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Simulation Modeling and Analysis of In-Plant Logistics at a Cement Manufacturing Plant in India

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***Abstract*—**This paper presents the findings of successful implementation of Business Process Reengineering (BPR) of cement dispatch activities in a cement manufacturing plant located in India. Simulation model was developed for the purpose of identifying and analyzing the areas for improvement. The company was facing a problem of low throughput rate and subsequent forced stoppages of the plant leading to a high production loss of 15000MT per month. It was found from the study that the present systems and procedures related to the in-plant logistics plant required significant changes. The major recommendations included process improvement at the entry gate, reducing the cycle time at the security gate and installation of an additional weigh bridge. This paper demonstrates how BPR can be implemented for improving the in-plant logistics process. Various recommendations helped the plant to increase its throughput by 14%.

***Keywords*—**Business process reengineering, simulation modeling, in-plant logistics, distribution process, cement industry.

I. Introduction

LOGISTICS outsourcing has attracted the attention of firms, academics and researchers. Logistics outsourcing has proven to be an effective way to achieve a competitive advantage, improve customer services and reduce logistics costs [1], [3]. Logistics outsourcing can reduce fixed costs and increase flexibility, allows for a greater focus on a firm's core activities, reduction in heavy asset investments and an improvement of service quality [2], [4]. At the same time, the decision to outsource includes a number of risks related to the loss of control, long-term commitment and the failures of some LSPs to perform their duties [5]-[8] This dependence sometimes causes disturbance in the supply chain, if the operations are not well managed. These disturbances may be in the form of interruptions in the inbound logistics flows from subcontractors or interruptions in the production facilities owing to in-plant logistics provided by the transporters and also in the outbound logistics flows to customers. There are instances when these disturbances in supply chains have been absorbed by inbound, internal and outbound inventories or by maintaining a variety of parallel subcontractors for necessary deliveries of material and components. However it would be very difficult to absorb them in the absence of multiple subcontractors. That is, when a company follows a single sourcing policy, and is dependent on a limited number of logistic service providers for dispatches. This paper addresses the issues of in-plant (internal) logistics faced by a large CMP in India.

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II. Review of Literature

Reference [9] identified eight business analysis techniques used in business process reengineering. The author found that some business analysis techniques are preferred over others. Some possible reasons are for the same related to the issues of fit between analysis technique and the problem situation, the ease of use-of-use of the chosen technique, and the versatility of the technique. Some BR projects require the use of several techniques, while others require just one. It appears that the problem complexity is correlated with the number of techniques required or used. Reference [10] proposed a business process reengineering (BPR) approach to a public administration of Italy, which first assess the efficiency of the administration, then to redesign its internal processes and finally to improve the current performance.

Reference [11] provided a holistic view of the BPR implementation process, by reviewing the hard and soft factors that cause success and failure for BPR implementation, as well as, examines the effectiveness of the critical success factors (CSFs) of BPR on both primary (operational) and secondary (organizational) measures of business performance in Nigerian oil and gas industry. Reference [12] analyzed Business Process Reengineering as today's prominent management trend for organizational change and examined a reengineering project that has been undertaken in a multinational electronics and electrical equipment company, made suggestions for the areas that can be improved, and finally presented survey results of employees` point of view regarding this project in their company. Reference [13] proposed a framework for implementation of BPR, based on their experience from a case study conducted in a British Company. The step wise framework included three main steps, viz., identifying the processes, analyzing the processes and reengineering. The framework considered three main categories of measures, which are cost, time and quality.

From the literature review the use of BPR in different scenarios across different industries. This paper is based on BPR implementation using a case study approach. The purpose of the study is to investigate the potential of reengineering in a real-life situation. The study is conducted in a Cement Manufacturing Plant (CMP) in India, where production planning is severely constrained by the disturbances in the distribution process (loading of cement bags) caused due to inefficient flow of the vehicles in the plant area, thereby causing congestions leading to closure of the dispatch line. The decision-making scope in this paper is more focused on the improvement and simplification of the in-plant vehicle movement and realigning the loading facility rather than considering the distribution network or routing problem. Simulation modeling is used as the tool for analyzing the improvement areas while BPR is implemented.

