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Topping Refining Plants: Approach to Value Maximization

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Abstract

Topping refining plants are characterized with the inability to produce petroleum products outside the natural yield pattern of the crude oil processed and provide negative or barely marginal returns where a higher proportion of residuals and others fractions with low market value are obtained. Increasing revenues from better yields or higher capacity processing and decreasing the cost of operations or capital expenditure expectedly improve viability. In consideration of using feedstocks with inherently high API gravity, the yield of lower value fractions is minimized, and the recovery of additional products to widen the slate, especially with the production of kerosene and diesel, will increase revenue by virtue of the wider spread in unit prices in comparison to crude oil processed. Though higher capacity processing requires additional capital and operating expenditure, the unit cost per barrel installed is expected to decrease from economies of scale. In summary, the combined impact of higher revenues from higher yield from expanded products slate and lower unit costs from higher capacity processing, topping refineries viability is sustained.

Keywords: Topping; Refinery; Products; Slate; Feedstocks; Crude oil; Scale; Capacity; Distillation; Viability

Introduction

The most common application for topping plants is for the recovery transportation fuels and heating oils from remote locations endowed with small quantities of petroleum reserves. A clear distinction complexity of refineries. Topping refineries have only crude distillation and basic support operations, with no capability to alter the natural yield pattern of the crude oils that they process [1], and the simplest refinery configuration designed to prepare feedstocks for petrochemical manufacture or for production of industrial fuels in remote oil-production areas [2]. Also, topping facility is basically a distillation tower that split crude oil into its main components [3]. Table 1 [3] clearly shows classification of refineries based on plant complexity.Topping Plant Viability Challenges

Table 1: Classification of Refinery Categories by Complexity.

Classification	Name	Complexity range
Very simple	Topping	< 2
Simple	Hydro skimming	5-Feb
Complex	Cracking, conversion	14-May
Very complex	Coking, deep conversion	>14
Specialty	Lube oils, asphalt	> 5
Integrated	Petrochemical	> 10

Topping refining plants have been known to be implemented in remote locations, especially low-income economies, to produce naphtha and kerosene are needed by processing feedstocks obtained locally and at lower acquisition cost due to lessened transportation costs, as such the finished and unfinished products produced from topping plants are mostly consumed in the local markets at lower prices. The processing of low API and highly viscous heavy crude in distillation columns of topping units produces a larger fraction of residual fuel oil and less naphtha and kerosene. Conversely, processing feedstocks with a high API gravity produces a higher quantity of low-boiling distillates such as kerosene and naphtha and a smaller amount of residual fuel oil. The low complexity of topping plants results in higher yield of residuals and other low value fuels that attract less prices. The two important elements that impact profitability of a refinery are crude oil purchases and plant operations, and the refining industry is capital intensive such that even one percent improvement can increase the profit significantly [4]. The need to enhance yield or value comes at the detriment of higher cost from further processing, procurement and utilization of more expensive higher API feedstocks, and additional capital expense from configurations that increase products slate. Options for Viability Enhancement

Maximizing returns on investment requires that the products slate be increased to ensure more lighter fuels are produced at higher yields. Achieving this will necessitate the need to selectively use feedstock with high API gravity, implement high-capacity plants, and design the distillation unit for maximum distillate recovery.Feedstock Selection

Refinery profitability is significantly impacted by the changing quality characteristics of crude oil and quality of products and needs to be considered in purchasing decisions [5], and the quality and yield of each product is principally determined by the characteristics of the crude oil processed. Efforts at characterization of Bonny light and Bonny medium crude oils to reveal the maximum liquid volume fraction of the different distillate at an ideal condition [6] was undertaken. Heavier crude oil with API gravity below 30 are prone to producing higher proportion of residuals, while higher API alternatives produce more of higher value distillates like kerosene, diesel, and sometimes heavy naphtha. The use of light naphthenic crude oils such as bonny light, escravos, and qua iboe will selectively produce a higher proportion of diesel and kerosene. The revamp and expansion of refinery units to operate successfully due to changing crude oil qualities [5], and the improvement of the economic efficiency of the atmospheric distillation unit due to changes in the characteristics of the crude feed [7] revealed the impact of feedstock selection on yields, thus the implementation of designs that utilize high API feedstocks enables higher yields. Products Slate

Products that attract low market price, either due to subpar quality, heating value or demand, depress the viability of topping refineries, while the ones that attract higher price enhances return on investment due to the higher price spread with the feedstock. Residual sold as fuel oil and naphtha attract lower price as such the recovery of distillates with higher market value such as diesel and kerosene ought to be prioritized. Achieving higher products slate necessitates retrofitting or configuring distillation column to extract more stable distillate flows as indicated in the proposed control strategy by dynamic modeling of a crude distillation unit to obtain stable distillate flows of kerosene and diesel [8], successful revamp of crude distillation towers for increased diesel quality and yield which depended on reliable design and accurate assembly [9] and the required trade-off shown between process throughput, yields showed how products slate can be improved. The smaller price spread between the residual and crude oil makes the processing of heavy crude oils uneconomical. However, as more and more lighter distillates with wider spread with crude oil are implemented higher revenues are obtained. To maximize the profit and the value of the products, refineries are expanding their product portfolio to include high value products [10].Economies of Scale on Plant Capacity

Revenues from plant operations is the sum of the receipts from various products reckoned from the unit price and the quantity of each product sold, and any increase in yield translates to a proportionate increase in incomes, thus higher capacity processing is bound to enhance revenue. However, the cost of operations is made up of fixed and variable charges, largely determined by the incremental outlay associated with changes in dimensions and ratings which are not proportionate due to economies of scale. The impact of refinery complexity on the development has been analyzed. For a given utilization rate, the refining cost per ton of crude decreases as the size of the refinery increases [11]. Minimizing these through higher capacity will enhance refining margins due to lower unit cost per barrel installed.Conclusion

Topping refineries will continue to be relevant for extracting fuels in remote locations with availability of crude oil or hydrocarbon reserve despite anticipated lower value. The improvement of the products slate with more fuels of higher value, use of light naphthenic crude oils with higher API gravity and operating at higher capacity will provide assurance of improved viability. With the processing of high API crude oils, a higher yield of higher value fractions is billed to be obtained when compared to heavier lower value fractions, while designing or revamping crude column with additional strippers to increase products slate through the recovery of more distillate fuels like diesel and kerosene will enable attracting higher prices. In addition, to the choice of feedstock and products slate, installing and operating higher capacity topping plants contributes to enhancing viability via minimizing the unit cost of development and operations. Overall, the implementation of topping plants processing light naphthenic crude oils to recover all valuable distillates at higher capacities will sustainably maximize value and viability.

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