Process Re-Engineering -: A Study of Managing and Optimizing Petroleum Products Terminal

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Abstract

Oil Marketing Companies (OMCs)ensure efficient supply chain management to deliver petroleum products to retail outlets in time and at an optimized cost. Terminals are an essential component in the supply chain and distribution network of petroleum products for retail outlets and consumers of petroleum products. These terminals have large capacities to store products distributed using trucks, railway wagons, or barges. Optimizing operations of the terminal leads to reducing the operational cost of OMCs. This study discusses a petroleum products distribution network managed and operated by OMCs in India. It further discusses the layout plan and operations at the terminals. The methodology adopted for the study is an analysis of tank truck turnaround time at one of the petroleum-petroleum-product of an Indian OMC. The tank truck turnaround time analysis is undertaken to identify the bottlenecks in the tank truck turnaround process. It has been identified that the efficient functioning of the Supply and Distribution(S & D) department in managing the tank truck turnaround time is vital for the entire process to be optimal. The optimization results in higher throughput from the terminal over a period of time. Thus, it saves investment in setting up new terminals to serve higher demand.

Keywords: Process Re-Engineering, Logistics, Optimization, Petroleum Products, Oil Marketing Company

Introduction:

The thick, black substance known as crude oil is delivered to the final user as either light brown or colourless petrol or diesel. This happens due to refining, which converts heavy crude oil extracted from the earth into petroleum products like fuel, diesel, plastic, and agricultural chemicals. To meet the rising global energy demand, refineries are essential for delivering petroleum products to the market.

The primary means of delivering crude oil to refineries are crude oil transmission pipes, railways, and truck tankers. When crude oil arrives at the refineries, it is processed there utilizing cutting-edge technological advancements, including automation, cogeneration, and solvent-

extraction systems, which help to extract more value from each barrel of processed crude oil. Then manufactured, refined goods are shipped to petrol stations for marketing or distribution by truck tanks, railways, or pipelines.

India has a network of pipelines, trucking systems, and railways carrying, among other petroleum products, petrol and diesel to terminals and fuel stations. They transport the petroleum products that Indian consumers and businesses require by connecting refineries to the distribution network and other entities in the petroleum value chain.

The petroleum products distribution Network in India comprises the following types of terminals.

(i) Coastal Installations: These are situated along the coast and receive supplies generally by tankers and pipeline transfers from the nearby refineries—the total tankage here typically exceeds50 000 Kiloliters (Kilos).

(ii) Inland Installations: The supplies are generally received by tank wagons and/or by pipeline transfers from nearby refineries/tap-off Points (TOP). The total tankage here ranges typically from 10,000 Kiloliters to 50,000 Kiloliters.

(iii) Tap-off Points: These are locations where the supplies are primarily received by cross-country pipelines directly or through other OMCs.

(iv) Depots: The facilities here are on a smaller scale than facilities at installations. Suppliesare received by tank wagons, except at very few locations where supplies are received onlythrough tank-lorries. At some depots, hospitality is also extended to OMCs.

(v) Hospitality Depots: These are locations where the particular OMC does not have a storage facility. Hence, another OMC receives stores and delivers products on behalf of the specific OMC and provides supervision and documentation.

(vi) Dispatch Units (Refinery Dispatch Units and Other OMCs Dispatch Units): These are generally situated at refinery locations where only documentation/ accounting work is carried out; the host company undertakes physical operations. Their function is to ensure that deliveries by road and dispatches by rail are made as per the demand and share of OMCs.

(vii) Special Agreement/Commission Operated Depots: Depots handling only lubricants are operated by Contractors. While the operating fee in the case of Special Agreement Depots (SADs) is paid in a lump sum, in the case of Commission Operated Depots (CODs), it is based on throughput.

(viii) Taluka Kerosene Depots: These are storage points for Superior Kerosene Oil (SKO) in remote areas operated by an operator. Supplies are received on a stock transfer basis and sold to agents of all OMCs.

(ix) Jetty: These are coastal locations where ocean tankers are handled for loading & discharge.