A.The Company

The study has been carried out at a leading CMP located in the northern part of India. The CMP is characterized by aggressive growth, economies of scale, large production capacity, operational performance and excellent relationship with its stakeholders. While the CMP had the main location advantage of proximity to the core raw material, i.e., limestone, it is situated at a high altitude of around 1250 m above sea level without direct access to rail. The nearest railway point is available at a distance of 100 km away from the plant. Therefore, the CMP had to be totally dependent on the road transport services for inbound and outbound logistics. The sales tax advantage and other tax benefits offered by the state government to promote industry has attracted large industrial houses to set up their manufacturing and processing facilities around the CMP. This lead to greater demand for trucks to move material. To counter this situation, CMP has entered into an agreement with two third-party logistics service providers for its inbound and outbound transportation. CMP has a capacity of 4.5 million tons per year. The finished product i.e., cement in 110 lbs bags, is distributed 100% by road from the plant using third-party logistics service provider. At present an average of 1400 trucks/day are required for finished cement (in bags) dispatch.

B.The Problem

As per the installed capacity, the plant is not able to dispatch 4.5 million tons of cement that is produced in the plant due to the in-plant logistics inefficiencies. However, an average of 1400 vehicles is available per day and the plant is only able to dispatch an average of 1250 vehicles/day. In accommodating this inefficiency the company is also facing a forced shut down of plant hence suffering a production loss of almost 15000 MT/month. The management felt the urgent need to conduct a study to address the above-mentioned issue and approached the consultants. This study is based on the findings of the logistics study conducted by the authors at the above-mentioned CMP, with an objective to improve in-plant logistics and to streamline the outbound logistics service as mentioned earlier. More specifically, the study was based on the framework as proposed by [13], which included the following main steps:

i. Identifying the processes through review of present systems and procedures
ii. Analyzing the processes based on detailed study and critical analysis of present practices.
iii. Reengineering the processes.

III. Analysis and Findings

A.Identifying the Processes through Review of Present Systems and Procedures

The present cement-dispatch process was studied and simulated to identify the areas of bottlenecks and areas requiring improvement. The entire process starting from production planning to dispatch of the loaded vehicle from the plant is presented below. The simulation model capturing the details, starting with the vehicles (9MT capacity Trucks) entering the main gate and leaving the exit gate is shown in Fig. 1.

1.Capacity and Storage

Two types of cement are manufactured at the factory viz., OPC-43 and PPC. Plant 1 produces 160000 MT/month of OPC-43 and plant 2 produces 220,000 MT/month of PPC.

Subject to technical quality clearance, the cement produced is stored in silos for subsequent packaging in bags of 50 kg each. Cement produced at plant 1 can be stored in 4 silos with total capacity of 15,000 MT and the cement produced at plant 2 can be stored in 3 silos with a total capacity of 35,000 MT.

2.Production- Distribution Interface

The production distribution interface takes place at the loading/packing area where the empty trucks position themselves for loading of the cement. This area comes under the supervision of the production department and is closely coordinated by the logistics department for the smooth and safe movement of the trucks and also to ensure availability of the trucks. The packing house is highly automated with 19 automatic loading machines (nine for plant 1 and 10 for plant 2) with belt conveyors guiding the packed cement bags into the truck for loading. The loading rate for plant 1 is 400 Tons/hour and that for plant 2 is 540 Tons/hour, equally distributed over all the loading points.

3.Cement Dispatch Planning and Truck Allocation

The plant logistics decides on the quantity of the cement to be dispatched to the different markets. It takes into consideration the cement availability and the existing warehouse stocks at different locations. The planned dispatches thus arrived for the day is intimated to the Cement Dispatch Section (CDS). On the basis of this information, CDS places the demand for trucks with the transport contractor at 7.00 am on a daily basis, so that the required numbers of trucks are available for the days dispatch. CDS issues a demand ticket for each truck. The tickets are collected by the respective contractor. The transport contractor office announces the day's requirement (termed 'Announcement') and the truck operator interested to go for the announced destination is allocated the delivery slip. Truck list with necessary details is maintained by the transport contractor office and the priority to select a destination is according to the serial number in the register. The announcements are done thrice a day at 8 am, 10 am and 2 pm. The truck allocation slip is valid for one day (up to 2 pm on next day) and the truck operator can report at the plant at any time during the validity period. The allocation slip will bear the signature of the authorized representative of the transporter and will contain the details pertaining to plant from where the cement is to be loaded (plant 1 or 2), the quantity and the destination name. The truck driver reports at the main gate with the demand ticket and proceeds for the loading

