

More Efficient in Oil & Gas Extraction

# Nitrogen Stimulation Technology

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# Content

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I . Brief Introduction of Kerui Group

II . Nitrogen Stimulation and Injection-production Technology

III . Application Cases

## I . Brief Introduction of Kerui Group

**Kerui Group** is a very rapid development of comprehensive International enterprise group integrating **high-end petroleum equipment research, integrated oilfield engineering technological service, and oilfield EPC turnkey contracting.**



- 57 Global Branch Organization
- 16 R&D centers
- 7 Technical Support Centers
- 6 Research Laboratories

## I. Brief Introduction of Kerui Group — High-end Petroleum Equipment Research



Drilling Equipment Industrial Park



Oilfield Special Operations Equipment Industrial Park



Natural Gas Compressor Industrial Park



Wellhead Equipment Industrial Park

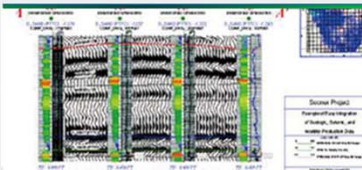
- High-end industrial park covers oil and gas exploration and development, oil and gas gathering processing, marine equipment, petroleum equipment full industry chain, in an area of **2.4 million** square meters.
- Meeting customers demand for **one-stop sourcing** (Drilling and workover machines, production equipment, operating equipment, wellhead equipment, compressors, process equipment of oil and gas, LNG equipment, special equipment, oil pipeline, etc).



# I. Brief Introduction of Kerui Group — Integrated Oilfield Engineering Technological Service

## Oil & Gas Field Integrated Solution Provide

- Oil & Gas Field Block Evaluation
- Single Well Program Design
- Single Production Increasing Program Design
- Economic Evaluation



## Drilling and Completion Integrated engineering technology service

- Drilling Engineering Service
- Drilling Fluid and Completion Fluid Technology Service
- Cementing Technology Service
- Directional Well Technology Service
- Mud Logging and Well Logging Technology Service
- Well Completion Engineering Technology Service



## Workover Operation Engineering Technology Service

- Conventional Workover Technology Services
- Complicated Oil & Gas Well Fishing Service
- Horizontal Well Sidetracking Technology Service



## Special Operation and Production Increasing Service

- Membrane Nitrogen Injection Engineering Technology Service
- Acidification and Fracturing Engineering Technology Service
- Coiled Tubing Engineering Technology Service
- Wet Steam Generator Technology Service



## Unconventional Oil and Gas Development Integrated Engineering Technology Service

- Individualized Geological Research and Evaluation
- Factory Mode Design and Construction
- Large-scale Project Implementation and Organizational Management
- Digitization Development Whole Process Management Platform



## I. Brief Introduction of Kerui Group — Oilfield EPC Turnkey Contracting



### DESIGN CAPACITY

- Kerui Group has long-term strategic cooperation with Xinjiang branch, CPE Beijing branch and Xinan branch
- 600 professional technicians
- 173 senior engineers



### PROCUREMENT CAPACITY

- Professional EPC procurement teams with more than 100 engineers
- Procurement localization
- Completed international procurement network platform and the excellent global transportation arrival capability



### CONSTRUCTION CAPACITY

- More than 1,200 engineering and construction personnel
- With more than 10 years construction experience to realize the localization of construction resources
- Construction and testing equipments are nearly 480 sets
- Comprehensive manufacture equipments are more than 200 sets, including pressure vessel, large-scale lifting, forming, welding and machining facilities



Oil and gas gathering and processing, gas processing and comprehensive utilization, LNG, water treatment, oil refining project, etc.

## I. Brief Introduction of Kerui Group



Powerful combination of multi-national enterprises with the best supplier integration capacity



All-in-one petroleum equipment manufacturer, reducing external procurement cost



Excellent capacity of global arrivals with the low transportation cost and high efficiency



Professional technical team, comprehensive integration of technical services, to ensure the project run efficiently



Fast and Efficient Ensure Global Customers Achieve Higher Revenue

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# Content

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I . Brief Introduction of Kerui Group

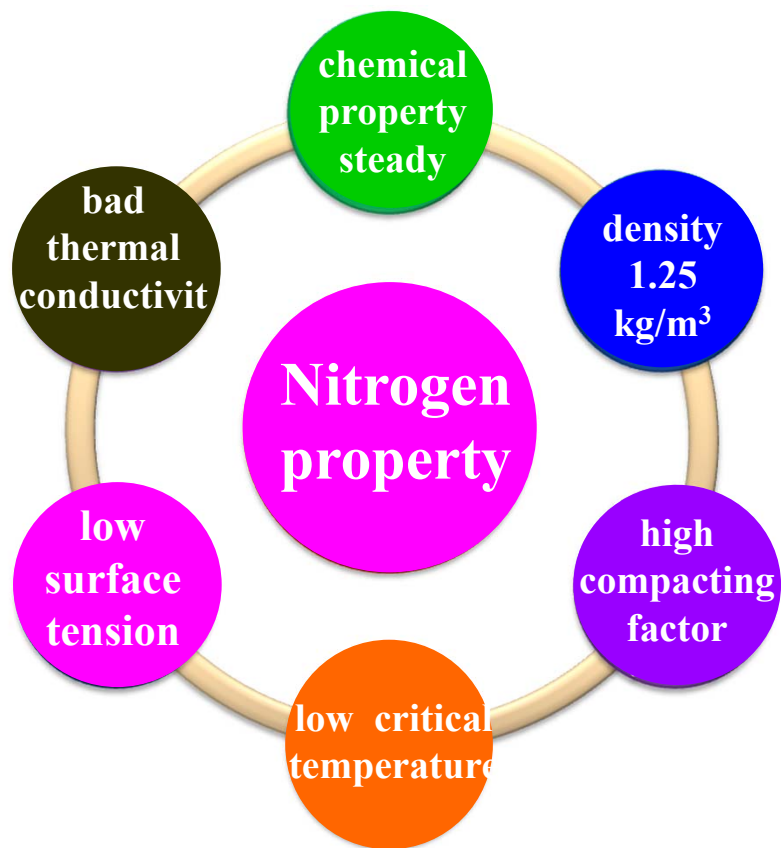
II . Nitrogen Stimulation and Injection-production Technology

III. Application Cases



## II. Nitrogen Stimulation and Injection-production Technology

### 1. Why Choosing Nitrogen



A kind of clean, efficient and safe renewable resources

## II. Nitrogen Stimulation and Injection-production Technology

### 1. Why Choosing Nitrogen

Comprehensive cost performance comparison table of different injection media

Comparative item	N <sub>2</sub>	CH <sub>4</sub>	CO <sub>2</sub>	Flooding
Price	Cheap	Expensive	Expensive	Cheap
Material obtain	Easy	Easy	Not easy	Easy
Security	Well	Bad	Well	Well
Miscibility	Hard	Little hard	Easy	Hard
Cost performance	High	General	General	Higher
Ground construction investment	Small	High	High	High
Displacement efficiency	Middle	High	Highest	Low
Maintenance workload	Light	Heavy	Lighter	Heaviest
Impact on environment	Nothing	Great	Nothing	Great

