FOXOIL®

CHALLENGE FOR HEAVY OIL

Heavy Oil Overview

The lack of easily accessible light crude oil resources of a sufficient amount available for exploiting to replace depleted light oil reserves, is causing a monumental shift in the oil production. Combined with a soaring worldwide demand, the oil world is standing against unprecedented oil production challenges.

The petroleum industry is currently faced with a great dilemma worldwide: the production of heavy petroleum is higher, compared to that of light petroleum. Heavy crude oil is a thick, black, gooey fluid, harder to handle and more expensive to refine in order to produce the most valuable petroleum products.
It is referred to as "heavy", because its density or specific gravity and viscosity (ability to flow), are significantly higher than that of light crude oil. The issue with heavy crude oils is, that they possess a high content of impurities (sulphur, nitrogen, metals and asphaltenes), as well as a high yield of residue, which results in low production of valuable distillates (gasoline and diesel). The consequence of heavy crude oil being very viscous and not easily flowable, is a difficult and demanding transportation.

Heavy oil crude or extra heavy oil crude is any type of crude oil, which does not flow sufficiently, or which does not flow at all. Generally speaking, heavy petroleum classification is as follows:

- *Heavy crude oil*. It is dense and viscous oil that is chemically characterized by its high content of asphaltenes (very complex and large molecules). Its upper limit of API gravity is 20° and its viscosity is of 100cP.
- *Extra-heavy crude oil*. It is characterized for having an API gravity of less than 10°.
- *Bitumen*. It has similar properties to heavy oil, yet it is more dense and viscous. The main difference between bitumen and heavy oil is that the former does not flow at all. Natural bitumen is oil that has a viscosity greater than 10,000 cP. Bitumen is a valuable part of so called "tar sands" or "oil sands."

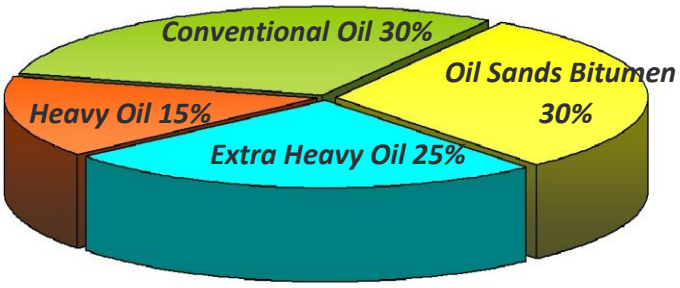
Moreover, like most unconventional fuels, heavy oil requires more energy to make than conventional oil does. Fuels that require lots of energy to make energy, ultimately provide fewer returns to society. Economists refer to this challenge as Energy Return on Energy Investment (EROI). EROI is the ratio of the amount of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource.

At the turn of the 19th century, it took one barrel of oil to find and liquidate 100 barrels. But ever since the glory days of the Texas oil fields, the EROI ratio has slowly diminished from the world. It is estimated that EROI for U.S. oil production has dropped from 24:1 in 1954 to 11:1 in 2007. Upgrading and processing of the heavy oil and bitumen is even worse. The EROI of heavy oil and bitumen processing to produce Synthetic Crude Oil (SCO) amounts from 5: 1 to 7:1.

These characteristics, in turn, are responsible for the low price of heavy petroleum. Additionally, existing refineries are designed to process only light crude oil; heavy oil can not be refined to 100%. To allow the flowing of heavy oil for its transportation the common practice is to dilute heavy oil with lighter crude oils or with solvents, although this is only possible to a certain extent and it is not cheap.

On the other hand, heavier crude oil (heavy oil) provides tremendous economic potential for petroleum development. The resources of heavier oil (heavy oil) in the world are more than twice those of conventional light crude oil, approximately 900 billion barrels.

Total World Oil Reserves



To process heavy crude oils would require either major changes (reconfiguration) in the processing units of already installed refineries or the installation of new units. In both cases, the investment costs are high, because of the diversity of the processing plants that must be reconfigured or installed.

