THE SIMULATION OF PETROLEUM TANK WAGON LOADING RACK OPERATION

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Simulation and Evaluation of Rack Facilities (SERF) is a GPSS/360 language program which simulates the flow of trucks through the loading facilities of a marketing bulk plant. The general bulk plant represented in SERF is a distribution point for a wide variety of petroleum fuels including gasolines, light oils, and heavy oils. The bulk plant is characterized by a set of loading racks at which various fuels are dispensed from a number of storage tanks to a fleet of compartmentalized tank wagons. The bulk plant serves both a company-owned transport fleet and trucks owned and operated by various independent jobbers or resellers. The loading operation is monitored and supervised from a control tower with the dispatching and accounting functions being carried out in close coordination.

THE SERF BULK PLANT

A complete representation of the SERF bulk plant would demand detailed consideration of all aspects of the environment surrounding the bulk plant. Since a large percentage of the trucks passing through the bulk plant will be both controlled, and operated by the bulk plant, these trucks may be considered to behave in a closed loop fashion. The characteristics of the environment as defined by truck routes, customer locations, and demands will have a definitive influence on the pattern of the arrivals of the trucks as it appears to the bulk plant. A fully comprehensive study of the bulk plant and its environment was not considered to be within the scope of this simulation. Instead, the SERF bulk plant may be considered to have been abstracted from its environment and the arrival pattern of trucks treated strictly as an observed phenomenon. Then the program can be separated into two distinct parts, (a) the arrival pattern generator which provides the designer with the facility of reproducing the arrivals to match any given objective, (b) the SERF bulk plant which processes the trucks through the dispatching and loading rack facilities.

For the purpose of the simulation, and ease of analysis, it was considered convenient to separate the totality of products dispensed at the bulk plant into Product Classes. This approach was guided by the fact that certain racks were reserved for the various classes of petroleum products, viz. gasolines, middle distillates, bunkers, etc. A Product Class encompasses the group of products, the set of rack positions and the types of trucks ascribed to that Product Class. Since these groups are not necessarily mutually exclusive, that is, they may contain products in common, SERF allows a truck to change Product Classes prior to loading.

Within each Product Class, SERF generates, in a random manner, successive truck arrivals such that, over the long run, the arrival rate tends towards a specified average. The arrival rate is modified from hour to hour, and day to day, in order to reflect periodicities while maintaining the required average over the full day and the full week. SERF identifies the truck by randomly selecting from a list in accordance with the specified relative arrival frequencies for each type. The products to be loaded are randomly selected, compartment by compartment from a list in accordance with the specified product mix.

Upon the arrival of the truck at the bulk plant, communication between the driver and the plant can occur at the dispatch office prior to entering the racks, at the racks via intercom and pneumatic delivery systen, or at the dispatch office after leaving the racks. The communication may be in the form of cash, invoices, loading or meter checks, customer delivery cards, etc. SERF simulates the dispatching function by delaying the truck by an amount of time equivalent to processing the driver. The plant may provide parallel service such that more than one driver may be served at a time. If a truck arrives and finds the dispatching facilities are busy, that is, all of the parallel servers are occupied, then the truck remains in a queue awaiting service. Statistics are maintained by SERF on the length of the queue and the amount of time spent in waiting for service.

After leaving the dispatch office, the trucks separate and enter the various queues, preceding the rack facilities serving the different product classes. In the event that the products required by a given truck are dispensed in more than one Product Class, SERF introduces the truck to the shortest of the eligible queues.

When a truck secures a rack position, SERF computes the filling time for the truck based on the facilities available at the rack position, the characteristics of the truck, the status of other rack positions serving the same products, and the type of rack operation. The specific elements involved in the computation

include the number and size of compartments, the product load distribution on the truck, the size, number and product service of the spouts at the rack, the number and size of spouts drawing on the product pumping circuits at other rack positions serving the same products, the effective pumping capacity curves for the products, and finally the type of loading operations employed at the rack, viz., single spout loading, multi-spout automatic stop loading, selective spout loading, etc. The filling calculation also includes some fixed increments of time chosen by the designer to represent the passage of time for standard operations, such as parking the truck, connecting the ground wire, lowering the platform, transmitting documents to the office, etc. SERF tabulates the truck loading times, evaluates the utilization statistics for the rack positions, pumps and spouts, and accumulates the volume throughput for all products.

Before leaving the plant, SERF allows additional time to be spent at the dispatch office. The same dispatching facilities are available at the exit as at the entrance.

As each truck courses through the plant, statistics are maintained on the waiting time for the trucks and on the active employment of the facilities. Since SERF can simulate weeks of plant flow in minutes of real time, it is possible to arrive at good estimates of the waiting time, maximum queue lengths, and facility utilizations associated with a given set of loading rack configurations at relatively low cost. A designer defines a "base case" configuration of rack facilities, simulates several weeks of activity, and studies the SERF statistics produced during the computer run to achieve a more efficient design. This iterative approach to design of rack facilities can in short order bring the designer to a satisfactory configuration, even in the event of the selection of a poor "base case." Each design case studied under SERF has associated with it the investment cost and the cost of truck and driver waiting. The selected design, then, will be that which best achieves a balance, in terms of effective marketing policy, of the twin objectives, satisfactory bulk plant operation and minimal investment.