Valuation of Coal Liquids as Refinery Feedstocks Using Linear Programming Tool (PIMS)

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ABSTRACT

Product pricing follows the simple law of supply and demand, and therefore, it is extremely dependent on the market situation. As long as the identifiable market is established, product valuation should not be complicated. Because of the inherent characteristics of coal liquefaction products, however, direct marketing of coal liquid products to the end user may not be feasible. For coal liquid products, the market is primarily through the refinery. The purpose of this paper is to demonstrate the proper method of evaluating the economics of coal liquids as refinery feedstocks.

The approach of having a dedicated refinery to upgrade coal liquids to marketable products may not be a practical solution. When the products are brought into an existing refinery with a certain configuration already built in, the obvious question will then be how best the product can be routed to the various processing sections of the refinery to obtain the maximum margin for the various coal liquids. In addition, the coal liquid products are envisioned to be routed to more than one refinery in order to maximize product value. This complex scheme could be optimized by the application of linear programming (LP) method. However, because of the complexity of the situation, the success of the product pricing evaluation is very much dependent on the type of LP tool being used. In this paper, the LP tool utilized is Bechtel's proprietary linear programming tool, called Process Industry Modeling Systems (PIMS). The approach described in the paper utilizes PIMS in assigning value to various products obtained by direct liquefaction of coal.

INTRODUCTION

Depending on the complexity of the problem, there are three (3) possible ways of assessing product valuation and economic analysis in a refining environment. These three possible ways are: Back of the envelope calculations, application of Lotus (or similar) worksheets and utilization of LP-based optimization.

Back of the envelope type calculations could be sufficient for a topping refinery. Likewise, a Lotus worksheet tool may be suitable for a hydroskimming refinery. As combinations of crudes are processed in a refinery, and as the refinery configuration becomes more complex, it becomes difficult, if not impossible, to conduct a reasonably decent analysis by following either of the above mentioned two methods. In such situations, linear programming (LP) becomes, the only practical option of choice for such calculations.

The objective of this paper is to show how an LP system (PIMS) can be used effectively in determining the relative value of the coal liquids as they relate to a petroleum refinery as a feed stock. In a given refinery PIMS is able to assess the global effects of processing and/or blending the various coal liquids, either as a total mixture or as separate fractions.

PRODUCT VALUATION BY LINEAR PROGRAMMING (PIMS)

Typically the linear programming tool, PIMS, takes into account an array of data such as: product prices, crude oil price, utility costs, crude oil assays and characterization data (API, sulfur, distillation, octane number, Cetane number, Bromine number, etc.).

When coal liquid is brought in as feed to a given refinery, PIMS allows the optimum disposition of the feed and assign the value of the coal liquid products with reference to the petroleum feed. The product valuation scheme is schematically shown in Figure 1.

Bases and Assumptions

Methodology - The evaluations have been conducted using Bechtel's proprietary LP system, PIMS (Process Industry Modeling Systems). The approach to the economic analysis is based on the break-even value concept, i.e., that value of incremental volume of coal liquid that will result in no monetary loss (or gain) compared to the current, i.e., base case. The resulting product value is then expressed in terms of its syncrude premium ratio (SCP) relative to the price of PAD-II crude mix.

Refinery Configuration - The refinery LP model emulates a typical PAD-II district configuration (Refer to Fig. 2). Rated capacities of various process units are indicated in Table 1.

Prices/Volumes - The prices of feedstocks and finished products, including appropriate limits on supply and demand, were based on the recent DOE Study on direct liquefaction of coal (DOE Contract No. DEAC22 90PC89857) conducted by Bechtel.

Unit Capacities - The refinery is rated at 150 MBPD total crude charge (130 MBPD PAD-II, 20 MBPD Alaskan North Slope).

Case Definitions

The volume of the coal liquid mixture is estimated to be 30,973 BPSD, and consists of the following:

			LV%
MNC	C5-350°F	Coal Naphtha	31.0
LDC	350-450°F	Coal Lt Distillate	12.6
HDC	450-650°F	Coal Hv Distillate	34.9
LVC	650-850°F	Coal Lt Vac Gas Oil	21.5
		Coal Liquid Mix	100.0

The cases are separated into two broad categories. These two categories designated as A and B are defined below:

A Production is limited by market demand, and
B All products can be sold in the marketplace.

The individual cases are then further defined as follows:

Case 1	Base Case, Zero Coal Liquids
Case 2	100% Coal Liquid Mix
Case 3	100% Coal Naphtha
Case 4	100% Coal Lt Distillate
Case 5	100% Coal Hv Distillate
Case 6	100% Coal Lt Vac Gas Oil

Processing Coal Liquids in a PAD-II Refinery

Coal naphtha (MNC) is fed to the Reformer and converted into high-octane reformate. Light distillate (LDC) is blended into finished diesel and finished fuel oil. Heavy distillate (HDC) is sent to the Cat Cracker as well as directly to diesel and fuel oil blending. Light vacuum gas oil (LVC) is used as a fuel oil blending component and as a Cat Cracker feedstock.