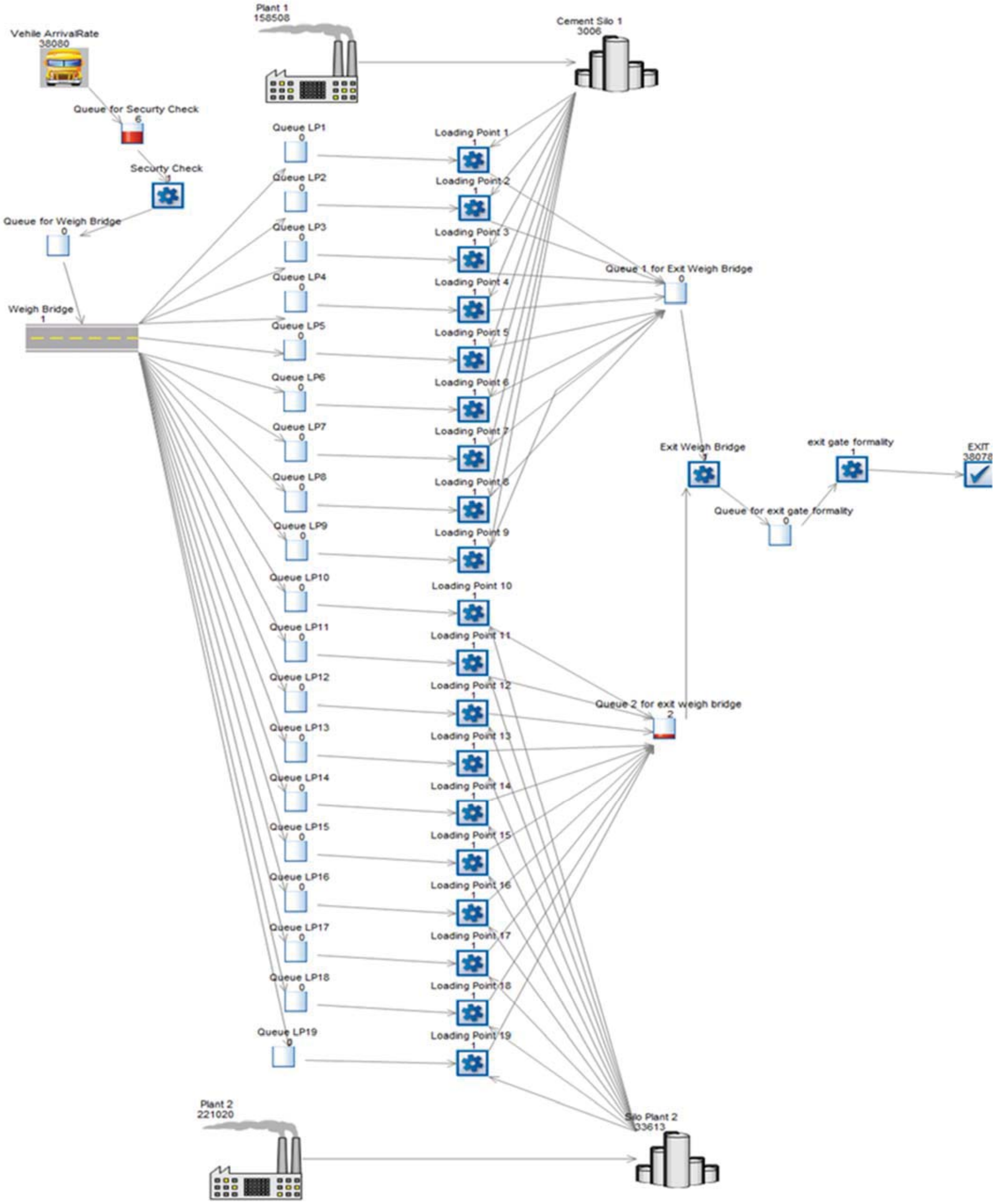

Fig. 1 Simulation model for in plant logistics activities

4.Acknowledgement Receipt, Issue of Delivery Note and Security Check

Before entering the main gate, the truck driver is required to furnish the acknowledgement receipt of the previous delivery as a proof of successful dispatch and the present allocation receipt. After receipt of the delivery note, the truck driver reports for security check. The security check involves inspection of the truck for possible additional material and driving license of the driver.

5.Recording Tare Weight

On clearance by the security at the CDS gate, the truck enters the plant and proceeds to the weighbridge for recording tare weight. The empty truck is weighed at the weighing bridge and the tare weight is recorded. The truck from there moves to the loading area after waiting in the queue.

6.Loading of Cement Bags

After recording the tare weight, the truck along with the delivery note joins the queue as per the allocation of the truck for the mentioned plant (plant 1 or plant 2). The truck driver aligns the truck by taking reverse at any chute for the designated plant as per his convenience and availability of the space. His convenience is based on queue length and the congestion in that area. The truck driver produces the delivery note to the loader and gets the cement bags loaded in the truck. During loading of cement bags, the truck has to slowly move forward to allow uniform loading of the cement bags.

7.Issue of Excise Gate Pass and Transporters GRN

After loading of the cement bags in the truck, the truck reports the exit weighbridge for recording of the gross weight. Excise gate pass is issued based on the weight. The truck driver collects the excise gate pass from the weighbridge office and reports at the transporter's office for collection of Goods Receipt Note (GRN). At the transporters office, the vehicle number is recorded and GRN is issued to the driver. The driver after collecting the GRN proceeds to the exit Gate.

8.Exit

The security at the exit gate checks all the relevant documents. They also carry physical verification of the cement bags stacked in the truck.

B.Analyzing the Present Processes

