文章编号：1000－7393(2005)02－0041－03

AD－4微生物防蜡剂培育与应用*

吴慧敏[1]　刘延坡[2]　吴莉玲[2]　胡　斌[2]　皮存学[2]
(1.开封市奥德科技有限公司，河南开封　475004；2.河南油田公司采油一厂，河南南阳　474780)

摘要　介绍了微生物防蜡剂的培育、室内性能检测及现场防蜡试验过程。用现场油水样中菌种驯化的菌种和实验室菌种配伍、优化、筛选，培育成 AD－4微生物防蜡剂。通过室内试验验证，AD－4微生物防蜡剂对现场蜡块的乳化降解作用使蜡块凝固点降低 4～8.5℃，原油培养液表面张力降低率 30.3%～49.3%，黏度降低 35%～50%，原油流动性得到了很大的提高。经现场 12口油井试验证明，应用 AD－4微生物防蜡剂后，油井电流、负荷下降，示功图显示结蜡现象明显减轻，检泵周期延长，部分井检泵周期可延长到原来的 2倍，投入产出比可达 1∶2.8。

关键词　微生物　试验　清防蜡　降黏　应用

中图分类号：TE357.2　　文献标识码：A

微生物清蜡降黏技术作为一种高新技术，已经在加拿大等国家广泛应用。在国内，大港、胜利等油田也相继引用。河南油田原油为蜡质石油，因为结蜡所造成的杆断堵塞每年多达 120井次，常采用热洗加药进行清蜡防蜡，但因油层能量低，热洗经常污染地层，热洗恢复期一般在 2～6 d，加药防蜡有效期短，价格昂贵。为此，结合河南油田所得蜡样培育成 AD－4微生物菌种。

1　微生物防蜡机理

(1)微生物自身作用：黏附在金属和黏土矿物上，形成微生物保护膜，有防止蜡质结晶的作用。

(2)微生物代谢产物的作用：原油中正构烷烃在微生物的作用下，自然降解成为异构烷烃，而得到脂肪酸、糖脂、类脂体等具有表面活性剂特征的物质和气体。这些代谢产物具有以下特点：表面活性剂和蜡晶作用参与蜡晶的形成，促使蜡晶畸化，阻止结晶；代谢产物中产生的有机酸、乙醇、乙醛等物质提高了溶解能力；代谢产物中大量的二氧化碳、甲烷气体降低了原油的黏度。

微生物对原油中的石蜡起到降解乳化作用，其代谢产物改变了原油的流动性，阻止石蜡在井筒内的沉积，达到清防蜡的目的。

2　室内试验

针对河南油田采油一厂提供的原油样品 A2106、A2036、A2104、B252、T205、H214、2331、T219及油井沉积蜡块样品特性和油藏物性特点，对微生物进行室内评价，对影响作用效果的因素进行分析，以便为现场试验和效果分析提供依据。

2.1　菌种筛选

由油田提供的油水样，经富集分离培养，再经固体石蜡定向驯化，得到能利用固体石蜡生长的菌种；另从实验室原存菌选育得到可利用固体石蜡生长的菌种，然后再经优化配伍、性能评价，最终优选出矿场应用的清防蜡菌种 AD－4。

2.2　微生物对原油、油井沉积蜡块及固体石蜡的乳化降解作用

在 250 mL不同锥形瓶中各加入 100 mL地层水和少量无机盐营养物，分别加入原油、油井沉积蜡块或固体石蜡各 3 g，各瓶均接入 AD－4菌液 10 mL。用橡皮塞密封瓶口，在缺氧条件下置于 60～65 ℃恒温油浴培养 7 d，取出后对原油进行脱水，在 50 ℃下测其黏度，计算降黏率。结果见表 1。

表 1结果表明，所筛选的 AD－4菌种对以上试验用原油都具有较好的乳化降黏作用，降黏率均大于 35%，最高降黏率达 50%以上。

2.3　微生物对油井沉积蜡块的降凝作用

在 250 mL锥形瓶中加入 100 mL地层水和少量

*作者简介：吴慧敏，1968年生。1990年毕业于河南大学化学化工系，现从事油田化学品的研究与推广工作，工程师。电话：0378－3667008。

表 1 AD-4菌种对不同原油的乳化降黏作用

原油	菌种处理后黏度/mP·s	对照样黏度/mP·s	降黏率/%
A2106	36	65	44.6
A2036	40	68	41.2
A2104	28	58	51.7
B252	24	42	42.8
T205	89	138	35.5
H214	76	121	37.1
2331	59	99	40.1
T219	35	72	51.4

无机盐营养物、20 g油井沉积蜡块、20 mL菌液,用橡皮塞密封瓶口,置于 65~67 ℃恒温油浴处理 7 d,沥出液体,密封瓶口,置于 75 ℃恒温箱脱水 24 h,冷却取水,再脱水 24 h。

