Input on Inaccessible Heavy Oil and Bitumen Extraction

INTRODUCTION

Due to time constraints, the following represents a preliminary and quick analysis of a number of processes that are being considered to recover "inaccessible" heavy oil and bitumen.

A coherent analysis of current technologies, both within Alberta and outside is required for the different categories of inaccessible heavy oil and bitumen. In many cases, significant innovation and development of new technologies will be required for economic recovery of inaccessible heavy oil and bitumen.

SUITABILITY OF PROCESSES

COLD PRODUCTION WITH SAND (CHOPS)

Initiating Process without Pre-Heat

Requires unconsolidated sands, an initial oil viscosity less than 50,000 mPa.s, an initial GOR of at least 5 std m^3/m^3, and pay thickness greater than 1 m. It may be possible to push the viscosity limit upwards as high as 500,000 mPa·s by addressing down-hole production problems caused by the high concentration produced sand slurry. It is important to avoid excessive gas production rates to obtain solution gas drive rather than bulk gas flow. Cold production could be attractive as an initiation process for a subsequent EOR recovery scheme, to allow injectivity and improved reservoir access, provided it is controlled to prevent ‘thief zones’ from stealing injected fluids.

SAGD AND ES-SAGD

Initiating Process without Pre-Heat

Without pre-heat, SAGD and ES-SAGD require an initial oil viscosity less than 60,000 mPa.s and a vertical permeability greater than 1 Darcy.

Intermediate Process after Formation of Chamber and Voidage Creation

After initiation (if necessary), by processes such as steam cycling in wells for oil viscosity greater than 60,000 mPa.s and/or vertical permeability greater than 1 Darcy.

Supplemental Process to Use Residual Energy in Reservoir following another Recovery Process

SAGD and ES-SAGD can be used to obtain additional oil following cyclic steam stimulation (CSS) especially if vertical production wells were used in the CSS and drilling of horizontal producers allows more oil to be contacted.

SAGD and ES-SAGD may have limited application in carbonates due to the low permeability matrix (md) which contains much of the oil. They also have limited application in thin reservoirs.

CYCLIC STEAM STIMULATION (CSS)

Initiating Process without Pre-Heat

CSS has often been used as an initiation process prior to steam drive. To create injectivity in a sand formation high injection pressures may be required, which result in dilation and possibly fractures following the initial dilation. Care must be taken that the fractures do not result in loss of the injected steam.

Intermediate Process after Formation of Chamber and Voidage Creation

Re-compaction during production is an important recovery mechanism. CSS works well in Cold Lake because much of the dilation is recovered during production. As a result of greater hysteresis during loading and unloading of the formation sands, this occurs to a much lesser extent in Athabasca. CSS is not applicable for shallow formations as re-compaction will be minimal due to low overburden stress.

STEAM DRIVE

Initiating Process without Pre-Heat

Usually steam-drive is a follow-up to CSS where initial communication between wells has been created. The CSS period may be short in fractured reservoirs such as carbonates if the fractures provide communication between wells. In fact, communication between wells may have to be reduced by the use of foams and/or gels.

Intermediate Process after Formation of Chamber and Voidage Creation

Steam-drive is typically an intermediate process. It cannot be used for thin pays because of heat loss. Conformance is usually an issue. This can be improved by the use of horizontal wells and/or foam. Conformance control additives may have an improved chance of economic success as a result of increased oil prices.

IN-SITU COMBUSTION

Initiating Process without Pre-Heat

It requires air/O_2 injectivity to ensure in-situ combustion occurs rather than low temperature oxidation. Fractured systems should have sufficient injectivity unless the fractures are plugged with cold bitumen. In that case another process may be required to recover oil from the fractures. The effect of high combustion temperatures (e.g. 1,000°C) on particular formations needs to be considered.

Intermediate Process after Formation of Chamber and Voidage Creation

Top-down combustion would probably have a horizontal producer and probably vertical injectors above the producer. Issues for carbonates may be confinement of injected air and premature breakthrough of injected air if vertical fractures exist at unsuitable locations.