The simulation model was run with the details captured from the first step. The simulation model was developed using SIMUL8 software and run for a period of 30 days, with three shift operations. The warmup period for the simulation run was taken as 480 minutes for obtaining some stability for the model. The performance results obtained above showed a total exit of 36340 vehicles from the plant as against a total of 45721 vehicles reporting at the entry gate. 9379 vehicles (loss of 84411 Tons of cement) were blocked and not allowed to enter the simulation for some reasons, which needed to be analyzed. Further the findings also revealed a low working time for the loading points in the range of 42-55% with high waiting times (idle time). The other major finding from the model was the stoppage of plant 2 resulting in a production loss of 15090 tons of cement.

C.Reengineering the Processes

This section presents the important observations and the process reengineering initiatives to be taken by the CMP for improved processes leading to increased cement distribution. The reengineering initiatives suggested here were discussed with the CMP executives for its feasibility, before incorporating them in the simulation model and simulating the improved model.

1.Availability of the Vehicle at a Uniform Rate in all the three shifts

It was observed from the simulation that the different arrival rates of the vehicles across the three shifts disturbed the in-plant logistics movement providing irregular vehicle supply. The plant had an average requirement of 1400 vehicles/day. However it was only able to use on an average 1250 vehicles/day. The discussion with the executives at the plant revealed that the main reason for this was non availability of the vehicles on the stipulated time. At present CDS places the entire day's demand of trucks in three lots (starting at 7 am) to both the transporters indicating the destination. When the 'Announcement' is made at the parking plaza, there is no certainty that the truck is physically available over there. Any representative of the truck operator/driver is allowed to collect the demand ticket from the transporter irrespective of availability of the truck at the site. As the demand ticket is valid for 24 hrs, the representative will collect the ticket on behalf of the truck operator in anticipation of the truck availability in the next 24 hrs. These practices sometimes lead to non-availability of trucks for the cement dispatches and in situation where a truck failed to reach the plant within the validity period and hence shortage of truck availability. Further, on most of the occasions, the truck operators reported to the plant for dispatches at their convenient time causing congestions at specific period of time. For example, during summer, most of the drivers would like to report in the evenings whereas, they would prefer, afternoons during winters.