Nitrogen is the ideal medium injection

## II. Nitrogen Stimulation and Injection-production Technology

### 1. Why Choosing Nitrogen

#### ■ Nitrogen foam

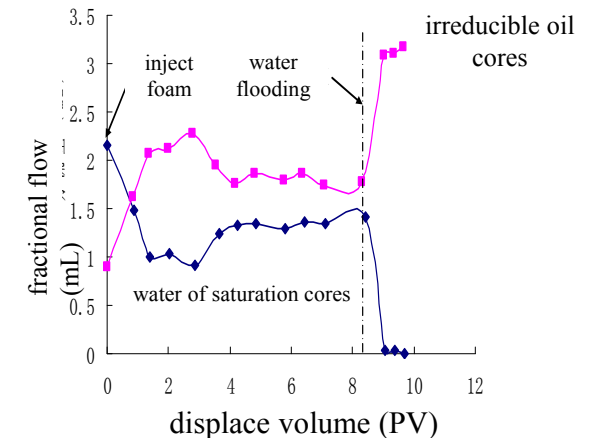
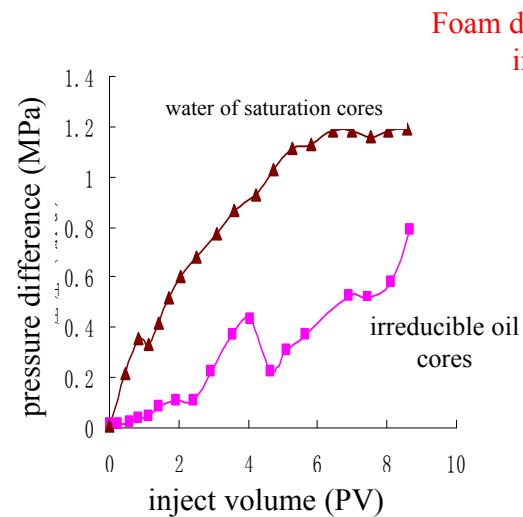
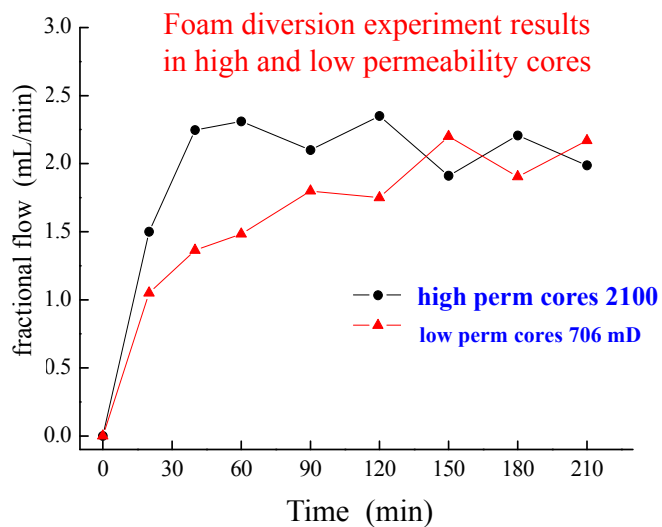
Foam system:  $N_2$ +foam agent+water;

Foam compound system: foam + polymer solution



#### Selective water plugging + SAA

- ◆ Adjustable density ; good stability;
- ◆ Small affected by temperature and pressure;
- ◆ High viscosity, strong carrying capacity;  
Reduce the loss of adsorption;
- ◆ Strengthen plugging ability and selectivity.

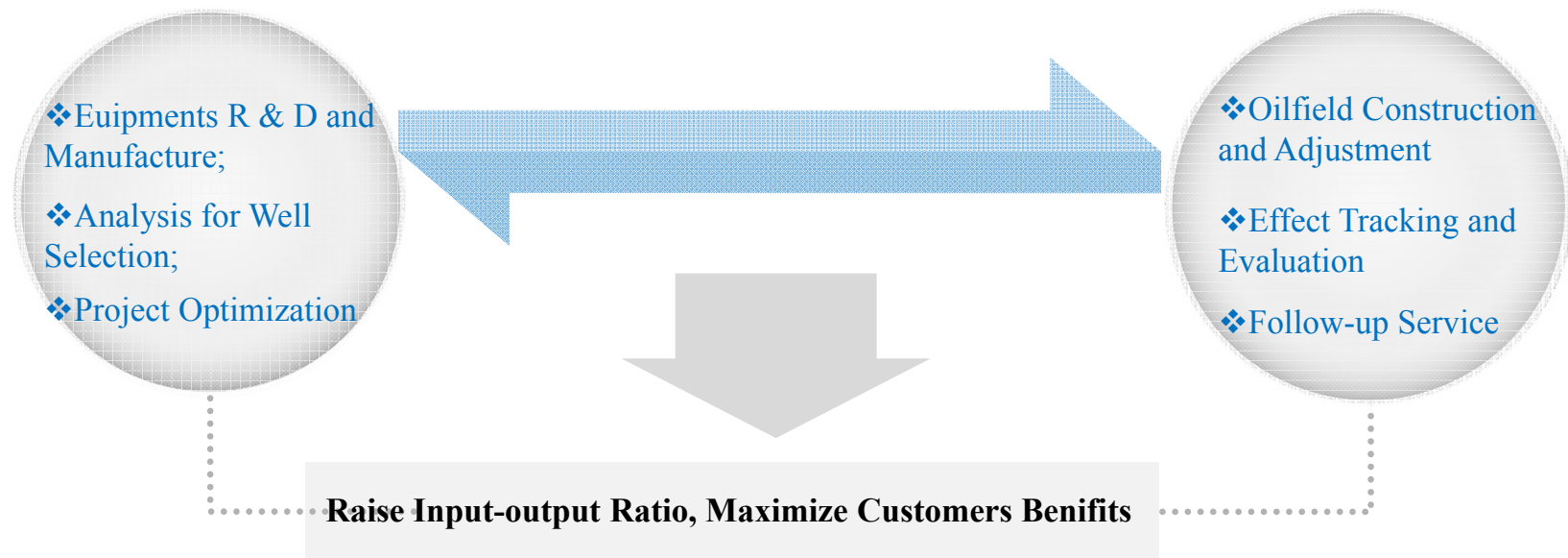


## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (1) “One-stop” All-around Service

#### Integrated Services and Solutions for End-to-end Oil Field Nitrogen Generation and Injection



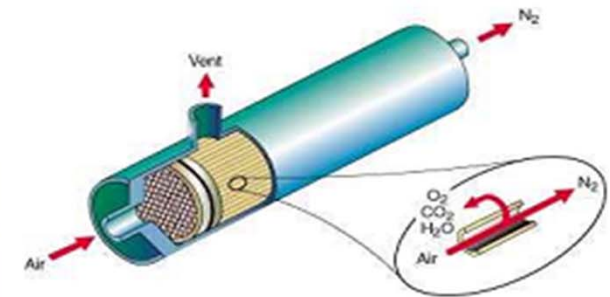
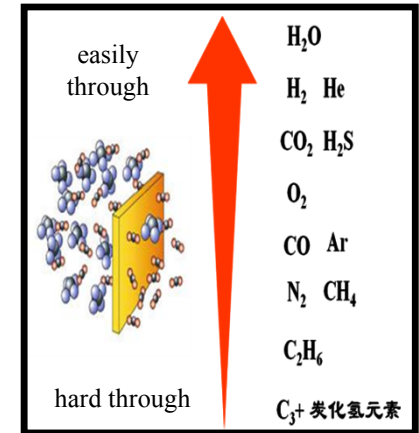
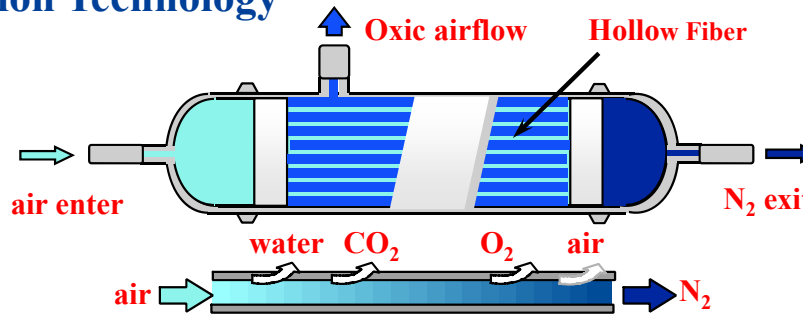


## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (2) Membrane Nitrogen Generation Technology

- **PRISM Composite Membrane;**
- Dry-wet Spinning and waterproof;
- Design index of oil resistance is 20 ppm;
- Radius of membrane wire is 0.5 mm and dust permeability through the membrane is high;
- Working pressure: 1.8 ~ 2.4MPa;
- Working temperature: 5 ~ 65°C;
- Separation Efficiency: 48 ~ 53%;
- Attenuation ratio per year:  $\leq 1.2\%$ ;
- The unit can work stably for ten years.



Applicable to high temperature, frigid, windy and dusty oilfield worksite.

## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (2) Membrane Nitrogen Generation Technology

- ❑ Meet the demand of Nitrogen for all kinds of construction conditions
- ❑ Simplify working process, cost savings
- ❑ More convenience and economy

**Nitrogen generation and  
nitrogen injection  
seamless docking**



Skid-mounted membrane separation  
Nitrogen generation equipment



Vehicle-mounted membrane separation  
Nitrogen generation equipment

## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (3) Manufactured the first offshore platform membrane nitrogen generation



- ❑ **N<sub>2</sub> flow capacity: 900Nm<sup>3</sup>/h**
- ❑ **N<sub>2</sub> purity: 95%-99.99%**
- ❑ **Normal discharge pressure:  
35MPa**
- ❑ **Diesel engine driven**

- Researched and manufactured the first offshore platform membrane nitrogen generation.
- Production of "the water filling nitrogen low density foam fluid flushing system" review by CCS
- The first application of offshore platform of diesel driven membrane separation nitrogen generation device, and applied to the cnooc bohai sea oil field.

## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (4) High volume, super pressure nitrogen gas generation

- Flow capacity: 2000, 3600Nm<sup>3</sup>/h
- Normal discharge pressure:
  - 35MPa (5000psi)
  - 50MPa (7000psi)
  - 70MPa (10000psi)
- Adapt environment temperature: -60°C~65°C





## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (5) High Purity Nitrogen

##### □ PSA Nitrogen making machine

(Carbon molecular sieve pressure swing adsorption nitrogen making machine)

- Electric power: 1650kW
- Nitrogen flow rate: 2000Nm<sup>3</sup>/h
- Output pressure: 50MPa
- Purity: **99.99%**



Medium voltage upcharging equipment in skid



High voltage supercharging equipment in skid



Air compressor



Nitrogen generating equipment in skid



Airhandling equipment in skid



Storage tank in skid

## II. Nitrogen Stimulation and Injection-production Technology

### 2. Nitrogen Service of Kerui Group

#### (6) Motivation in a Variety of Forms

Device Type	Air Compressor/ Booster	Pressure Rating (MPa)	Characteristic	Remark
Diesel driven	Diesel driven	35/70	Equipment performance is stable, suitable for remote scattered Wells	High cost
Electrical drive	Electrical drive	50	Low cost, easy to maintain and environmental protection	Use the wellsite power grid
Combination drive	Electrical drive	35/50	Power load small	Costs less
Driven by gas engine	Driven by gas engine	50	Nearby using natural gas, high performance-price ratio	Use gas source

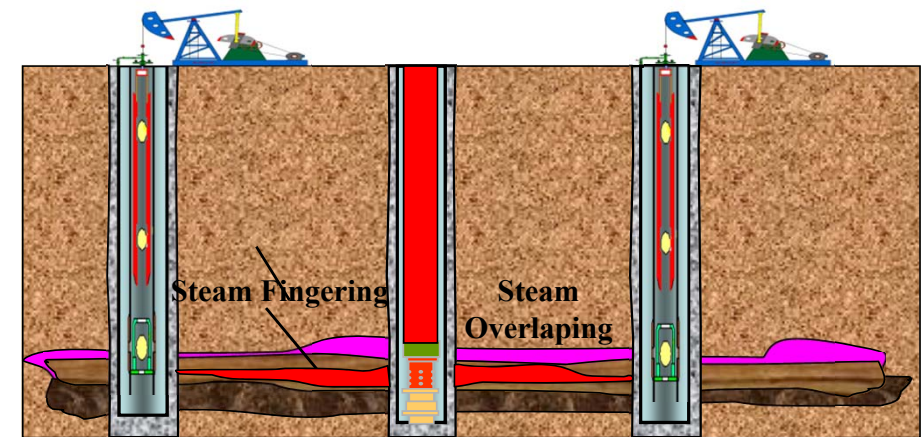
Combination drive and Electrical drive can be exchanged , improve the complex environment adaptability and economy.

## II. Nitrogen Stimulation and Injection-production Technology

### 3. 9 Nitrogen Stimulation Service Technologies

#### Enhance Oil Recovery

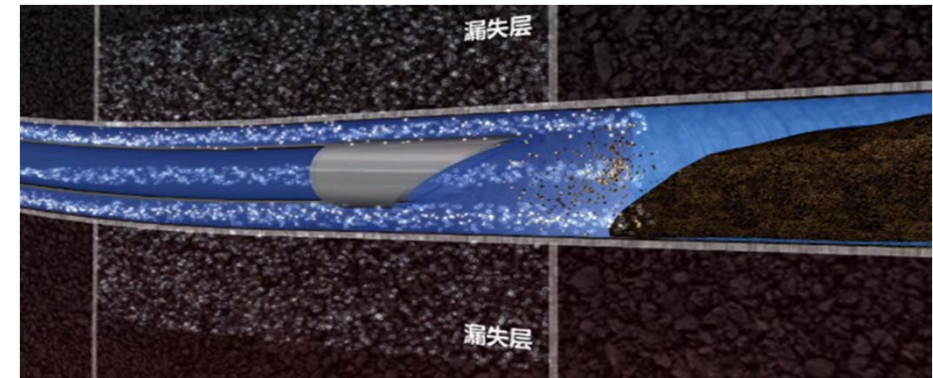
- Nitrogen Huff and Puff Technology
- Nitrogen Flooding/WAG Flooding Technology
- Nitrogen Foam Combination Flooding Technology
- Nitrogen Foam Profile Control (Water Coning Control) Technology
- Nitrogen Energization and viscosity reduction (heavy oil reservoir)



Nitrogen foam profile control technology

#### Production Auxiliary

- Nitrogen Unbalanced Drilling Technology
- Nitrogen Foam Sand-washing Technology
- Nitrogen(Foam)Flowing Back & Induced Flow Technology
- Nitrogen Displacement/ Sweep Technology



Nitrogen foam sand-washing Technology

## II. Nitrogen Stimulation and Injection-production Technology

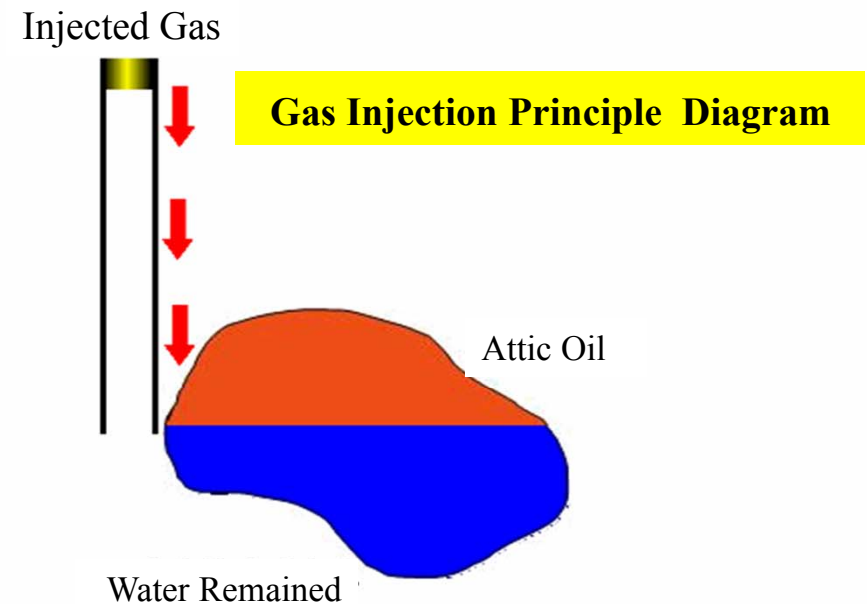
### 3. 9 Nitrogen Stimulation Service Technologies

#### (1) Nitrogen Huff and Puff

To inject a certain amount of nitrogen into oil well in a short time and shut in for some time. When the nitrogen diffuses in the reservoir :

- Gravitational differentiation displacement
- Dilatation energy displacement
- Water coning control

are employed to displace the crude oil in the reservoir to enhance oil recovery.

