

# Development and Application of Oil Sand

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**Abstract**— the oil sands is one kind of sand-like unconventional ore resources depositing of crude oil, it is made up of asphalt, minerals, clay and water in a way of conjuncting with each other. Oil and natural gas are important energy and chemical raw materials, its resources are gradually reduced. With the rapid development of the global economy, the conventional oil resources can't meet the rapid growth of oil demand, people began turning to unconventional oil resources, one of which is the oil sands. Oil sands is unconventional oil resources, if its proven reserves are converted into oil, it will be much larger than the world's proven oil reserves. Canadian oil sands reserves stand ahead in the world, followed by the former Soviet Union, Venezuela, the United States and China. However, due to its special properties, different mining and processing technology, and higher mining costs compared with conventional oil, the research of oil sands makes slow progress. At present, due to the rising of world oil price, oil sands mining technology have attracted more and more attention, and have developed a lot.

**Index Terms** — oil sands, mining, alternative energy, application, energy resource, unconventional energy.

## 1 INTRODUCTION

The oil sands is one kind of sand-like unconventional ore resources depositing of crude oil, it is made up of asphalt, minerals, clay and water in a way of conjuncting with each other. Asphalt is its main ingredient, whose content can be accounted for 1% to 20%. Oil sands formed in Cretaceous. There are more than 70 countries in the world that reserve oil sands, but more than 90% of the proven oil sands reserves concentrate in Canada at present; if all these oil sands resource were exploited, according to the current level of the world energy needs, they can be used 100 years by the world. Oil sands asphalt is usually the organic mixture of hydrocarbon and non-hydrocarbon, it is a viscous semi-solid substance, containing about 80% of carbon, certain hydrogen, and a small amounts of nitrogen, sulfur, oxygen, and trace metals. Oil sands is one of the main sources of man-made oil. Through mining, extraction, separation, modification, we can get synthetic crude oil from it, and the separated clean sand can be used as construction materials or used for backfill process.

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## 2 EXPLOITATION TECHNIC

Oil sands differ greatly from conventional oil and natural gas, in the original state, it is difficult to use ordinary methods to mine. In order to exploit it, special treatment is needed. According to the differences of the depth of oil sand reserves, the mining methods of oil sands can be divided into in situ mining and open-pit mining. The combining of thermal recovery and chemical flooding method can improve the production rate and oil recovery rate, it is a promising method. Hot alkaline extraction method is the most widely used method of open-pit mining, but it will cause serious environmental pollution. When combining with surfactant, this method can improve the recovery rate of asphalt, lower production costs, reduce environmental pollution.

### 2.1 Open-pit Mining

The process of open-pit mining is: first, remove the oil sands on the first cover, and then mine by the open-pit mining techniques. The exploited oil sands were then shipped to the factories to separate asphalt, sand and other non-hydrocarbon substances. And finally, convert the separated asphalt into synthetic crude oil. Surface mining method can take out more than 90% of the oil. The hydrocarbons, sulfur, metals and rocks in the oil sands have been utilized to the fullest. There are only 10% of the oil sands around the world that can use open-pit mining technology to mine. Open-pit mining has a better asphalt recycle rate than other methods, and it is technically more mature. There have formed large-scale industrial mining in Canada and Venezuela. The Syncrude company in Canada is the world's largest manufacturer that produces oil from oil sands, who engaged in the open-pit mining activities in the Athabasca. Its open-pit mining technology of oil sands leads the world.

### 2.2 In-situ mining

The site separation method that is used to exploit deep underground oil sands has also been very mature. This approach is to heat and dilute the asphalt to be flowable in the underground, and then pump the flowable asphalt to the ground. Nowadays, widely used methods are as following:

- 1) Cyclic steam stimulation (CSS): cyclic steam stimulation, also known as cyclic steam injection, steam soak, or steam production and so on, is injecting high-pressure steam into the oil sands formations, shut-in for a few weeks, use heat to soften the asphalt, use the water vapor to dilute the bitumen and make the asphalt and sand separate, and then open the wells to pump the bitumen that can flow to the surface[1]. In addition, through the application of chemicals, the viscosity of heavy crude oil will reduce, this can improve heavy oil's mobility in the reservoir and on the ground, improve the state of steam stimulation, enhance oil recovery [2]. Its main advantage is the immediate producing of oil after the project be implemented, while its main limitation is that it can exploit

20% of the original underground reserves[3]. Steam-assisted gravity drainage method (SAGD): Drill two wells in parallel to the oil sands formations, one up, one down, then continuously injecting steam to the upper well, when the steam heat the oil formation, oil Sands will be softened and flow by gravity to the below well, then be pumped to the ground. At present, this production technology can harvest 25% to 75% of the underground storage of asphalt, which is far greater than conventional light oil recovery. UTF Consortium's application in ForMt cMurray area is SAGD technology. The future development of oil sands is expected to mainly depend on the combination of CSS technology and SAGD technology, which will surely become the 21st century's major commercial mining method.

