Chapter 14

CHARACTERIZATION OF HEAVY OILS AND HEAVY ENDS

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1. INTRODUCTION

Current global reserves of conventional crude oils are estimated at approximately 1,000 billion barrels (1 bn bbls = 10^9), while extra heavy crude oil (XHC) plus tar sand in place volumes are estimated at around 7,000 bn bbls. From the former estimation, Canada and Venezuela respectively, appears to be the leading countries in tar sand and XHC oil sources. Another study showed that three geographical regions in the world possess the majority of these resources. The combined tar sands from Canada plus the former Soviet Republics and XHC from Venezuela plus the former Soviet Republics account for more than 90% of Earth’s reserves.

There is not a general agreement on the definitions of heavy and extra-heavy crude (HC/XHC) and bitumen. Boduszynski and Altgelt provided useful insights on these definitions, as well as a review of common misconceptions. In this chapter, the proposed definitions from the UNITAR Center for Heavy Crude and Tar Sands are as follows; HC comprises the API° range from 10-20 (specific gravity range from 1.00-0.93), XHC crude represents less than 10 API°, and natural bitumen is the one that shows a viscosity greater than 10000 cP in-reservoir. However, from the current production figures of nearly 70 million barrels/day (b/d), only 10% correspond to HC and only 1.4% to XHC.

Despite the actual low production figure of HC/XHC, the importance of these resources cannot be neglected. Population is expected to increase from 5.8 to 8 billion people by the year 2020. This population increase will demand an additional oil consumption of 20 million b/d. However, an important point is that light and medium crude oil reserves (>20 API°) are declining and the void will have to be filled by HC and XHC. It has been pointed out that by the year 2050, estimate world consumption will reach 50% XHC. Therefore, by the middle of
the 21st century at least half of the oil production is expected to be XHC, demanding optimized production, transportation, oil upgrading, and new environmental schemes to be fulfilled.

Cost-effective production of HC/XHC is the first aspect that requires close attention. Understanding their production mechanisms is a key aspect for operational improvements. Technology has been shown to lie at the core of cost reductions and has been exemplified by the success achieved during the past decade. Steam is probably the most widespread technology applied during enhanced oil recovery (EOR). Steam assisted gravity drainage (SAGD) is a related technique that has recently gained widespread acceptance. New alternatives like solvent extraction with simultaneous deasphalting and microbial enhanced recovery are also currently used. The cold production or “foamy oil” mechanism is far from understood, but is currently applied and investigated. Well known technologies like in-situ combustion, continue to find their application niches under the right geological conditions.

Transportation of highly viscous HC/XHC is the ensuing issue once the oil has been brought to surface facilities. A review on heating, dilution, emulsion, core annular-flow and partial field upgrading summarizes the main technologies applied for HC/XHC transportation. The emulsion technology has received particular attention, particularly in Venezuela, creating a new fuel known as Orimulsion. Cost reduction by natural surfactant activation in Orimulsion production and microbial enhanced emulsification are two aspects currently under investigation for improvement. Partial upgrading at the wellhead with a novel homogeneous catalytic process appears to be a breakthrough in XHC transportation.

Upgrading of HC/XHC has received a continuous attention during the past three decades. Low demanding technology schemes like asphalt production, intermediate technologies like carbon rejection and high technology approaches based on catalytic conversion (with/without hydrogen addition) have been reviewed. However, the substantial cost involved in such processes made cheaper alternatives appear viable, as in the case for asphalt production. Venezuela is such an example, with its primacy in the above business and an ever-increasing refinery diet of HC/XHC.

Technological issues related to HC/XHC were discussed in previous paragraphs. Several alternatives were identified to cope with practical issues imposed by the particular nature of these crudes. However, in order to optimize operations, knowledge of the raw material is one of the key aspects that need to be investigated. Distillation can be considered as the fundamental benchmark for the oil industry. Unfortunately, in spite of great efforts conducted to date, characterization is still an area on which more information is deemed necessary. HC, and particularly XHC, contain large amounts of heavy ends, vacuum residua in particular. The term heavy end refers to hydrocarbon mixtures boiling above