2nd World Congress
on Petroleum and Refinery

Experiment Studies on N_2 - viscosity Depressant with Steam Stimulation for Shallow Thin Super-heavy Oil Reservoirs

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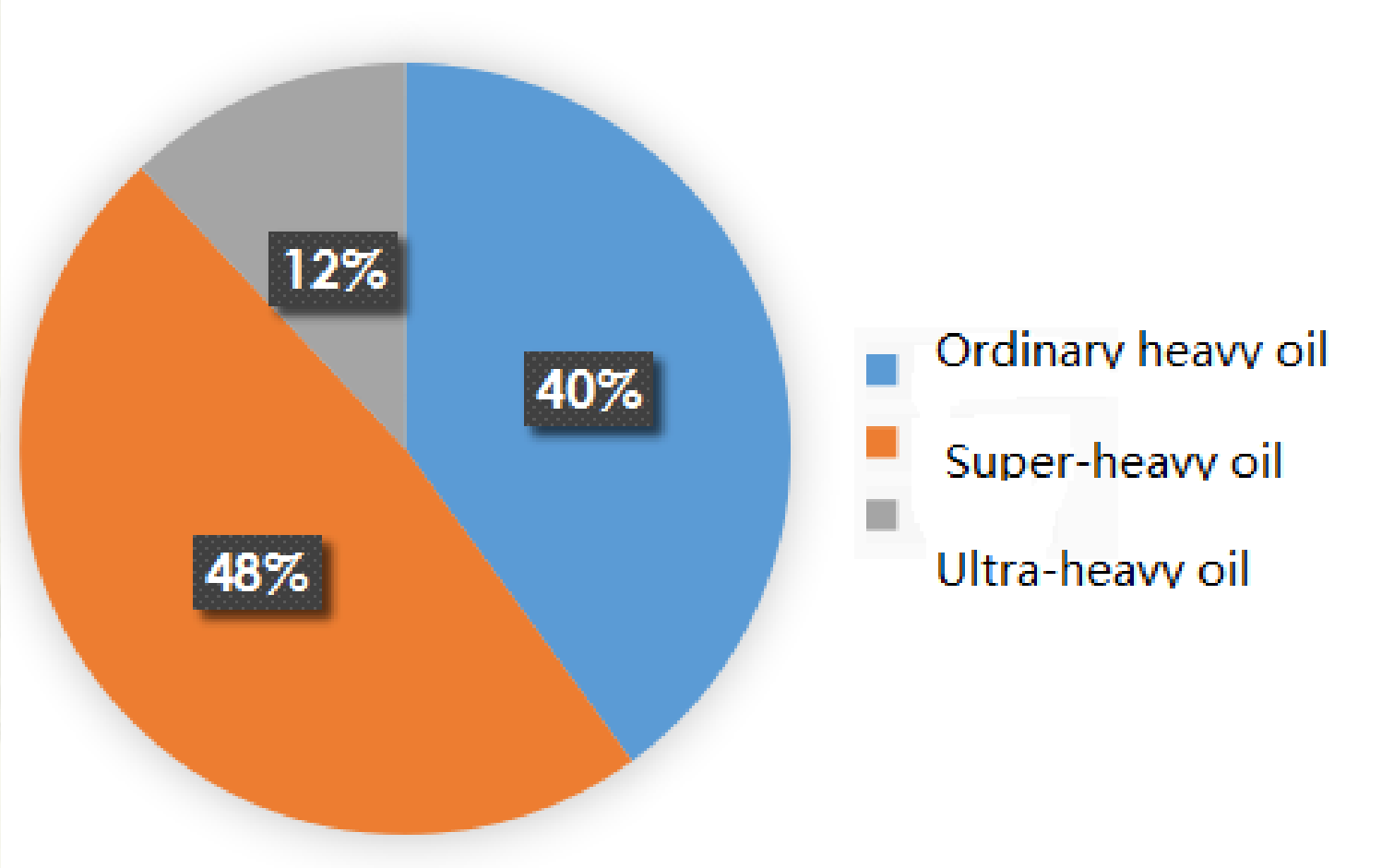
Contents

1 Introduction

Table 1 Classification of heavy oils

Type		Viscosity(cp)	Specific Gravity
Ordinary heavy oil	1	50-150	>0.92
	2	150-10000	>0.92
Super-heavy oil		10000-50000	>0.95
Ultra-heavy oil		>50000	>0.98

1 Introduction



1 Introduction

Methods:

(1). Steam stimulation

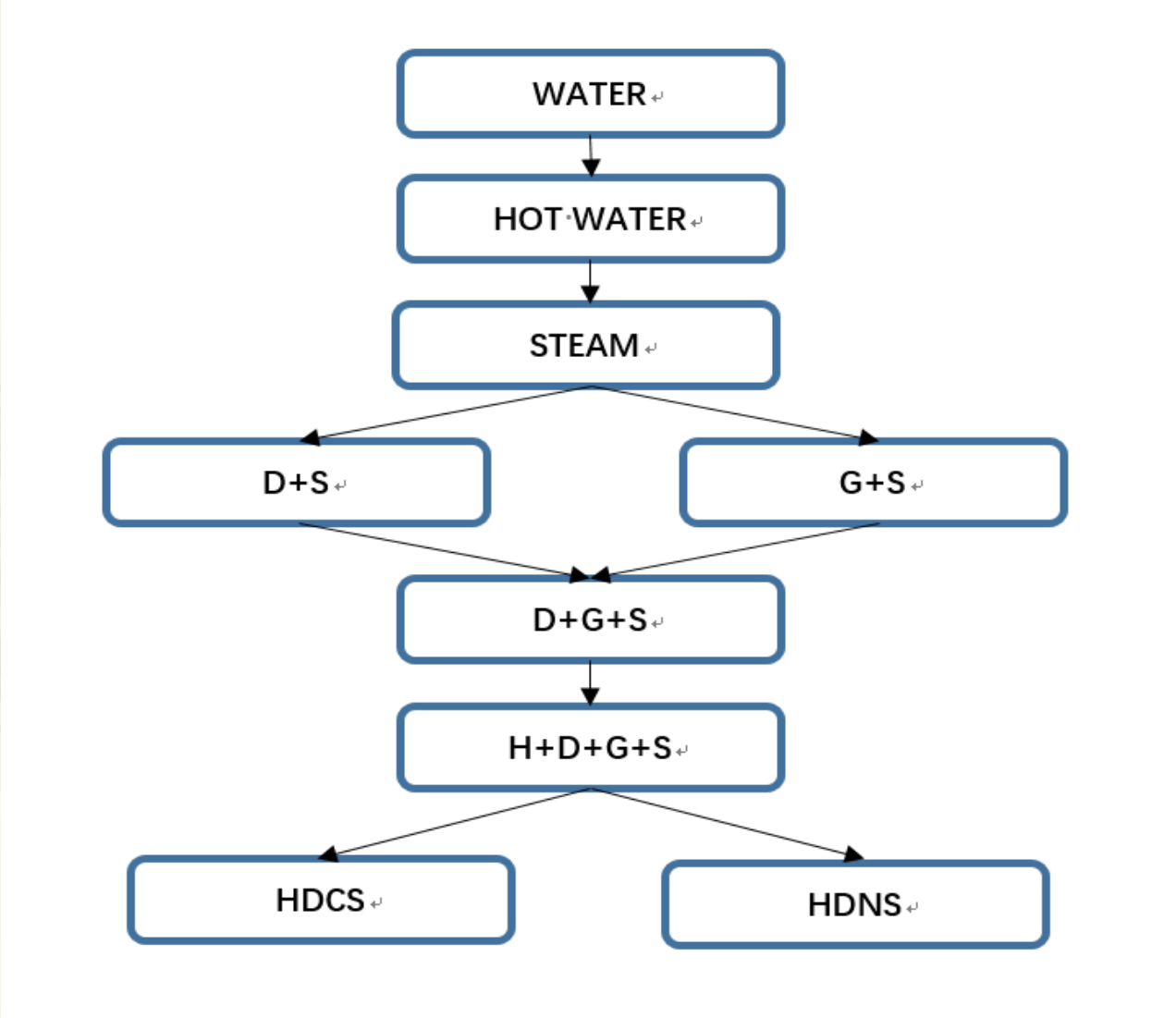
(2). Steam flooding

(3). Combustion in-situ

(4). Hot water flooding

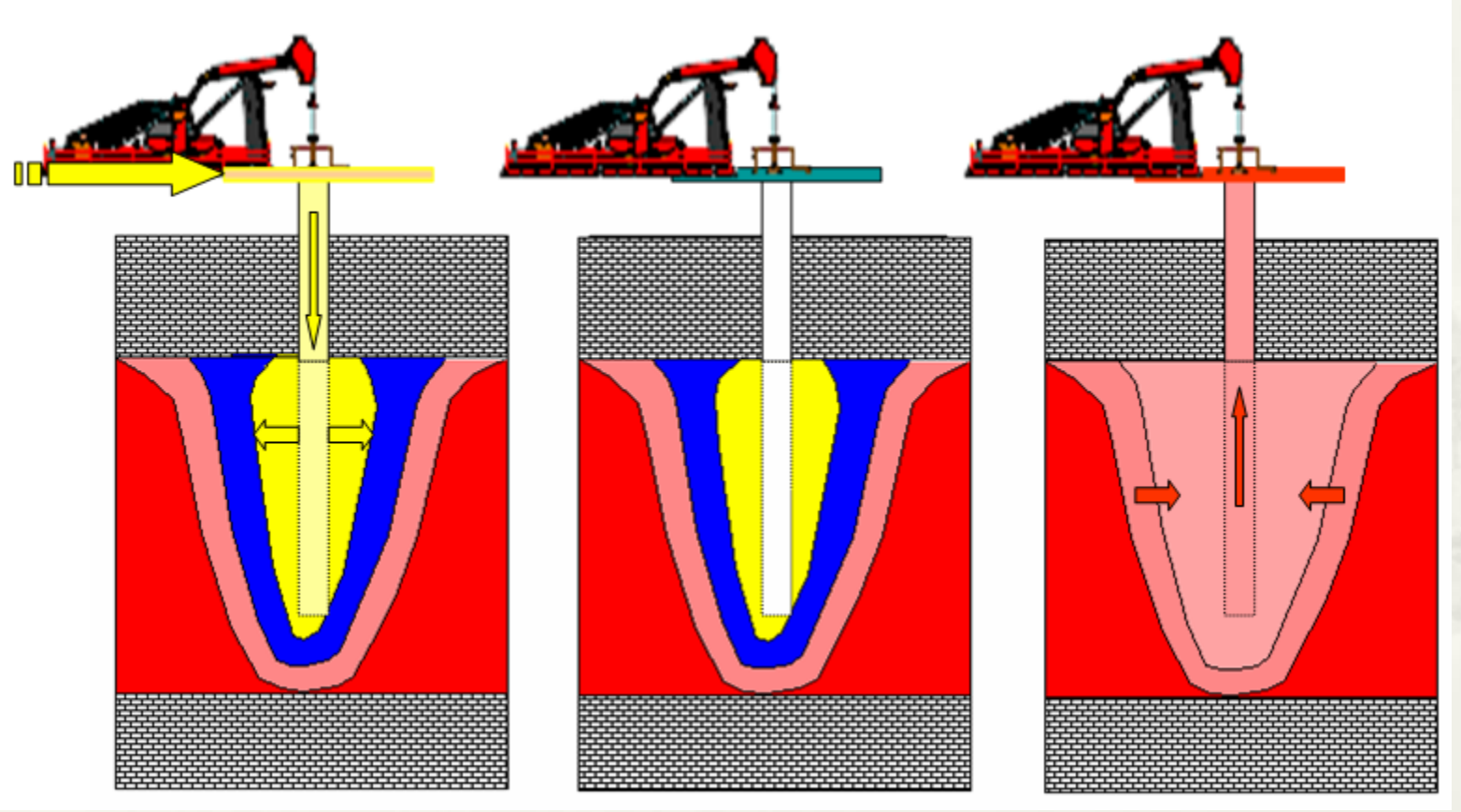
(5). Electromagnetic heating

1 Introduction



1 Introduction

Steam huff and puff



1 Introduction

Cyclic steam injection, steam soak, steam huff and puff

Mechanism:

