低渗透油田特高含水期开发技术对策

——以渤南油田义11井区为例

高宝国[1,2],滑 辉[2],丁文阁[2],陈 军[2],李华玲[2]
(1.中国石油大学(华东)地球科学与技术学院,山东 青岛 266580;
2.中国石化胜利油田分公司 河口采油厂,山东 东营 257200)

摘要:渤南油田义11井区平面、层间和层内非均质性严重,进入特高含水期后,注采矛盾突出,自然递减率达到14.8%,产量快速下降。为减缓递减,改善开发效果,开展了开发技术对策研究。针对主力油层主体部位动用程度高,水淹严重的状况,通过不稳定注水和优化油井采液强度,实现控水稳油;针对局部注采不完善,储量水驱动用程度低的状况,通过完善和恢复注采井网,提高储量水驱动用程度;对合采合注井,通过分层注水和封堵高含水层,减缓层间矛盾;对采出程度低,含水率低的砂体边部和非主力油层,通过储层改造、分层注水、单层开采等措施,提高储量动用程度。区块开发效果明显改善,年递减率下降至4.1%,基本保持稳定,采收率进一步提高,由30.7%提高到32.0%。

关键词:特高含水期 流动单元 开发技术对策 提高采收率 注采完善 渤南油田
中图分类号:TE341 **文献标识码**:A **文章编号**:1009-9603(2013)06-0097-03

中国东部油区以注水开发为主,主力单元多数已处于特高含水开发阶段,但其年产油量、剩余可采储量在中国仍占有较大比例。因此,特高含水期油田的稳产和水驱采收率的提高,是油田开发的重要研究内容之一。针对渤南油田义11井区特高含水期的开发矛盾,开展流动单元划分与对比,实施提高采收率开发技术对策,实现产量及综合含水率基本稳定,年递减率下降至4.1%,采收率由30.7%提高到32.0%。

1 油藏概况

义11井区是渤南油田的主力开发区块之一,南北被2条近东西向的断层切割,区块内部断层不发育,地层西高东低,南、北部分别存在1个局部高点,油层埋深为2 880~2 960 m,含油层系为沙三段和沙二段。

义11井区为低渗透稀油油藏,1971年投入开发,1975年开始注水,1994年进入特高含水阶段,2005年后综合含水率在95%以上。该阶段主力油层动用程度高,水淹严重,综合含水率达97.5%以上,但砂体边部部分井组注采不完善,仍存在剩余油富集区;非主力油层由于层薄、物性较差、砂体规模小等原因,投入开发以来,一直没有建立独立完善的注采井网,动用程度相对较低,采出程度仅为1.6%~17.3%,但是挖潜难度较大。

2 精细油藏描述及剩余油分布

为改善义11井区开发效果,提高采收率,开展了精细油藏描述和剩余油分布研究,对区块地质特征和开发潜力进行了再认识。

2.1 沉积相

渤南油田义11井区为近源湖相重力流沉积,浊积岩沉积构造齐全,且滑塌变形构造丰富;岩石颗粒分选大都较差,个别中等;概率曲线上为一段式或两段式,*C*—*M*图上分布区与*C*=*M*大致平行;岩石组合为典型的鲍玛层序,“ABE”和“CDE”组合最常见,“BCE”和“BC”组合次之[1-3]。沉积事件经历时间很短,粗碎屑只沉积于由重力流形成的水道内,沉积物几乎未经明显的机械重力分异,溢岸沉积物少而细,导致纵向及侧向上岩相相变很快。

收稿日期:2013-09-09。
作者简介:高宝国,男,高级工程师,在读博士研究生,从事油田开发地质研究。联系电话:(0546)8662236,E-mail:gaobaoguo.slyt@sinopec.com。
基金项目:国家科技重大专项“胜利油田特高含水期提高采收率技术”(2011ZX05011)。

