

连续油管受力分析方法在水平井作业中的应用

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摘 要 连续油管作业简单省时、安全可靠、节约成本, 在水平井作业中具有其他设备不可替代的优点。但由于连续油管与钻具、常规油管相比的轻、柔属性使其在井下受力特别复杂。文章通过介绍连续油管受力分析方法, 用于分析井下受力, 也可预测大斜度井中连续油管的动作。

主题词 连续油管 受力分析方法 水平井 应用

连续油管作业设备广泛应用于油气田修井、钻井、完井、测井等作业。在油气田的勘探开发上发挥着越来越重要的作用。但由于连续油管与钻具、常规油管相比的轻、柔属性使其在井下受力特别复杂。本文通过介绍连续油管井内受力分析方法, 用以分析连续油管受力, 确定作业是否进行或如何进行, 以安全、有效地满足作业要求, 达到作业目的。

连续油管受力分析方法

将计算基础建立在无流体和压力的倾斜直井内, 通过取连续油管段长, 分解重力, 该段轴向实际力即为轴向分力与径向分力产生的摩擦力的矢量和, 累加后, 就得到整个连续油钢管串所受实际力结果 (实例分析如图 1)。

对于悬在井内一段末端封闭的连续油管, 其实际力与有效力的区别是, 实际力考虑了内外压力的影响, 而有效力为该段连续油管重力减去浮力与管

内液柱压力之和。连续油管的屈服性取决于有效力, 实际力决定连续油管所承受的应力和张力。

连续油管设备进行不压井作业是通过自封实现的, 作业中通过对自封施加最小液压推动液缸轴向挤压, 使弹性橡胶件径向密封将井筒与大气隔离, 实现起下油管时的动密封。在自封下方, 实际轴向力如上所述, 但在自封上方管外压力为大气压力, 自封上方实际力与下方有效力的关系是:

自封上方实际力 = 自封下方有效力 - 井口压力 + 管内压力 ± 自封摩擦力

自封上方有效力与下方有效力的关系是:

自封上方有效力 = 自封下方有效力 - 井口压力 ± 自封摩擦力

用于受力分析的地面重量与指重表所显示的“重管力”不同, 它与自封上方实际力的关系是:

地面重量 = 自封上方有效力 - 井口压力 - 滚筒返转弹力

通过图 2 和图 3 可以看到, 随连续油管入井深度的增加, 地面重量在增加, 而有效力却在“减小”, 这是因为计算基础是将连续油管悬在井内从管的末端分析段长然后累加得到的结果。越接近地面有效力越大, 这也是深井小管径连续油管作业采用变径连续油管的原因之一。

在井内弯曲部分, 皮带效应 (belt Effect) 会引起与连续油管起下方向相反的附加摩擦力增加, 连续

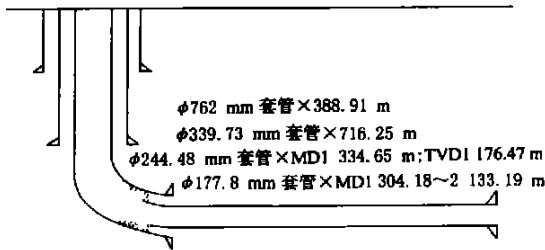


图 1 X 井井身结构图

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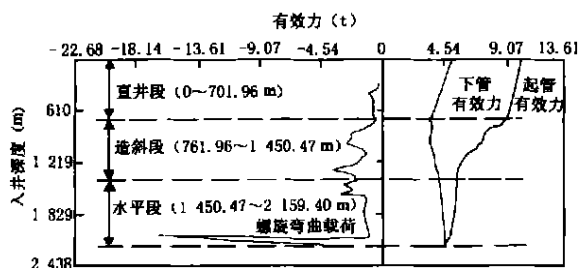