取 AD-4菌作用后的脱水原油,采用玻璃套管法进行凝固点测定,与未经微生物处理的脱水原油对照,分析微生物的降凝效果,结果见表 2。

表 2 AD-4菌种对不同原油的降凝作用

原油	菌种处理后凝固点	对照样凝固点	降低值
A2106	36.5	39.0	2.5
A2036	36.7	38.5	1.8
A2104	37.4	40.2	2.8
B252	37.3	39.4	2.1
T234蜡块	46.5	55.0	8.5
B162蜡块	68.0	72.0	4.0
2331	40.3	42.8	2.5
T219	40.8	43.9	3.1
T205	24.7	26.3	1.6
H214	26.0	27.5	1.5

试验结果表明,所选菌种对油井沉积蜡块均有较明显的降凝作用,凝固点降低 1.5~8.5 ℃。

2.4 微生物对培养液表面张力和 pH值的影响

在 250 mL锥形瓶中加入 100 mL地层水和少量无机盐营养物,再加入原油或油井沉积蜡块 3 g,接入 10 mL菌液,密封,置于 60 ℃恒温油浴培养 7 d。用滤纸过滤,取滤液用酸度计测 pH值,用界面张力仪测表面张力,以不接菌种的反应瓶基质为对照,并以表面张力降低值和 pH值变化表示菌体代谢产生表面活性剂和酸的能力,结果见表 3。

表 3 AD-4菌种作用后原油表面张力和 pH值的变化

原油	表面张力/mN·m^{-1}		降低率	pH值	
	菌种处理样	对照样	/%	菌种处理样	对照样
A2106	41	72	43.0	6.4	7.4
A2036	39	73	46.6	6.5	7.4
A2104	37	73	49.3	6.2	7.4
B252	39	71	45.0	6.4	7.4
T205	45	72	37.5	6.8	7.4
H214	48	73	34.2	6.7	7.4
2331	40	73	45.2	6.5	7.4
T219	37	72	48.6	6.3	7.4
T234井蜡块	45	76.1	41.1	6.5	7.4
B162井蜡块	53	76.6	30.3	6.8	7.4

结果表明,所选菌种能降低培养液表面张力,其降低率为 30%~49%;菌作用后试样的 pH值范围为 6.2~6.8。随时间延长,培养液的 pH值降低。有利于微生物生长繁殖的 pH值范围是 7~8。

2.5 原油全烃气相色谱分析

在 250 mL锥形瓶中加入 100 mL地层水及无机盐、5 gT234井积蜡原油,接入菌种液 10 mL,置于 60 ℃恒温油浴培养 8 d。沥出液体,取残油脱水后进行全烃气象色谱分析,以用无菌水代替菌液的反应瓶为对照。

色谱条件:色谱柱为 SE-30 0.25×30 m,分流比为 100∶1;检测器为 FID氢火焰离子检测器;柱温 80 ℃,恒温 16 min,以 4 ℃/min升到 320 ℃;气化室和检测室温度:330 ℃;尾吹:60 mL/min;载气:N_2,流速为 12 cm/s;燃气:H_2,流量 0.6 kg/cm^2;助燃气:空气,流量为 0.5 kg/cm^2。

原油的全烃气象色谱分析结果表明,经解烃细菌作用后的原油,轻质组分明显增加,C_{25}以上的重质组分减少(图 1);原油组分的变化说明原油经菌作用后,重质组分发生了降解作用。

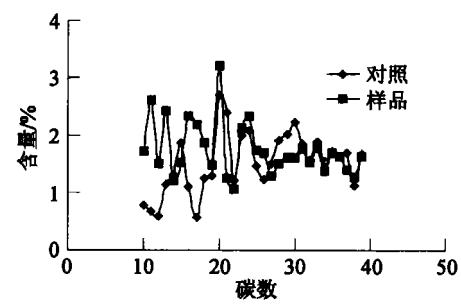

图 1 AD-4菌种作用后原油组分的变化

3 现场试验

3.1 试验区块和地质简况

本次试验选择了河南油田双河矿、下二门矿 12口井, 12口井分布在 3个区块中, 都属于低渗透油层, 原油含蜡在 30%以上, 日常热洗周期为 45~60 d 加药周期为 3~7 d.

3.2 微生物防蜡操作方法

微生物防蜡前, 要进行一次彻底热洗, 待产量稳定后, 将微生物防蜡剂与培养基从套管加入即可, 刚开始加入时需循环 4~8 h 使微生物防蜡剂与原油充分混合, 以便菌种繁殖、运移并进行新陈代谢。

3.3 微生物用量和加入周期确定

根据现场电流、负荷的变化及产出液中微生物菌种密度, 确定微生物初始加入量 300 kg 稳定期加入量为 100 kg 加入周期为 30 d.

