Implementation of CO2-EOR Huff ‘n’ Puff Pilot Test in Oil Fields Offshore of Vietnam

- Advances in CO2-EOR Research –

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Agenda

1. Introduction
2. Operation Planning and Design
3. Pilot Test Operation
4. Pilot Test Results
5. Conclusions
Agenda

1. Introduction

2. Operation Planning and Design

3. Pilot Test Operation

4. Pilot Test Results

5. Conclusions
1. Introduction - objectives

To study the CO2 EOR applicability to the offshore oil field in Vietnam through an international joint study between Japan and Vietnam.
1. Introduction - test field overview

= Reservoir Description =

- API Oil Gravity : 36-38
- Pressure (initial) : 3,100 [psi]
- Depth : 2,100 [m]
- Oil Saturation : over 30 [%]
- Permeability : over 10 [md]

About 120km Offshore of Vung Tau
Agenda

1. Introduction

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3. Pilot Test Operation

4. Pilot Test Results

5. Conclusions
Three Stage Actions

- Huff
- Soak
- Puff

Objectives

- To Confirm **CO2 Injectivity**
- To Confirm **Increased Oil Production**
- To Confirm Some **Mechanisms of CO2 EOR**
  - Volumetric Swelling
  - Viscous Reduction Effects
  - Change in Oil Property

- Single Well
- Short Test
- Small CO2 Requirement
- Minimum Impact to The Facility
2. Operation Planning and Design

“Test Well”
(LM Section of BM producer)

Lower Miocene

Actual Reservoir Pressure (=2,800 psi)
Higher than Expected (2,400~2,600 psi)

Actual Oil Saturation (=Avg 31-36% by RST)
(Estimated Oil Saturation before The Test=20-30%)

Low Deviation (24 deg)
Agenda

1. Introduction

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3. Pilot Test Operation - operation sequence

- P&A of Lower Reservoir Section
- Perforation of The Target Section
- Pre CO2 Injection Flow
- Shut-in & RST Logging #1
- CO2 Injection
- Soaking & RST Logging #2
- Post CO2 Injection Flow
- Shut-in & RST Logging #3
- MPLT Logging & BHS
- P&A of Target Section

Total: 18 days
Agenda

1. Introduction
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4. Pilot Test Results - CO₂ injection performance

Total CO₂ Injected Volume = 111 [ton] (=2.1 [MMscf]), MMP = 2,980 [psi]
4. Pilot Test Results - production performance

- **Oil Rate**
- **GOR**
- **BS&W**
- **Choke Size**
- **CO2 in Gas**
- **API 60**

**Pre Flow**

<table>
<thead>
<tr>
<th>Date</th>
<th>Oil Rate [bb/d]</th>
<th>GOR</th>
<th>BS&amp;W</th>
<th>Choke Size</th>
<th>CO2 in Gas [API]</th>
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**Post Flow**

- **API**
- **Oil Rate**
- **Water Cut**
- **CO2 Concentration**


**Growth**: 950 bpd -> 1,500 bpd +550 bpd (1.6 times)
4. Pilot Test Results - production performance

Oil Rate

<table>
<thead>
<tr>
<th>Date</th>
<th>Oil Rate [bbl/d]</th>
<th>GOR (scf/stb)</th>
<th>BS&amp;W</th>
<th>Choke Size</th>
<th>CO2 in Gas</th>
<th>API 60</th>
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</table>

Water Cut = 50-60% -> 0%

Water Cut [API 60; Choke Size [1/64'']; CO2 in Gas [%]]

Date
4. Pilot Test Results – the logging analysis

- **ELAN** (OH Log in 1997)
- **#1 RST** (Before CO2)
- **#2 RST** (After CO2)
- **TPHI**
- **#3 RST** (After Post-Flow)

**Zone**

- **Mainly Water**
- **Perm**
- **0.1**
- **100**
- **So**
- **1**
- **Zone**
- **4**
- **Zone**
- **5**
- **Zone**
- **6**
- **Zone**
- **7**
- **Zone**
- **8**
- **Zone**
- **9**

**CO2**
- **Best CO2 Injected Zone**
- **So reduction by CO2 Inj.**
- **2nd Best CO2 Injected Zone**
- **Oil bank**

**Swept out**

**Perf.#1**

- **High Perm.**
- **Shale**
- **Mid. Perm.**

**Perf.#2**

- **High Perm.**
- **Shale**
- **Mid. Perm.**

**TPHI**

- **Before CO2**
- **After CO2**
- **Post-Flow**

- **0 So 1**
- **0.45**
- **-0.15**

**Net**

- **Swept out**
4. Pilot Test Results – the fluid analysis

Oil Samples
- Oil Fingerprint
- Oil Composition

Viscosity & Swelling Test

- Oil fingerprint analysis shows the same type of oil produced as the other Lower Miocene wells.
- Oil composition analysis also indicates there is not much difference with the representative Lower Miocene oil.
- Oil swelling and viscosity reduction test shows the improvement of oil mobility by CO2 is calculated more than 3 times of the original flowing condition.
4. Pilot Test Results – the simulation analysis

Simulation Model

Production Oil Rate
- Actual
- No Injection Case
- CO2 Injection Case

At The End of Soaking

<table>
<thead>
<tr>
<th>Layer</th>
<th>Zone</th>
<th>Assumption</th>
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<td>7</td>
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<td>Oil Zone</td>
</tr>
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</table>
4. Pilot Test Results – the simulation analysis

Production Oil Rate

The differential oil rate between No injection and CO2 injection indicates 214 [bbl] oil increment by CO2 injection.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Simulation Calculation Result</th>
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<tbody>
<tr>
<td>Injected CO2</td>
<td>Mscf</td>
<td>2,100</td>
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<tr>
<td>Oil Increment</td>
<td>bbl</td>
<td>214</td>
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<tr>
<td>CO2 Utilization factor</td>
<td>Mscf/bbl</td>
<td>9.8</td>
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</tbody>
</table>
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The first CO2-EOR Huff ‘n’ Puff pilot operation in Vietnam offshore field was successfully achieved. No critical issue about operation including CO2 injection and flow back was identified.

Good and stable CO2 injectivity was confirmed. At the same time, good responses to show CO2-EOR effect were also observed as oil increase, water cut oil saturation reduction, and component/property change.

The pilot test indicated over 200 barrels of oil increase by 111 tons of CO2 injection, which is equivalent to around 10 Mscf/bbl of CO2 utilization factor.
XIN CAM ON!

ARIGATO!

THANK YOU!