Canadian Oil Sands
-Technical challenges in SAGD project-

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Hiroyuki Nakagawa
Japan Petroleum Exploration Co., Ltd.
>1.7 Trillion barrels of Original In-place in Canada

Proved Reserves: ~170 Billion barrels (Bbbls)

“Oil sand” is a naturally occurring mixture of sand, clay or other minerals, water and “Bitumen”

Crude bitumen is extra heavy and “viscous” oil that in its natural state will not flow to a well

Source: Government of Alberta
Oil Sands Production in Canada

- 132 producing projects (66 projects proposed or under construction)
- 2.1 Million bbls per day (MMbpd) in 2013
- Projected to increase to 4.1 MMbpd by 2023

Source: Alberta Energy Regulator
Steam-assisted Gravity Drainage

- Horizontal well pair near the bottom of reservoir
  - Continuous high temperature (>200degC) steam injection from upper well to form a growing ‘steam chamber’
- At the steam-oil interface, steam gives its heat energy to the adjacent oil zone. As a result, steam is condensed to water and oil is mobilized.
- The mixture of oil and water is drained by gravity, not viscous force.
- Typically 2 - 4 bbls of steam is required to produce 1 bbl of bitumen.
JAPEX Oil Sands Development

- Operated by ‘Japan Canada Oil Sands Limited’ (JACOS)
- Four Oil Sands Leases in Athabasca Area, Alberta, Canada
- Estimated Resources: 1.7Bbbls
- Producing 7,000bpd from 24 SAGD well pairs at Hangingstone Lease (32MMbbls since 1999)
- Expanding the Project Area for Additional 20,000-30,000bpd (expected to come on stream in 2016)
Compared to Conventional Oil

- More Energy Required to Produce Bitumen
- More Sensitive to Reservoir Heterogeneity
- Larger Capital Investment (more wells and water recycle requirement)

\[ \Rightarrow \text{Max. Production & Min. Energy Consumption is the Key for Success.} \]
Key Characteristics in SAGD Project

- Key Indicators: Oil rate & SOR (Steam Oil Ratio)
  - SOR: Amount (in barrels) of steam (heat) required to produce one barrel of Oil

- These are mainly resulted from:
  - Reservoir Thickness & Quality
  - Oil (Bitumen) Viscosity
  - Fluid Complication (Water & Gas)
Reservoir Thickness & Quality

- Since the Bitumen flows by “Gravity” to producing well, even minor shale intercalation in the reservoir could significantly affect the well performance.

- Quality Geological Model is required to optimize Development plan (i.e. project economics).
  - Development sequence
  - Well placement & completion
  - Operation strategy

- Seismic data helps to estimate rock properties between wells. But resolution has been the issue.
Oil (Bitumen) Viscosity (1)

- Higher steam pressure gives lower viscosity (i.e. higher oil production rate) but more heat loss from the reservoir
  ⇒ “High pressure to Low pressure” is a typical strategy

- Cap rock integrity is one of the main focus of regulator’s attention

- Geo-mechanical modeling & reservoir monitoring could help to ensure Safe operation
Solvent injection to reduce viscosity by “Dilution”

Some field tests where solvent was added to steam injection stream were successful

However, phase behavior and transportation mechanism are not fully understood
Fluid Complication

- In case target bitumen zone is in contact with Water and/or Gas zone, the injected steam (heat energy) could escape into these zones (called ‘Thief zone’).

- Well performance could be significantly affected depending on the extent and pressure of Thief zone.

- Thief zone management such as ‘Pressure balance operation’ is the key to mitigate the negative effect of Thief zone.
Conclusion

- To exploit vast bitumen resource, SAGD is one of the greatest inventions. But as this is still in its early development, this technology has some room for improvement.

- To overcome the technical challenges in SAGD project, a number of efforts for optimization and technology development have been made (the presentation covers only a part of them).

- All these efforts could give access to less preferable reservoir that can not be economically developed today. Furthermore, more efficient and safe operation will be key for SAGD to be an environmentally sustainable technology.