Matching Gasoline Supply with Distribution Requirements Optimizes Depot Storage Capacity

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1. Summary

This study was done for one of the Nigerian National Petroleum Corporation (refiner) depot supplied by a multi-product (gasoline, diesel and kerosene) pipeline. Distribution/loading facility designed for two arms each for gasoline, kerosene and diesel (or 33.33% for each product) whereas gasoline storage capacity is 55%, diesel, 33%, kerosene 11%, and slops, 1% of the total depot capacity. The design supply to distribution chain capacity ratio showed a mismatch, which in actual operation becomes 2:1. The above design created ullage problem at sustained supplies, gross under utilization of supply chain infrastructures and poor operational performance. After a technical evaluation, a section of the depot storage to loading pipeline network was re-designed and modified to enable products supply capacity match loading, and minimize storage. Hence the gasoline loading became 66.67%, kerosene and diesel, each of 16.67%, increasing the actual supply to distribution chain capacity ratio from 2:1 to 2:2 (and when required, can be maximized to 2:3) thereby correcting the apparent mismatch between the supply and distribution chain capacities. The modification has enabled the refiner to increase depot and upstream supply chain utilization.

Keywords: Supply, distribution, match, stock, capacity.

2. Extended Abstract

The Nigerian National Petroleum Corporation, a refiner, owns and operates a petroleum products pipeline network connected to twenty one storage depots across Nigeria. Products are supplied to the depots from the local refineries and ex-jetties (for imports) mainly by pipeline. The main objective of establishing the pipeline network and the depot facilities by the refiner was to ensure efficient product distribution, reduce transportation cost and minimize products price differential across the country.

The concept, design and layout of the depot facilities were such as to maximize gasoline supply and distribution, which as a major transportation fuel, has the highest demand profile over kerosene and diesel. Since the early 1990s, as gasoline demand increased by over 30% the entire supply/distribution chain appeared inadequate. The refiner then began to find a solution to products supply and distribution. As gasoline is the priority product, the study aimed at maximizing its availability at all times.

Technical Evaluation

The Depot is supplied by a 6-inch multi-product (gasoline, diesel and kerosene) pipeline at 82 m3/hour and loading/distribution of 100 m3/hour per arm inside the depot. Distribution/loading facility designed for two arms each for gasoline, kerosene and diesel (or 33.33% for each product) whereas gasoline storage capacity is 55%, diesel, 33%, kerosene 11%, and slops, 1% of the total depot capacity. The design supply to distribution chain capacity ratio showed a mismatch, which in actual operation becomes 2:1, creating bottlenecking in supply-distribution value chain. After a technical evaluation, a section of the depot storage to loading pipeline network was re-designed and modified to enable products supply capacity match loading, and minimize products accumulation over a period. The tank farm loading facility flowsheet is defined by the following matrix (design and modification cases):

Design

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
G1	1	1	0	0	0	0	0	0	0
G2	0	0	1	1	0	0	0	0	0
D1	0	0	0	0	1	1	0	0	0
K1	0	0	0	0	0	0	1	1	1
D2	0	0	0	0	1	1	0	0	0
K2	0	0	0	0	0	0	1	1	1

Modification

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
G1	1	1	1	1	0	0	0	0	0
G2	1	1	1	1	0	0	0	0	0
G3	1	1	1	1	0	0	0	0	0
G4	1	1	1	1	0	0	0	0	0
D1	0	0	0	0	1	1	0	0	0
K1	0	0	0	0	0	0	1	1	1

Where for i=1,….,n, T_i, represents the tanks, and G_i, D_i, K_i, represent the loading arms (G for gasoline, D for diesel and K for kerosene): T_{1-4} (gasoline), T_{5-6} (diesel) and T_{7-9} (kerosene).

For day i (i=1,…m), the relationship between supply (x_i), distribution (z_i) and stock (y_i) can be defined as $y_i = x_i - z_i$ with accumulation as $\sum y_i = \sum x_i - \sum z_i$. The strategy here is to minimize Stock Index (SI) defined as (SI) = $((x_i - z_i)/x_i)$. Since the pipeline is a multi-product system scheduling for optimum utilization is very critical[1,2]. The depot pipeline network ***(Design)*** was modified ***(Modification)*** at negligible cost, resulting (from June 2004) in significant improvement in pipeline transportation scheduling, depot stock (Figure 1) and overall products distribution (Figure 2).

Conclusion

Consequently, gasoline loading became 66.67%, kerosene and diesel, each of 16.67%. Overall, the actual supply to distribution chain capacity ratio was increased from 2:1 to 2:2 (and when required, can be maximized to 2:3) thereby correcting the apparent mismatch between the supply and distribution chain capacities. The modification has enabled the refiner to increase depot and upstream supply chain utilization.

Fig.1 Stock Profile For Produces Scheduling/Distribution

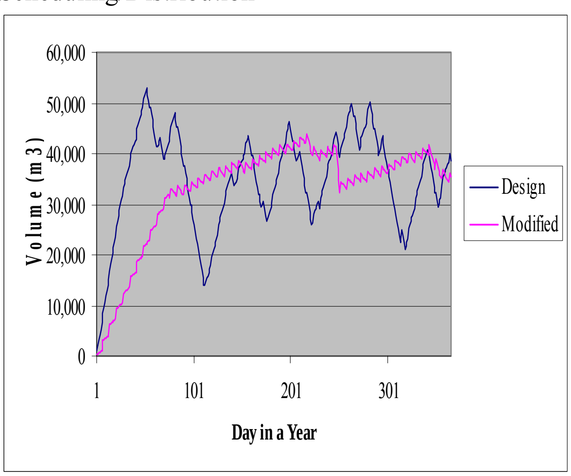
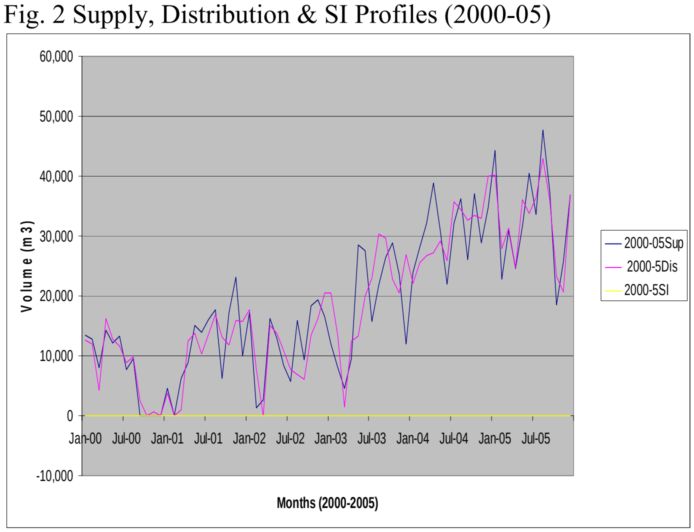


Fig. 2 Supply, Distribution & SI Profiles (2000-05)



Reference

1. Milidiu, RL, Liporace, F, and P. de Lacena CJ, Pipesworld: Planning pipeline transportation of petroleum derivatives. ICAPS Workshop on Competition, Italy, June, 2003
2. Smith, R Chemical Process design and integration. John Wiley & Sons, USA (2005).