依据粒度和沉积构造特征，组合出砂质岩类和泥质岩类2大类10种岩相类型：递变层理砂岩相、块状层理中细砂岩相、平行层理砂岩相、波状交错层理粉细砂岩相、水平层理粉砂岩相、变形层理砂岩相、深灰色水平层理粉砂质泥岩相、棕黄色块状泥岩相、深灰色水平层理泥岩相、深灰色块状泥岩相。根据岩心分析，结合测井资料，将义11井区湖底扇沉积体系细分为沟道、沟道间、沟道末稍、深湖泥及滑塌透镜体5种沉积微相。

2.2　流动单元对比与划分

沙三段是济阳坳陷1个三级地层层序，依据岩电关系特征，利用测井曲线，按“旋回控制，逐级对比”的原则进行储层流动单元划分与对比。用渗透率、砂体厚度、有效厚度、孔隙度、含油饱和度等参数，进行储层流动单元的聚类分析，将储层划分为E型、G型、F型、P型[4]4类流动单元。根据测井资料，计算每口井各分隔单元的综合判别参数值，结合沉积微相图，编制分隔单元的流动单元平面分布图。在储层精细对比的基础上，对储层砂体展布、夹层展布及油藏微构造进行了研究，为剩余油分布研究奠定基础。

2.3　剩余油分布

2.3.1　层间剩余油分布

主力油层采出程度和水淹程度高，剩余含油饱和度较低。义11井区主力油层沙三段2砂层组和3砂层组经历过3次加密调整和细分层系开发，注采井网完善，油水井连通好，注水井单井注水量一般为200～400 m^3/d，地层能量充足，地层压力保持水平达到99%，油井单井产液量基本为100～300 t/d，采出程度达到40%左右，水淹严重，综合含水率高（表1）。沙三段2砂层组和3砂层组剩余含油饱和度分别为35.2%和38.3%。

表1　渤南油田义11井区层间采出状况对比

层位	采出程度,%	综合含水率,%	备注
Es_3^2	41.4	97.6	主力油层
Es_3^3	36.1	97.9	主力油层
Es_2	17.3	89.6	非主力油层
Es_3^0	1.6	80.8	非主力油层
Es_3^1	13.6	84.7	非主力油层
Es_3^4	8.3	53.5	非主力油层
Es_3^5	3.4	65.6	非主力油层
Es_3^6	13.9	76.3	非主力油层

非主力油层储量动用程度低，水淹程度相对低，剩余含油饱和度高。义11井区共有6个非主力油层，综合含水率均在90%以下，储量动用程度远低于主力油层。其中沙三段4—6砂层组分布零散，物性相对较差，渗透率小于30×10^{-3} μm^2，采出程度低，水淹程度低，含水率低，油井单井产液量小于10 t/d；沙三段0砂层组和1砂层组以及沙二段储层厚度薄，单层厚度小于2 m，原始含油饱和度低，采出程度低，水淹程度中等到强。

2.3.2　平面剩余油分布

在特高含水期，油藏不同部位储量动用及剩余油分布差异大[5-8]，在储层边部的尖灭线附近和断层附近存在注采不完善区域，主要有4个井组。义11-601井组位于西部尖灭线附近，储层薄，物性差，2口油井生产，地层能量不足，日产液量分别为1.9和12.5 t/d，含水率分别为10%和86%。义11-53井组靠近尖灭线，缺少控制井点。义11-381井组和义11-391井组位于南部断层附近，在靠近断层的区域缺少控制井点。

3　开发技术对策

3.1　不稳定注水

在特高含水期，为减缓主力油层平面矛盾，控制含水上升速度，对义11井区开展了持续不断的不稳定注水，根据井组生产动态，对井组注采比为0.7～1.3进行优化，注水量调整周期为4～6个月，每年实施2～3轮大幅度的注水调配，既保持地层能量，又进一步提高注入水波及系数，为提高采收率奠定了基础[9]。