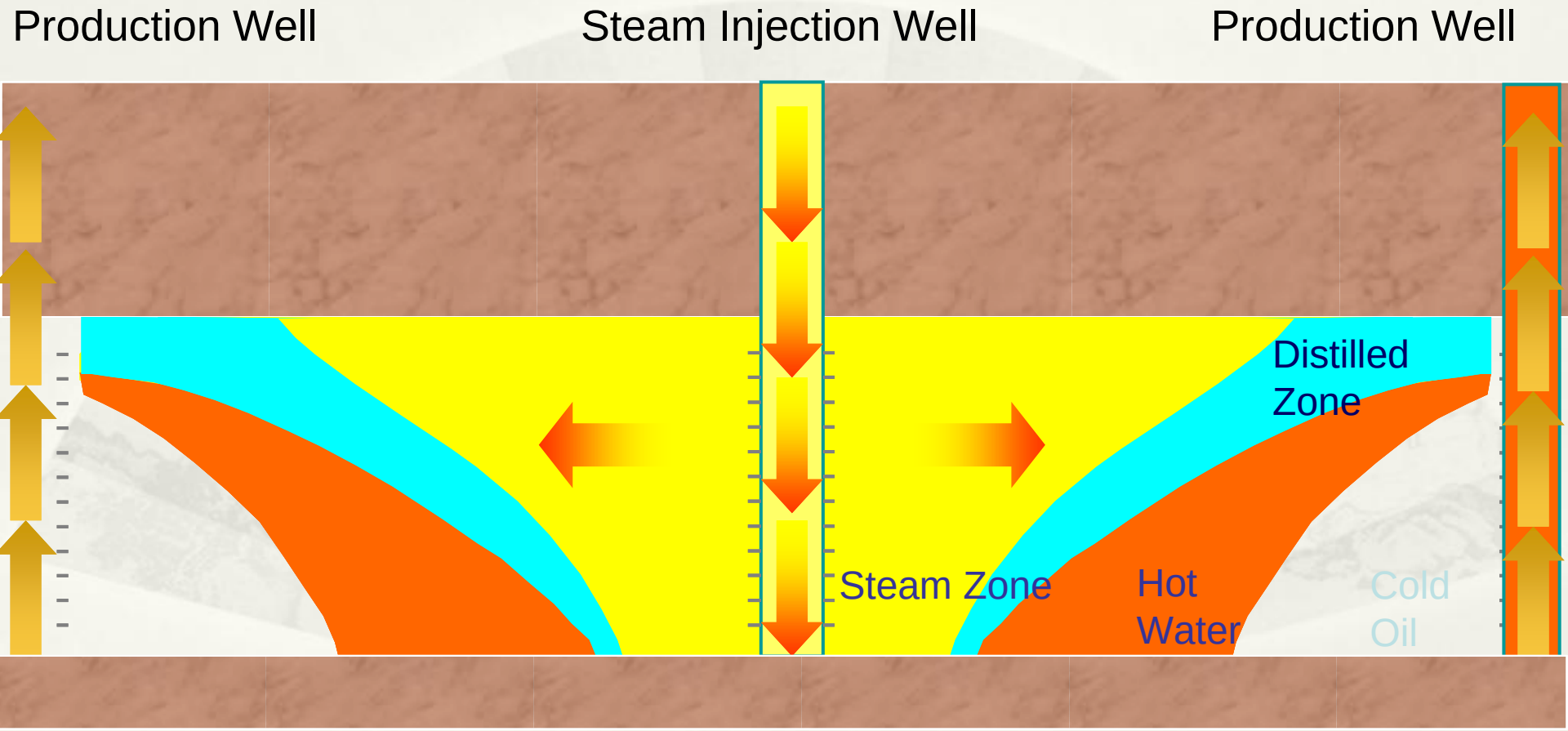
(1) Thermal expansion of fluids

(2) Compression of solution gas

(3) Reduced residual oil saturation

(4) Wellbore cleanup effect

1 Introduction



Steam Flooding

1 Introduction

In-situ combustion

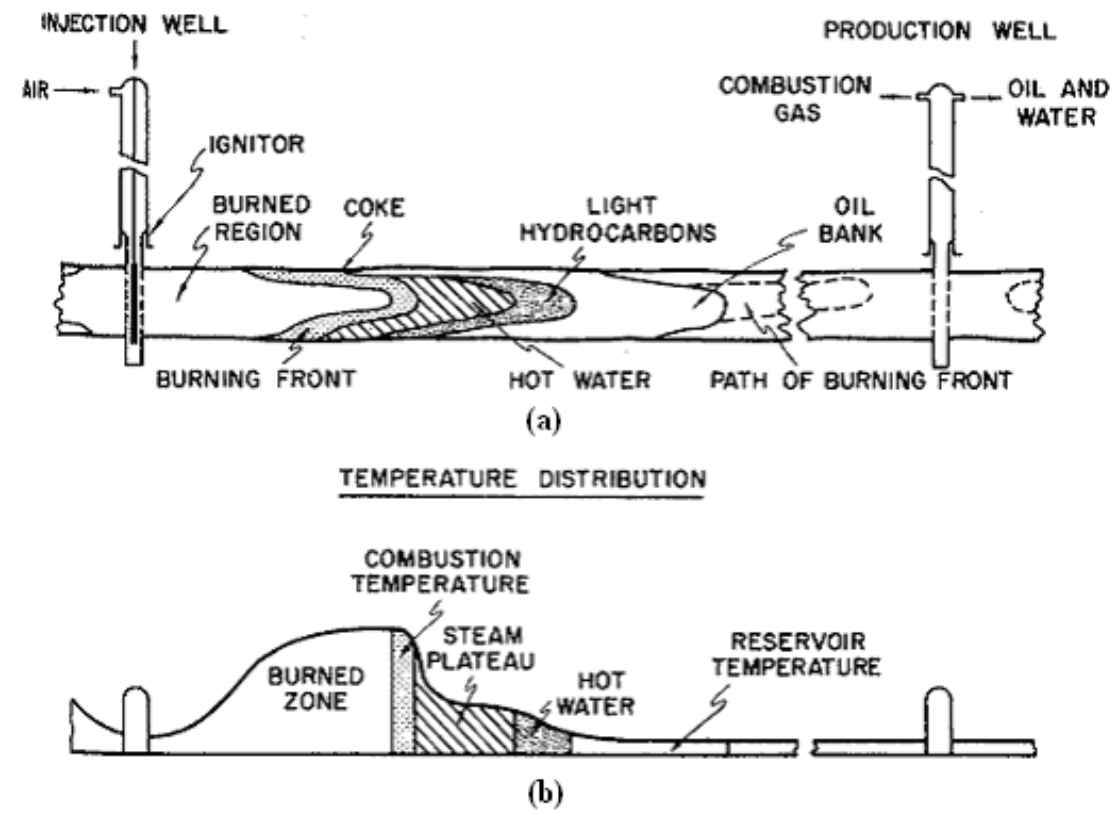


Fig. 4.2.5 Schematic diagram of in situ combustion process (modified from Nelson and McNeil, 1961)

1 Introduction

Classifications of gas injection:

(1) Miscible displacement

(2) Near-miscible displacement

(3) Immiscible displacement

Gas used:

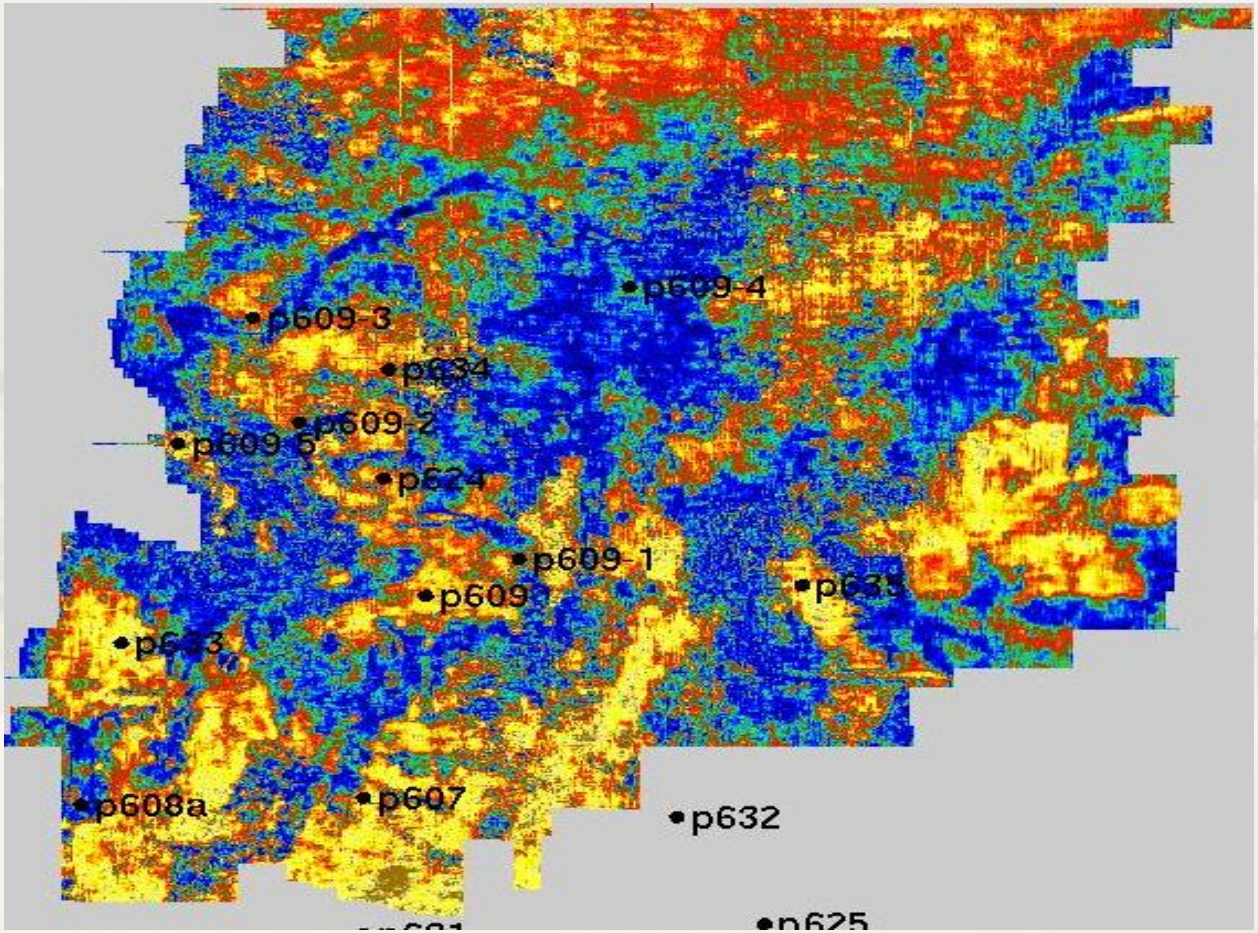
(1) CO_2

(2) N_2

(3) air

1 Introduction

The typical Oil Field



1 Introduction

Characteristics of the heavy oil reservoir:

Shallow:

the reservoir Depth 400-700m

Thin:

The reservoir thickness 2-8m

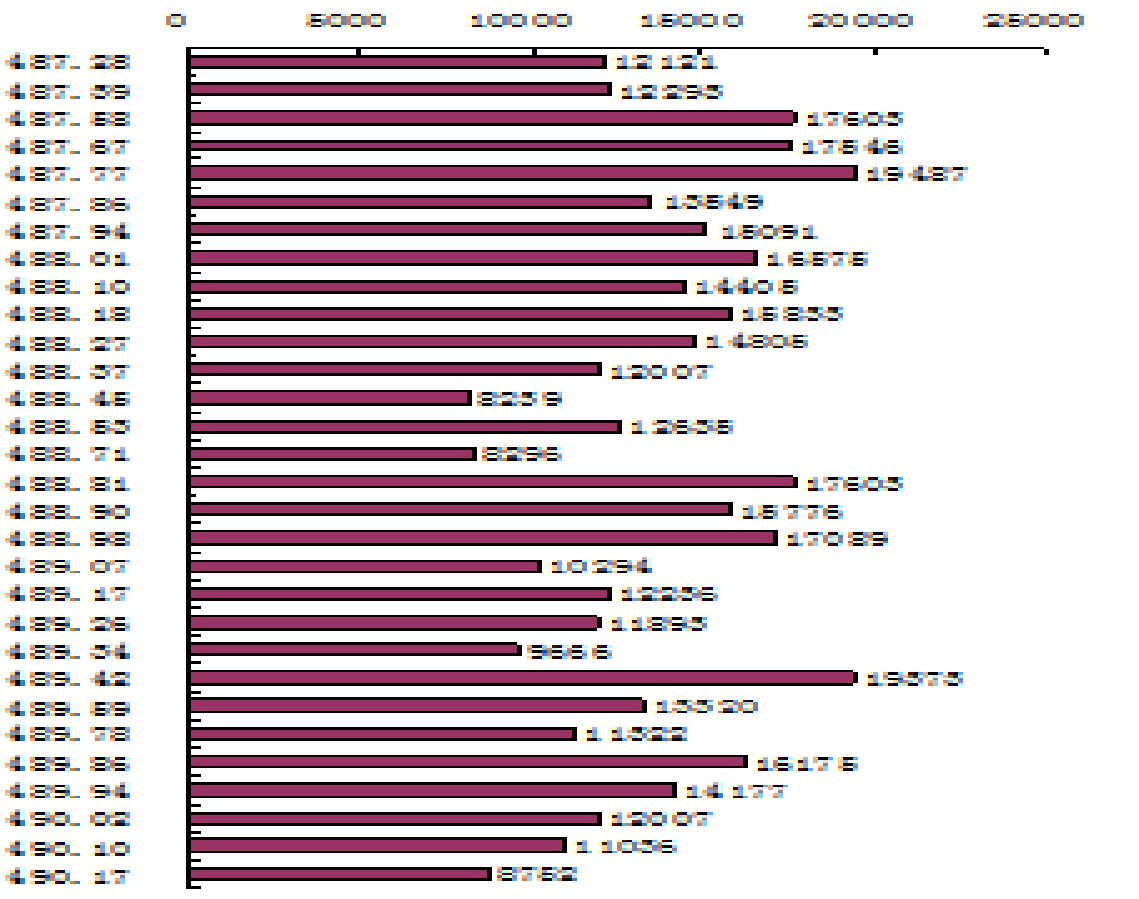
Low temperature: 30℃

Low pressure: The reservoir pressure <5.0MPa

Viscous:

Oil viscosity 50000-90000mPa·s @ reservoir temperature

1 Introduction



Vertical distribution of permeability

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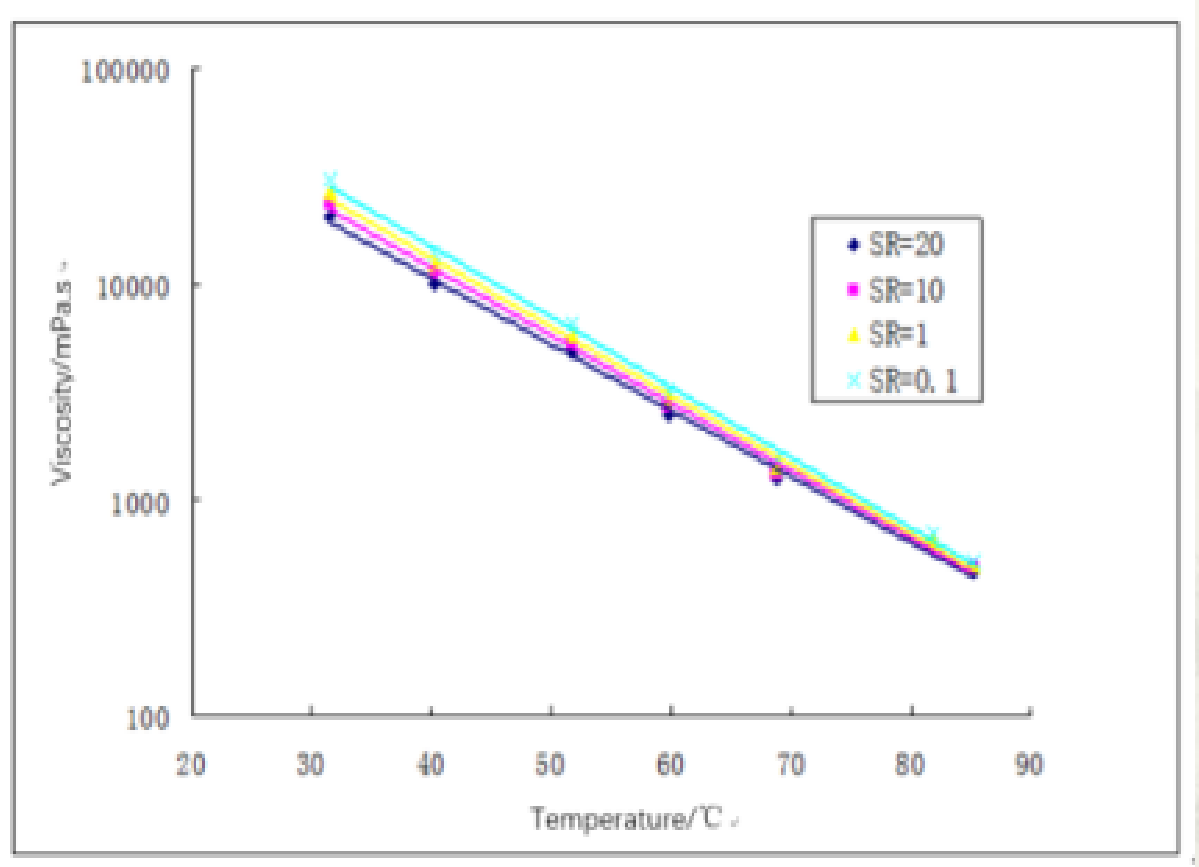
2 Experimental



The relationship between viscosity and temperature of the oil sample

2 Experimental

2.1 Materials

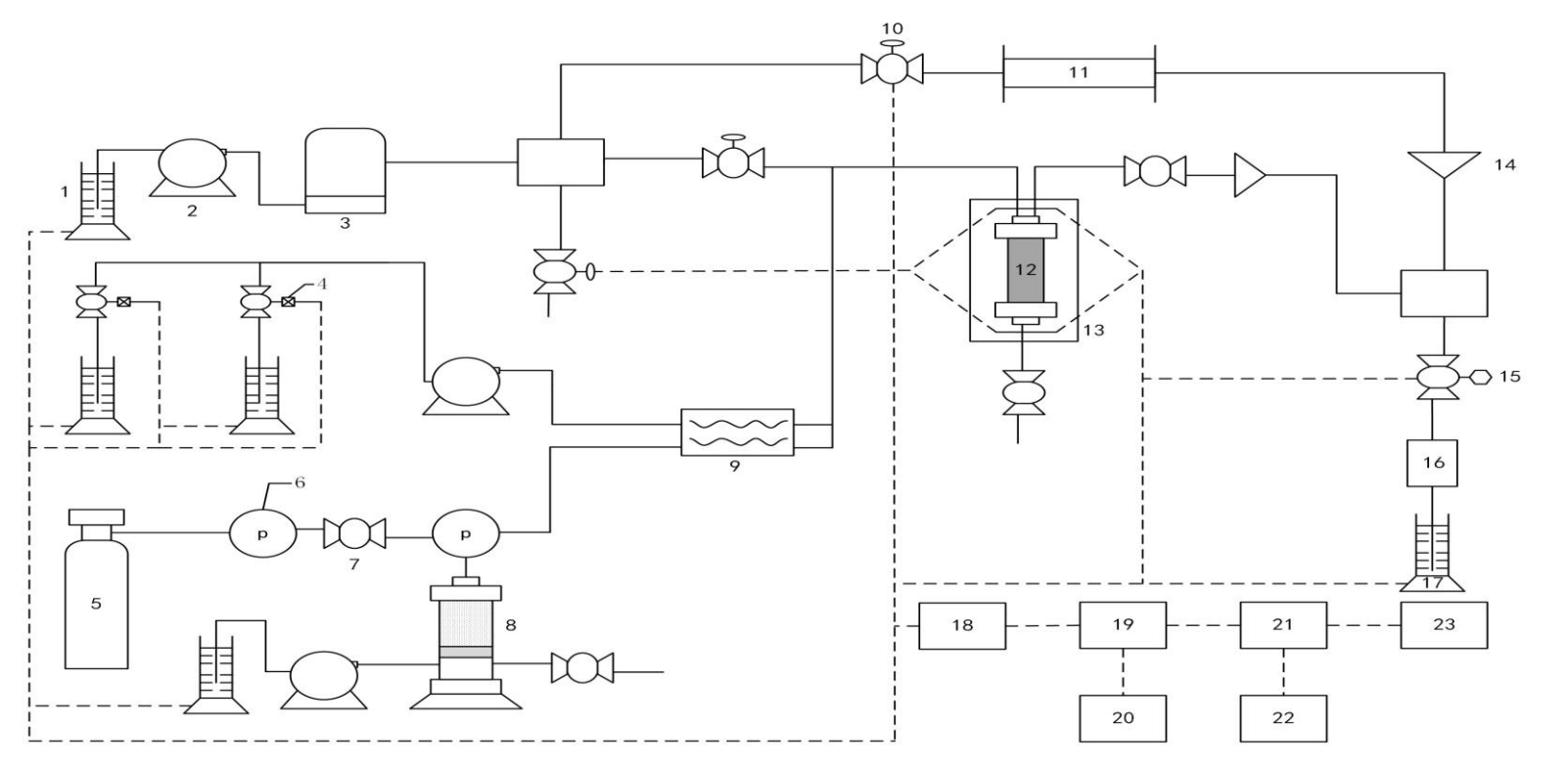
Crude oil; Simulated Water (35000mg/L, KCl); YR-2 Oil soluble viscosity reducer; Nitrogen; Sand filled models

