Refinery Equipment of Texas

Mini - Refinery Feasibility Overview

Introduction

This paper is intended to provide information, answer questions, and assist the owner or project developer in making informed buying decisions. A mini-refinery typically is a small refinery that fractionates less than 5000 barrels of crude oil per day by atmospheric distillation. Small refinery profitability is inversely proportional to current crude oil price and refined products sale price! If crude oil cost are high $$$ and product sales prices are low then margins are minimal, i.e. $58.00 per barrel of crude oil and $1.85 per gallon diesel; however, if the inverse is true and crude prices are reasonable, i.e. $80-90.00 per barrel and $3.65 per gallon for diesel then profit margins are very rewarding. With the current sales price for refined products, specifically diesel, a highly desirable product, it is very profitable to set up and operate a mini-refinery as shown in exhibit "A".

Refinery Equipment of Texas engineers can provide meaningful assistance and answer questions during this preliminary pre-purchase phase.

Feasibility

A mini-refinery does not always have to be economically feasible to be justifiable and may very well be an absolute requirement in certain geographical locations where economics is not the deciding factor but where local needs are the determining factor.

If you must have diesel at a remote hospital to run generators to save lives then cost is secondary. Where this is not the case; it is beneficial for certain conditions to exist for these small refineries to help their economics. This requires an understanding of what a mini-refinery does and technical issues relating to plant engineering & design, plant feedstock, and what crude oil is available, and what are the desired end products. Intimate knowledge and familiarity of local market conditions are equally important considerations.

Definitions

Mini-refinery: typically a small refinery that fractionates less than 5000 barrels of crude oil per day by atmospheric distillation.

Modular refinery: a refinery that is built in sections or modules so that it can be easily transported or relocated; most mini-refineries are modular in design.

Crude oil: Petroleum crude oil is a naturally occurring flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights and other liquid organic compounds, that are found in geologic formations beneath the Earth's surface.

Barrel: a unit of volume equal to 42 U.S. gallons

BPD: barrels per day

Product slate: the end products that are the fractional crude oil cuts

HFO: Heavy fuel oil

MDO: Marine diesel oil

Naphtha: is defined as the fraction of hydrocarbons in petroleum boiling between 30 °C and 200 °C. Naphtha consists of a complex mixture of hydrocarbon molecules generally having between 5 and 12 carbon atoms and typically constitutes 15–30% of crude oil, by weight. Naphtha is used primarily as feedstock for producing high octane gasoline and by the chemical industry for solvent (cleaning) applications. Common products made with naphtha include lighter fluid, fuel for camp stoves, and some cleaning solvents.

Assay: detailed laboratory analysis of a specific geographical crude oil.

Fractionation column: is an essential part of a refinery used in the distillation of crude oil to separate the mixture into its component parts, or fractions, based on the differences in their volatilities.

Crude heater: is an essential part of a refinery for heating the crude oil feedstock.

Heat exchanger: is a piece of equipment built for efficient heat transfer from one medium to another.

De-salter: A unit that washes out salt from the crude oil before it enters the atmospheric distillation unit.

Simulation software: is based on the process of modeling a real phenomenon with a set of mathematical formulas. It is, essentially, a program that allows the user to observe an operation through simulation without actually performing that operation. Simulation software is used widely to design equipment so that the final product will be as close to design specs as possible without expensive in process modification.

Refinery optimization: verification that the existing equipment is being used to its fullest advantage by examining all operating parameters and automation controls.

Economic Conditions

Specific economic conditions enhance the profitability of these small refineries and justify these units as stand-alone profit generators. This is evident by the recent upsurge in mini-refinery demand. Examples of these conditions are listed below.

- access to cheap crude oil from remote locations
- high fuel transportation costs (typically in remote or inaccessible regions)
- high fuel / diesel prices (which exist currently exist in the marketplace - 2012-2013)
- diesel requirements for construction equipment in remote locations
- diesel requirements for power generation in remote locations
- fuel requirements for military vehicles and equipment
- existing government incentives to support economics' in isolated communities.
- disaster sites without adequate fuel that may require extensive rebuilding
- electrical power is a necessity and not an option
- market for residual products (HFO / MDO)
- time considerations, how long do I need this capacity
- re-sell considerations, can I sell the unit after my requirements are complete?
- Refinery re-configuration in the future

Remote or inhospitable inland locations will tend to provide favorable conditions for mini-refinery fuel production as distances and/or road conditions results in high transportation costs for imported fuels.

To minimize its capital cost, the mini-refinery is most often supplied only as a simple straight run atmospheric distillation refinery for diesel production with fuel oil as by-products; fuel oil in this text meaning HFO (heavy fuel oil) and MDO (marine diesel oil). HFO & MDO are both valuable and saleable products used by the Power Industry for power generation and the Marine industry for Ocean going vessels.