3.2　单井采液强度优化

针对义11井区主力油层地层能量充足、油井含水率特高的特点，实施单井采液强度优化，即降低高含水井产液量，提高低含水井产液量。对含水率在98.5%以上、产液量高的油井采取降低产液量措施，控制采液强度，促使注入水向水淹程度相对低、含水率相对低的油井推进，实施3口井，平均单井产液量由248 t/d下降到177 t/d，含水率相对较低的邻井产液量上升，井组产油量增加3.6 t/d（表2）。对含水率小于96%的油井实施提液措施，增大采液强度，优选4口油井实施电泵提液，单井产液量平均增加155 t/d，单井产油量平均增加4.9 t/d。通过差异化的采液强度优化，既改善了单元产液结构，降低了综合含水率，又提高了注水利用效率，实现了控水稳油[10]。

3.3　完善注采井网

在局部注采不完善、储量动用程度低的砂体边部，通过钻新井、油井转注等技术对策，完善注采井

表2　渤南油田义11井区特高含水油井降低产液量效果统计

井号	措施前			措施后			备注
	产液量/(t·d⁻¹)	产油量/(t·d⁻¹)	含水率,%	产液量/(t·d⁻¹)	产油量/(t·d⁻¹)	含水率,%	
义11-3	134	1.3	99	84.7	0.9	98.9	控液井
义11-20	240	2.9	98.8	147	1.9	98.7	控液井
义47	370	4.4	98.8	300	4.5	98.5	控液井
义11	252	5	98.1	283	6.8	97.6	邻井
义11-11	154	2.4	98.4	174	2.4	98.6	邻井
义11-111	126	2	98.3	146	2.2	98.4	邻井
义11-31	268	7.5	97.2	273	7.6	97.2	邻井
义11-65	154	5	96.7	198	7.9	96	邻井
义11-17	88.3	2.3	97.2	82.8	2.3	97.1	邻井
义11-斜112	186	5.6	96.9	184	5.5	97	邻井
小计	1 972	38.4	98.1	1 873	42	97.8	邻井

网,提高储量动用程度[11-12]。对油水井因套管损坏等工程原因停产造成的局部注采不完善,通过大修恢复、老井转注、钻更新井等技术对策,恢复和完善注采井网。共钻3口新井,5口井实施了老井转注、停产井恢复等措施,增加和完善水驱储量为127×10^4 t。例如在尖灭线附近新钻完善井义11-斜531,注水后对应油井见效显著,产油量增加22 t/d。

3.4　提高非主力油层储量动用程度

3.4.1　分层注水

为了减缓多层合注井层间矛盾,采取分层注水技术,提高非主力油层注水量[13]。由于义11井区油层埋深大、温度高,注水井分层注水技术难度较大。为了保证分注效果,对分注管柱进行了改进:应用补偿锚定式分注管柱,通过水力锚、水力卡瓦补偿器的共同作用,减小管柱蠕动对封隔器造成的伤害,延长管柱有效期;应用轨道配水器,不需投捞死芯子便能保证Y341压缩封隔器的座封压力以及水力卡瓦、补偿器工作的启动压力,能够及时验证管柱密封性。实施分层注水4口井,非主力层相对吸水量由之前的13.9%提高到41.9%,有效减缓了层间矛盾,改善了合注井非主力油层注水状况。

3.4.2　储层改造

水力压裂是提高低渗透油藏油井产能的重要手段[14-15]。义11井区砂体边部及非主力油层低孔隙低渗透、油井自然产能低,通过压裂改造储层提高油井产量。针对注采井距大、油藏埋藏深,油层温度高、闭合压力大、施工压力高的特点,采取了控制裂缝高度、增加裂缝长度,提高压裂液破胶后返排率的压裂技术思路。共实施压裂改造井2口,累积增油量为3 956 t(表3)。

表3　义11井区油井压裂效果统计

井号	所处位置	压裂前产量/(t·d⁻¹)	压裂后产量/(t·d⁻¹)	有效天数/d	累积增油量/t
义11-12	非主力层	0.8	21	756	2 463
义11-601	砂体边部	1.7	9.2	>430	1 493