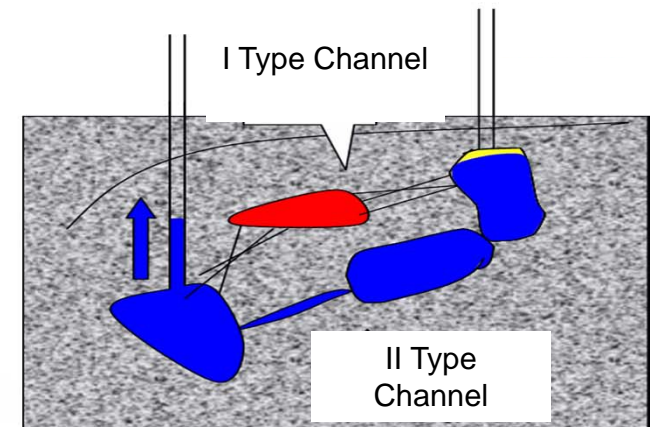
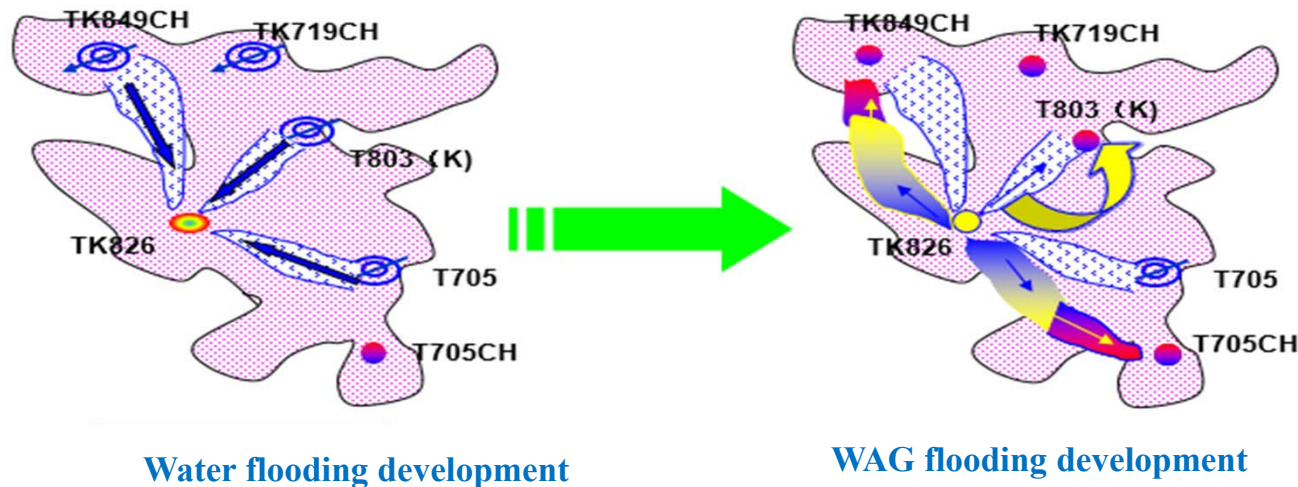




## II. Nitrogen Stimulation and Injection-production Technology

### 3. 9 Nitrogen Stimulation Service Technologies

#### (2) Nitrogen Flooding/ WAG Flooding

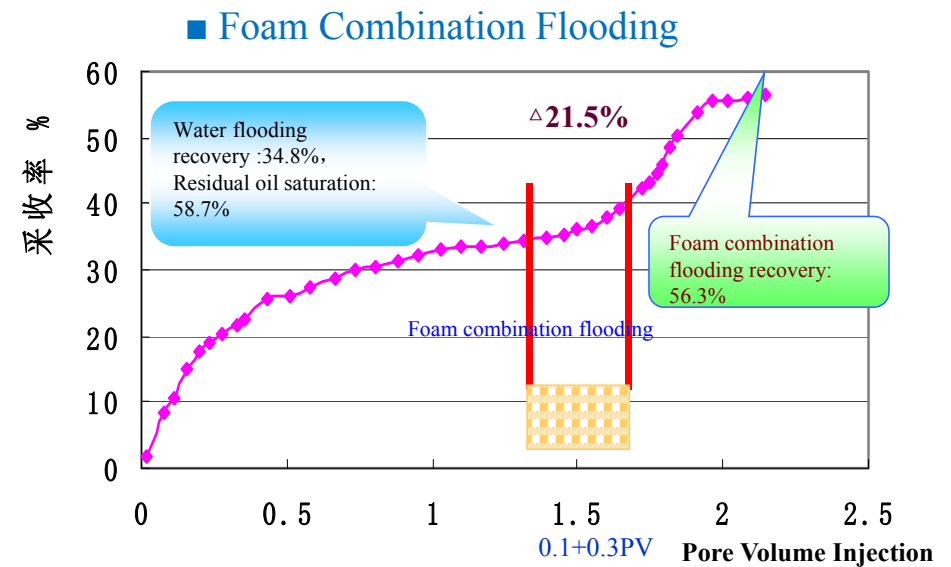
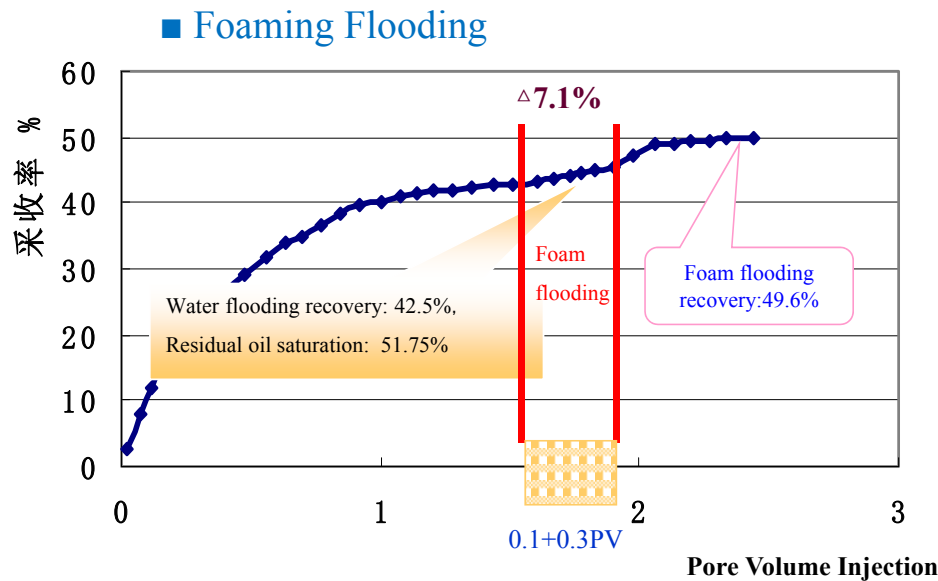


Utilize high injection/ low production well pattern and WAG injection mode to change strong/weak streamline distribution (After gas is injected to higher part of the reservoir, it gathers at II type of channel. With the pressure increase weak streamline will open ). Thus residual oil between wells is driven out and oil recovery is enhanced.

## II. Nitrogen Stimulation and Injection-production Technology

### 3. 9 Nitrogen Stimulation Service Technologies

#### (3) Nitrogen Foam Combination Flooding



Test model: double tube: 60×2.5cm  
permeability: 2, 0.8μm<sup>2</sup>  
temperature: 80℃

back pressure: 6.0MPa  
oil viscosity: 81mPa·s  
water salinity: 8379mg/L

## II. Nitrogen Stimulation and Injection-production Technology

### 3. 9 Nitrogen Stimulation Service Technologies

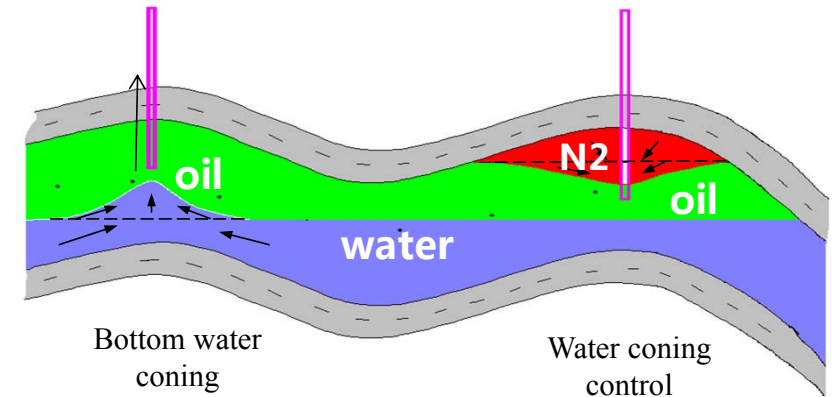
#### (4) Nitrogen Foam Water Coning Control Technology

##### Deficiency in traditional schemes

- It is not easy to control the pressure.
- Plugging rate reduced with the increase of water injection.
- Artificial interlayer and anti-water-coning application effect is not ideal.