Results and Discussions

The product valuation for coal liquid was conducted utilizing the PIMS model described above. A typical PADD II refinery configuration and crude mix with a fixed price were used and assuming that the various fractions of coal liquid are available to the refinery. It was also assumed that the naphtha fraction of the coal liquid (C5-350°F) was sent to the reforming unit, the light distillate fraction (350-450°F) was sent for blending (diesel and fuel oil), the heavy distillate fraction (450-650°F) was available for diesel and fuel oil blending and also used as FCCU feed, and the vacuum gas oil (650-850°F) was used as fuel oil blending stock and FCCU feed. The product valuation was then calculated under two distinct scenarios. These two scenarios are: 1) force the refinery to make the same product slate that would make on its typical crude oil feed and 2) allow the product slate to float to maximize the profit. The product valuation, was expressed as the syncrude premium factor (SCP) which relates the coal liquefaction plant product values to a typical crude oil in PAD II refinery.

A low SCP value of 1.07 was determined for scenario 1 and 1.27 for scenario 2 described above. In actual case SCP can range anywhere between these two limits.

The SCP is ultimately used to calculate the economics of coal liquefaction where the economics is expressed in terms of crude oil equivalent price. Figure 3 depicts a interrelationship of various models developed in the previously referred DOE study on direct liquefaction of coal. The crude oil equivalent price is observed to be very sensitive to the value of SCP. When SCP was changed from 1.07 to 1.27 in the earlier referred DOE study on direct liquefaction of coal it was observed that the crude oil equivalent price reduced by $5.35. The result indicates that the accurate determination of SCP is important. The refinery model itself and the input data utilized in PIMS need to be carefully examined to make a better assessment of SCP. Recently a refining end use study has been funded by DOE whereby Bechtel Corporation (contractor) in conjunction with a number of subcontractors has started updating the PIMS preliminary baseline model and the coal liquid products characterization data.

Table 1
Rated Capacities of Various Process Units

Refinery Unit	Rated Capacity*
Crude Unit #1	130,000
Crude Unit #2	20,000
Vacuum Unit #1	59,300
C5/C6 Isomerization	11,200
Naph Hydrotreater	45,900
Low-P Reformer	39,400
Kero Hydrotreater	6,000
Dist Hydrotreater	15,300
Catalytic Cracker	53,300
Sulf Acid Alkylation	11,900
Hydrocracking (Dist)	7,500
H2 Plant MMSCFD	0.030
Delayed Coker	16,800
Sulfur Plant MLT/D	0.070

***All rated capacities unless listed, are in BPD**

Figure 1
PIMS Product Valuation Scheme

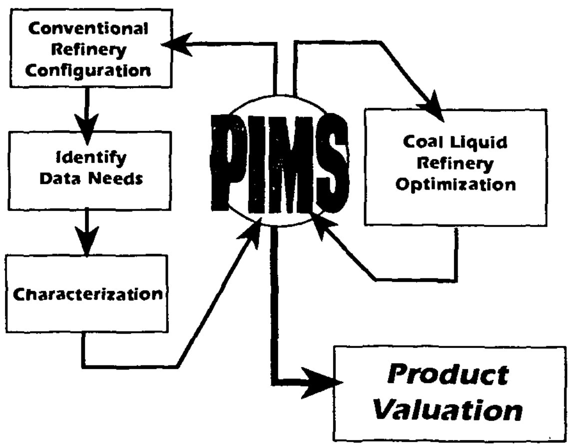

Figure 2
Coal Liquefaction Product Disposition Scheme for a Given Refinery

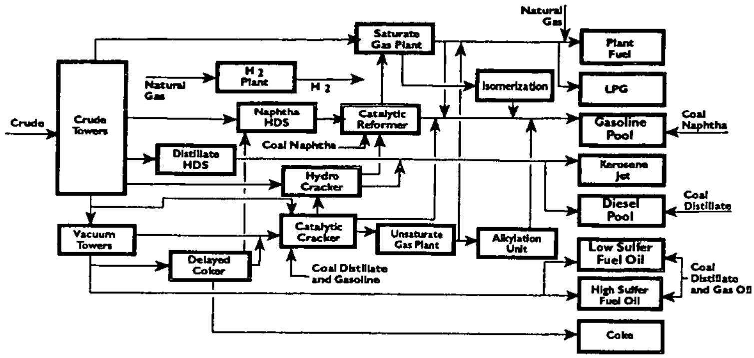

Figure 3
Interrelationship of Various Models Developed in DOE Study on Direct Liquefaction of Coal