3.4.3　单层开采

为了避免层间干扰,提高非主力油层储量动用程度,采取了封堵强水淹层和水平井挖潜等技术对策。对层间矛盾特别突出的油水井,采取封堵强水淹特高含水主力油层技术措施,实现非主力油层单采单注,同时对油井采取储层改造、小泵深抽等增产技术,对注水井采取提压增注技术。共实施4口井,非主力层产油量增加了26 t/d,注水量增加了40 m^3/d。义11井区沙三段5砂层组为低渗透储层,北部砂体局部储量无油井控制,油层平均有效厚度为10.1 m,新钻1口水平井,新增可动用储量为6.1×10^4 t。

4　结束语

低渗透油田进入特高含水开发期后,需要不断创新,综合运用多种技术手段,充分挖掘油藏潜力。根据油藏各部位的储层特点、开发矛盾和剩余油潜力,采用不同的针对性开发技术对策,实施差异化注采管理,能够减缓产量递减,进一步提高采收率。通过不稳定注水和优化油井采液强度,对水淹严重的主力油层主体部位实现控水稳油;通过完善和恢复注采井网,提高储量的水驱动用程度;通

(下转第103页)

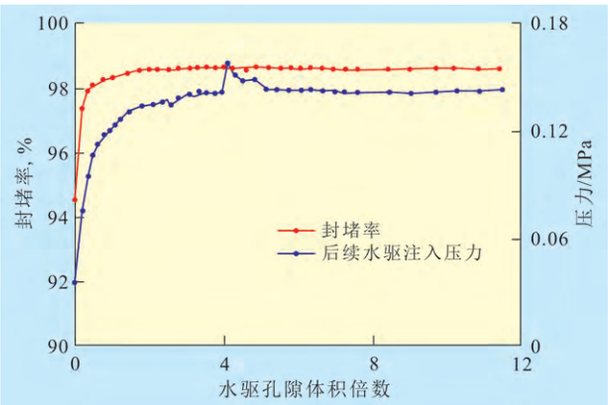

图5　压力和封堵率随注入孔隙体积倍数的变化

4　结论

研究了以氯化铝和尿素组成的无机铝凝胶体系，该体系具有较好的抗剪切性能和较强的耐盐性，能够满足较高矿化度地层对深部调剖的要求。

铝凝胶体系在温度小于80 ℃油藏条件下具有较好的热稳定性，适用于温度为60~80 ℃油藏的深部调剖。物理模拟实验表明，铝凝胶具有良好的注入性能，较高的封堵能力，封堵率达到98%以上，具有较强的耐冲刷性能。

参考文献：

[1] 韩大匡.深度开发高含水油田提高采收率问题的探讨[J].石油勘探与开发，1995，22(5)：47-55.

[2] 赵光，戴彩丽，程明明，等.石南21井区低渗透油藏弱冻胶深部调剖技术的研究[J].石油与天然气化工，2011，40(6)：594-597.

[3] 由庆，赵福麟，王业飞，等.油井深部堵水技术的研究与应用[J].钻采工艺，2007，30(2)：85-87.

[4] 王代流，肖建洪.交联聚合物微球深部调驱技术及其应用[J].油气地质与采收率，2008，15(2)：86-87.

[5] 张建华.聚合物凝胶体系在孔隙介质中交联及运移封堵性能研究[J].油气地质与采收率，2012，19(2)：54-56，63.

[6] 戴涛，朱维耀，王小峰，等.炮眼剪切对注入聚合物溶液粘度影响的数学模型[J].油气地质与采收率，2012，19(2)：29-32，36.

[7] 熊春明，唐孝芬.国内外堵水调剖技术最新进展及发展趋势[J].石油勘探与开发，2007，34(1)：83-88.

[8] 梁树权.尿素是有机物么?[J].化学通报，1994，57 (3)：45-47.

[9] Busolo M A，Mogollón J L.Permeability modifications by in-situ cations hydrolysis[R]. SPE 64990，2001.

[10] 曲萍萍.水溶性硅酸盐堵剂的性质研究[D].东营：中国石油大学(华东)，2007.

[11] 司学芝.无机化学[M].郑州：郑州大学出版社，2006：52.