##### Advantages of this technology

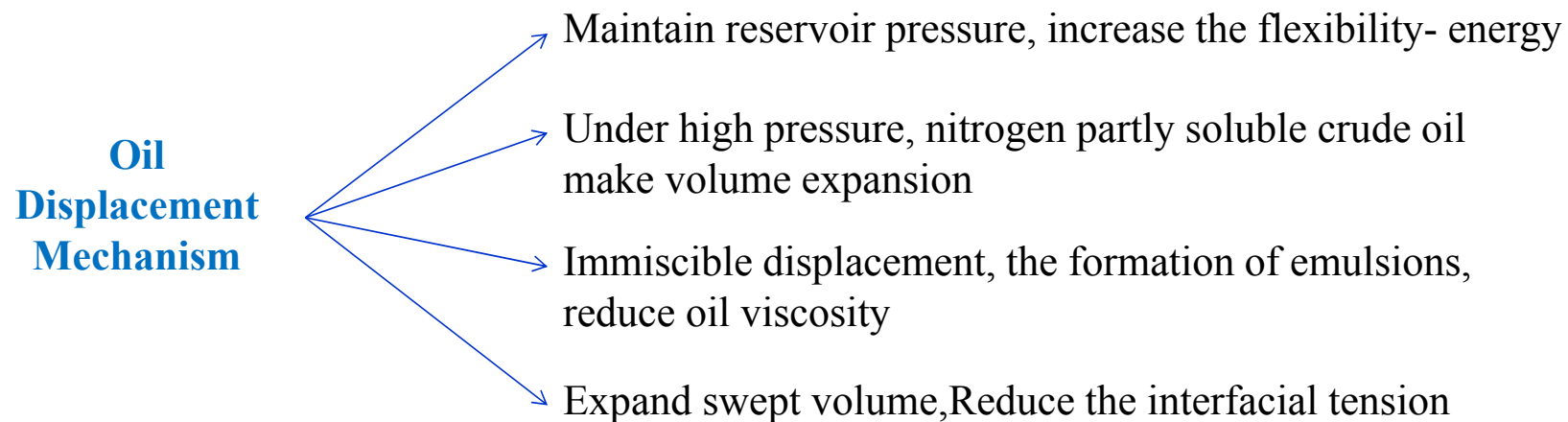
- Covering deficit of formation energy and slowing down bottom water coning
- Gravitational differentiation forms secondary gas top to increase elastic energy
- Nitrogen foam blocks bigger pores to shut off water
- Nitrogen foam has good stability in porous media



## II. Nitrogen Stimulation and Injection-production Technology

### 3. 9 Nitrogen Stimulation Service Technologies

#### (5) Technology of energizing & viscosity reduction with Nitrogen (Heavy oil reservoir)





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# Content

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I . Brief Introduction for Kerui Group

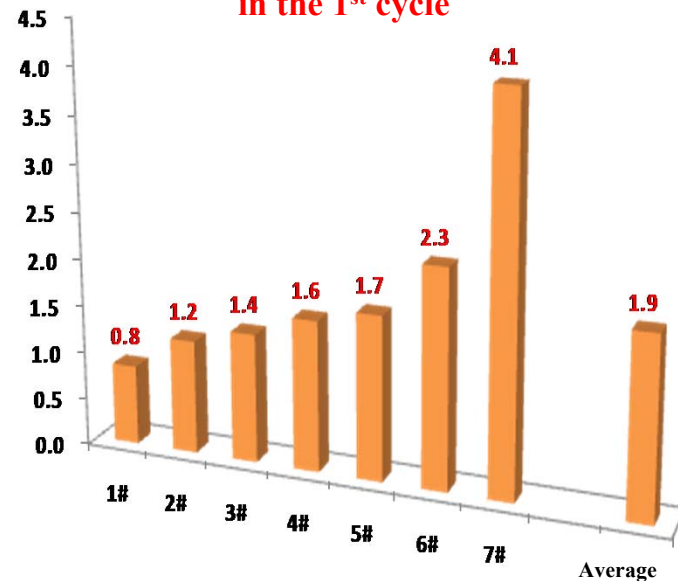
II . Nitrogen Stimulation and Injection-production Technology

III . Application Cases

### III. Application Cases

#### 1. Nitrogen Huff and Puff (Carbonate Reservoir)

**Gas oil replacement ratio  
in the 1<sup>st</sup> cycle**



Well No.	Gas injection rate (10 <sup>4</sup> m <sup>3</sup> )	Water injection rate (m <sup>3</sup> )	Before gas injection			After gas injection			Compare		oil increment in the 2 <sup>nd</sup> Cycle (t)
			Daily fluid production (t)	Daily oil production (t)	Water cut (%)	Daily fluid production (t)	Daily Oil production (t)	Water cut (%)	Daily oil production (t)	Water cut (%)	
1#	826m <sup>3</sup>	200	35	0	100	53.0	12.6	69.0	12.6	-31.0	1453
2#	50	979	10	0.4	93	24.2	22.6	6.7	22.2	-86.3	131.4
3#	50	1093	16	0.5	99	19.3	7.2	62.7	6.7	-36.3	895
4#	60	1348	23	2	87	19.6	5.6	71.7	3.6	-15.3	554
5#	50	1850	41	1.5	96	45.1	6.3	85.7	4.8	-10.3	6.3
6#	50	793	54	2	93	28.3	9.5	61.0	7.5	-32.0	742
7#	55	1379	17	0.1	92	57.0	11.3	54.3	11.2	-37.7	799
Average	/	/	28	0.93	94.3	35.0	10.7	58.7	9.8	-35.6	654

### III. Application Cases

#### 1. Nitrogen Stimulation (Tight Sand Reservoir) —— tight sandstone reservoir in Peru

##### Challenge

- Porosity 5%-25%
- Low permeability, between 0.01 ~ 2mD
- Low recovery with flexible develop

##### Solution

- Nitrogen energizing, lifting formation pollution, dredging oil flow passage
- Nitrogen form a "gas cap", increase the driving pressure, increase crude oil production

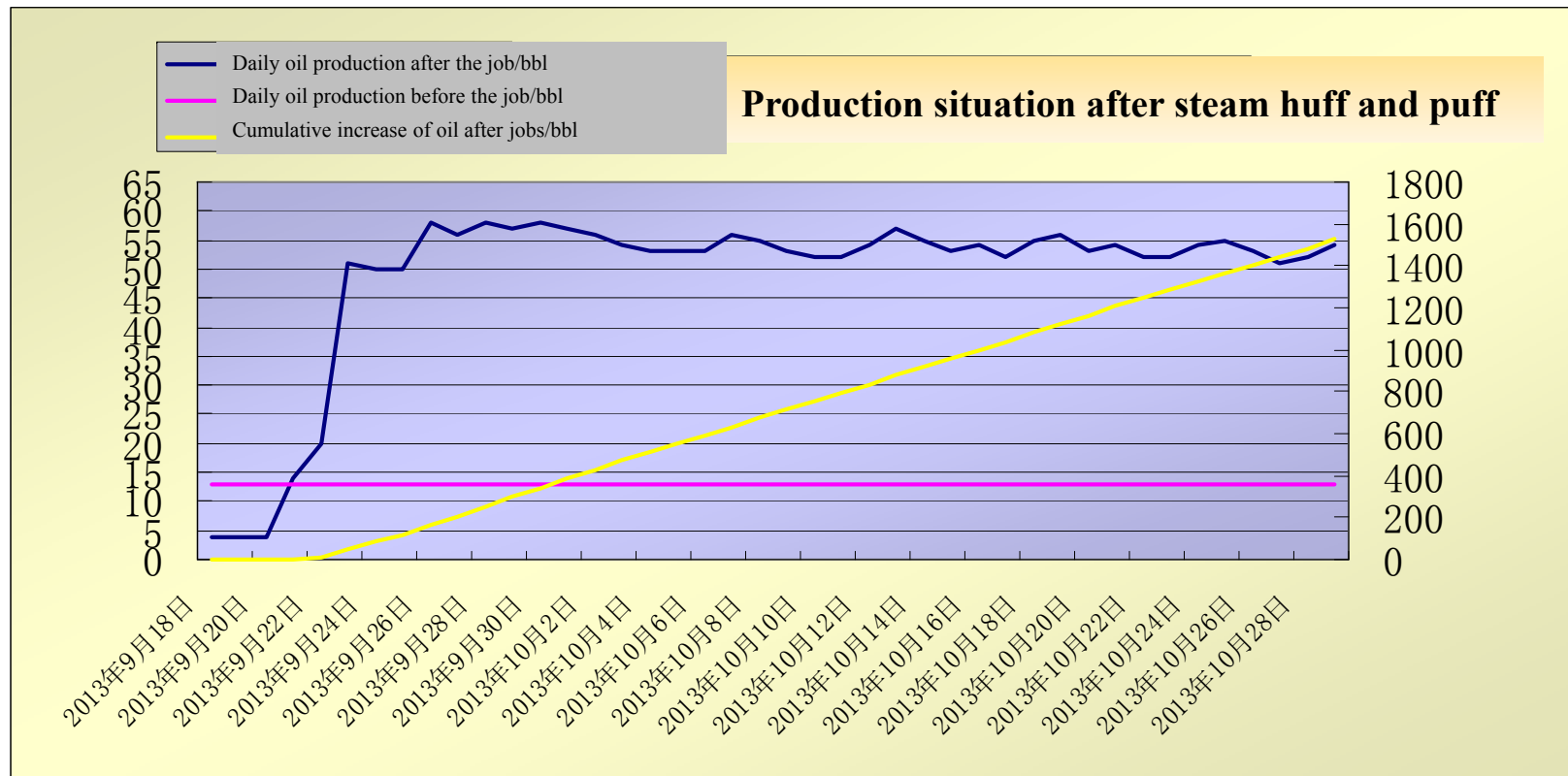
##### Customer value

- Operation results in 40 wells show that the single well production increment is 2,300 barrels



