Technologies for Removing Sulfur from Heavy Crude Oil

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Abstract

Removing sulfur is a stinky proposition for oil refineries. Petroleum industry is tightening limits on the sulfur content of gasoline at the same time the crude oil coming out of the ground is becoming increasingly "sour," or sulfurous. Success in applying today's sulfur-removal methods to heavy crude oil depends primarily on the oil's concentration of polycyclic aromatic hydrocarbons, not on the nature of the oil's sulfurous molecules. On the basis of newly developed analytical methods, pilot-scale hydrotreating tests, and kinetics investigations of several heavy oils, the researchers conclude that three-ringed and larger polycyclic aromatic hydrocarbons, such as anthracene, reduce the effectiveness of heavy-oil desulfurization by blocking the access of sulfur compounds to catalysts' active sites.

Refineries separate crude oil by boiling point, which is related to density. Heavier fractions contain more sulfur, and too much renders the petroleum useless. Decades ago oil refineries adopted a process called hydrodesulfurization (HDS) to strip sulfur atoms from oil molecules. Sulfurous fractions are mixed with hydrogen and a cobalt-molybdenum catalyst, yielding hydrogen sulfide. Providing hydrogen for the process is expensive, and as oil get more sour, higher pressures and more stable catalysts are needed to break the sulfur bonds. Sourer oils also tend to be heavier, which requires further refining and brings along nitrogen and heavy metals, which foul the catalyst.

Alternative technologies floated in recent years include sulfur-eating bacteria and sulfur-oxidizing reagents, and some experts see room for better-designed catalysts, too. These methods tend to operate on the distilled fractions, but pretreatment of the crude oil itself may be an attractive option. One pretreatment option may be ultrasound. When blasted with ultrasonic waves, liquids can undergo a process called acoustic cavitation, in which bubbles form and violently implode. Refineries would have to integrate such units into their process, combining pretreatment and post-treatment. The treatment would make downstream desulfurization more efficient, and the capital investment would be only 5 percent that of HDS. To deal with heavy oils, refineries would typically thermally "crack" the oil (that is, cook it) and then treat the liquid products. This paper will review some of the technologies for removing sulfur from heavy crude oil.