(x) Contracted Tankage: These locations have only tankages on contract for storage and distribution.

Terminal Operations

The terminal operations can be divided into three sections:

1. Receiving: Petroleum products are received from the refinery by pipelines, railway wagons, tap-off points, tank trucks, etc.

2. Storage: The products are received in tanks. There are different above-ground tanks and underground tanks which are used for the storage of various petroleum products.

3. Dispatching: The mode of dispatch to different retail outlets is Tank Trucks (TTs)/Tank Lorries. Gantry is the central dispatching unit at the terminals. All dispatch planning is done by Supply& Distribution (S & D) department. TTs are generally 12 Kiloliters, 20 Kiloliters, and 25 Kiloliters.

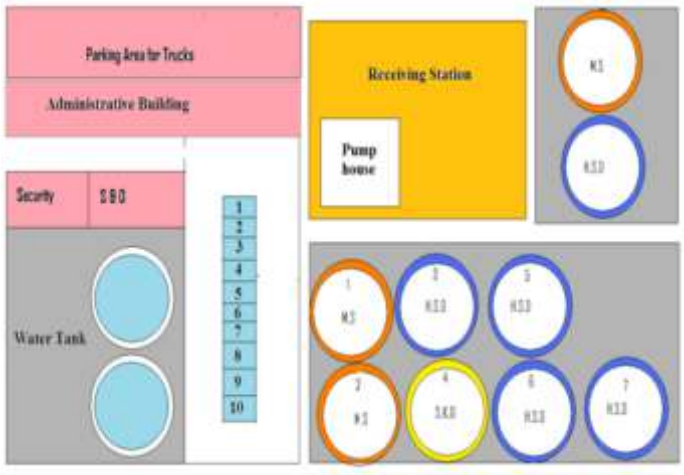
Tanks on tank trucks (TTs) are generally divided into 3 or 5compartments. Different combinations of tank compartments are as follows:(a) 12 KL = 4KL + 4KL + 4KL OR 3KL + 4KL + 5KL(b) 20 KL = 5KL + 5KL + 5KL + 5KL(c) 24 KL = 5KL + 5KL + 4KL+ 5KL + 5K

The terminal serves the following customers.

(i) Retail Outlets (ROs), (ii) Consumers (who do not resell the fuel). (iii) State Transport Department (iv) Indian Railways.

This study is of a terminal that handles Motor Spirit (Bharat Stage, i.e., BS-2 and BS-4), High-Speed Diesel (BS-2 and BS-4), SKO, and Motor Turpentine Oil. The terminal receives various products through pipelines. The layout of the terminal is shown in Figure 1.

Figure 1: Layout Plan of Terminal



A Chief Terminal Manager usually heads the terminal. The various departments at the terminal and their role are briefly discussed below.

(a) Security:

-To allow tank trucks into terminals one by one after the trucks have obtained permission to enter for filling.

-Manage exit of trucks that have been loaded with fuel.

(b) Supply and Distribution:

- Validate requests from retail outlets and consumers.

- Issue permission receipts for filling.

- Generate challans after filling.

(c) Control Room: Oversee filling, replenishment, and maintenance operations.

(d) Quality Control: Keep samples of products for 30 days and hand them over to the sales officer in case of any quality complaints from consumers.

(e) Tank Farm Loading: Inspect the fuel-filling operations. Open the lock of the compartments before filling and lock it once filling is complete.

(f) Administration: Oversee the entire terminal operations and plan for fuel replenishment and disbursement.

Literature Review:

The process analysis tool is used to optimize processes in business organizations. Cho, Song, and Yoo (2015) used process analysis to improve clinical processes like waiting time for consultation, optimizing reservation systems, etc. The study by Lee, Sung, Song & Choi (2015) suggested a framework for incorporating the effects of organizational structure into business process simulation. Further, it demonstrated the application of the proposed approach through a case study of a Korean prosecutor's office. Yadav & Paliwal (2011) used process analysis to optimize the billing process of a natural gas utility company. This research paper shows an application of process analysis to optimize terminal operations by optimizingtank truck turnaround time inside the terminal.