微生物用量的确定: 试验井先进行热洗, 以确保井筒中无影响微生物的化学药剂。首次加入量根据各井情况确定, 一般为 300~450 kg 以后加入量按上次的 2/3递减, 直到维持油井正常生产的最小量。

加微生物周期确定: 加入微生物量确定后, 间隔时间 20 d. 30 d. 40 d 测定在各个间隔期间的负荷和电流, 从示功图和电流中, 看出在 20 d内, 电流、负荷无明显变化, 间隔 45 d时, 后期示功图最大负荷增加, 最小电流减小 (见图 2), 有一定的结蜡现象, 间隔 30 d时有轻微的结蜡现象。通过试验最后确定, 最终加入量为 100 kg 加入周期为 30 d.

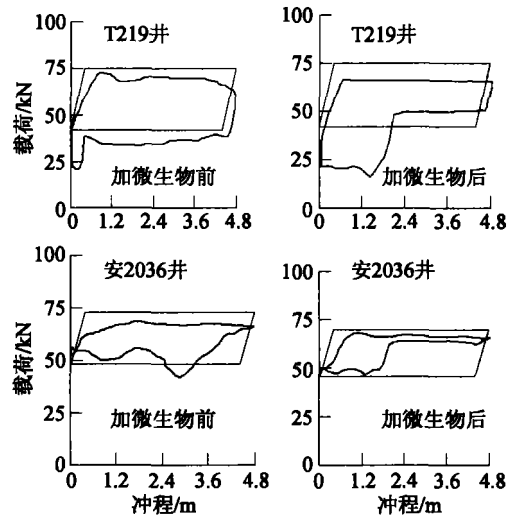

图 2 加微生物防蜡剂前后示功图对比

3.4 效果分析

2003年 6月开始在河南油田进行 12口井微生物防蜡现场试验, AD-4微生物防蜡剂在减轻油井负荷、降低开采电流、延长检泵周期等方面都有明显的作用(见表 4)。现场投入 8.4万元, 节省热洗、加药费用 12.3万元, 减少热洗占产损失 11万元, 投入产出比达 1∶2.8.

表 4 加微生物防蜡剂前后参数对比

井号	加前负荷/kN		加后负荷/kN		加前电流/A		加后电流/A		检泵周期/d	
	最大	最小	最大	最小	上	下	上	下	加前	加后
B162	60.48	20.53	59.20	19.34	39	42	35	38	343	718
T234	66.04	40.16	63.63	41.80	85	74	58	50	343	340
T219	72.74	20.97	66.49	15.77	24	26	15	15	128	426
安2036	68.58	41.8	68.43	47.01	22	17	20	21	57	102
安2105	70.66	30.2	69.91	35.11	23	18	26	25	77	185

4 结论及建议

(1)使用微生物防蜡对减轻油井负荷、降低电流、延长检泵周期有明显的效果, 且操作简单, 有效期长, 价格适中。

(2)在使用 AD-1微生物防蜡剂中也有一定的不足之处。在井底温度超过 100 ℃、原油含水高于 90%、日产液小于 3 m^3 的油井适用性差。

参 考 文 献

[1] 柳文国. 嗜蜡菌种的筛选、性能评价及在低渗透油藏的现场应用. 特种油气藏, 1999, 8(3): 85~88, 92

[2] 付亚荣, 靳海鹏, 李伟, 胡占国, 刘建华. 泽10断块微生物清蜡菌种的开发与应用, 石油钻采工艺, 2002, 24(4): 72~74

(收稿日期 2004-11-30)
(修改稿收到日期 2005-03-08)
〔编辑 付丽霞〕

solubility for 32 hours at 70℃, increased capability bearing temperature and pressure and improved stability of ASP.

Key words ASP blooding system extra – low boundary tension viscosity acting principle

ACCURATE MEASUREMENT OF MOLECULAR WEIGHT OF POLYMER AND DEGREE OF HYDROLYSIS IN PRODUCT FLUIDS

You Qing, Wang Yefei, Ren Shang Jiao Cui, Dai Caili, Zhao Fulin (China University of Petroleum, Dongying 257061, Shandong)

Abstract The measurement of molecular weight and degree of hydrolysis of polymer produced in polymer flooding well is a problem not been solved which may effect the study on concentration and existence form of the polymer. The traditional way can only be used for pure polymer solution, for the influence of salinity and other impurities leading to great error. In this paper using ultra filtration technique, pure solution is got to eliminate the influence and determine molecular weight and degree of hydrolysis accurately. The result of experiments shows that using the technique the relative error is no more than 2.0%, and without that procedure, the relative error of molecular weight is above 25.0%, and degree of hydrolysis is even more than 100% to 104%. Furthermore, concentration of the polymer produced in polymer flooding well could be determined accurately. In a word, this way can determine molecular weight and hydrolysis degree accurately and suit for the need of the field.