basic parameters of sand filled models

No.	L/cm	D/cm	Φ/%	K/μm²	No.	L/cm	D/cm	Φ/%	K/μm²
1	18	3.83	34.82	3.15	9	18	3.83	35.46	3.18
2	18	3.83	35.19	3.23	10	18	3.83	36.04	3.26
3	18	3.83	35.14	3.07	11	18	3.83	35.22	3.21
4	18	3.83	35.23	3.16	12	18	3.83	36.43	3.35
5	18	3.83	34.95	3.23	13	18	3.83	36.18	3.32
6	18	3.83	36.36	3.21	14	18	3.83	34.88	3.02
7	18	3.83	35.78	3.35	15	18	3.83	35.54	3.19
8	18	3.83	34.92	2.99					

2 Experimental

2.2 Equipment



1.aquamanile 2.pump 3. Steam generator 4. Solenoid valve 5. nitrogen vessel 6. pressure gauge 7. Valve
8. intermediate vessel 9. heat preservation jacket 10. electromotive valve 11. Damper 12. Sand Pack
13. Thermostatic Box 14. check valve 15. Pressure regulating valves 16. oil-water separator 17. electronic balance
18. Intermediate coefficient 19. Acquisition date20. Console 21. microcomputer data processing and control system
22. Printer 23. Graph-Plotter

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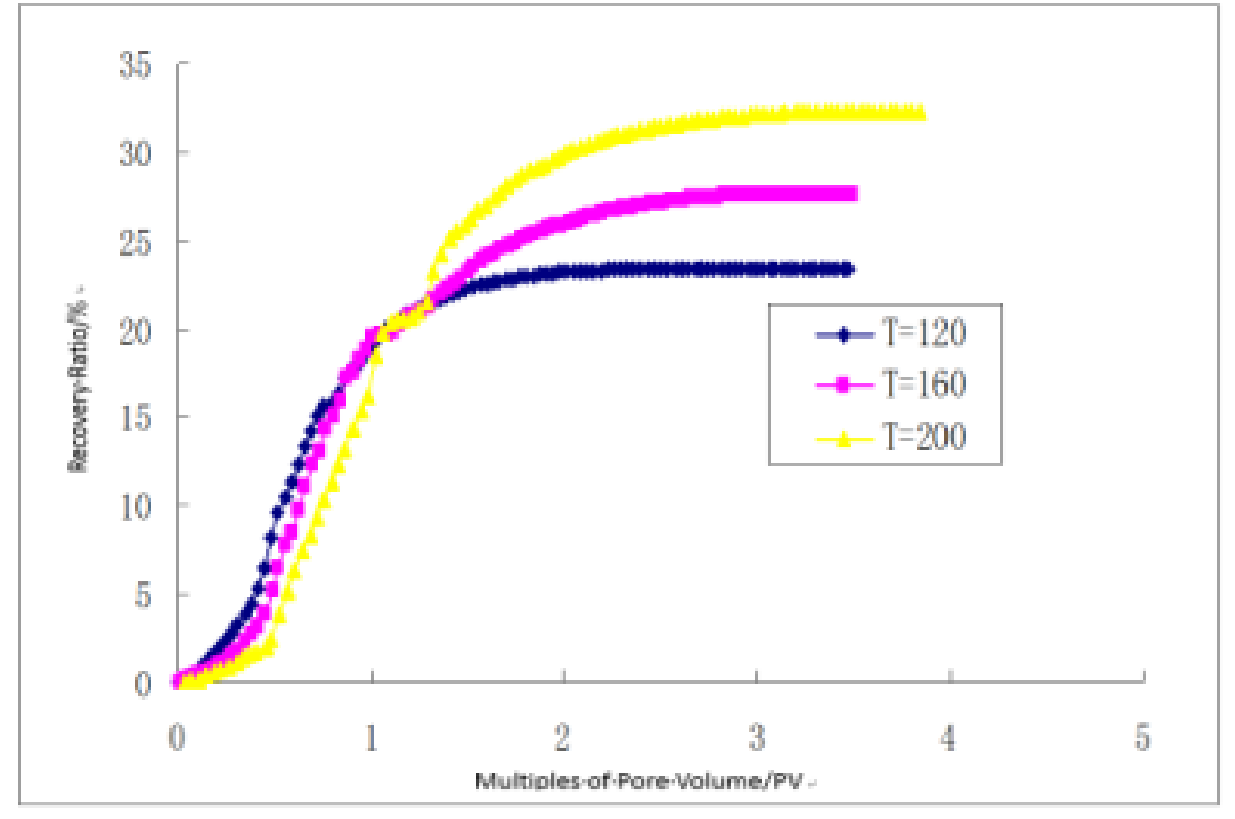
3 Results and Discussions

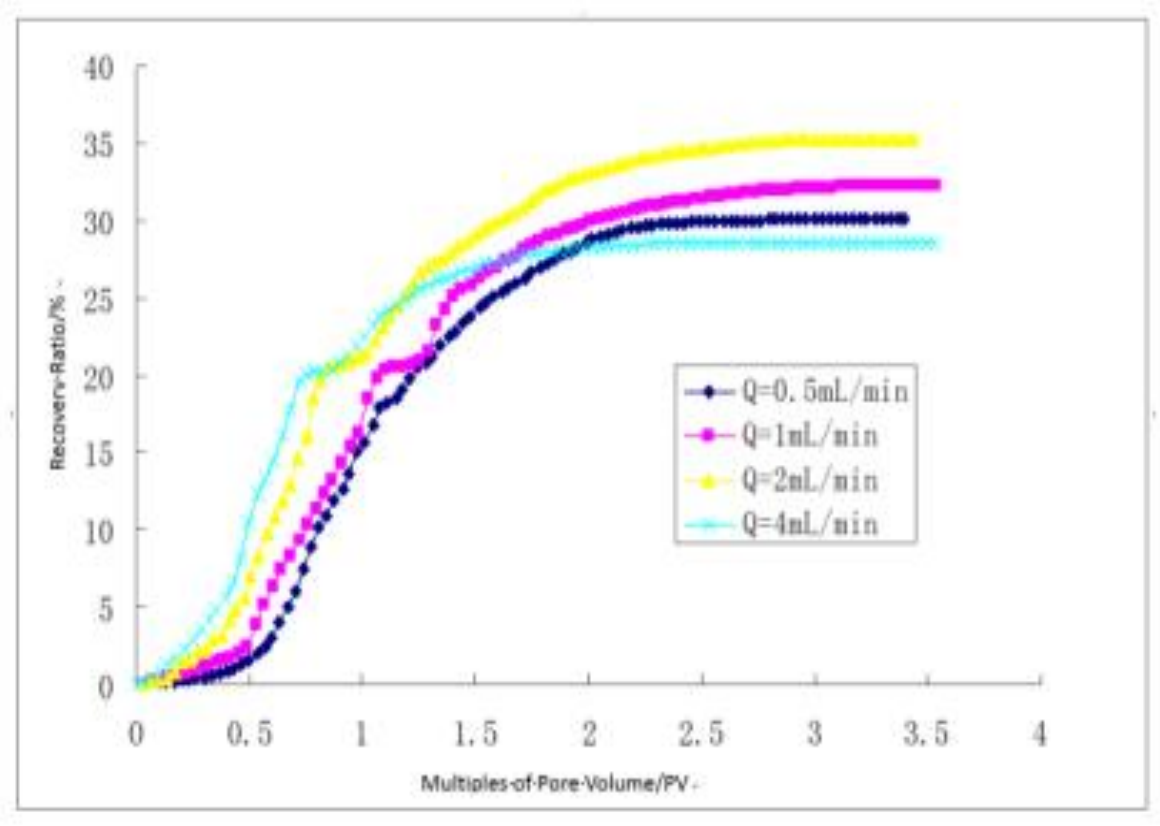
3.1 Effect of Steam Temperature



The relationship of recovery ratio with injected pore volume for different steam temperature