One solution to this problem, is the upgrading of the heavy oil before sending this raw material to a refinery. These upgrading plants installed directly on the oil fields would convert heavy oil to medium oil with reduced amounts of impurities and higher contents of valuable distillates. There are several upgrading processes reported in the literature and in praxis that are based on two main principles: carbon rejection and hydrogen addition. The main technology in the first category is the delayed coking process, which is most widely used in the refining industry. Catalytic hydro treating belongs to the second category and is the second largest process within the industrial application.

The **Foxoil®** process uses a principle which does not require hydrogen whilst heavy oil is processed. Thus this is one of the technologies that is built on the 'carbon rejection' technique. The **Foxoil®** process is, however, significantly different to other 'carbon rejection' technologies because of the construction of the major technological device as well as the operational parameters. The patent **Foxoil®** technology is based on a revolutionary principle of the process, which uses an unconventional reactor. Consequently, the outcomes are unconventional and revolutionary economical as well as technical parameters whilst using disruptive technology for heavy oil upgrading.

There are two main areas for the application of the **Foxoil®** for Heavy Oil (HO) Upgrading.

Upstream application. The **Foxoil®** upgrading facility can be located directly on the oil producing field. The conversion of the heavy crude with the high content of impurities in Foxoil unit to lighter fraction synthetic crude oil (SCO), significantly reduces the amount of impurities and increases the value of the oil and allows a long distance pipeline transportation of upgraded crude, without the need of high cost diluents or light oil, to decrease the crude viscosity for the transport to the refinery. The upgraded oil can be also used as diluents for the original heavy oil. The unit can be self-powered from the process gas.
Due to low capital and operational costs, the operation of the device is highly profitable. Furthermore the capacity of processing is relatively small, which allows an advantageous placing of numerous smaller devices directly on the oil field.

Downstream application. The **Foxoil®** upgrading facility in refineries can be used for the conversion of atmospheric and vacuum tower bottoms, refining residue oils into lighter fractions for reintroduction into the refining process. For example like input stream for hydrocracker. Another option is to add an upgraded stream to the atmospheric tower, distilled into product increasing the slate volumes of distillates per barrel or unload an existing upgrader, to increase capacity and refinery output of higher value transportation fuels.

Foxoil® Pilot Plant

Advantages of the FOXOIL® Over Other Technology Solutions for HO upgrading

- Lowest known Capital Expenditures CAPEX – from 5.8 to 7.1 (USD thousand per daily barrel)
- Very high energy efficiency of synthetic crude oil (SCO) production
  * expressed as EROI from 13:1 to 15:1 (Energy Return on Energy Investment)
  * expressed as self consumption of produced SCO energy content from to 6 to 8%
- Volumetric liquid yield over 100%
- Unmatched viscosity improvement, e.g. from 2,410 cSt (mm^2/s) to 8.8 cSt at 40^oC
- Favourable density improvement from HO to SCO
  * e.g. from 7.9API to 24API expressed as API gravity
  * e.g. from 1,015 kg/m^3 to 910 kg/m^3 expressed as specific density
- Very high removal efficiency of Asphaltenes from heavy oils (99.2 - 99.8% removed)
- Very high removal efficiency of Nickel & Vanadium from heavy oils (96 - 97% removed)
- High removal efficiency of Nitrogen from heavy oils (55 - 60% removed)
- Moderate removal efficiency of Sulphur from heavy oils (about 30% removed)
- Other important benefits
  * One through system - no recirculation stream
  * No catalyst, hydrogen, chemicals or other auxiliary inputs (solvents, diluents) necessary
  * Working pressure up to 50 kPa (0.5 bar) - safe operating conditions, no pressure vessels
  * No waste water production
  * No production water required
  * Limited coke and solid waste production

Many of mentioned advantages of the **Foxoil®** are unique compared to other available and used technologies for upgrading of Heavy Oils. Thus when using Foxoil, it allows the user to gain more value whilst having the same expenses. At the same time, it enables a profitable operation with devices of lower production capacity, which means the capital expenses necessary for the launch of the project can be significantly lower compared to other technologies.

---

www.kemia.at
kondor@kemia.at

Kemia GmbH
Hietzinger Hauptstraße 50
1130 Vienna, Austria