Naphtha represents the gasoline fraction of the crude oil but it is unsuitable for automotive gasoline without octane enhancement by blending with oxygenates such high octane gasoline, toluene, MTBE, ETBE or Ethanol, etc. to produce low octane gasoline. The largest consideration in a mini-refinery is not what to do with the diesel, which is highly desirable, but to develop channels for the remaining product slate.

Crude Oil

A straight run refinery merely fractionates by distillation the crude oil feedstock into its boiling point components. Distillation does not alter the molecular structure of the crude oils chemical components. Therefore, the natural characteristics of the crude oil (or condensate) and the required specification of the final refined products are the determinants of the product yields from the refinery.

To avoid scaling and fouling within a refinery, the crude oil should have a maximum salt content of 1 Kg per 1000 barrels. Where the salt content exceeds this level, a pre-treatment process may be required or special metallurgy designed into the fractionation column. Although adding a de-salter to a mini-refinery is quite feasible, it does require a fresh water supply and a means for disposing of the salt water waste.

Other undesirable components in the crude oil such as sulphur will carry over into the refined product streams. The maximum allowable sulphur levels for refined products are normally set by government regulations. Crude oils with <1% sulphur will normally refine within the allowable fuel specifications for diesel and naphtha without the need for a de-sulphuring process.

Fuel oil specifications may determine the maximum allowable sulphur content in the crude oil to avoid the expense of de-sulphuring equipment.

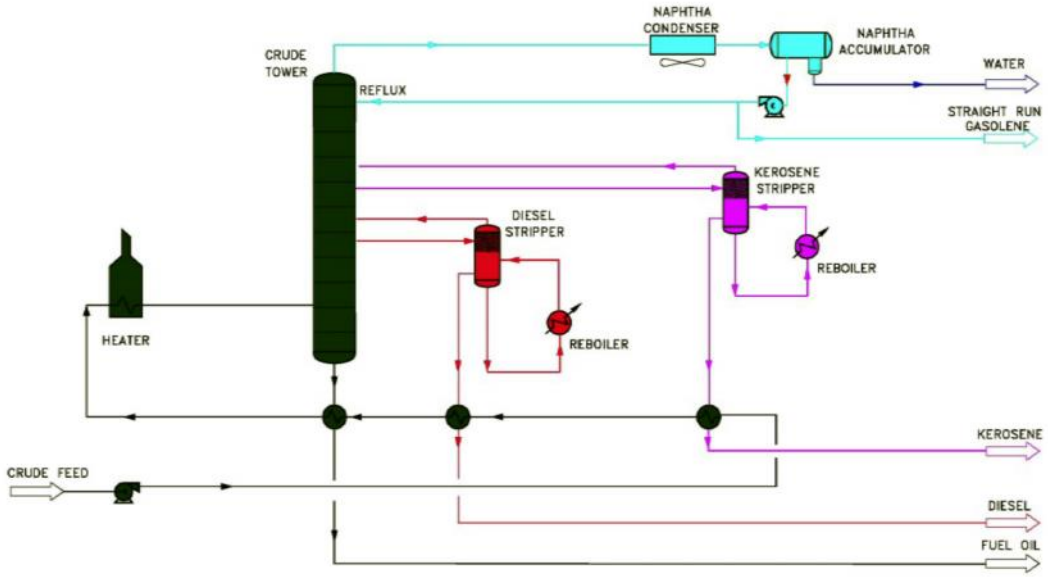
In summary, the optimal feedstock for a mini-refinery is generally a high API crude oil or condensate that has a relatively high natural diesel fraction in its assay. It also should be low in sulphur, salt or other contaminants.

The refinery products

The usual products from a straight run mini-refinery are naphtha, diesel and fuel oil (residual oil). Small mini-refineries can also be designed to produce kerosene but most do not since this is a small percentage of the crude and is not the primary requirement. “Diesel is a highly desirable product”.

Process Flow Diagram

The following process flow diagram is just one of many possible configurations depending on what the end product or products you require. A Kerosene stripper would not be required if you do not want Kerosene. The Kerosene cut would flow back into the residual to provide a higher quality residual fuel oil.



Operating costs

To minimize operating costs, the REOT Modular Refinery does not require cooling water or steam. It does require the customer to provide electrical power as well as products storage tanks, load out facilities and associated pipe work. REOT can provide a turn-key or completely engineered refinery solutions package.

Recommended manning requirement is 1 man per 12 hour shift with a supervisor on call. The automated design of the REOT Modular Refinery means that it will be sufficient to have refinery operators with a basic technical background and who can be trained in the operation of the refinery.

Optimizing the project

There are a number of things that can be considered to improve the project dynamics:

1. In the case where there are a number of possible oilfields to supply from, choose the oil fields that have the best crude oil qualities, particularly the one with the highest diesel yield in its assay.