3 Results and Discussions

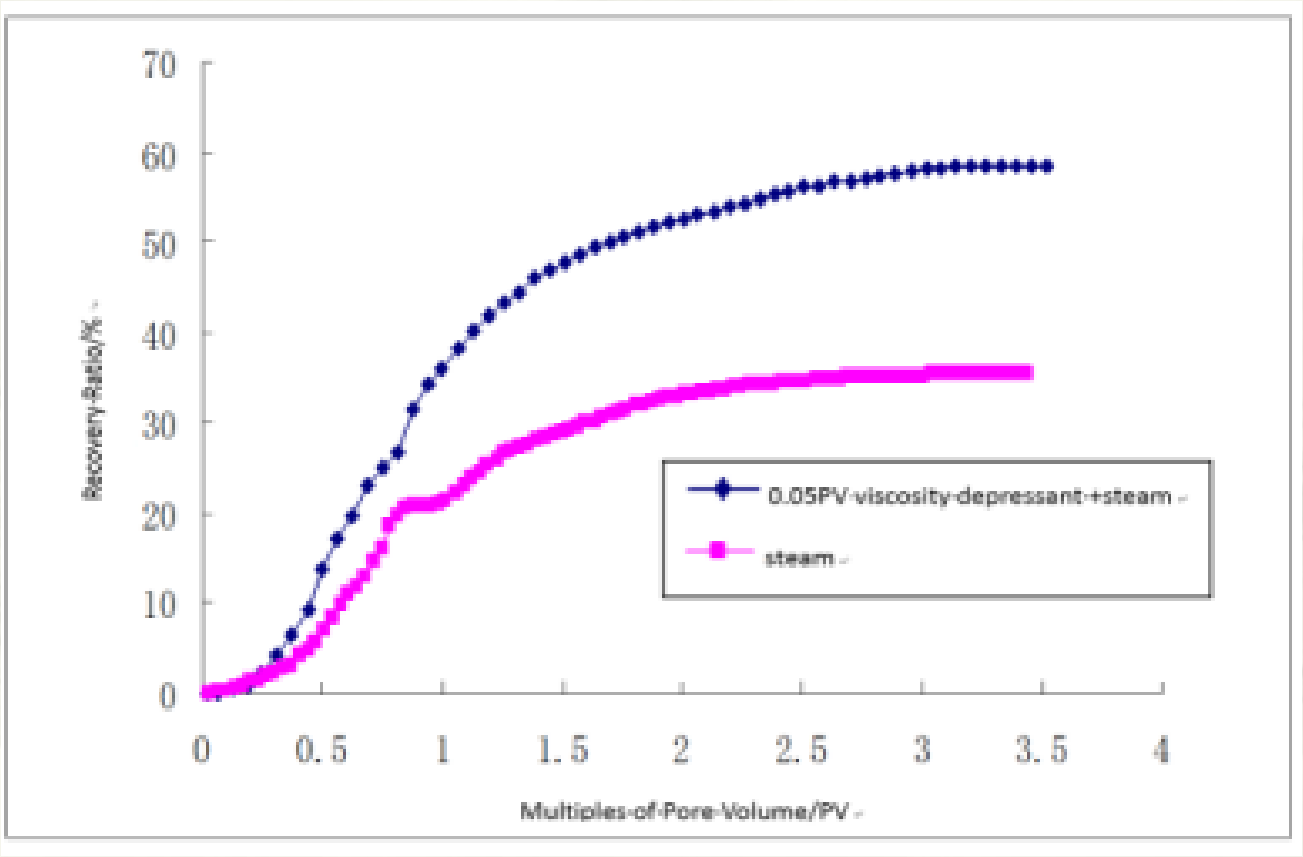
3.2 Effect of Steam Injection Rate



The relationship of recovery ratio with injected pore volume for different steam injection rate

3 Results and Discussions

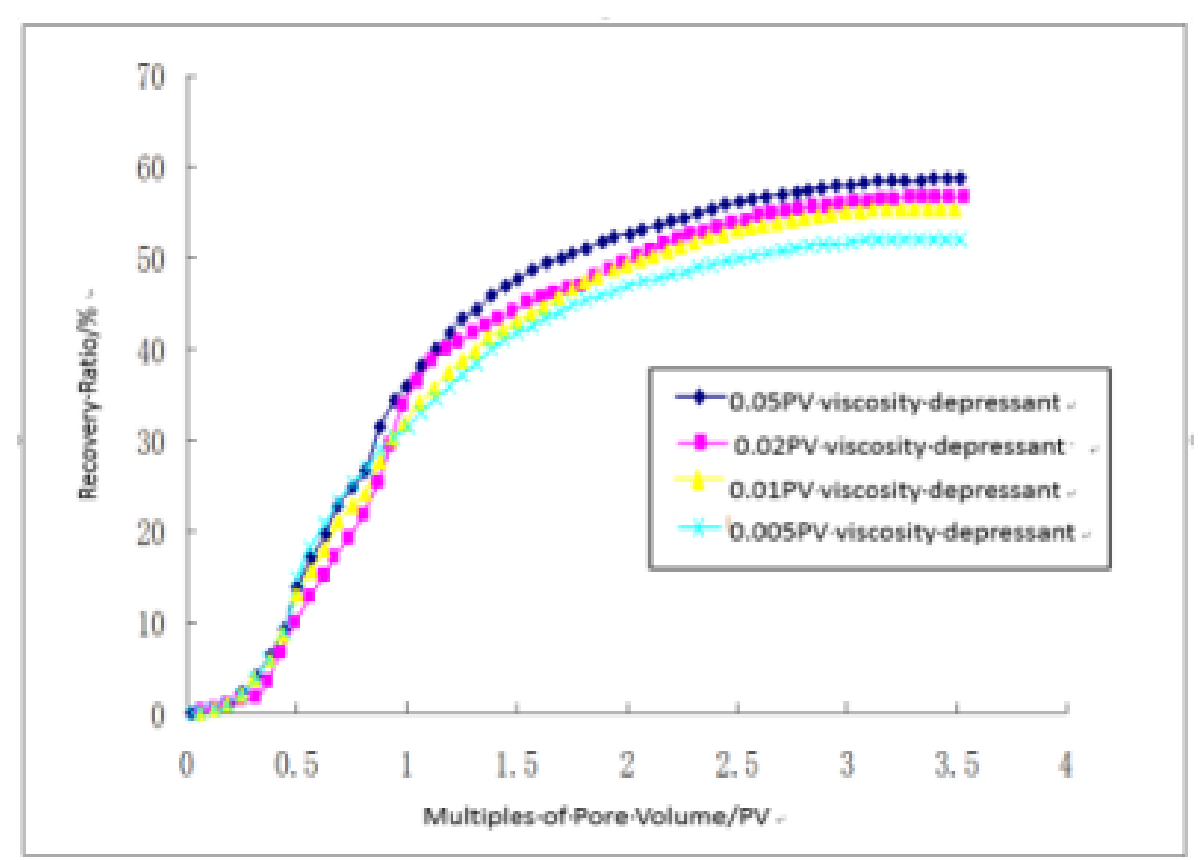
3.3 Effect of Viscosity Depressant



The relationship of recovery ratio with injected pore volume for D+S

3 Results and Discussions

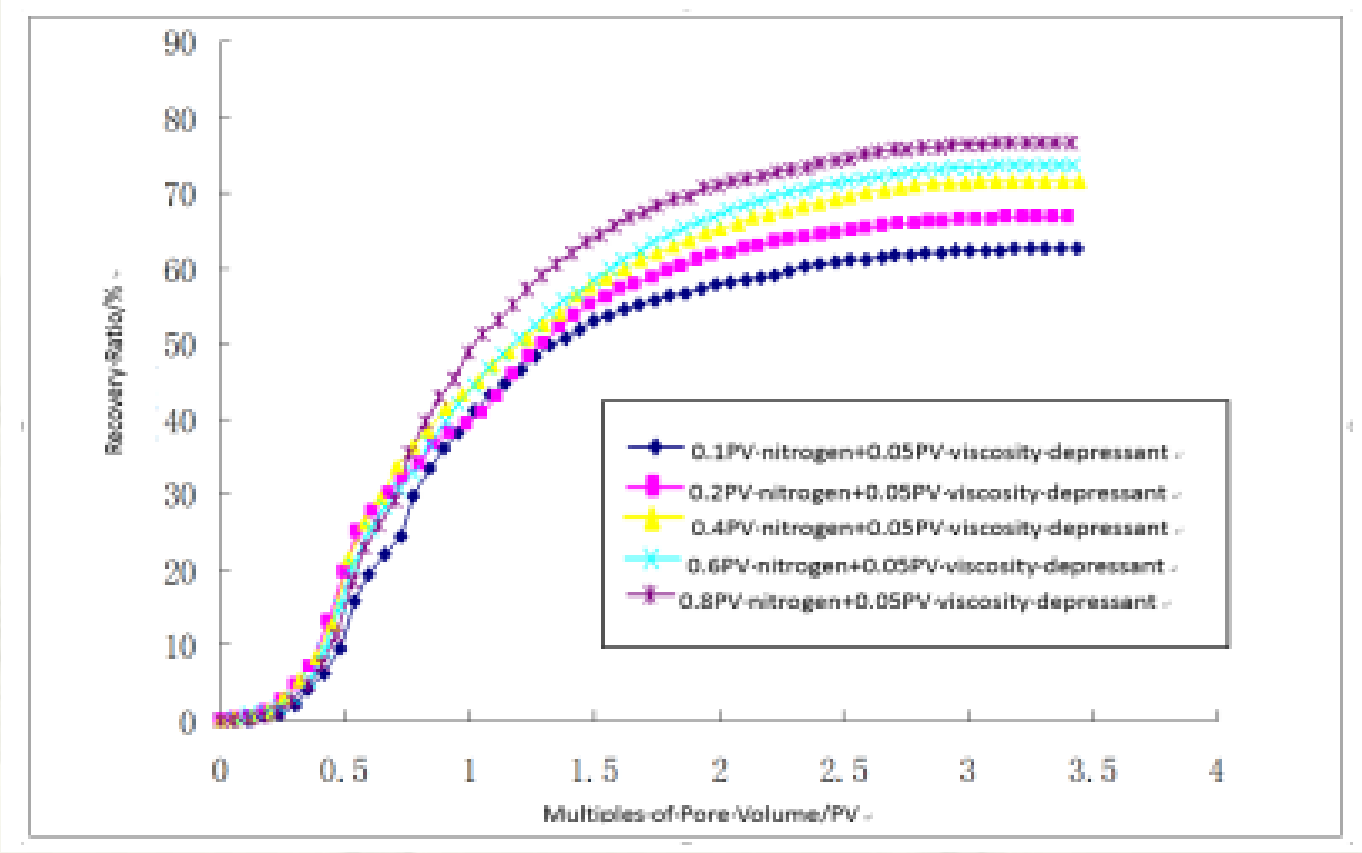
3.4 Effect of injected volume of viscosity depressant



The relationship of recovery ratio with injected pore volume for different volume of viscosity depressant