Supplemental Process to Use Residual Energy in Reservoir following another Recovery Process

In-situ combustion could be used following another breakthrough process as potential disadvantages of ISC (destruction of producer and problems with produced fluids (formation of acids etc.) would not be as important as for a virgin reservoir. In addition, the reservoir heat (from earlier steam injection) and injectivity could be used to initiate combustion. An issue may be how to prevent channeling of the air through the depleted region.

VAPEX

Initiating Process without Pre-Heat

Depending on the oil viscosity, an initialization process may be required.

Intermediate Process after Formation of Chamber and Voidage Creation

A relatively thick reservoir is required as this is a gravity based process. As for SAGD, this is probably not an appropriate process for the carbonates due to the low permeability matrix. In addition, the high oil viscosity probably rules out VAPEX for the carbonates in Alberta. The solvent selected depends on the reservoir pressure.

Supplemental Process to Use Residual Energy in Reservoir following another Recovery Process

VAPEX can be used following a steam-based process as the higher temperatures will allow faster solvent diffusion.

CYCLIC SOLVENT INJECTION (CSI)

Initiating Process without Pre-Heat

CSI can be used to initiate processes depending on the injection pressures allowed.

Intermediate Process after Formation of Chamber and Voidage Creation

As for CSS, dilation in unconsolidated formations is an advantage and may also have some fractures. However, extreme care must be taken when creating fractures as solvent confinement is essential. CSI has potential in carbonate reservoirs. However, it may not be as good as CSS as diffusion of solvent from the fractures into the matrix is much slower than conduction of heat into the matrix. A solvent drive process may have some applicability.

Supplemental Process to Use Residual Energy in Reservoir following another Recovery Process

CSI can be considered as a follow-up process especially after CHOPS where reservoir access has been created and much of the oil is still available for recovery. CSI may have less potential following a thermal process where less oil remains in the depleted region. It must be remembered that oil production during CSI must be at least 5 to 10 times that of the unrecovered solvent at the end of the process.

CO_2 INJECTION

Initiating Process without Pre-Heat

CO_2 can be used to initiate processes depending on the injection pressures allowed.

Intermediate Process after Formation of Chamber and Voidage Creation

CO_2 has typically being used in EOR processes for lighter oils although it does have an impact when used as a steam additive. In other solvent processes, the desire is to recover the solvent to minimize costs whereas with CO_2 the desire is to leave the CO_2 in the reservoir. It is typically considered that CO_2 should be used where higher pressures occur as its solubility in oil increases and miscible conditions may occur. However, in terms of potential CO_2 sequestration, carbonate reservoirs may be suitable depending on the reactions that occur in the reservoir.

WET ELECTRIC HEATING

Initiating Process

ARC has developed a wet electric heating process for pre-heating the formation prior to SAGD. This process has potential use in the carbonates as it is not limited by channelling of injected fluid. It uses the saline water in the reservoir to generate heat away from the wellbore as compared to other electrical heating processes whose effect is only felt near the wellbore. It has not yet been field tested.

CARBONATES

It will be most effective to select the reservoir or area of interest and then design the appropriate EOR process. Reservoir screening needs to be used to select an area with the best opportunity for technical and economic success in recovering heavy oil. Selection of an EOR method for the carbonate triangle should be based on a good understanding of the oil recovery mechanisms applicable to the reservoir.

The combination of the Alberta's carbonates' highly fractured system and high oil viscosity means that a tailor made process will be required including:

- Selection of a carbonate reservoir for development; availability of existing field facilities (e.g. for oil production in an overlying formation) will be an advantage
- Development of commercial and government interest in the project
- Appropriate reservoir characterization.
- Selection of the best EOR technologies that could be applied in the area.
- An economic analysis to support the design and application of a pilot test.

ARC is currently expanding its experience in carbonate reservoirs and is examining a number of different processes. In addition, it is developing risk analysis technology related to EOR and CO_2 sequestration that can be used to predict economic success or failure for proposed field projects. It can also be used to decide on the best location for a new well based on the actual conditions and the best technology to be applied for solving a specific problem.

SOME ARC REFERENCES

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