Worldwide, the importance of hydrotreating heavy oils is growing in order to meet the demand for low sulfur, improved quality heavy fuel oils and feedstocks for fluid catalytic cracking (FCC), resid FCC and, lately, hydrocracking and coking. Increasing production of higher sulfur and gravity crude oils, increasingly stringent sulfur and other environmental regulations and increasing global demand for transportation fuels are factors driving the growth. Furthermore, the production and refining of bitumens and other heavy alternate crude oils (syncrudes) is forecast to increase significantly in North America.

Heavy petroleum oils are characterized as boiling above about 650°F (343°C) and having relatively high specific gravity, low hydrogen-to-carbon ratios, and high carbon residue. They contain large amounts of asphaltenes, sulfur, nitrogen and metals, which increase hydrotreating difficulty. Feed properties are important in setting the process design and operating conditions.

Hydrotreating of heavy oils reacts them with hydrogen over a selective catalyst under high pressure and temperature to cleave sulfur, nitrogen and metals from the oil and to partially saturate polynuclear aromatic rings in order to reduce the carbon residue. Sulfur and nitrogen leave as H₂S and NH₃. As metals and coke accumulate on the catalyst, the reactor temperature is increased to compensate for reduced activity until the maximum operating temperature is reached.

Advances in heavy oil hydrotreating are a combination of catalyst development and reactor development. Heavy oil hydrotreating is performed in a series of reactors, each containing catalyst optimized for a different purpose. The reactors in the hydrotreating unit may be fixed bed, moving bed, ebulliated bed or a combination. A guard bed protects downstream catalyst from metals and contributes to sulfur removal.

This PEP Report provides an overview of heavy oil hydrotreating developments in chemistry, catalysts, process and hardware technology since PEP Report 214, Hydrotreating, issued in 1996. The report then develops the process economics for hydrotreating two heavy oil feedstocks: vacuum gas oil (VGO) and the heavier atmospheric residue (AR), each by a generic, conventional hydrotreating process. Additionally, the economics of hydrotreating VGO by our concept of the new IsoTherming™ type process is evaluated.
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