The success of an enterprise relies on its supply chain systems. Better coordination among the supply chain members is required to satisfy the final demand and ensure the enterprise systems' success. The prime objective of logistics is to ensure that materials and products are available in the right quantities and at the right place and time to satisfy the demand and give a competitive advantage to the company.

Terminal operators invest in new technologies to improve container handling and operational efficiency. The time truck spends at the terminal loading or unloading the cargo is the actual cost affecting the overall container trade cost.

There exists a variety of operations in the distribution chain. The characteristics of the specific operations are affected by demand density, laws and regulations, and competitive environment. The study by Ronen (1995) examines the variety of operational environments in dispatching petroleum products and the operations research tools oil companies to use to deliver such products. Operation research can play an essential role in improving the efficiency and robustness of supply networks (Gorman et al., 2014). Business Process Redesign has excellent potential to reduce cost and processing time and enhance customer satisfaction (Vanwersch et al., 2016).

The study by Kiani et al. (2010) suggests a model that reduces truck congestion at the entrance, gate exit, and

transit weighbridge. The main idea behind the research was to flatten the gate activities to an efficient level to reduce the trucks' queuing time. The study found that Truck Arrival Management and gate capacity expansion help achieve queue reduction.

A study by Mili and Sadraoui identifies different measures of various types of production and difficulties faced while maximizing the container terminal's productivity. Correct planning and execution of operations on a container-carrier vessel is a decisive element in a strategy of a terminal. Experience and knowledge of the problem that can arise are fundamental while attempting to treat these operations. The degree of professionalization specific to the sector is also essential. (Mili & Sadraoui, 2015).

Aksyonos et al. (2020) discuss the planning and modeling of the logistics process and delivery of oil product supply networks of the gas station. It suggests the solution to the problem of oil and gas supply to a network gas station using a hybrid approach, i.e., multi-agent and simulation, as well as its software implementation in the form of complex decision-making and simulation.

A study by Carla Marquês on a retail distribution company's process analysis and operations productivity focuses on reformulating warehouse operations andtheirs optimization level. It also discusses reformulation in the company's logistic strategy. It develops possibilities to improve quality and performance in a retail distribution center using quality management, layout planning, and statistics tools.

A study by Vizzon et al. (2020) proposes a model for redesigning organizational business processes of cultural production enterprises, which incorporates three levels, i.e., organizational, business processes, and implementation. Critical success factors and barriers have been identified and analyzed, focusing on organizational, social, and technical dimensions.

Another study by Liu S. et al. focuses on the production, distribution, and capacity planning of global supply chains considering cost, responsiveness, and customer service level simultaneously. A multi-objective mixed integer linear programming approach is developed with a total cost, total inflow time, and total lost sales as key objectives (Liu S. et. al. 2013).

A study by Helo P. (2021) suggests that Artificial Intelligence (AI) powered Supply Chain Management (SCM) improves everything from process automation to process optimization. A business can use methodologies of AI to improve its internal processes. AI has been developed to enhance human decision-making processes and business productivity due to the ability to understand patterns and business phenomena. AI techniques can be implemented in four identified attributes in the supply chain, namely, optimization, prediction, modeling and simulation, and decision support ((Soleimani, 2018)

Research Objective and Background of Research:

(i) To determine the turnaround time of a tank truck inside the terminal.

(ii) To identify any potential bottleneck in the process if the tank truck turnaround time is greater than 50 minutes

(iii) To suggest remedial actions to remove the bottleneck.

(A) Tank Truck Turnaround Time

Definition and relevance of research variable:

(i) Tank truck turnaround time: Tank turnaround time refers to the total time spent by a tank truck inside the terminal, starting from entering the terminal gate to exit from the terminal.

(ii) Relevance of Tank Truck Turnaround Time

(a) The turnaround time is significant because there is a massive demand for petroleum products from consumers and retail outlets. Failure to meet the demand means loss of customers to OMCs.

(b) The demand is higher on Saturdays and the eve of any other holiday at the terminal. This requires more tank trucks to be accommodated at the terminal daily.