图2 X井连续油管入井深度与有效力关系图

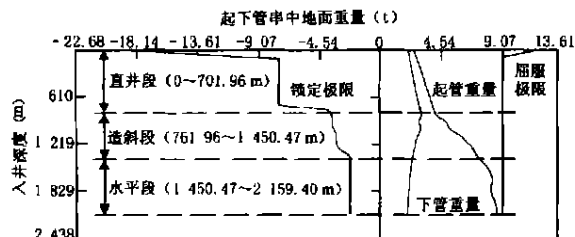


图3 X井连续油管入井深度与地面重量关系图

油管处于张力状态时靠在弯曲内侧,处于压缩状态时抵靠在弯曲外侧。张力或推力越大,紧贴套管的径向负载越大。连续油管进入水平套管内,管串分三段,推力随连续油管入井逐渐增加,附加的管壁接触力和附加摩擦力相应增加。在载荷达到正弦弯曲临界载荷点以前为平直部分;然后正弦弯曲段在套管内径范围内仅产生轻微的弯曲,直到载荷达到螺旋弯曲临界载荷点。由于产生了螺旋弯曲,连续油管实际入井长度比实际井深位置略长。最后是螺旋弯曲段,如果井壁接触力的增长速度大于轴向载荷的增长速度,克服摩擦力所需的附加轴向力的增长速度就会大于实际的轴向载荷,导致“螺旋锁定”。一旦达到锁定,不能继续将连续油管下入井内。

在水平井连续油管作业中的应用

使用连续油管能在不上钻机和压井条件下,向井内泵送流体和通过完井管柱下工具仪器,其本身固有的强度和柔性也特别适用于水平井作业。以大斜度井或水平井使用连续油管传送电缆测井为例,能在不压井情况下测井,并随时能进行正反循环。作业简便,不需使用旁通和湿接头。减少使用钻机或修井机的周期和费用。能以最佳速度连续进行生产测井和裸眼测井。由于连续油管的钢性以及连续油管与测井仪器管串的硬性连接,起下简便。电缆在连续油管内部也受到良好保护。

实例分析:X井属长曲率半径水平井,如图1,该

井实际井深(MD)2159.40 m,垂直井深(TVD)1215.20 m,水平位移1151.57 m。在完井测试前曾用连续油管传输测井仪器在 $\varnothing 177.8$ mm衬管内测井,由于仪器在水平段中途遇阻无法下至井底,未获成功;起连续油管时,由于连续油管接头损坏,仪器落入井中,因水平段中打捞困难,最后用铣锥将落鱼推至井底。计算输入参数。采用 $\varnothing 88.1$ mm QT700型连续油管(质量:1.98 kg/m)内装 $\varnothing 10.82$ mm电缆(质量:0.47 kg/m)测井, $\varnothing 69.22$ mm工具仪器长6.4 m,井内 $\varnothing 101.6$ mm油管总长1523.93 m。预计入井至井底2153.31 m,井内液体密度 1 g/cm^3 ,滚筒返转弹力136.08 kg,自封加压136.08 kg,导向器半径1.8 m,井口压力13.79 MPa,起下管串时连续油管末端受力为4536 kg。使用Orpheus软件计算,分别得到起下仪器过程中有效力、地面重量(非重管力)与入井深度的关系图(图2、图3)。图2说明,起下管串过程中,有效力距螺旋弯曲载荷极限较远,井口段的连续油管所承受的有效力最大,在761.96~1450.47 m造斜段,由于径向载荷的增加,螺旋弯曲延迟产生。还可计算实际力与入井深度的关系图,结合管材的抗拉极限采取相应的防范措施。

如图3示,下管时在直井段重量与下入深度成正比;刚进入井内弯曲段时,由于皮带效应的影响,径向载荷增大引起连续油管与油管间的负向摩擦力陡然增加,地面重量随之减少;进入造斜段后,地面重量又与下入深度成正比;继续进入水平段,由于轴向推力,正向摩擦力随入井深度的增加而增加,地面重量逐渐减少。起管时,由于除连续油管自重外,还要克服相应摩擦力,地面重量接近9.07 t,逐渐降低,提至直井段时,起出深度与地面重量又成正比减少。在屈服和锁定极限间,起管不会被拉断,下管不会发生锁定,在上述条件下作业可行。