### III. Application Cases

#### 1. Nitrogen Stimulation (Tight Sand Reservoir)

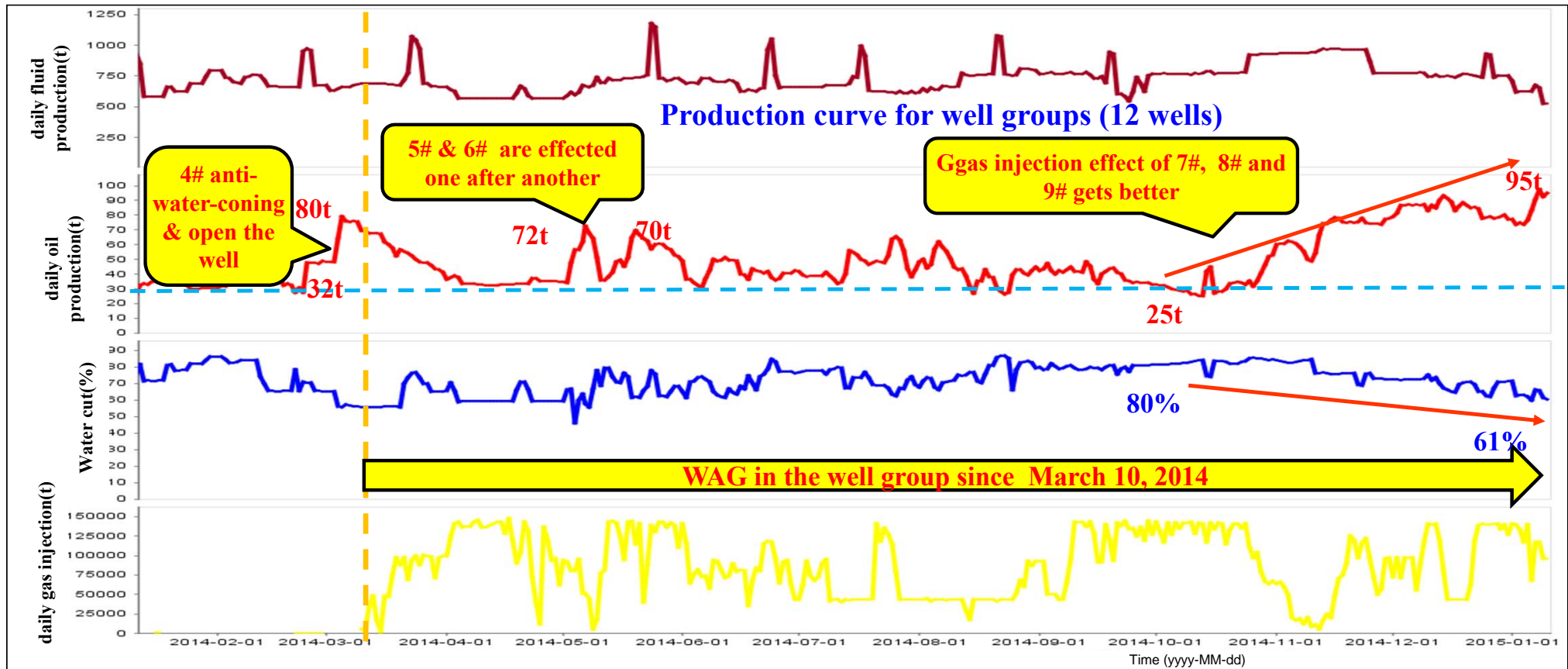


Gas injection rate 48321 cube (1,546300 c . f . ), gas injection time 49h, increase production > 3000bbl by the end of that year.



### III. Application Cases

#### 1. Nitrogen Stimulation (Tight Sand Reservoir)



### III. Application Cases

#### 3. Nitrogen Foam Combination Flooding

##### Reservoir Characteristics:

■  $D=1125\text{m}$  ,  $\varphi=37\%$  ,  $K=2304\text{mD}$

■  $\rho=0.9743\text{g/cm}^3$  ,  $\mu_o=1619\text{mPa}\cdot\text{s}$

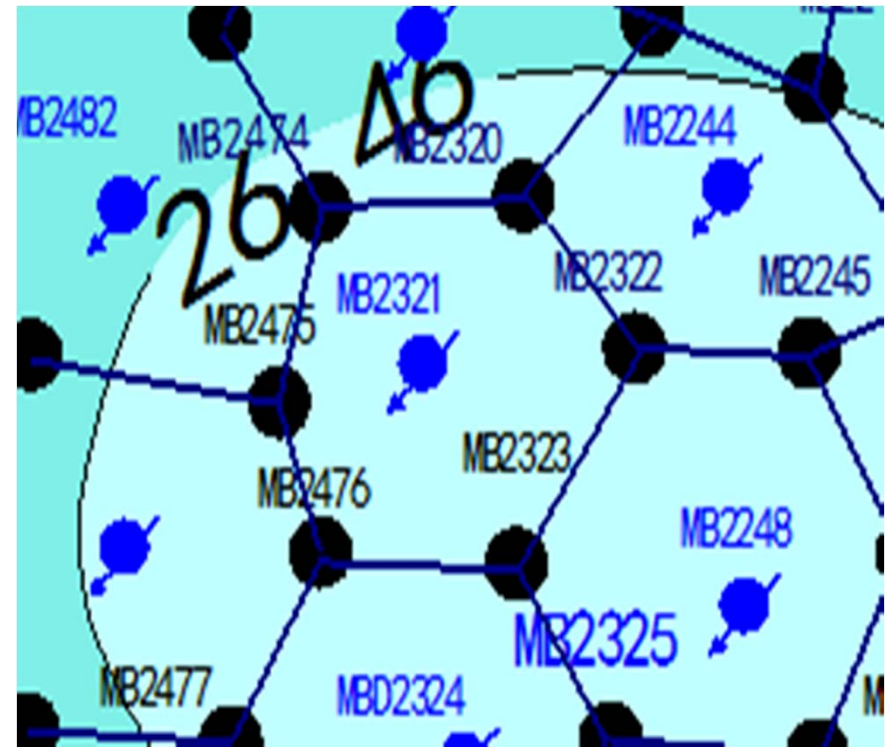
■  $P_i=11.27\text{MPa}$  ,  $T=60^\circ\text{C}$

##### Implementation Situation:

■ Utilize clear water to prepare mother solution and inject after dilution with waste water.

■ Pre-slug:  $0.03\text{PV} \times (1800\text{mg/L Polymer} + 1.0\% \text{ Foaming agent})$ , it is used for leading edge pretection and sacrifice.