3 Results and Discussions

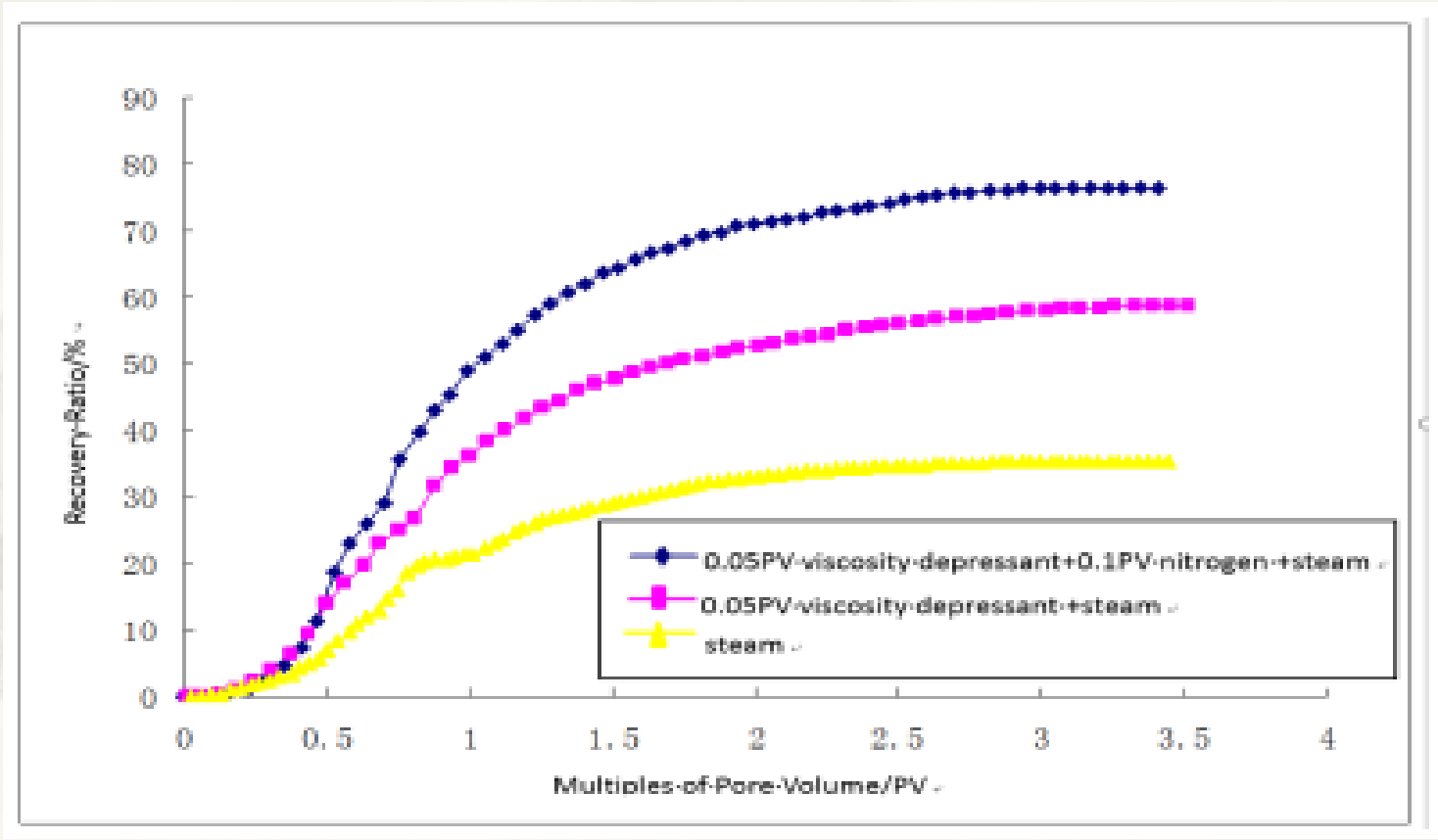
3.5 Effect of Nitrogen



The relationship of recovery ratio with injected pore volume for different amount of nitrogen

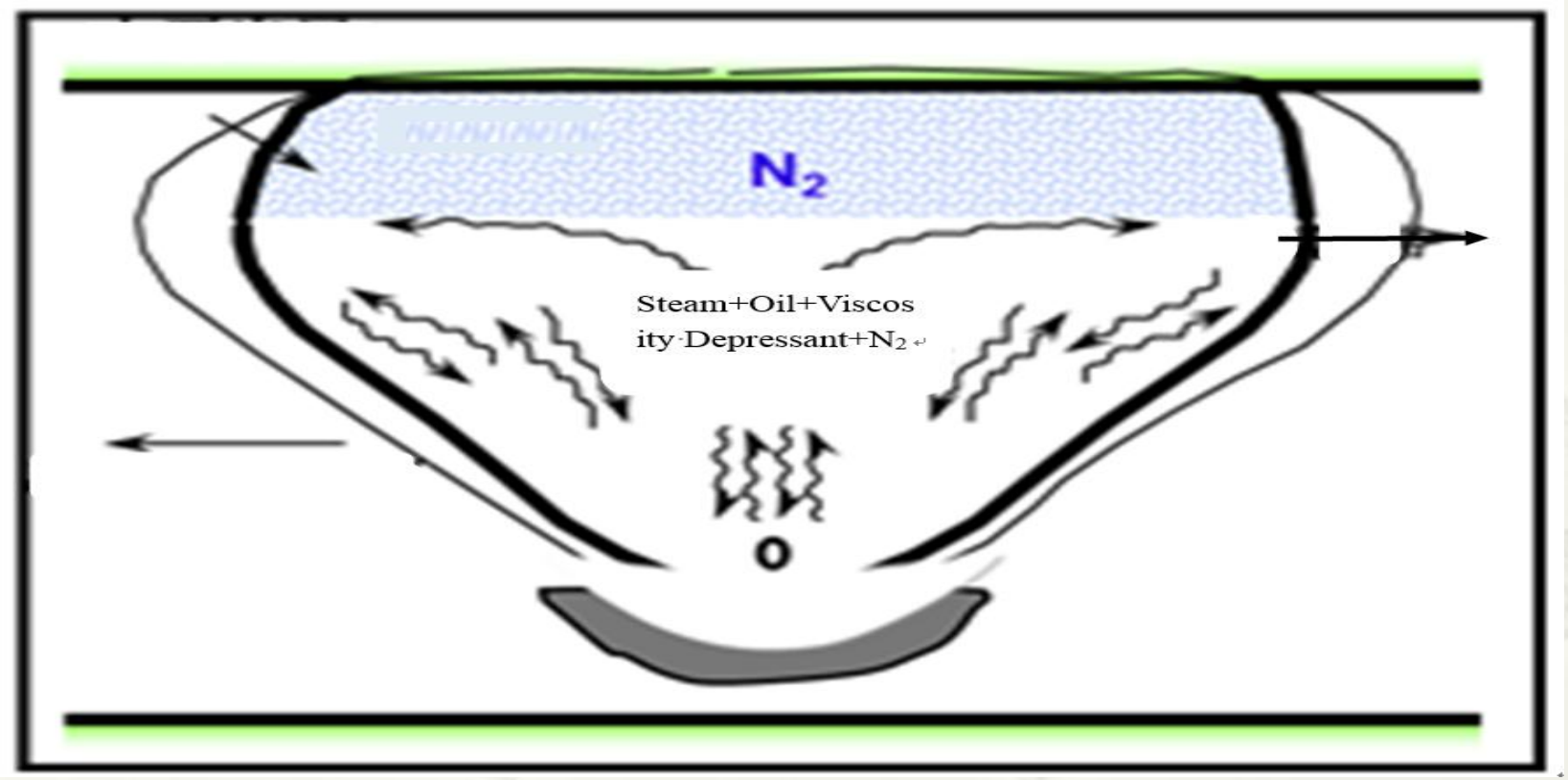
3 Results and Discussions

3.6 Comparison of Different Recovery with Different Flooding Methods



The relationship of recovery ratio with injected pore volume for different flooding methods

3 Results and Discussions



Mechanism of HDNS

3 Results and Discussions

(1) The function of heat insulation and preservation: the nitrogen thermal conductivity is lower than oil, water and rock. It conducts heat slowly into the formation, reducing heat loss. And nitrogen gas can be accumulated in the top of the reservoir, suppressing the steam over-reduced heat loss, improve thermal efficiency.

(2) Increasing energy: under the same conditions, nitrogen provides elastic energy is 1.25 ~ 1.5 times as that of carbon dioxide gas, so the nitrogen can increase the pressure.

3 Results and Discussions

(3) Reducing viscosity: oil-soluble viscosity reducer can break down gum and asphaltenecan, forming a dispersion system in which the colloidal asphaltene is a dispersed phase and the crude light component is a continuous phase. And viscosity reducer can improve the flow condition, which is conducive to enhancing oil recovery. Moreover, the synergistic effect of viscosity reducer and nitrogen can further expand the radius of viscosity.

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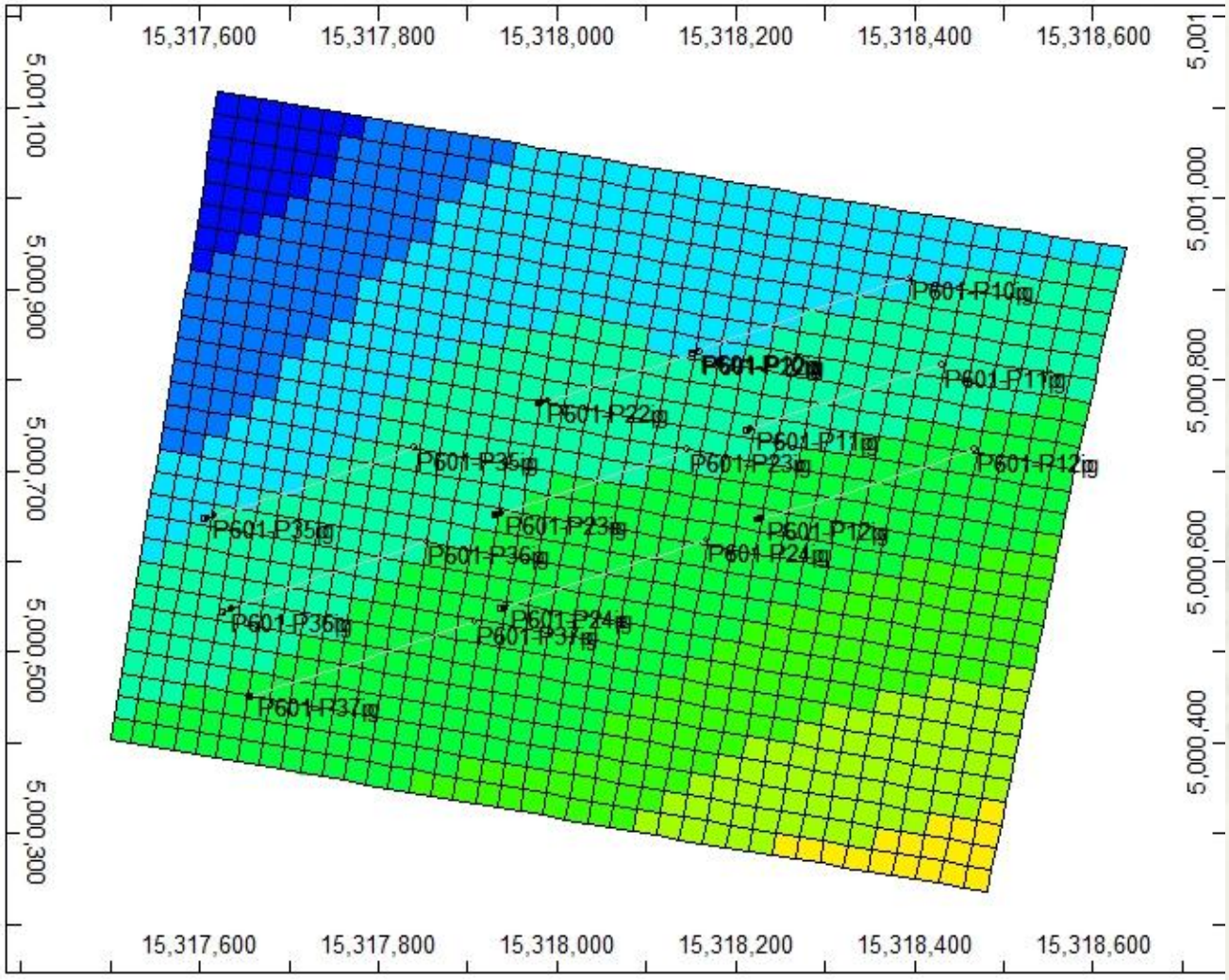
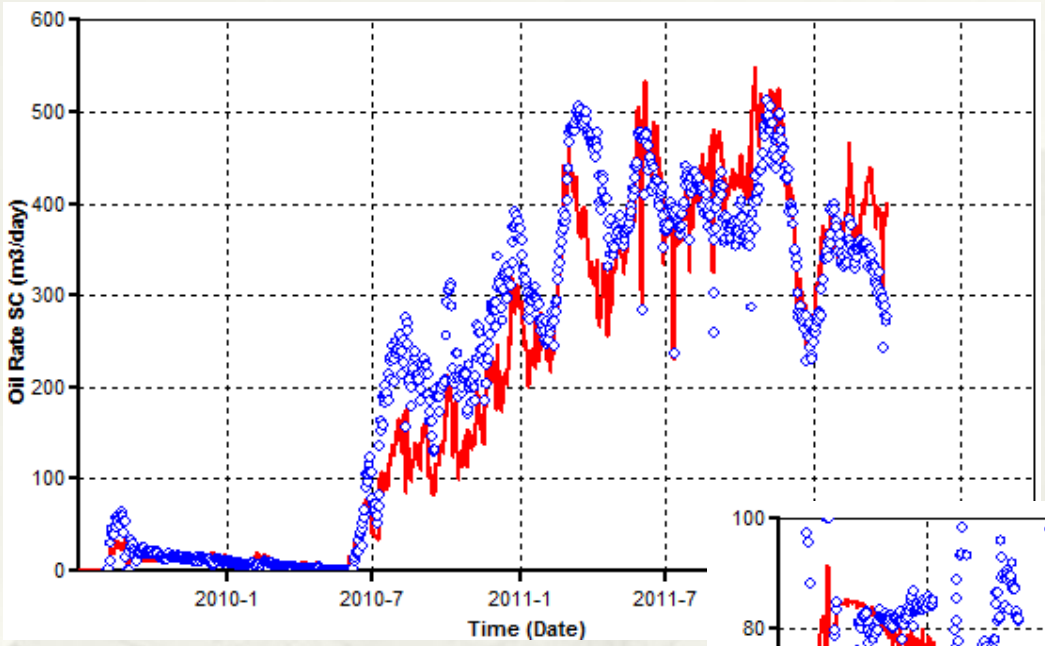
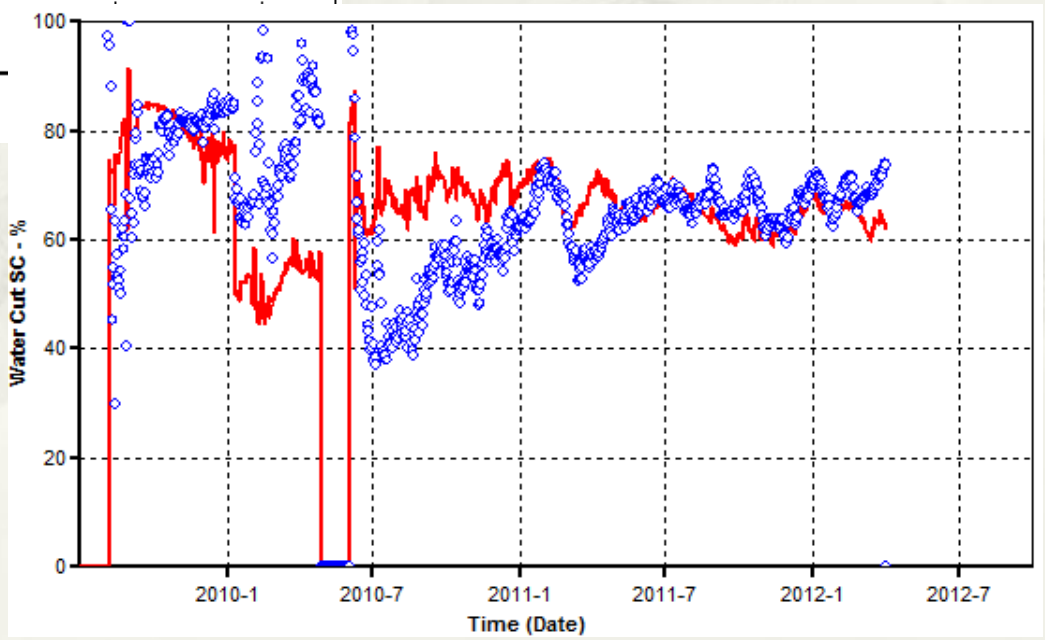
4 Applications in China