但仅将井口压力增大6.9 MPa,屈服极限就与起管重量曲线发生交叉,若盲目起管连续油管极有可能拉断。针对这个问题,就应该采取措施,如下管前提前防喷降压、采用一定量的压井液、强度更高的连续油管等使作业能安全、有效进行。

参考文献

- 1 李介士. 水平井钻井完井及增产技术. 北京:石油工业出版社,1991
- 2 李志明,关志忠译. 水平井完井和增产措施技术. 北京:石油工业出版社,1995

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THE COILED TUBING FORCE ANALYZING METHOD FOR HORIZONTAL WELL OPERATIONS *

Zhou Chongzi , Wang Ling and Chen Che (Downhole Services Group , SPA). *NATURAL GAS IND.* v. 22 , no. 4. pp. 59 ~ 60 , 7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:The coiled tubing can make work easy , safe and reliable and also can save time and reduce the costs so that it cannot be replaced by any other equipments in horizontal well treatment. However ,compared with drilling tools or regular oil tubes ,the coiled tubing is so light and flexible that it makes it complicated with its own endured forces in the well. A new analyzing method is used to study on the forces on the coiled tubing and to forecast its behavior in the large-deviated wells.

SUBJECT HEADINGS:Coiled tubing , Tubing force analyzing method , Horizontal well , Application

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INVESTIGATION OF THE MICROVISUAL FLOW AND RELATIVE PERMEABILITY LAW OF CONDENSATE OIL AND GAS

Su Chang , Guo Ping , Li Shilun , Sun Liangtian and Sun Lei (Southwest Petroleum Institute) . *NATURAL GAS IND.* v. 22 , no. 4. pp. 61 ~ 64 , 7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:It is necessary for well predicting the performance and economic returns of condensate gas reservoir to model correctly its flow state and phase state and it is most important for modeling the flow state to obtain the representative relative

permeability curves of condensate oil and gas which are the basic cures most commonly used in mathematical model and well testing analysis. The relative permeability curves of analog oil and gas are generally adopted for replacing those of condensate oil and gas at present. The flowing law , however , of the conventional oil and gas with low interfacial tensions in porous media is different from that of the condensate oil and gas , because the physical properties of the condensate oil and gas are approaching to each other and through forming a hydrodynamically conducting film included between water and condensate gas , the condensate oil can flow together with the condensate gas. Meanwhile , the degree of the influence of these parameters as porous media , initial water , wettability , gravity , interfacial tension , viscous force and flow velocity , etc. , on the flow law of the condensate oil and gas is also different from that of the conventional oil and gas. Because of different microvisual percolation flow laws , the change laws of relative permeabilities of the condensate oil and gas are different from those of the conventional oil and gas , therefore the relative permeabilities of the oil-gas system with low interfacial tensions can 't be used for replacing those of the condensate oil and gas. Finally the importance of the relative permeability curves measured through experiment and the trend studied in the future are determined in the paper.

SUBJECT HEADINGS: Gas condensate , Condensate gas , Oil and gas production , Reservoir performance , Flow property , Porous media , Relative permeability

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COMPUTING METHOD OF WELLBORE PRESSURE IN THE GAS WELL WITH HIGH GAS-WATER RATIO

Huang Wei and Yang Wei (Xi 'an Petroleum Institute) . *NATURAL GAS IND.* v. 22 , no. 4. pp. 64 ~ 66 , 7/ 25/ 2002. (ISSN1000 - 0976 ; **In Chinese**)

ABSTRACT:The Cullender-Smith model firstly taken for computing gas well bottom hole pressure is widely used for calculating wellbore pressure in a dry gas well. Through correcting the Cullender-Smith method for water content , a new model of computing wellbore pressure in a gas well with high gas-water ratio was set up by the authors. In the paper , on the basis of the energy equation of gas steady flow , the computing methods of