[12] 周莹.无机化学[M].长沙：中南大学出版社，2005：53-58.

编辑　刘北羿

(上接第99页)

过分层注水和封堵高含水层，减缓层间矛盾；通过储层改造、分层注水、单层开采，提高砂体边部和非主力层储量的动用程度。

参考文献：

[1] 刘魁元.渤南洼陷沙三段浊积水道砂岩油藏相控储层预测[J].中国石油大学学报：自然科学版，2008，32(1)：24-28.

[2] 许金慧，史桂生，彭海军.渤南义11井区浊流储层特征[J].断块油气田，2004，11(6)：28-30.

[3] 刘瑞娟，王永诗，张博，等.渤南洼陷浊积砂体岩石学特征及其对储层物性的影响——以沙三段0—9砂组为例[J].油气地质与采收率，2011，18(6)：32-36，41.

[4] 郭康良.流动单元研究在渤南油田开发中的应用[J].石油天然气学报(江汉石油学院学报)，2006，28(2)：45-47.

[5] 唐晓红.埕岛油田中高含水期综合调整对策研究[J].油气地质与采收率，2011，18(6)：90-93.

[6] 刘传鹏，陈元，王宏宇，等.高含水期油田提高采收率方法[J].油气地质与采收率，2001，8(5)：63-65.

[7] 方伟，张居和，冯子辉，等.水驱不同注采位置油藏特征——以萨尔图油田北二西区块油藏为例[J].油气地质与采收率，2012，19(5)：100-103.

[8] 郑舰，李顺明，康波，等.温米油田轻质油藏高含水期剩余油分布与技术对策[J].油气地质与采收率，2012，19(5)：104-107.

[9] 赵春森，吕建荣，杨大刚.大庆油田葡北二断块南部周期注水应用方法研究[J].油气地质与采收率，2008，15(6)：76-79.

[10] 任允鹏，李秀生，吴晓东.埕岛油田馆陶组提液时机及技术界限研究——以埕北11井区为例[J].油气地质与采收率，2009，16(2)：91-93.

[11] 杨晓培.二次聚合物驱后剩余油分布及挖潜措施——以河南油区下二门油田H2II油组为例[J].油气地质与采收率，2011，18(4)：61-64.

[12] 宋正江.大庆油区头台油田扶余油层小排距注水中后期综合调整方法[J].油气地质与采收率，2011，18(1)：85-88.

[13] 崔传智，姜华，段杰宏，等.基于层间均衡驱替的分层注水井层间合理配注方法[J].油气地质与采收率，2012，19(5)：94-96.

[14] 李宗田，李凤霞，黄志文.水力压裂在油气田勘探开发中的关键作用[J].油气地质与采收率，2010，17(5)：76-79.

[15] 刘艳艳，刘大伟，刘永良，等.水力压裂技术研究现状及发展趋势[J].钻井液与完井液，2011，28(3)：75-78.

编辑　刘北羿

lem of horizontal well into two parts, one is the problem in several ellipsoidal supply boundary near the wellbore, the other is the linear flow far from the well bore, based on the displacement between two similar flow mode and the law of equivalence percolation resistance, then eventually proposing a new productivity formula of horizontal well. Through case study, the results calculated by new formula has been compared with that calculated by the formulas of Borisov et al, it shows that the new result is more than the results calculated by conventional formulas, meanwhile, the new result has a small relative error compared to the practical oil production by only 10.09%. Analysis shows that this is because the resistance in ellipse drainage area is less than that in pseudo-circular drainage area, and the assumption of pseudo-circular will bring a great relative error. So, we can conclude that the new formula will not only predict the productivity accurately, but also accord with the practical flow mode of horizontal well.