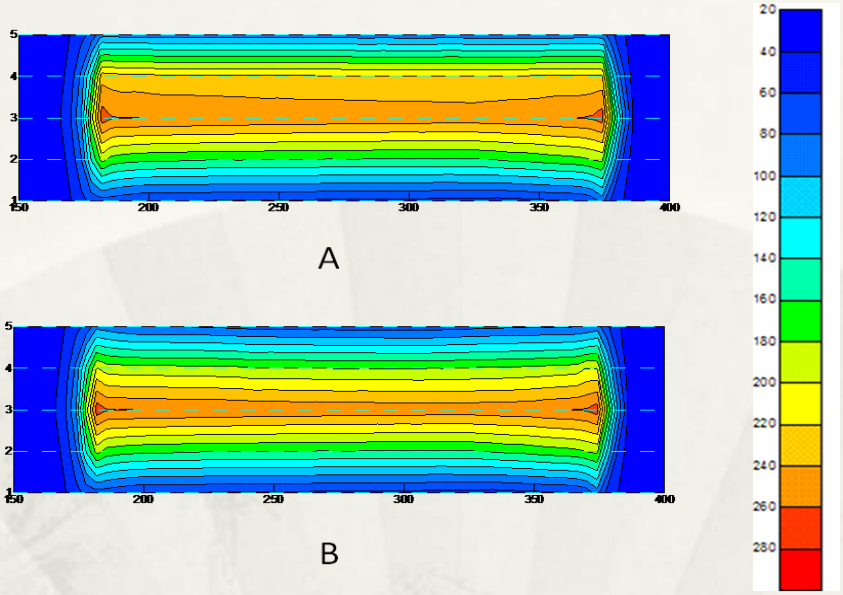


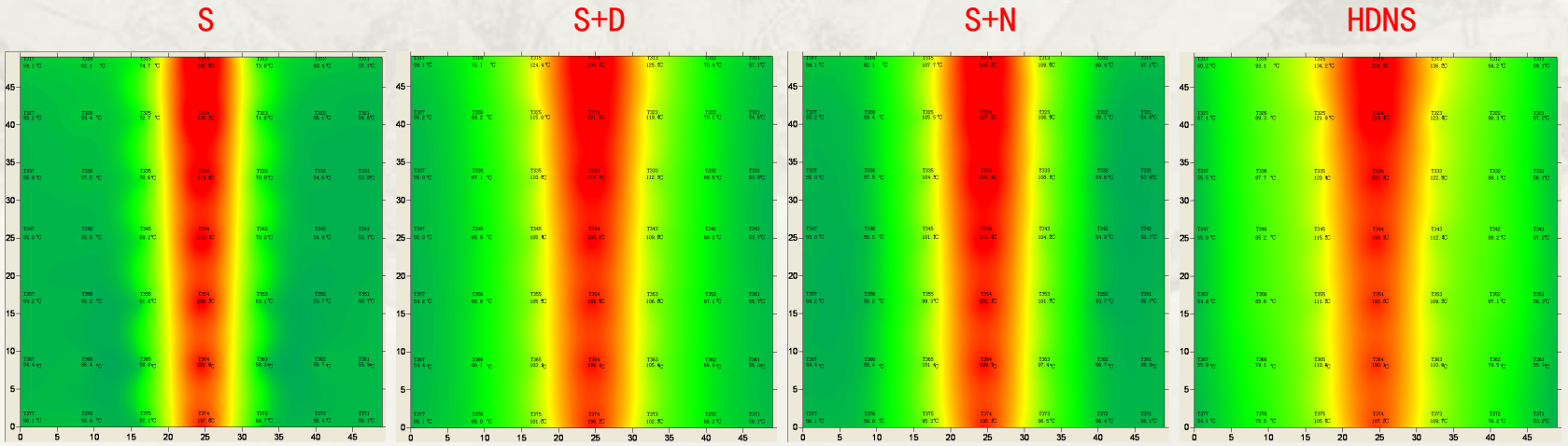
4 Applications in China



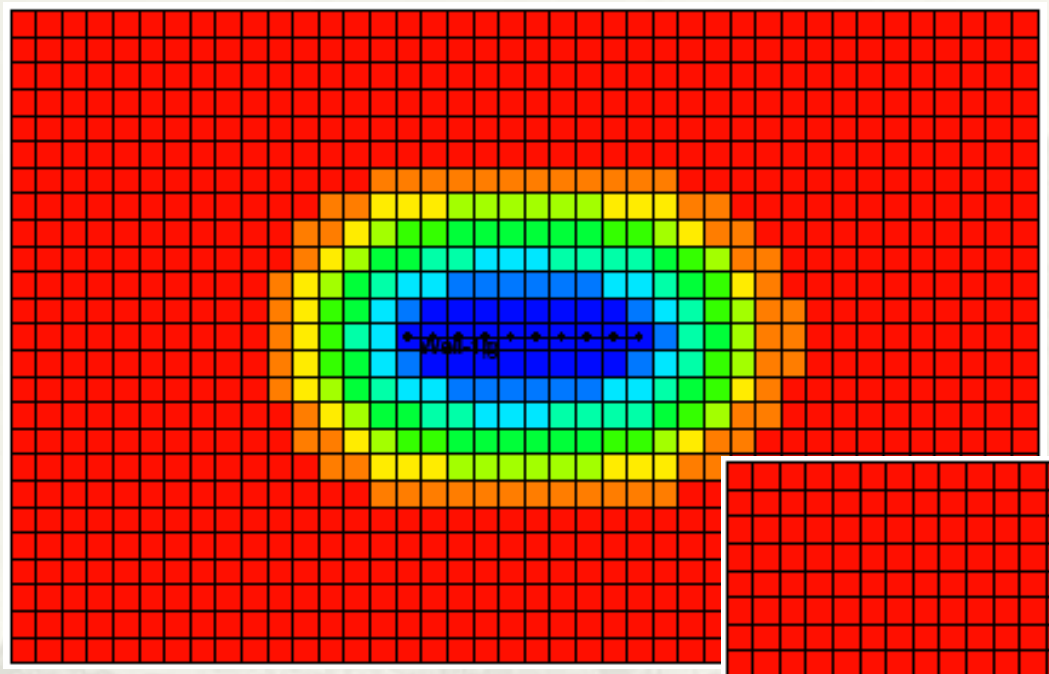


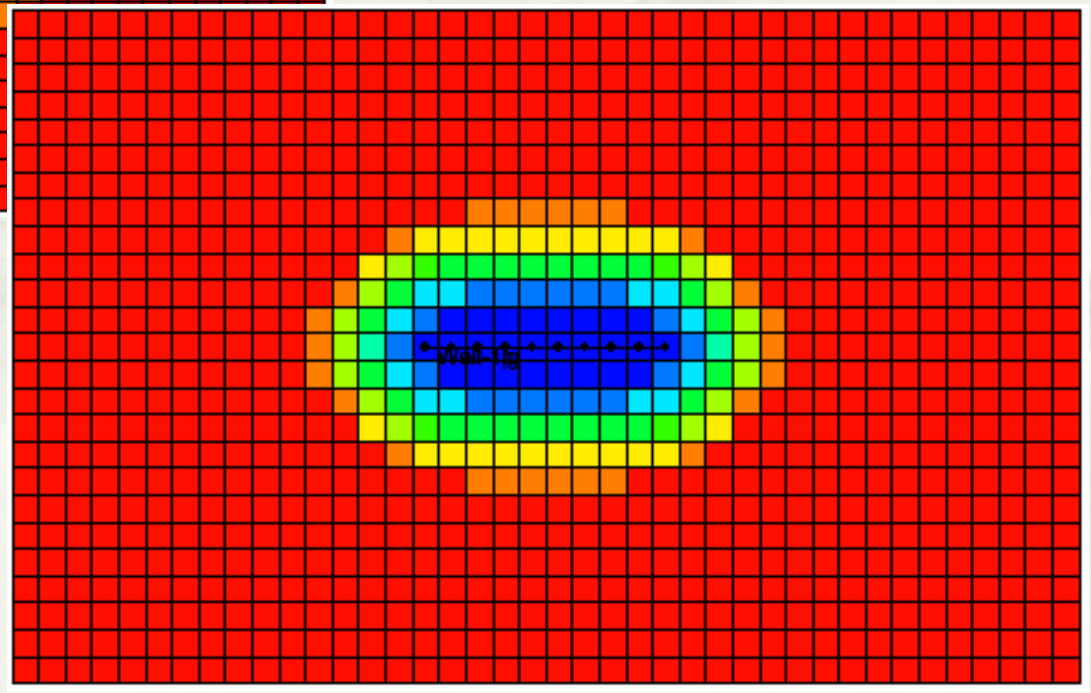
4 Applications in China



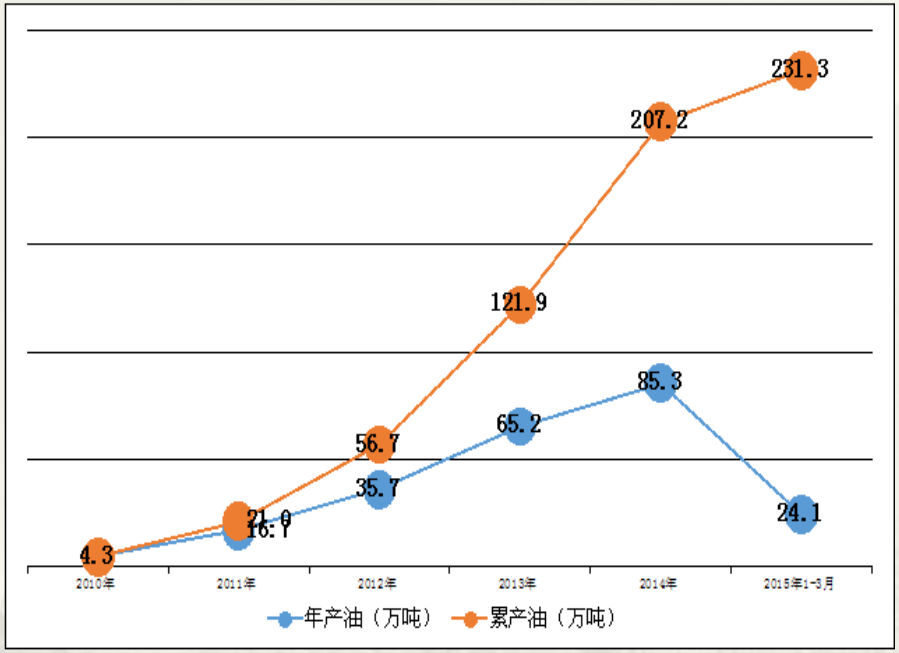


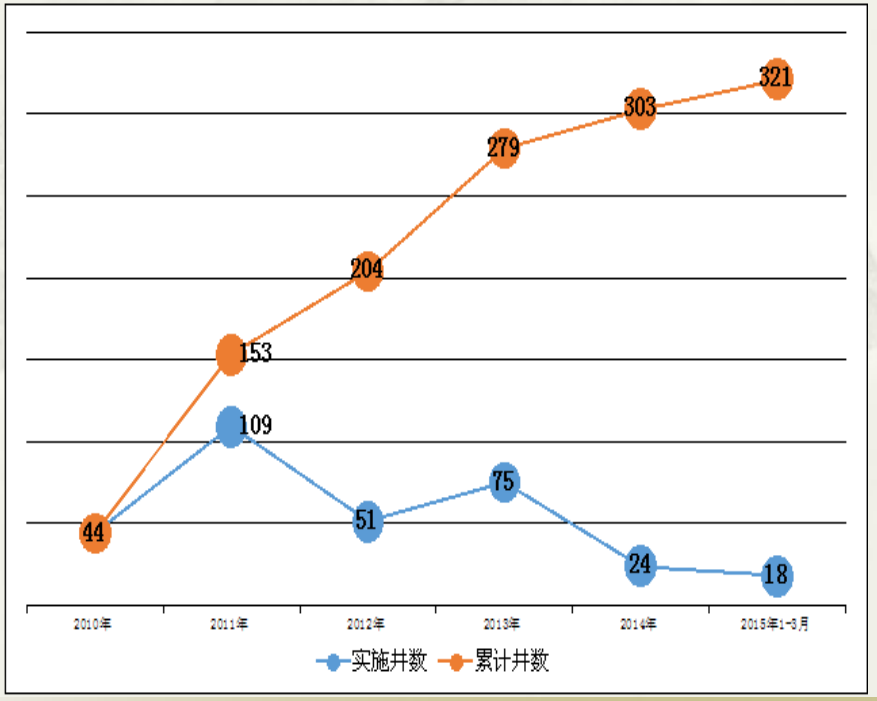
4 Applications in China





4 Applications in China





4 Applications in China

应用证明

项目名称	薄浅层超稠油油藏高效开发关键技术研究与应用		
应用单位	中国石油化工股份有限公司胜利油田分公司新春采油厂		
通讯地址	山东东营市西四路 633 号胜建大厦新春采油厂，257000		
应用成果起止时间	2014.4-2014.06		
经济效益（万元）			
年　　度	2014		
新增产值（产量）	63		
新增利税（纯收入）	21		
年增收节支总额	7		

阿拉德油田位于准噶尔盆地北缘，哈浅 22 块位于该油田东部，油藏埋深 570m 左右，油层厚度 7m，含油面积 2.5km^2，50℃脱气原油黏度 5720 mPa•s。哈浅 22 井采用蒸汽吞吐辅助氮气技术试采三个周期，峰值日产油 3~6t/d，周期生产天数 36~121 天，周期产油 174~425t，周期油汽比 0.15~0.22，回采水率 10%~52%。

为改善开发效果，部署了 1 口水平井（哈浅 22-平 1 井），水平段长度 230 米，采用 HDNS 开发技术，注入蒸汽 1600t，注氮气 2×10^{4}Nm^3，注降粘剂 15 t，投产后，峰值日产油 12t，已生产 17 天，平均日产油 10t，含水 51.2%，累产油 176t。原油价格 3620 元/吨，新增产值 63 万元，新增利税 21 万元，增收节支 7 万元。

应用单位（盖章）　　应用单位财务专用章

2014 年 6 月 10 日

应用证明

项目名称	薄浅层超稠油注氮类效开发关键技术研究与应用		
应用单位	中国石油化工股份有限公司胜利油田分公司新春采油厂		
通讯地址	山东东营市西四路 633 号胜建大厦新春采油厂，257000		
应用成果起止时间	2010.01-2013.12		
经济效益（万元）			
年　　度	2011	2012	2013
新增产值（产量）	60456	129130	230866
新增利税（纯收入）	33121	59330	103356
年增收节支总额	33421	59900	104250

车排子凸起春风油田位于准噶尔盆地西北缘，油藏埋深浅（450~600m），油藏温度低（26~29℃），油稠（油藏条件下原油黏度为 50000~90000mPa•s），属于超稠油；油层薄，油层有效厚度为 2~7m，油层平均厚度为 5m。采用常规热采技术开发效果差。

为改善开发效果，实现浅薄层超稠油油藏的高效开发，在春风油田排 601 中区、南区、排 6 南区、排 601-20、排 612 等 5 个区块探索实施了 HDNS 开发技术，共应用 277 口水平井/988 井次。

项目实施后，2011 年增油 16.3 万吨，原油价格为 3709 元/吨；2012 年增油 34.9 万吨，原油价格为 3700 元/吨；2013 年增油 63.8 万吨，原油价格为 3620 元/吨；2014 年 1-5 月增油 34.2 万吨，原油价格为 3620 元/吨。截止目前，累计增油 153.2 万吨，新增产值 480968 万元，新增利税 195807 万元，增收节支 197621 万元。