(c) The more time a tank truck spends inside the terminal, the higher the risk that the driver over speeds to meet the commitment of delivering the product on time.

(d) The safety compliance requirement suggests that not more than 30 Tankers (assuming ten bays at the terminal, i.e.,10 Bays*3 Tankers) can stay there.

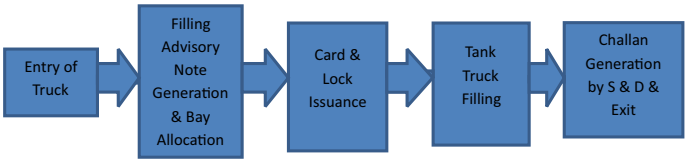
The various steps the tank truck needs to follow once

inside the terminal are discussed in the tank turnaround process.

(B) The Tank Truck Turnaround Process

The process diagram of the Tank Truck Turnaround process in the studied Petroleum Products terminal is given below (Figure 2).

Figure 2: Process Diagram of Tank Truck Turnaround Process



(a) Entry of truck: The trucks first enter the parking area and get their entry time registered. The security department checks the fire safety equipment of the truck and the driver's documents. Then the trucks are called for Filling Advisory Note (FAN) issued by S & D Department at the terminal gate. The first Come, First Serve Queue System is followed. The tank trucks can also use the SMS (Short Messaging Service) facility. Such trucks that give prior intimation of the loading through SMS are given priority and are allowed to break the queue at entry.

(b) Filling Advisory Note (FAN) Generation and Bay Allocation: FAN is generated for the truck after checking the filling request form provided by the dealer, which contains the name of the fuel required and the quantity required. As per the bay logic described below, the loading bay is allocated for the tank truck.

The bay allocation logic ensures that not more than three trucks are queued up for loading at the loading point at any time.

- Only one truck is currently loading
- Only one truck lined up to load
- Only one "queue jump" truck position to load next.

The bay allocation logic uses the following guidelines:

1. Only enabled bays are considered.
2. Both multiple products and single product bays are considered for single product load.
3. Both multiple-product and single-product bays will be considered for multiple-product loads.
4. If the bay allocation logic assigns multiple product loads to a single product bay or vice versa, a message will be displayed at the bottom of the screen, which can be changed with the authorization of the Local in Charge (LRC).
5. If the product is unavailable at the assigned bay for multiple product loads, then the driver completes loading at the bay initially assigned. The LRC will re-execute the bay allocation logic to give the next bay.
6. Bay allocation logic will ensure optimum utilization of all loading bays available at the terminal by assigning the bay that will result in a minimum waiting period. The minimum waiting period is calculated as follows:

(i) Determine the product match between load requirement and product available.

(ii) Calculate the time to load the truck.

(iii) Add the time to load each truck in the queue.

(iv) Select the bay with the shortest total loading time.

(c) Card and Lock Issuance: After FAN Generation, the security staff provides the truck driver two locks, i.e., Petrol Tank Lock and Magnetic Lock.

A petrol/Fuel Tank Lock is used to avoid pilferage inside the terminal from the compartment to the truck's petrol tank. This lock is removed when the truck exits the terminal area.

Magnetic Card – it contains the details of the load per compartment. This would automatically start the filling process in the bay.

The truck personnel is checked for safety equipment like helmets and fire extinguishers; if satisfactory, the truck is allowed inside the terminal.

(d) Tank Truck Filling Time: Once a tank truck enters the terminal, it moves to the respective bay for loading. If the bay is occupied, the tank truck waits until the bay is empty. The time required by the tank trucks to fill varies with capacity (12Kilos, 18Kilos, 20Kilos, Mixed, etc.). For a 20Kilos truck, the filling time is about 35 minutes; for a 12Kilos truck, 25 minutes; for a mixed load, the filling time is about 10-12 minutes. Different products are simultaneously loaded into multiple truck

compartments in mixed bags, thus saving valuable filling time. After the filling is complete, the compartments are locked.

(e) Time to Exit: This is the time required to exit from the terminal after being loaded. After loading, the compartments are locked to prevent pilferage. S & D department issues the exit challans, and the petrol/fuel tank locks are removed. The security at the gate does exit checking by verifying the documents. The time to exit would include all these activities.