Key words: horizontal well; productivity formula; similar flow; ellipse; pseudo-circular

Yuan Lin, State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu City, Sichuan Province, 610500, China

Ming Yukun. Electrolytic simulation experiment of multi-stage fracturing horizontal well for water flooding development. *PGRE*, 2013, 20(6): 91-93

Abstract: In order to study the production stimulation mechanism of water flooding by multi-stage fracturing horizontal well, the electrolytic simulation experiment of fractured horizontal well is designed according to the water and electricity resembling principle, and the pressure distribution and the productivity influence factors are studied. The experiment results show that the pressure contour is distributed in parallel in the middle of horizontal which has the fracture, and the fluid flow is unidirectional, it shows that the multi-stage fracturing horizontal well can improve the fluid flow characters and decrease the percolating resistance. The horizontal productivity can be enhanced by increasing the horizontal penetration ratio, the fracture numbers and penetration ratio, the angle between horizontal and fracture. The best parameters are as follows: the horizontal penetration ratio is 0.8, the fracture numbers are 6 (the space between fractures is 91 m), the fracture ratio is 0.25, the angle between the fracture and the horizontal section is 90 degree. The well pattern is staggered line-drive well network, and the ranges of those parameters which have effect on the productivity are 0.032, 0.024, 0.018, 0.018 and 0.004. The field application showed that the productivity of multi-stage fracturing horizontal well is 2 times than that of vertical well, and it is the effective development style for low permeability reservoir.

Key words: multi-stage fracturing; horizontal well; water flooding; electrolytic simulation experiment; productivity

Ming Yukun, Geoscience Research Institute, Shengli Oilfield Company, SINOPEC, Dongying City, Shandong Province, 257015, China

Cao Gongze, Liu Tao, Ba Yan et al. Microbial flooding after polymer flooding pilot test in N*g*3 of Zhong1 area, Gudao oilfield. *PGRE*, 2013, 20(6): 94-96

Abstract: In order to study the adaptation and effect of microbial flooding after polymer flooding pilot, the test was conducted as pilot project in N*g*3 of Zhong1 area. The indigenous microorganisms are first activated and then filtrated; at the same time, 4 strains of functional bacteria are obtained, the bacteria are mass propagated at the reservoir environment, and the crude oil can be emulsified by the microbe. Meanwhile, the physical simulation experiment is studied under the pressure and temperature of the reservoir, and, the result indicates that the oil recovery is enhanced by 7.8%-8.3% by the bacteria. The field test indicates that the microbe is activated and the concentration of metabolism of acetate may reach 105 mg/L. The production dynamic is improved, and the oil recovery is enhanced by 1.27%, and the recovery factor in the pilot is increased by 4.7% to 57.8%.

Key words: MEOR; post-polymer flooding; pilot test; enhanced oil recovery; Gudao oilfield

Cao Gongze, Research Institute of Oil Production Technology, Shengli Oilfield Company, SINOPEC, Dongying City, Shandong Province, 257000, China

Gao Baoguo, Hua Hui, Ding Wenge et al. Technical treatment in extra-high water cut stage for low permeable reservoir-case study of Yi11 area, Bonan oilfield. *PGRE*, 2013, 20(6): 97-99

Abstract: Due to the serious heterogeneity in plane, interlayer and layer, it is full of imbalances in injection-production pattern, and the production decline reaches 14.8% in Yi11 area of Bonan oilfield, so the technical treatment is needed to ameliorate the decline of the development. The non-stable injection and optimized liquid yielding are adopted to control the water and stabilize oil production in response to the high water cut and serious flooding in the major oil-production layers. Moreover, the water drive producing reserves are produced by improving and completion of well pattern in response to incomplete injection-production pattern. The interlayer problems are resolved by means of layer-oriented injection and plugging of high water cut layer. For the sand body edge and secondary oil-bearing layers, the reservoir reformation, intensive injection, individual layer production are adopted to enhance the reserve utilization. The development effect is remarkably improved. The production decline rate decrease to 4.1% and the recovery factor is further increased from 30.7% to 32%.

