

# 表面活性剂在单井注水吞吐采油中的应用研究

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**摘要** 单井注水吞吐采油是开发无能量补充小型油藏的一种有效方法,但关井平衡时间长达1年以上,经济效益较低。在注入水中加入表面活性剂和粘土防膨胀剂的全模拟对比实验结果表明,关井时间可缩短50%,并保护了储层,其采出程度可提高3.15%。

**关键词** 注水吞吐采油 全模拟试验 表面活性剂 粘土防膨胀剂 采出程度

开发小型断块油藏,从经济的角度考虑,不可能打更多的井,国内一些油田从水淹井长期关井放溢流采出石油得到启示:在无能量补充井,采用注水恢复地层压力后关井一定时间,使水湿油藏毛细管力自吸水与油产生置换,然后重新开井而将置换出的油与部分注入水一起采出,即注水吞吐采油新工艺。这种采油法一般需要多个周期来实现,以达到提高采收率的目的。现场实施单井注水吞吐已取得了满意的效果,但关井时间一般需1至2年,甚至更长时间,经济效益低。本文介绍了分别采用现场实际注入水和改性的注入水对同一块岩心、同润湿性、相近油水饱和度、同温压条件下的模拟降压开采和三个周期的模拟注水吞吐采油试验。试验证明,采用改性注入水,其关井时间缩短了50%,且采出程度提高了3.15%。

## 1 概况

试验模型为DGN油田实际产层的中—细粒岩屑长石砂岩岩心,孔隙度为17.2%~18.5%,渗透率在 $(92.51 \sim 197.22) \times 10^{-3} \mu\text{m}^2$ ,油藏润湿性为弱亲水储层,原始地层压力24 MPa,地层温度70℃,在50℃时原油粘度为15 mPa·s。

油田使用的注入水分析资料见表1。

表1 油田水分析数据表

阳离子	K <sup>+</sup>	Na <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	NH <sub>4</sub> <sup>+</sup>
含量,mg/l	29.100	2 225	59	10.300	10
阴离子	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	F <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>
含量,mg/l	821.300	3 047	4.200	2.670	<2.500

## 2 模拟试验

### 2.1 注入水

为了使试验结果更接近实际,模拟的注入水均按

水分析资料配制,其密度为1.04 g/cm<sup>3</sup>,粘度为1.07 mPa·s。改进的注入水是在模拟的注入水基础上加入0.1%非离子型表面活性剂和0.25%粘土防膨胀剂而配制的。

### 2.2 模拟油

模拟油选用试验区块的井口流出物,在温度为50℃、粘度为15 mPa·s的条件下,加入煤油配制而成。

### 2.3 模型及试验程序

为保证计量的精度要求,试验模型为Φ10.4 cm × 12 cm全直径岩心,经洗油后测定物性参数,两种注入水的模拟试验都将岩心处理成油田弱亲水状态,采用状态恢复法建立原始油水饱和度后,将岩心放入岩心室,然后在上覆压力57 MPa,地层压力24 MPa,地层温度70℃的条件下平衡2 h后:

- (1) 模拟弹性降压开采至10 MPa;
- (2) 反向注入油田注入水和改性的注入水,分别模拟关井2天和1天后;
- (3) 模拟弹性降压开采至10 MPa;
- (4) 分别计量两种注入水初始和各周期注水吞吐的采出油量。

## 3 试验结果

部分样品在两种注入水关井平衡后的弹性降压开采试验数据见表2所示。

表2表明:(1) 每个周期的采出程度都有所增加,随注水周期的增加,采出程度的增加呈增多的变化趋势;(2) 三块样品的累计采出程度分别增加了2.82%至3.43%,平均增加了3.15%;

试验说明,加入表面活性剂和粘土防膨胀剂后,既可缩短关井时间,保护了储层,又可提高注水吞吐的采收率。

表2 模拟注水吞吐采油试验数据表

样品号	初始弹性驱		注入水	模拟注水吞吐采油周期						累计 采出程度 (%)
	产油量 (cm <sup>3</sup> )	采出程度 (%)		1		2		3		
				产油量 (cm <sup>3</sup> )	采出程度 (%)	产油量 (cm <sup>3</sup> )	采出程度 (%)	产油量 (cm <sup>3</sup> )	采出程度 (%)	
YC1	5.8	5.75	原始水	5.4	5.35	2.9	2.87	1.4	1.39	15.36
	5.3	5.50	改性水	5.6	5.82	3.8	3.95	2.8	2.91	18.18
YC2	11.1	8.22	原始水	10.0	7.41	6.0	4.45	3.4	2.52	22.60
	11.2	8.59	改性水	10.1	7.75	7.1	5.45	5.2	3.99	25.78
YC3	7.1	6.44	原始水	5.7	5.17	3.4	2.72	1.5	1.36	15.69
	7.6	7.16	改性水	6.0	5.65	3.9	3.67	2.8	2.64	19.12