- 2) gy developed in Canada in recent years is a new mining technology. To the underground heavy oil t steam-assisted gravity drainage method (SAGD) [4]: Drill two wells in parallel to the oil sands formations, one up, one down, then continuously injecting steam to the upper well, when the steam heat the oil formation, oil Sands will be softened and flow by gravity to the below well, then be pumped to the ground. At present, this production technology can harvest 25% to 75% of the underground storage of asphalt, which is far greater than conventional light oil recovery. UTF Consortium's application in ForMt cMurray area is SAGD technology. The future development of oil sands is expected to mainly depend on the combination of CSS technology and SAGD technology, which will surely become the 21st century's major commercial mining method.
- 3) Vapor extraction technology of the underground horizontal wells (VAPEX): This method is a further development of the steam assisted gravity drainage method. In VAPEX, hydrocarbon gas is injected rather than steam. The main advantage of the process is: compared with SAGD, VAPEX's necessary equipments are cheap, simple to handle, and the gas dissolves selectively. It only dissolves in the oil, not in the water. So this method can apply to a wide range.
- 4) Cold heavy oil production technology (CHOP): the cold heavy oil production technolo hat has certain mobility, cold heavy oil production wells can greatly improve the wells' ability of producing conventional oil. In the Inner Mongolia oil fields of China, the cold heavy oil production technology is relatively successful.
- 5) Aquarthermolysis mining technology: In this mining technology, under the conditions of injecting steam, by the help of chemical reactions that occurs between heavy oil and steam, the viscosity of heavy oil will reduce, thus achieving the purpose of lower viscosity underground mining.
- 6) Recovery heavy oil by in-stu reducing viscosity techniques: In simple thermal effects, thermal cracking and visbreaking will happen to the heavy oil and its quality will change. Therefore some people proposed that in the heat treatment, injecting hydrogen and other substances that can produce hydrogen element to the underground. In addition to integrating into the crude oil to make the oil expand, the hydrogen can enter the tiny pores; when the underlying pressure re-

duce, the expansion of the compressed gas and crude oil can produce more oil, and heat the crude oil at the same treatment. Due to expansion, the viscosity of crude oil will reduce.

- 7) In Situ combustion: In Situ combustion uses electricity and chemical methods such to burn oil reservoir to increase its temperature to burn point. In the meantime, inject air to allow the crude oil to burn continuously[5]. The disadvantages include that the implementation of in situ combustion process is difficult. Controlling the underground combustion is also not easy. Also, the cost of injecting a mass of high-pressure air into the reservoir is high. Usually, this method uses when steam flooding method is not applicable, especially in the thin layers or deep layers whose crude oil is of medium density.

### 3 OIL SEPARATION TECHNOLOGY

Currently, there are three main kinds of oil sands separation technology at abroad-hot water washing method, solvent extraction method, pyrolysis distillation method. Different oil sands structures may use different separation methods. Generally, moist oil sands are for washing method, oily sand for organic solvent extraction or pyrolysis distillation separation. Thermo-chemical washing method and distillation ATP will be the main ground separation methods of oil sand in the future, which are still dominated by chemical washing. But with the rising of the oil prices, ATP carbonization technology will have a period of vigorous development [5].

Domestic oil sands separation technology is still stay in the laboratory study stage. To the oil sands of Inner Mongolia, Cao Zubin, Professor of Liaoning Shihua University, proposed water-washing separation technology, and had developed three series of washing separation reagents. The results prove to be very ideal. The dry distillation simulation test that was conducted on Xingjiang oil sands by Langfang Branch of China Petroleum Exploration and Development Research Institute had also achieved desired gains, which proved that the dry distillation process of Xinjiang oil sand is technically feasible.