应用单位（盖章）　　应用单位财务专用章

2014 年 6 月 1 日

应用证明

项目名称	薄浅层超稠油油藏高效开发关键技术研究与应用		
应用单位	中国石油化工股份有限公司胜利油田分公司新春采油厂		
通讯地址	山东东营市西四路 633 号胜建大厦新春采油厂，257000		
应用成果起止时间	2010.06-2012.12		
经济效益（万元）			
年　　度	2010	2011	2012
新增产值（产量）	12887.1	35977.3	24420.0
新增利税（纯收入）	4747.1	16577.3	11220.0
年增收节支总额	4955.5	19070.0	12310.5

春风油田排 601 北区具有“浅、薄、低、稠”的特点，在开发中面临以下难点：(1) 地层温度下原油粘度高；(2) 储层埋藏浅，生产压差小；(3) 油层厚度薄，地层能量低。

为实现该区的高效开发，从 2010 年 6 月开始，在排 601 北区开始实施 HDNS 开发技术。项目实施后，2010 年实现增油 3.7 万吨；2011 年实现增油 9.7 万吨；2012 年实现增油 6.6 万吨。累计增油 20.0 万吨，新增产值 73284.4 万元，新增利税 32544.4 万元，增收节支 37231.0 万元。

同时，“春风油田排 601 浅层超稠油 HDNS 热化学吞吐开发试验” 被中石化授予“高效开发试验项目”称号。

应用单位（盖章）　　应用单位财务专用章

2013 年 1 月 5 日

Cumulative oil production: 173.22×10^{4}t

Contents

5 Conclusions

(1) The oil recovery factor are affected by the steam temperature and injection rate.

(2) The viscosity of crude oil can be obviously reduced by the injection of viscosity depressant, and the higher volume of viscosity depressant, the higher oil recovery factor. The injection volume is 0.05PV of viscosity depressant.

5 Conclusions

(3) Through the injection nitrogen ,the recovery can be enhanced by profile control and pressurization. And when 0.05PV viscosity depressant and 0.8PV nitrogen were injected, the recovery rate was heightest ,which was 76.48%.

(4) Steam, nitrogen and viscosity depressant have good synergistic effect, the HDNS technology provides a solution for the effective exploitation of super heavy oil reservoirs which are hard to be developed in the ordinary way. The injection parameters of these three parameters can be optimized rationally according to economic indicators in field application.

Contents

6 Acknowledgements

Thank you
for your attention