#### 4 机理

注水吞吐的机理是毛细管力自吸裂缝或大孔隙中的水置换基质或相对较小孔隙中油的过程。

根据毛细管力的基本公式  $P_c = 2\sigma \cos\theta/r$ , 当储层一定时, 毛细管力主要与油水界面张力和岩心润湿接触角的余弦成正比。为了采出油湿表面和亲油孔隙中的油, 只有降低油水界面张力以减小注入水克服油湿表面或亲油孔隙对水所构成的阻力。最有效的办法是在原始注入水中加入表面活性剂即可达到目的。为了防止注入水对地层所造成的损害, 同时加入粘土防膨剂, 以保护储层, 防止以后的周期注不进水而使吞吐无法进行下去。

#### 5 结论

注水吞吐是开发小型复杂断块油藏的有效采油方

法, 模拟对比试验证明: 注入水中加入表面活性剂和粘土防膨剂, 既可缩短关井平衡时间, 又有效保护了储层, 达到了提高注水吞吐效率和原油采收率的目的。

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This paper summarizes the followings: the influencing factors of olefins content in FCC gasoline (operational condition for catalytic cracking, raw material and catalysts), the functioning mechanism and influencing factors of hydrogen transfer reaction.

**SUBJECT HEADINGS:** catalytic cracking, new gasoline standard, olefins

#### SUSPENDED COLLOID FUEL AND ITS APPLICATION

Zou Honglin (Guangzhou Energy Institute, Chinese Academy of Sciences). *CHEMICAL ENGINEERING OF OIL & GAS*, VOL. 32, NO. 2, pp95 ~ 96, 2003 (ISSN 1007 - 3426, IN CHINESE)

**ABSTRACT:** This paper reported the characteristic of suspended colloid fuel and situation of combustion test, and compared it with other fuels. The results show that the suspended colloid fuel has good utilization value and it is a new substitutive fuel to be worthily popularized.

**SUBJECT HEADINGS:** suspended colloid fuel, emulsion oil, combustion

#### APPLICATION OF BIODESULFURIZATION TECHNOLOGY IN NATURAL GAS PURIFICATION

Tu Yan (RINGT, South West Oil and Gas Field Company, PetroChina). *CHEMICAL ENGINEERING OF OIL & GAS*, VOL. 32, NO. 2, pp97 ~ 99, 2003 (ISSN 1007 - 3426, IN CHINESE)

**ABSTRACT:** This paper introduces the research present some properties and application status of biodesulfurization technology in natural gas purification. This technology development trends and relative research areas are suggested.

**SUBJECT HEADINGS:** biodesulfurization, natural gas, H<sub>2</sub>S removal, bacterium, bioreactor

#### SYNTHESIS OF HYDROPHOBIC ASSOCIATING POLYACRYLAMIDE

Xu Fugui, Dong Xiaochen, He Jidong (College of Polymer Science and Engineering, Qingdao University of Science and Technology). *CHEMICAL ENGINEERING OF OIL & GAS*, VOL. 32, NO. 2, pp100 ~ 101, 2003 (ISSN 1007 - 3426, IN CHINESE)

**ABSTRACT:** With K<sub>2</sub>S<sub>2</sub>O<sub>8</sub>/Na<sub>2</sub>SO<sub>3</sub> as initiating agent, the hydrophobic association polyacrylamide derivatives were synthesized by copolymerization of acrylamide, cation monomer and substituted ethylene

monomer with dispersion polymerization and got nanoparticles (diameter 60 ~ 80nm). The effects of different initiating agents, stabilizing agent, dispersing agent and emulgent volume in polymerization have been discussed.

**SUBJECT HEADINGS:** hydrophobic association, acrylamide, nanoparticles, molecular weight

#### APPLICATION RESEARCH OF SURFACTANT IN SINGLE WELL WATERFLOOD SWALLOWING - SPITTING

Xiang Yang<sup>1</sup>, Xiang Dan<sup>1</sup>, Du Wenbo<sup>2</sup> (1. the State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation in Chengdu University of Technology; 2. Research Institute of Yumen Oilfield Company, Gansu). *CHEMICAL ENGINEERING OF OIL & GAS*, VOL. 32, NO. 2, pp102 ~ 103, 2003 (ISSN 1007 - 3426, IN CHINESE)

**ABSTRACT:** Single well waterflood swallowing - spitting is a useful method for developing no energy complement small oil reservoir, but the well's closed - in time lasts more than one year, and economic profits is lower. The paper introduces whole simulation test using injection water with surfactant and clay swelling inhibitor. The result indicates that closed - in time reduces 50 percent, reservoir is protected, and recovery percentage increases 3.15 percent.

**SUBJECT HEADINGS:** oil production by waterflood swallowing - spitting, whole simulation test, surfactant, clay swelling inhibitor, recovery percent

#### SYNTHESIS AND EVALUATION OF TEMPERATURE - RESISTANCE AND SALT - TOLERANCE ABSORBENT RESIN JT - 1

Huang Ning, Shi Kangling, Wang Zhonghua (Drilling Engineering Technology Institute, ZPEB, PuYang, Henan). *CHEMICAL ENGINEERING OF OIL & GAS*, VOL. 32, NO. 2, pp104 ~ 106, 2003 (ISSN 1007 - 3426, IN CHINESE)

**ABSTRACT:** Absorbent resin JT - 1 is synthesized by using structural strengthening agent and acrylamide. The results show JT - 1 has good properties of temperature - resistance, salt - tolerance and temperature stability with the dosage of the structural strengthening agent accounting for 10% of monomer amount, the crosslinker for 0.1%