#### 3.1 Hot water washing method of Oil sands

Currently, the Canadian oil sands surface separation mainly uses hot water / surfactant. Hot alkali and surfactants role in changing the surface wettability of the sand, making the surface of sand more hydrophilic, achieving the separation of asphalt absorbing on sand. The separated asphalt oil will then float to the lye, while the quartz sand will take the lower part, thus achieving the objective of separation.

#### 3.2 Organic solvent extraction of oil sand

Pyrolysis s Organic solvent extraction of oil sands mainly uses the theory that similarities can be solvable easily in each other to achieve the recycle of oil sands bitumen. Using organic solvent to extract the gel bitumen in the sand, and then distill them to achieve separation. This method makes use of organic solvents to contact with the oil sands, separating the dissolved asphalt from

sand. And the extraction agent can be recycled. Solvent extraction method applies to theoretical and laboratory research stage. This method is less demanding on the quality of oil sands, it can be wet oil sands with high oil content, it can also be sands with little oil, or just dry oil sands. Compared with the hot water washing method, its applicability is broader, and washes oil more efficiently.

Disadvantage of this approach and also its largest problem, is serious environmental pollution. Therefore, this method is rarely used in industrial production.

### 3.3 Pyrolysis Separation Method of Oil sands

About the pyrolysis separation technology—the main idea of Canadian Alberta's Oil Sand Technology Administration is transforming the heavy oil sands components to be light components. Aostar Taciuk Process referred to as the ATP process, the principle is the use of high temperature of above 250e to pyrolysis. After the heat treatment, greatly improving the quality of asphalt improves greatly. Molecular mass becomes smaller, the quantity of gum also reduces. During the heat treatment, the most important change is the emerging of light oil.

In the 1990s, Canada began to apply ATP technology to oil sands mining. AOSTA and UMATAC cooperated to make efforts in the feasibility studies of the oil sands pyrolysis. In the past 17 years, the technology went through continuous development and improvements. The ATP pilot plant in southeast Calgary has processed more than 1.7 @ 104t oil sands, showing the ATP method is a technically effective way for separation and primary modification.

## 4 PROCESSING TECHNOLOGY OF OIL SANDS

The key to the processing routes and process selection of oil sands asphalt is the technical and economic feasibility. To the characteristics of oil sands asphalt, Xing Dingfeng and his colleagues, probe and conclude that the processing of oil sands asphalt mainly has decarbonization and hydrogenation two routes.

### 4.1 Hydrogenation of oil sands bitumen

On the hydrogenation routes, according to different reactors, the heavy oil hydrogenation process can be divided into fixed-bed, boiling bed, suspending bed and moving bed 4 species. Nowadays the application of fixed bed and boiling bed technology is relatively mature. But the further processing of oil sands bitumen uses residual oil boiling bed hydrogenation cracking technology.

Currently, the oil sands bitumen hydro-processing technology of Canadian mainly employs boiling bed technology. One of the typical boiling bed hydrogenation cracking technology is the LC-Fining process. Except the processing of conventional sour crude oil. This technology mainly uses to process heavy residual oil. In this processing scheme, considering the maturity of the technology, the scale of the completed device and the serviceability of its processing raw materials, LC-Fining technique is recommended.

### 4.2 Decarbonization process of oil sands asphalt

Decarbonization routes mainly include solvent de-asphalting, catalytic cracking and coking process, but it seems that only the

coking technology is feasible for the processing of oil sands asphalt at present. Residue oil coking technology is the primary means for the deep processing of residue oil and for improving the recycle rate of light oil. Currently, the technology is already very mature, including delayed coking, fluid coking and flexible coking. Coking process can process a variety of low-quality raw material, it is unlimited to materials' properties.

## 5.CONCLUSION

Current oil sands development and utilization is just limited to a few countries, while Canada is the largest oil sands producer among them. Although the current cost of oil sands mining and refining is high, with the development of technology and global oil prices will remain at a high level of expectations, the economic value of extracting oil from oil sand will increase.

The depletion of conventional oil resources, makes the huge gap of future energy largely depend on oil sands to make up. The world began to realize the importance of oil sands resources, and start pouring a lot of manpower and material to develop this unconventional energy sources. And, the advances in mining technology will allow the extraction of some oil sands and ores that do not have the economic value before also economically possible.

In the conditions that domestic oil resources is tense, be familiar with the state of our oil sands resources and preparing for the exploitation of oil sands resources will make sense to China's energy strategy.

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