of downhole drilling string in the process of drilling. In the paper,the effect of the downhole damper is analyzed according to the continuous system vibration model of drilling string ;it is pointed out that the effect of the damper is irrelative to WOB but is mainly dependent on the rigidity of the damper and the exciting frequency of the longitudinal vibration of drilling string;a certain effect can be found in the use of any damper in most circumstances,however the smaller the rigidity,the better the effect ;and in the process of using each damper ,along with an unceasing lengthening of drilling string the amortization effect of the damper is also uninterruptedly changed and a covibration may be formed under the action of resonance ;and at this time ,the utilization of the damper can increase the vibration of drilling string ,which may be avoided through revising the technological parameters of drilling. A novel vibration absorber of adopting vibration absorption principle has been studied ,which is introduced in the article. This absorber can absorb the downhole exciting force acting on drilling string through the vibration of absorbing system added on the surface of drill collar. And the larger the mass of the additional system ,the greater the amplitude formed after exciting ,the more obvious the amortization ef-

fect on drilling string.

SUBJECT HEADINGS :Drill stem dynamics ,Damper , Vibration absorber ,Vibration control ,Effect ,Analysis

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THE PRINCIPLE AND SIMULATION OF TWO - AXLE EXCITATION VARIABLE ELLIPTIC MOTION SHAKER *

Hou Yongjun , You Sikun and Zhang Minghong (Southwest Petroleum Institute) . *NA TUR. GAS IND.* v. 22 ,no. 4. pp. 56 ~ 58 ,7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:Two-axle excitation variable elliptic motion shaker is characterized by this main point as follows:the throwing index on the screen surface becomes smaller and smaller from the end of entrance to that of discharge. The bigger throwing index at the end of entrance can effectively increase the detaching speed of solids from fluids and also cut down the flowing distance of drilling fluids on the screen surface. The smaller throwing index at the end of discharge can decrease the amount of solids broken and thrown through the screen. At the same time ,solid conveyance speed is almost kept at a certain level on the surface of screen ,which makes solids discharge smoothly and avoids the superfluous conveyance at the discharging end of balance elliptic shaker. Therefore ,this shaker can improve the ability of dealing with drilling fluids. It is then discussed the working principle of this shaker ,the motion simulation of screen surface and the effects on the motion regularity by the different distances between the center of excitation force and the mass center of the shaker box. Results given out can be relied on to help in designing and studying on the two-axle excitation variable elliptic motion shaker.

SUBJECT HEADINGS :Drilling , Shale shaker , Variable elliptic motion , Two-axle excitation , Working principle , Motion simulation

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