The present process was unable to handle these discrepancies and required some procedural changes. It was recommended to decrease the validity of the demand tickets to 6 h as against the present practice of 24 h. This will require having the announcement four times a day. Further, it was also suggested to have the demand tickets issued against the physical availability of the trucks. This will ensure that the trucks will be reporting the plant within the 6 h time frame as against the earlier bracket of 24 h.

2.Additional Requirement of Security Personnel and a Weigh Bridge

With the availability of the vehicles taken care, the bottleneck of the in-plant logistics shifted to the security check and the weighbridge activity which was normally blocking the entry of the vehicles at the entry gate. Therefore it was suggested to the management for adding additional personnel at the security gate and also installing an additional weighbridge. The additional personnel were also justified considering the poor condition of the vehicles leading to increase in the cycle time, as reported by the executives.

3.Reducing in-Plant Congestion by Increasing QUE Length

The plant at present accommodates trucks with the following break-up:

i. Entry gate: 10 vehicles
ii. Weigh bridge: 3 vehicles
iii. At the way to loading points of Plant 1: 36 vehicles
iv. At the way to loading points of Plant 2: 50 vehicles
v. From loading area of plant 1 to exit weigh bridge: 5 vehicles
vi. From loading area of plant 2 to exit weigh bridge: 10 vehicles
vii. Security check area at the exit gate: 3 vehicles

As depicted in the simulation model there is no separate entry route for the trucks entering plants 1 and 2. They enter from the same gate and follow a single path.

Sensitivity analysis with varying que length sizes was performed to see whether the queues length will have any impact on the number of vehicles entering the plant. The tests showed no significant effect on such efforts. However, a physical survey of the plant suggested that there was scope to create additional space to increase the queue length of the loading areas of plant 1 and 2. It was recommended that the area holding the garden, drivers' toilet and recreational room and transporter offices be cleared and surfaced for free flow of traffic and these may be moved to other location.

No changes were proposed at the exit gate.

4.Traffic/Security Personnel

It was observed during the study that there were no traffic or security personnel deployed to guide the traffic movement at the plant area 1 and 2. Movement of plant personnel was also unsafe during congestion of trucks, and might be resulting in fatal accidents. Taking into consideration the plant layout changes, provision for posting of security personnel for control and management of truck movement at the loading area was recommended.

The results of the simulation with the incorporated suggestions shows that the in-plant logistics process had an improved performance with the actual entry of vehicles improving to 41215 vehicles with a block rate of only 1693 vehicles as against 9379 vehicles earlier. Further, it was observed that the Plant 2 which was forced to stop its production earlier had produced to its full capacity. The total no. of vehicle exits from the system was observed to be 41153 vehicles as compared to 36340 vehicles earlier, showing an increase of 13.24% for month which is equivalent to 43317 MT /month or 519804MT/year.

IV.Conclusion

In this paper, it is shown that the CMP can gain benefit by implementing BPR and effective use of simulation. The paper presents the three-step framework as proposed by [13] for implementing the BPR. The present system and procedures were reengineered based on the cooperation and involvement of the senior executives and the actual stakeholders in these processes.

It was found from the study that the present systems and procedures related to the in-plant logistics required significant changes to be carried out in the area of allocation of truck demand to the transporters, movement of trucks from the main gate to the plant incorporating safety and security checks, having a proper plant layout for smooth flow of vehicles within the plant, etc. The recommendations made for the CMP are based on the operational needs and contextual information available with the plant. These suggestions have been discussed at length with the plant executives for its feasibility, hence implementing the same shall not be a difficult task.

The major contribution of this paper is that it demonstrates how a BPR can be implemented for improving the in-plant logistics process. This study does not cover the implementation phase and therefore various issues such as the resource constraints, the reluctance for change, change in productivity and the post-implementation evaluations are not discussed.

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