Key words produced fluids poly – acryl – amide molecular weight degree of hydrolysis measurement

RESEARCH AND APPLICATION OF PROFILE CONTROL AND OIL DISPLACEMENT TECHNOLOGY WITH SECTIONAL COMPOUNDING GEL

Li Zhiyan, Wang Xuemin, Cheng Meihua, Wu Guohui, Gang Lirong (Exploration and Develop Technology Research Institute of Dagang Oilfield, Tianjin 300280)

Abstract Research and applications of profile /displacement control technology in deep water wells were developed to solve difficulty of plugging big channels generally exist in reservoirs at Dagang oilfield. Based on the oil displacement profile control agent of developed pre – cross – link gel grains under ground cross – linking gel and elastic grain, developed profile / displacement control system of sectional compounding gel, it enhanced block capacity to big channels in reservoirs, and application in 193 wells since 2001 get 81.3% efficiency, increased crud oil 17.53×10⁴ t, this technology have inaugurated a new approach to tap the latent power of water flooding oilfield and will be gradually popularized and applied.

Key words PROFILE CONTROL AND OIL DISPLACEMENT slug flooding combina gel plugging

EXPERIMENTAL STUDY ON MICROSCOPIC MECHANISM OF OIL DISPLACEMENT BY MICROGEL FLOODING IN HENAN XIAERMEN OILFIELD

Sun Gengtao, Li Huabin (State Key Laboratory of Oil and Gas Reservior Geology and Exploration Engineering, Chengdu 610500, Sichuan), Li Xiyu, Dai Yahong

Abstract Micro – gel flooding is a new technique combine properties of profile modification and polymer flooding solved current problems such as polymer volume needed larger temperature and salt resisting ability poor and compounding of polymer with wastewater is difficult. Flooding experiments are carried out at first time using micro – real – sand model in combination with the reservoir feature and development status in Xiaérmen Oilfield, the experiment results show that micro – gel flow into large porous firstly, then into little porous and throat by deformation, and diversion and viscous – elastic behavior are main micro – mechanism that micro – gel improve oil recovery.

Key words micro – gel flooding real – sand model deformation diversion viscous – elastic behavior

BREEDING AND APPLICATION OF MICROBE PARAFFIN INHIBITOR AD – 4

Wu Huimin (AoDe Technology Company, Kaifeng 475004, Henan), Liu Yanpo, Wu Liling, Hu Bin, Pi Cunxue

Abstract Introduced breeding of microbe paraffin inhibitor property examine in laboratory and in – situ experiment of paraffin inhibitor microbe paraffin inhibitor AD – 4 was a field usable microbe, which composed of microbes tame from field profit and capability optimize select from laboratory. Experiment indicate that AD – 4 can decrease freezing point of wax to 4 ~ 8.5℃ by its emulsify and degradation capacity, decrease surface tension of crude oil cultivation liquid to 30.3% ~ 49.3%, and decrease viscosity to 35% ~ 50%, improved flow properties of crud oil. Applications in 12 wells showed that AD – 4 depressed electric current and loading of well, prolonged pump inspection period to tow times in some wells, and ratio of input/output can reached to 1∶28.

Key words microbiological manipulation laboratory experiment paraffin control and clear visbreaking field experiment

STUDY ON A PERFORATION – PLUGGING AGENT OF COMPOUND RESIN WITH SAFETY AND LOW CONTAMINATION

Zhao Xiutai, Li Peng, Qiu Guangmin (China University of Petroleum, Dongying 257061, Shandong), Zhao Mingchen, Sui Chunyan, Peng Xuyong

Abstract During plug of perforation, grout has disadvantages such as high risk, prolonged period of work and severe contamination of grout to reservoir, so a perforation – plugging agent (FD – 1) of compound resin was developed. Due to some dissolvable fiber and oil – solubility substance were added to the grout, FD – 1 has less contamination to the oil formation. It is proved to be better for plugging when it is used together with heal agent. With long hardening time and uneasy to freeze. The compressing intensity of FD – 1 reached to 16 MPa. The agent do not plug on the well during the work. The plugging rate to different rock exceeds 95%. The recovery of oil permeability exceeds 50%. Applications of FD – 1 shows that the agent adequate to plug perforation and big holes in well.

Key words plugging agent perforation plugging compound resin formula research reservoir protection

OPTIMUM DESIGN AND APPLICATIONS OF LIFT TECHNOLOGY AT REMOTE COMPLEX FAULT BLOCK OILFIELD

Geng Yuguang, Li Yanzhuo, Yang Xiaoping (Oil Production Technology Research Institute of Huabei Oilfield Company, Renqiu 062552, Hebei)

Abstract Deeply summarized the application of testing