Changing technologies in refining

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Many types of crude oil are extracted around the world. The market value of an individual crude stream reflects its quality characteristics. Two of the most important quality characteristics are density and sulphur content. Density ranges from light to heavy, while sulphur content is characterised as sweet or sour. Crude oils that are light (higher degrees of API gravity, or lower density) and sweet (low sulphur content) are usually priced higher than heavy, sour crude oils. This is partly because gasoline and diesel fuel, which typically sell at a significant premium to residual fuel oil and other "bottom of the barrel" products, can usually be more easily and cheaply produced using light, sweet crude oil. The light sweet grades are desirable because they can be processed with far less sophisticated and energy-intensive processes.

Worldwide, the petroleum refining industry is entering into a significant era due to the depletion of light crude. The light crude sources are turning into heavy or extra heavy, which contains large amounts of contaminants such as metals or asphaltene, and produces a large fraction of bottom of the barrel residue after distillation. Thus, the future composition of the crude slate is a key issue facing refiners who need to invest strategically in order to process larger quantities of sourer crude. Crude quality is vital not just from the refiner's interest for refining yields and environmentally-friendly products. Refinery operations have to evolve and include next-generation processes and catalysts to fulfill the demand for high-quality transportation fuels. Since the quality of these products has to be improved to satisfy stringent environmental regulations, refineries, which have been traditionally processing light crude oils, face drastic changes in their petroleum feed. The heavier crude oils produce a greater share of lower-valued products (residue) with simple distillation and require additional processing to produce the desired range of products.

At the same time refineries are under great pressure to meet market demand for high-quality fuels, especially in gasoline and diesel. The world demand for diesel fuels is increasing while fuel oil demand is decreasing. Refiners increasingly have to deal with the presence of high levels of impurities occurring in the processing of heavy feed stocks, such as:

- Large amounts of residue;
- High levels of metals, causing permanent deactivation of the catalysts;
- High nitrogen content, especially basic nitrogen, resulting in the temporary deactivation of acid catalysts;
- Higher coke deposition and poor yield of liquid products, resulting from higher contents of conradson carbon residue and asphaltene in the crudes;
- High sulphur levels in the feedstocks.

Dealing with heavy crude

Potential technology options to deal with heavy crude oil include:

- Direct use of heavy oil a as fuel for power generation;
- Blending heavy oil with light conventional oil to produce medium-quality crude oil suitable for refining in many conventional refineries worldwide;
- Blending heavy oil with synthetic crude oil produced from heavy oil to produce medium quality crude oil;
- Medium upgrading to medium-quality crude oil;
- Full upgrading using a hydro-treating process (conventional and non-conventional) or carbon rejection processes for conversion into sweet synthetic light crude oil.

The heaviest fraction of heavy crude oil is represented by the most complex molecule of asphaltenes. Asphaltenes are the precursor of the most hetero atoms and metals. Metals in the asphaltene aggregates are believed to be associated with the asphaltene sheets, making the asphaltene molecule heavier than its original structure. Therefore, the design of catalyst formulation requires a balance between textural properties, the number of active sites and resistance to deactivation. Therefore, it will be mandatory for researchers to understand the chemistry of complex fossil fuel feedstocks that will be required in order to design suitable catalysts and conditions for processing. Among all commercially applied options, catalytic hydro-processing, either as pretreatment or as upgrading, remains one of the most promising technologies for conversion of heavy oils.

The required conversion of heavy crude to distillate cannot be accomplished by only changing the process parameters or operations. New catalyst formulation and technologies will be required to achieve higher conversion and increased selectivity to the distillate range of products. On the other hand, the distillate fraction of heavy crude also contains large amounts of sulphur, nitrogen and aromatics. This is also becoming more important as refiners seek ways of gaining competitive advantage in a climate of generally poor global refining margins.