2. If a crude oil pipeline exists nearby; consider putting the unwanted by-products back into the pipeline. This will require an acceptable purchase arrangement for the refinery by-products with an oil brokerage company, pipeline company or end-of-pipeline refiner.

3. Find local markets for the by-products. For example naphtha could be used as a solvent or petrochemical feedstock. In arctic climates the naphtha is often used as a non-freezing well completion fluid instead of diesel. Fuel oil can be used as bunker or boiler fuel or heavy fuel oil for power generation.

4. If the naphtha has suitable properties it may be blended with octane improvers such as high octane gasoline, toluene or oxygenates (MTBE, ETBE, ethanol, etc.) to produce low octane gasoline.

5. Consider “DLM process enhancement”.

The above issues can only be effectively dealt with by the project developer or owner who is familiar with the local territory and markets.

Mini-refinery Questions:

Refinery location:

Is steam or water available on site?

Is there an approved means for disposing of waste water if crude oil desalting is required?

What is the anticipated price per barrel for the crude oil feedstock to be delivered?

What is the required refinery capacity (tones per annum or barrels per day)?

Distance from source of oil?

Distance to nearest oil pipeline?

Distance to nearest seaport?

Distance to main fuel markets?

Quality of crude oil: Need Assay

Product specifications:

Attach the required product specifications for Naphtha, diesel, and fuel oil:

Alternative fuel supplies

Can the market absorb additional electrical power generation?

What is cost per KWh for locally supplied electricity?

What storage capacity do you need? Ten days?

What is the average selling price for the refinery by-products?

Exhibit "A"

NOTE: Please review the three following calculations with **variations in crude oil price per barrel** being the only difference. Each geographical location will need to adjust the cost per barrel of crude and the price paid per gallon of refined product to arrive at the correct annual rate of return.

*These tables do not show refinery equipment cost or operations labor cost (two men).

Table 1 - $90 per barrel of crude oil

Refinery Profit Calculator - Per Day						
3000	Barrels per day		Cost per barrel USD	**$90.00**	Total	$270,000.00
		Percent of cost	Barrels	gallons	Sell $	Projected Sell $$
24%	Avg. % yield for naphtha	$64,800.00	720	30,240	$2.15	$65,016.00
34%	Avg. % yield for diesel	$91,800.00	1,020	42,840	$3.25	$139,230.00
42%	Avg. % yield for HFO	$113,400.00	1,260	52,920	$1.95	$103,194.00
Assumptions: Crude API between 32 & 39					return	$307,440.00
					cost	$270,000.00
www.platts.com					Daily $$	**$37,440.00**
					30 days	$1,123,200.00
					Annual	**$13,478,400.00**

Table 2 - $80 per barrel of crude oil

Refinery Profit Calculator - Per Day						
3000	Barrels per day		Cost per barrel USD	**$80.00**	Total	$240,000.00
		Percent of cost	Barrels	gallons	Sell $	Projected Sell $$
24%	Avg. % yield for naphtha	$57,600.00	720	30,240	$2.15	$65,016.00
34%	Avg. % yield for diesel	$81,600.00	1,020	42,840	$3.25	$139,230.00
42%	Avg. % yield for HFO	$100,800.00	1,260	52,920	$1.95	$103,194.00
Assumptions: Crude API between 32 & 39					return	$307,440.00
					cost	$240,000.00
www.platts.com					Daily $$	**$67,440.00**
					30 days	$2,023,200.00
					Annual	**$24,278,400.00**

Table 3 - $70 per barrel of crude oil

Refinery Profit Calculator - Per Day						
3000	Barrels per day		Cost per barrel USD	**$70.00**	Total	$210,000.00
		Percent of cost	Barrels	gallons	Sell $	Projected Sell $$
24%	Avg. % yield for naphtha	$50,400.00	720	30,240	$2.15	$65,016.00
34%	Avg. % yield for diesel	$71,400.00	1,020	42,840	$3.25	$139,230.00
42%	Avg. % yield for HFO	$88,200.00	1,260	52,920	$1.95	$103,194.00
Assumptions: Crude API between 32 & 39					return	$307,440.00
					cost	$210,000.00
www.platts.com					Daily $$	**$97,440.00**
					30 days	$2,923,200.00
					Annual	**$35,078,400.00**

The above “Refinery Profit Calculator” excel spreadsheet is available by request by contacting dan.mcguire@reftexas.com

Note: This document is provided as a tool to benefit and guide the project developer(s) or owner(s) in the decision making process. Information contained herein will change with market dynamics and will be updated periodically. All content was provided by Dan McGuire of Refinery Equipment of Texas. If you should have any questions or comments please direct all questions directly to his attention.

Best Regards,

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