Key words: extra-high water cut stage; flow unit; technical treatment; EOR; injection-production completion; Bonan oilfield

Gao Baoguo, School of Geosciences, China University of Petroleum (East China), Qingdao City, Shandong Province, 266580, China

Wang Ping, Dai Caili, You Qing et al. Experimental study on shearing and salt tolerant deep profile control agents composed of inorganic aluminum gel. *PGRE*, 2013, 20(6): 100-103

Abstract: Aiming at the problem of poor shear performance and salt tolerance of organogel, the deep anti-shearing and salt tolerant profile control agent is composed using anhydrous aluminum chloride and urea. The gelling behavior of the deep profile control agents is studied in this paper. The effects of concentration, temperature, and salinity on the gelling law are investigated. The application performances of the profile control agents, including the injectivity, plugging ability, and flushing resistance are evaluated. The results show that both the concentration and the temperature have great influence on the gelation time, and the gelation time can be adjusted from 16 to 824 h by adjusting the concentration of anhydrous aluminum chloride and urea. The inorganic salts including Na^+, Mg^{2+}, and Ca^{2+} have little effect on the gelation time. The salt tolerance, anti-shearing injectivity, plugging ability and flushing resistance of the gel system are very good, and the temperature limit is high as 80 ℃.

Key words: inorganic aluminum gel; salt tolerance; shearing resistance; anhydrous aluminum chloride; urea; deep profile adjustment

Wang Ping, State Key Laboratory of Heavy Oil Processing, China University of Petroleum (East China), Qingdao City, Shandong Province, 266580, China

Wu Wenming, Qin Fei, Ouyang dong et al. Study on water plugging technology in fractured-cavity carbonate reservoirs, Tahe oilfield. *PGRE*, 2013, 20(6): 104-107

Abstract: Fractured-cavity carbonate reservoirs in Tahe oilfield have a serious heterogeneity, with numerous fissure, hole and cave. The bottom water is easy to breakthrough from high angle fracture, and it's difficult to make water control for producing wells, so, the water plugging becomes important to oil production stabilization and water cut control. There is a significant progress of water plugging technology in fractured-cavity carbonate reservoirs in Tahe oilfield. The factors weight method for selecting well water plugging and five basic factors comprehensive analysis for plugging wells are formed. Three kinds of suitable plugging agents for fractured-cavity carbonate reservoirs are researched and developed. First, the soluble silicate, with good heat resistance and salt tolerance, is appropriate for well with small leakage and seam-hole reservoir. Second, the solidified grain, which has density selectivity and high strength, good heat resistance and salt tolerance as well, is suitable for fractured-cavity wells. Third, the organic-inorganic compound gel, with water-oil selectivity, is fit for fractured wells, horizontal wells and sidetracking wells. Based on plugging agent, the supporting water plugging technologies are formed and applied with good performance, including density selectivity, multistage slug holder plug and control pressure acidification.

Key words: carbonate reservoir; fracture-vuggy reservoirs; water plugging technology; plugging agent; supporting water plugging technology; Tahe oilfield

Wu Wenming, Research Institute of Engineering Technology, Northwest Branch of SINOPEC, Urumqi, Xinjiang, 830011, China

Liu Gang, Liu Pengtao, Han Jinliang et al. High frequency vibration signal acquisition system used for sanding monitoring in oil well. *PGRE*, 2013, 20(6): 108-110

Abstract: Moderate sand yielding technology can exploit crude oil with low cost and high efficiency, and improve the well productivity effectively. This technology needs to control sand concentration of the produced fluid in a certain range, which requires real-time monitoring wells sand conditions. In order to study the method of real-time monitoring of the sand signal, the laboratory has developed a system of high frequency vibration signal used for monitoring the signal of sand. Through the time-frequency analysis of vibration signals of different sizes of sand hitting on the pipe wall in the laboratory simulation of sand production, the frequency range of the characteristic frequency of vibration signals reflecting the information of sand is screened out between 10-12 kHz, which proves the feasibility of the pipeline high-frequency vibration signal monitoring system. It has an important guiding significance for further study on sanding monitoring.

Key words: sanding; real-time monitoring; high-frequency vibration signal; time-frequency analysis; sanding yielding

Liu Gang, College of Petroleum Engineering, China University of Petroleum (East China), Qingdao City, Shandong Province, 266580, China