All the above steps contribute to the truck's turnaround time inside the terminal. As per guidelines, the standard turnaround time at the studied terminal is approximately 50 minutes.

Methodology:

To address the objectives mentioned above time and motion study concept was used. The turnaround time of tank trucks, as observed through initial random sampling, had massive deviations from the prescribed guideline of 50 minutes. To find the average time taken for each step described above, continuous sampling was done on three different days in April 2022.

Findings and Analysis:

The Findings of our study in terms of Idle Time after Filling and Time spent inside the Terminal are shown in the following sample observation table 1. The number of observations recorded on three days is 75, 33, and 64 at different points of time during the day.

Table: 1 Sample Observations Table

Observation Day		Day 1	Day 2	Day 3
Number of Samples		75	33	64
Idle time after filling	Max	04:44	01:43	01:49
	Min	00:12	00:16	00:05
	Average	00:56	00:42	00:44
Idle time (more than 20 minutes after filling)	No. of Samples	64	30	56
	(% of samples)	85	88	87
Time Spent inside the Terminal	Max.	05:15:00	02:57:00	03:18:00
	Min.	00:55:00	00:42:00	00:58:00
	Average	01:58:43	01:39:05	01:48:51

Some of the Key observations are:

(i) The time the tank truck spent inside the terminal after completing the filling varied from as high as 4hr 44 minutes on Day 1(24th April 2022) to as low as 5 minutes on Day 3(26th April 2022).

(ii) The average time spent by a truck inside the terminal (starting from entry check to exit) was observed to be around 1hr 45 minutes on the three days.

(iii) It was further observed that the filling time for the product in the bays varied from 10 minutes to 40 minutes depending on the following factors: (a) If the requirement was a 20 KL load, the time taken was about 30 minutes. (b) If the requirement was 12KL, the filling time was lower and was about 17 minutes. (c)The filling time was further reduced for the mixed load, i.e., when two products were loaded into different compartments in the same truck. The filling operation would then be simultaneous and take as little as 10 minutes.

Bottleneck Identification & Recommendations:

It was identified through observation that the idle time after filling was attributed to the challan generation process at the S & D department. The challan generation process included printing the challans by the operator and signatures by the truck driver and the terminal officer. The time consumed by this process directly impacted tank truck turnaround time. On closer observation of the process in the S&D area, the following points were noted:

(i) The bulk generation of challan at the S&D department led to a few trucks waiting over an hour to move out of the terminal, while a few trucks moved out in just over 5 minutes. Therefore any delay in the S&D operation, i.e.be it, bulk challan generation or absence of the department's authorized personnel, affected the entire truck movement inside the terminal.

After the incident of fire at one of the OMC terminals in India, it is mandated by the OMCs that up to thirty tank trucks should be present inside the terminal at a time. The idling of the filled tank trucks inside the terminal delays the process and leads to colossal safety concerns.

Based on the sample data for truck movement inside the terminal, the major bottleneck was identified as described above. To remove this bottleneck, the following recommendations were made:

(i) Addition of one more officer (Signing Authority) at the S& D department to help reduce the idle time so that signing of exit challan (invoice) is continued.

(ii) Implement a standard process of challan processing (5 challans at a time) rather than processing it at random intervals, which results in piling up the challans.

(iii) Prepare exit challan at the time of preparing FAN. Later the temperature and density (which varies with time) can be entered manually during filling.

All the above recommendations were put forth to Senior Terminal Manager, keeping in mind that no option required any additional infrastructure in the S&D department. The process is optimized with reduced idle time of tank trucks after filling. From the above three recommendations, recommendation (i) was immediately implemented by Senior Terminal Manager. An additional officer was allocated to the S&D department to have a process running uninterrupted in case the primary officer is busy with any other important activity.

Results after implementation of recommendation:

Table 2 summarizes observations after implementing recommendation (i).