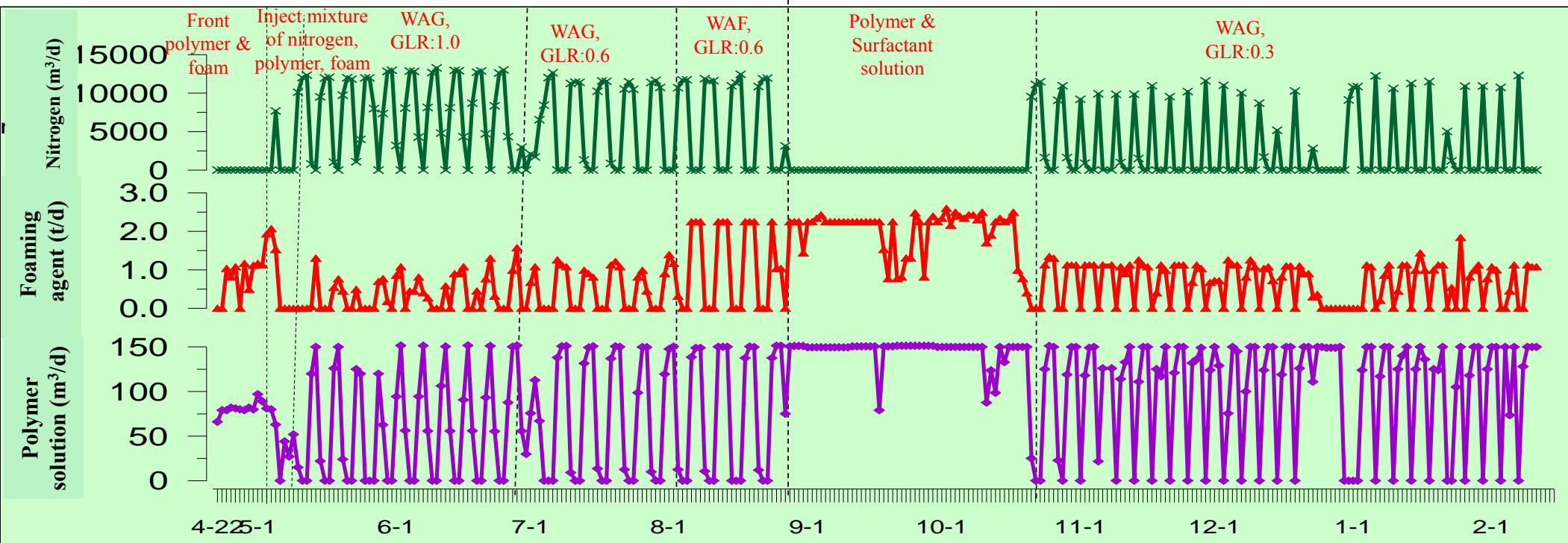
■ Main slug:  $0.3\text{PV}$ , Nitrogen and  $[1600\text{mg/L Polymer} + 0.5\% \text{ Foaming agent}]$ , alternate injection, alternate period is 4 days [Gas injection two days and liquid injection two days].



### III. Application Cases

#### 3. Nitrogen Foam Combination Flooding

Injection Curve for Central Well

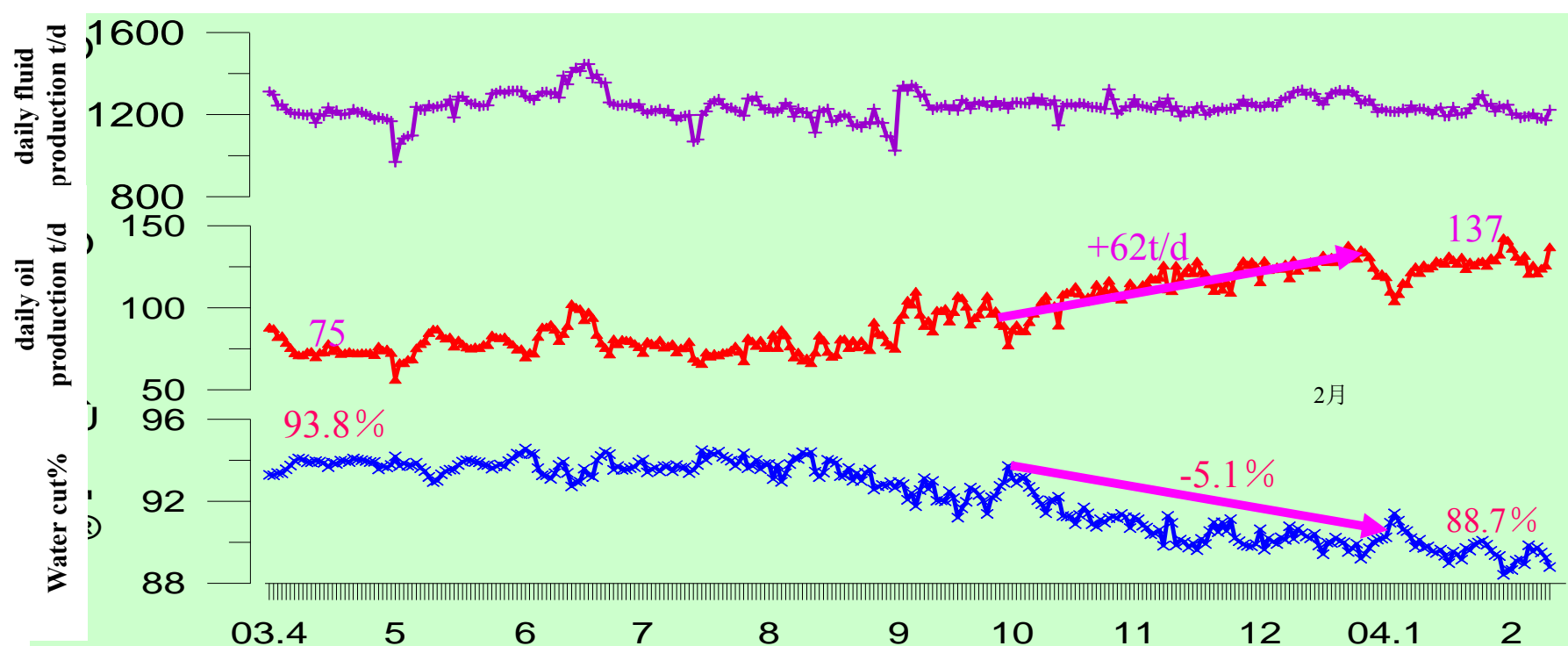


Cumulative injection: nitrogen  $103.6 \times 10^4 \text{ m}^3$ , polymer 53.4 t, surfactant 259.6 t.

### III. Application Cases

#### 3. Nitrogen Foam Combination Flooding

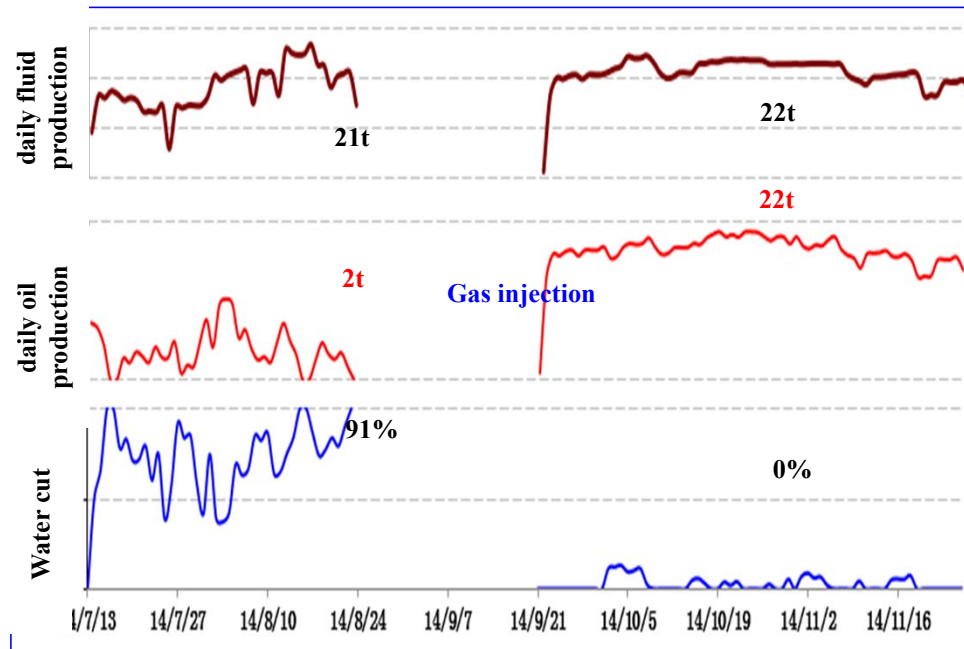
Daily oil production of this well group significantly increased while water cut remaining decline.



