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Canadian Oil Sands – Challenges and Opportunities

Mining, Separation, Upgrading

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"Alberta's oil-sands region is awash with companies from Japan, South Korea, China and Norway, as well as big international players like Royal Dutch Shell PLC and BP PLC – all competing for access to an estimated 170 billion barrels of oil recoverable using current technology. Alberta is now second only to Saudi Arabia in recoverable oil reserves, thanks to improvements in technology and higher oil prices that have made the labor-intensive oil-sands projects more economical. The oil sands represent a unique opportunity for investors. Of all the oil currently produced in the world, five out of six barrels are state-owned or state-controlled. Of the portion that remains – oil available for public investment – half is in Canada's oil sands." (Edward Welsh in the Wall Street Journal, November 29, 2010). The American Petroleum Institute has broadcast a series of radio advertisements supporting the growth of the oil sands industry suggesting that 300,000 American jobs will be created in support of this growth. Construction of the Keystone Pipeline, a $7 Billion investment, if built, will bring Athabasca oil to the Gulf Coast.

With today's technology, about 20% of the recoverable oil is available through mining techniques while the remainder is more deeply buried and is only accessible via in situ methods. Of the one and a half million barrels a day currently produced, most is generated via mining operations. Announced projects could easily double the production by 2020, and the majority of that, ~ 3MBBl/day production, will come from mining operations.

The mining process can be broken down into three operations: mining, bitumen (oil) separation, and upgrading. Typically the oil sands have 8-15 wt % hydrocarbon, with the remainder being inorganics and water. One challenge is managing the inorganics in a cost and environmentally effective manner.

Mining: As the ore is mined and sized, the actual volume of inorganic material after mining is greater than the volume of the oil sands in place. Thus land management based on simply this volume expansion needs attention. Given the temperature conditions in northern Alberta, material handling, equipment maintenance, and the associated operations are a continuous challenge.

Bitumen separation: The commercial separation process is now many decades old and is built on the work of Clark (CA 448231). Fundamentally, hot water (actually soapy hot water) is mixed with the oil sands to form a froth. This separates much of the sand from the oil. The oil then

Work Highlights

Mechanical Engineering

- *As part of consulting support being provided for a major refinery expansion project, mechanical engineering design audits were made of the technical specifications prepared by others for long-lead time and critical pressure vessels (e.g., heavy wall reactors, FCCU vessels, etc.). Recommendations were made to revise these specifications to improve the long-term reliability of the vessels.*
- *Onsite and offsite mechanical engineering consulting support was provided during a major, refinery-wide turnaround. Some of this support was as follow-up to piping system and pressure vessel recommendations and analysis work that had been done before the T/A, whereas the rest to address the typical piping and pressure vessel issue that arise during a T/A, especially when large capacity, fluid-solids type units are involved.*

Process, Operations, & Safety

- *Completed technical expert litigation support on a case involving an engineering company, licensor, and personnel connected to a refinery incident.*
- *Continue to provide facilitator and designer support on numerous HAZOP, project safety review, and Transient Operations HAZOP (TOH) efforts at many locations and clients.*

needs to be separated from the water. Even with significant improvements in water management, about two barrels of water are required to generate one barrel of oil. One of the challenges has been that fines are generated in this separation scheme and the fines are very slow to separate from the water. Thus water reuse is impeded by the fact that many years have been needed before the fines are sufficiently agglomerated. This issue has been the focus of substantial R&D and recently Suncor has introduced a technology (using gypsum and a flocculant) to accelerate the concentration and separation of fines. Nonetheless the time frame remains in the order of approximately ten years.

Another less well known technical issue is that the water based separation treatment of the oil sands brings some of the naphthenic acids into the water phase. Once in the water phase, the acid concentration in the water is substantially increased with negative impact on the ecology. See, e.g., US Patent # 7,638,057.

Upgrading: This is the area that readers of this article will be most familiar with. The oil from oil sands is generally referred to as bitumen. The API^{o} Gravity is quite low, the sulfur and oxygen content is relatively high, hydrogen to carbon ratio is quite low, and there is a significant metals content. Due to the vast areas where Athabasca oil sands are found, there is a range of properties of the hydrocarbon species. The table below gives some typical numbers ("Fuel Science and Technology Handbook", James G. Speight, ed., Marcel Dekker, Inc., NY, 1990, Table 4, p. 394).

TABLE I
Characteristics of Athabasca Bitumen

Sample	Athabasca, Wabasca McMurray
% Carbon	83.1
% Hydrogen	10.6
H/C	1.53
% Nitrogen	0.40
% Sulfur	4.8
% Oxygen	1.1
API^{o} Gravity	7.5
Conradson Carbon	18.5
Ni + V, ppm	350

The first point to make is that the material has such a low API^{o} gravity that it must be diluted with a light hydrocarbon such as naphtha before it can be moved. The mix of bitumen and diluent is often referred to as dilbit. Depending on the company, some upgrading combination of distillation, coking and hydrotreating is carried out either at or near the mine site or at a refinery. Refineries in Edmonton, Alberta and in the upper US are currently involved in this activity. Current technologies provide streams of diesel, sweet and sour crude oils, coke, and sulfur. The hydrogen for hydrotreating is generally obtained via natural gas reforming. Continuous improvement in the entire upgrading area is a subject of ongoing work.

With ever more demanding product specifications along with the continuing environmental challenges, winning quality products from Canadian oil sands is an ongoing opportunity for technical improvements.

About the Author

Richard has over 30 years ExxonMobil background experience. His expertise is new process/product research and development, strategic planning, market strategies, and intellectual property analysis, primarily in the chemical and petrochemical industry or related areas. Please contact Jerry Lacatena (jlacatena@carmagen.com) if you'd like more information on Carmagen's expertise in this area.