Table 2: Sample observation after implementation of recommendation

Observation Day		After implementing Recommendation 1
Number of Samples		95
Idle time after filling	Max	02:12
	Min	00:04
	Average	00:28
Idle time (more than 20 minutes after filling)	No. of Samples	52
	(% of samples)	55
Time Spent inside the Terminal	Max.	03:50:00
	Min.	00:34:00
	Average	01:31:52

It is observed from Table 1 and Table 2 that:

(i) The average time the tank truck spent inside the terminal after completing the filling drastically improved from 56 minutes on day 1 to 28 minutes after implementing the recommendation.

(ii) It was observed that the idle time after filling at times went as low as 4 minutes.

(iii) Number of trucks with idle time greater than 20 minutes after filling was reduced to 55 % compared to 85% and more than 85% over the initial three days of observations.

It can be further noted that although the idle time after filling was reduced by 50%, there is scope for further reduction through efficient functioning of the S & D department.

It is viewed that implementing the recommendations will lead to better business, better adherence to safety norms (as filled tank trucks quickly moved out of the terminal), and overall improvement in the efficiency of employees and a step towards optimum utilization of terminal capacity.

Conclusion:

Minimal tank truck turnaround time is essential for OMCs to ensure customer satisfaction. This also provides better safety levels inside the terminal, optimal bay utilization, and higher utilization of Tank Trucks resources. The efficient functioning of the S& D department is vital for the entire process to be optimal.

References:

- Aksyonov, K., Ayvazyan, H., & Aksyonova, O. (2020, November). Application of the multi-agent approach to developing the petrol dispatching system of gas stations network. In *IOP Conference Series: Materials Science and Engineering* (Vol. 971, No. 4, p. 042090). IOP Publishing
- Cho M., Song M., Yoo S. (2015), A systematic Methodology for outpatient process analysis based on process mining.*International Journal of Industrial Engineering, Theory, applications and Practices*", Vol. 22, No.4. 31-42
- Carla Marquês, "Process Analysis and Operations Productivity A real case study in the retail distribution industry"Instituto Superior Técnico Industrial Engineering and Management
- Gorman, M. F., Clarke, J. P., Gharehgozli, A. H., Hewitt, M., de Koster, R., & Roy, D. (2014). State of the Practice: A Review of the Application of OR/MS in Freight Transportation. *Interfaces*, *44*(6), 535-554.
- Helo, P., & Hao, Y. (2021). Artificial intelligence in operations management and supply chain management: an exploratory case study. *Production Planning & Control*, 1-18.
- Kiani, M., Sayareh, J., & Nooramin, S. (2010). A simulation framework for optimizing truck congestions in marine terminals. *Journal of Maritime Research*, *7*(1), 55-70.
- Liu, S., & Papageorgiou, L. G. (2013). Multiobjective optimisation of production, distribution and capacity planning of global supply chains in the process industry. *Omega*, *41*(2), 369-382.
- Lee J.; Sung S.; Song M.; & Choi I. (2015), A business process simulation framework incorporating the effects of organizational structure.*International Journal of Industrial Engineering, Theory, applications and Practices*, Vol. 22, No.4, 454-466
- Mili, K., & Sadraoui, T. (2015). Optimizing the operational process at container terminal. *International Journal of Econometrics and Financial Management*, *3*(2), 91-98.
- Ronen, D. (1995). Dispatching petroleum products. *Operations Research*, *43*(3), 379-387.
- Soleimani, S. (2018). A perfect triangle with: artificial intelligence, supply chain management, and financial technology. *Archives of Business Research*, *6*(11).
- Vanwersch, R. J., Vanderfeesten, I., Rietzschel, E., & Reijers, H. A. (2016, September). Improving business processes: does anybody have an idea?.In *International Conference on Business Process Management* (pp. 3-18). Springer, Cham.
- Vizzon, J. S., Scavarda, L.F; Ceryno, P. S., & Fiorencio, L. (2020). Business process redesign: an action research. Gestão & Produção, 27(2), e4305
- Yadav, S, & Paliwal, P. (2011). Re-Engineering Service Delivery Process: Case of a Natural Gas Utility.*Journal of Services Research* 11 (2),155-176