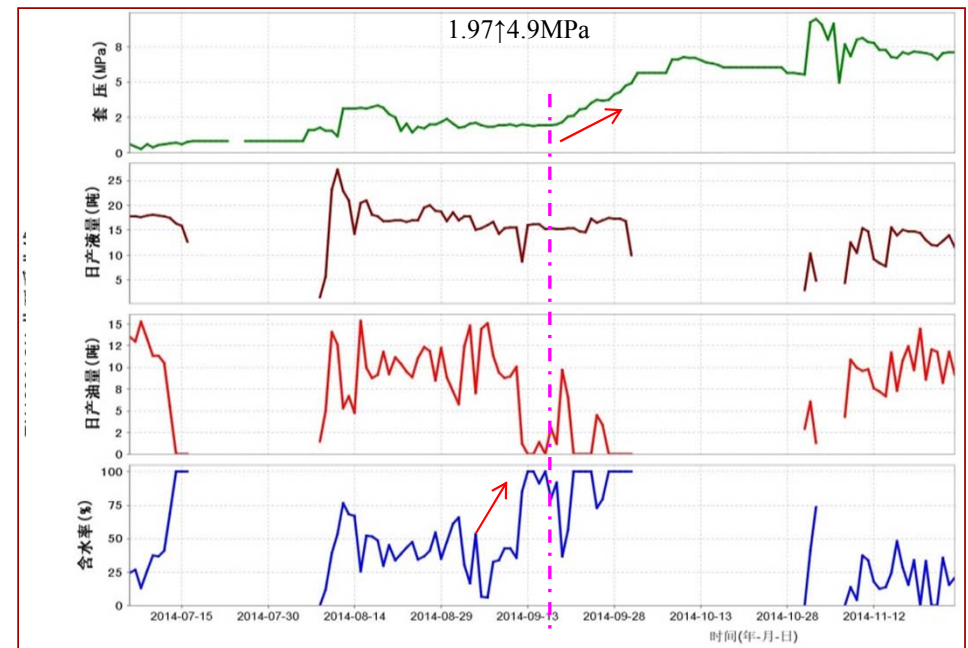


### III. Application Cases

#### 4. Nitrogen Foam Water Coning Control



Low water cut, stable oil production, good coning control effect, with the oil increment in this stage **1413t**.



Production curve for XX well during operation period

## Introduction for Kerui Nitrogen Stimulation Technology

More Efficient in Oil & Gas Extraction

### 4. Nitrogen Foam Water Coning Control

#### Challenge

- HS heavy oil reservoir: buried depth 504 m, low permeability, medium porosity, medium to strong acid sensitivity and medium to weak water sensitivity and salt sensitivity.
- Steam huff and puff: now in the high water cut development stage. With the continuous increasing of recovering, the edge-bottom water intrusion is serious due to reservoir pressure drop and heterogeneity.

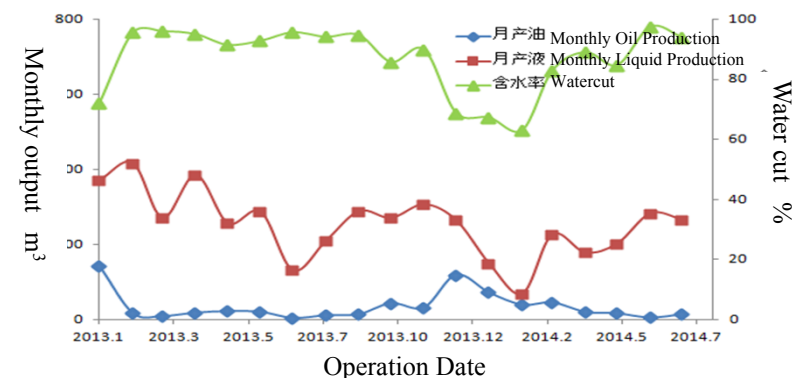
#### Solution

- To enhance oil recovery by the ways of injecting nitrogen foam, blocking high permeability zone, suppressing bottom water coning, and increasing the steam sweep efficiency.

#### Customer Value

- By the end of 2014, the success rate is over 80% in the overall project; water cut decreased by 22.0% after operation, monthly output in the peak increased by 86.0m<sup>3</sup> than before.

Production curve of H4 well before and after operation



### III. Application Cases

#### 5. Energization and Viscosity Reduction for Heavy Oil

##### Challenge

- Heavy oil exploitation in alternating thin layers of Columbia is hard to enhance oil recovery influenced by interlayer heterogeneity and physical properties of crude oil.
- Crude oil: API°12.5-15, high viscosity, poor fluidity. VSH: 10-15%, salinity: 8000-20000 ppm.

##### Solution

- Profile control technolog of thermal recovery system in alternating thin layers, supported with the casing insulation in injection process, Nitrogen and steam slug injection technologies, form the complete set of heavy oil development system in Colombia.

##### Customer Value

- Operation results in 556 wells show that the average single well production increment is 2600 barrels.

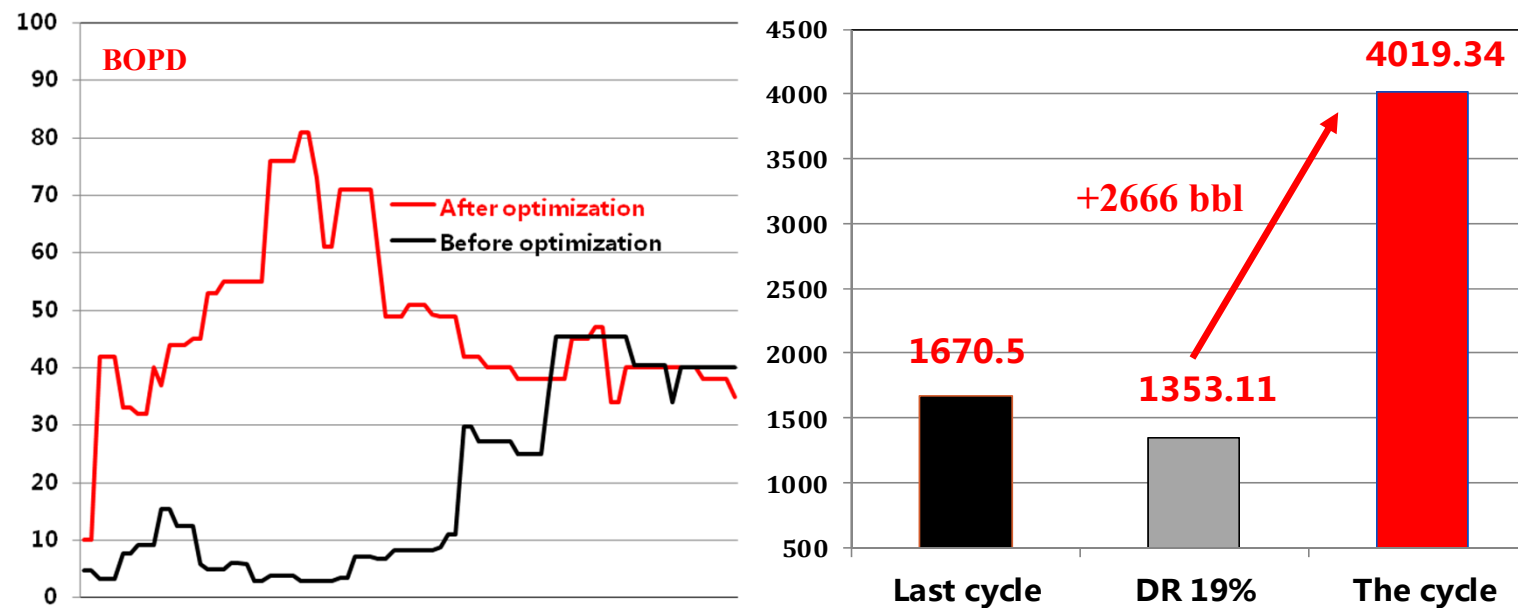
Heavy oil stimulation project in Columbia



### III. Application Cases

#### 5. Energization and Viscosity Reduction for Heavy Oil

##### Oli Increment Statistics of XX Well in G Oilfield



Steam: 5500MMBTU, Nitrogen: 65500m<sup>3</sup>, Foaming agent: 5t; Oil increment in one cycle: 2666 bbl



## Global Customers



We provide oilfield equipment, technical solutions and services for over **220** oil companies and over **350** engineering and service companies worldwide.

# Customer Referral

More Efficient in Oil & Gas Extraction

Best and high efficiency serves - got customer high approval from the customers



Customer referrals from overseas (Columbia, Peru etc.) and domestic (Sinopec, CNPC , CNOOC) petroleum companies.

## A Doer for Social Responsibilities



Kerui Charitable Foundation Establishment



Donating for Hope in Elementary School



Participating in Bogota Marathon



Donating for Yushu Earthquake Disaster Area



Participating in Dongying International Marathon



Donating for Kerui Charitable Foundation



MORE EFFICIENT IN OIL&GAS EXTRACTION

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- After-sales service email : [service@keruigroup.com](mailto:service@keruigroup.com)