Oil Sands Discovery Centre

Fact Sheet

Alberta

UPGRADING

Upgrading is the process that changes bitumen into synthetic crude oil. Bitumen, like crude oil, is a very complex mixture of chemicals (a hydrocarbon with chains in excess of 2,000 molecules). It also has a lot of carbon in relation to hydrogen. Some upgrading processes remove carbon, while others add hydrogen or change molecular structures. Upgrading also involves sorting bitumen into its component parts and then using them to produce a range of additional products and byproducts. Some of these products can be used "as is". Others become raw materials for further processing. The main product of upgrading is synthesized crude oil that can be later refined like conventional oil into a range of consumer products.

There are four main steps to the upgrading process: Thermal Conversion, Catalytic Conversion, Distillation, and Hydrotreating. The purpose of upgrading is to separate the light and convert the heavy components of bitumen into a refineable product. Different companies use these processes in different ways and at different stages in the transformation of bitumen into synthetic crude oil, but the principles behind this transformation remain the same. Syncrude and Suncor upgrade their bitumen at their plant sites. Albian Sands sends diluted bitumen down their pipeline to the Scotford Upgrader where it is upgraded into synthetic crude oil.

The initial step in upgrading is to remove naphtha in a simple distillation process (diluent recovery unit). This naphtha can then be re-used in the froth treatment process.

THERMAL CONVERSION (COKING)

Thermal Conversion or Coking involves breaking apart the long heavy hydrocarbon molecules using heat. Hydrocarbons have an interesting and very useful property. If they are subjected to high temperatures they will react and change their molecular structures. The higher the temperature, the faster these reactions will happen. This is sometimes called "Cracking" because large hydrocarbon molecules can be made to crack, or break down into smaller molecules. Coking is an intense thermal cracking process. It is particularly useful in upgrading bitumen into lighter, refineable hydrocarbons (naptha, kerosene distillates, and gas oils) and concentrates extra carbon into a material called coke. The coke is considered a byproduct of the coking process. Currently oil sands companies use two types of coking to upgrade bitumen: delayed coking and fluid coking.

Delayed coking is a process where bitumen is heated to 500°C (925°F), then pumped into one side of a double-sided coker. The bitumen cracks into two products: solid coke and gas vapour. It takes approximately 12 hours to fill one side with coke. When one coke drum is full the heated bitumen is diverted into the 2nd coker in the pair to continue the cracking process. A high-pressure water drill is used to cut out the solid coke from the first coking drum. The **fluid coking** process is similar except it is a continuous process. There is just one coking drum for fluid coking. The bitumen is heated to 500°C (925°F) but instead of pumping the bitumen it is sprayed in a fine mist around the entire height and circumference of the coker. The bitumen cracks into gas vapour and coke. The coke is in a much finer powder-like form, which is then drained from the bottom.

The coke's greatest value is as a fuel for coke furnaces, producing the heat needed for the hydro-cracking process. More coke is produced than is needed so it is stockpiled for future use.

UPGRADING, Continued:

CATALYTIC CONVERSION

Catalytic Conversion is another way to crack oil molecules into smaller, refineable hydrocarbons. Because it too requires high temperatures, catalytic conversion is really an enhanced form of thermal conversion. Catalysts have a very interesting effect on chemical reactions. They help those reactions to take place, but the catalyst itself is not chemically altered by the reaction. There can be different types of catalysts used (shaped like beads or pellets). The surface area of the catalyst is quite important; the cracking occurs when heated bitumen contacts active sites on the catalyst. Catalysts encourage “cracking” of hydrocarbons in two ways. When large hydrocarbons contact active sites on a catalyst, they react by breaking down into smaller molecules. Catalysts also act as sieves letting some molecules with specific sizes and shapes through while holding others back to continue reacting. Sometimes high-pressure hydrogen is added in the process of catalytic cracking. This is called hydroprocessing. Adding hydrogen helps to produce lighter, hydrogen rich molecules. This is necessary in upgrading bitumen, which is rich in carbon but proportionally less hydrogen than conventional oils.

Catalytic conversion is more expensive than thermal conversion but it does produce more upgraded product for later refining.

DISTILLATION

The third stage of the upgrading process is distillation. Bitumen is a mixture of hydrocarbon compounds. Distillation is a very common industrial process that can be used to sort liquids and gases into their component parts. A distillation, or fractionating tower works because different substances boil at different temperatures. The temperature inside the tower varies, with the hottest temperatures at the bottom and the coolest at the top. The lightest hydrocarbons with the lowest boiling points travel as a vapour to the top of the tower. Heavier and denser hydrocarbons with higher boiling points collect as liquids lower in the tower. The gas vapour condenses into heavy and light gas oils, kerosene and naptha.

HYDROTREATING

The fourth major process in upgrading is hydrotreating. This process is used on the gas oils, kerosene, and naptha produced from the original bitumen feedstock. In this process, heated hydrocarbon feedstock is mixed with hydrogen at high pressure and temperature ranging from 300 – 400°C depending on the liquid. The various petroleum liquids pass through separate towers and flow around special catalytic pellets. Hydrotreating stabilizes the crude oil synthesized from the original bitumen by adding hydrogen to some unsaturated molecules. If this were not done, the crude oil produced would continue to react and change its chemical composition on its way to final refining.

Hydrotreating also reduces or removes chemical impurities, such as nitrogen, sulphur and trace metals from hydrocarbon molecules. This is very important because impurities can be environmental concerns and they cause problems at the refineries.

The petroleum liquids are kept in separate storage tanks on site until they are ready to be blended and shipped down the pipeline for refining. Synthetic crude oil is not stored in its blended form anytime on site. The synthetic crude oil that is produced from oil sand is considered easy to refine because it is sweet. Sweet means that the product is very low in sulphur and other impurities.