Just-In-Time for Reducing Inventory Costs throughout a Supply Chain: A Case Study

Faraj Farhat El Dabee, Rajab Abdullah Hokoma

Abstract—Supply Chain Management (SCM) is the integration between manufacturer, transporter and customer in order to form one seamless chain that allows smooth flow of raw materials, information and products throughout the entire network that help in minimizing all related efforts and costs. The main objective of this paper is to develop a model that can accept a specified number of spare-parts within the supply chain, simulating its inventory operations throughout all stages in order to minimize the inventory holding costs, base-stock, safety-stock, and to find the optimum quantity of inventory levels, thereby suggesting a way forward to adapt some factors of Just-In-Time to minimizing the inventory costs throughout the entire supply chain. The model has been developed using Micro-Soft Excel & Visual Basic in order to study inventory allocations in any network of the supply chain. The application and reproducibility of this model were tested by comparing the actual system that was implemented in the case study with the results of the developed model. The findings showed that the total inventory costs of the developed model are about 50% less than the actual costs of the inventory items within the case study.

Keywords—Holding Costs, Inventory, JIT, Modeling, SCM

I. INTRODUCTION

THE cement industry is considered as one of the most energy intensive manufacturing industries around the globe as it is the basic component of making concrete, making this industry with a priority of having a clear understanding, and careful planning and control of its manufacturing and managerial activities and operations [1].

Libya is a large African country, bounded in the North by the Mediterranean Sea, in the East by Egypt and Sudan, in the South by Niger and Chad, and in the West by Algeria and Tunisia. It is mainly petroleum producing and exporting country. The economy within Libya was formerly based on agriculture, producing fruit, barely, olives, and dates. Libya was relatively poor until the discovery of oil and natural gas in the very beginning of the sixties of the last century. Since then, the country has turned to industrialization by engaging in petroleum processing as well as Cement industries. Libya is committed to develop enhanced abilities to produce goods that meet the quality requirements of present markets with all the possible products and services, which could be achieved by providing the most proper and highest technology available.

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However, according to the Global World Report, 2004, the current status of cement industry within Libya is running only with 50% from its capacity utilization [2,3]. The objectives of this paper is to study the present implemented techniques for setting economic order quantities of the spare parts within their related costs within Souk El-Khamis Cement Plant, Libya. Also to develop a model to optimizing the inventory quantities along with the total inventory costs within this plant, thereby suggesting a way forward to adapt some key-factors of Just-In-Time (JIT) system to eliminate the inventory costs throughout the studied supply chain.

II. AN OVERVIEW OF JIT

JIT is a management pull system used for planning and control operations that are carried out for producing and supplying the requested products and services at the right time they are needed, at the right place, and at the exact desired quantities [1]. It was stated that the distinctive feature of JIT system is to eliminate all types of waste, which could be achieved by organizing the entire activities throughout the operations' system. The JIT systems work towards eliminating all types of waste and continuously improving the processes throughout the entire supply chain within any company [4].

JIT focuses on the complete elimination of waste, which is defined as anything that does not add any value to the services and products [5]. In addition, the modern manufacturing and production companies consider the successful implementation of JIT system as a key factor for minimizing inventory and maximizing the quality of their products and services [6]. This could be achieved through setting well-organized networks for manufacturing and transporting the right ordered items exactly at the right time with the right quantities, establishing a long term relationship with suppliers in order to maintain regulated shipments to minimize ordering cost, and to buy enough parts as needed to avoid paying holding costs [1,5]. For all successful companies, certainly those that are claiming to be WCM, the implementation of JIT techniques is essential to their success in the recent global competitive marketplace.

III. SUPPLY CHAIN MANAGEMENT

Managing supply chains is gaining increased attention due to the expansion and complexity of the supplying networks. Managing the economic order quantity system in a supply chain is one of the important factors to reduce the inventory costs thereby increasing the companies' profits. Management systems could be used to resemble inventories throughout the supply chain. In fact, there are many reasons which delay the production processes, making negative effect on the productivity of the production system as well as increasing the related costs.

The role of inventory in a the supply chain can be considered as important factor that affecting the effectiveness of the supply chain as inventory is kept to avoid uncertainties throughout the supply chain [6, 7].

The supply chain consists of many stages including fulfilling of a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses and all other related operations and processes. The supply chain within any organization includes all functions involved in filling the customer request, such functions include, but are not limited to, new product development, marketing, operations, distribution, and finance and customer service. The primary purpose for the existence of any supply chain is to satisfy customer needs. Supply chain activities begin with the customer orders and ended after delivering the required items to the right customer in the right place with satisfactory level [8,9].

A company's supply chain encompasses all of the facilities, functions, and activities were involved in producing a product or service from suppliers to customers. Supply chain functions include purchasing, inventory, production, scheduling, facility location, transportation and distribution. All these functions are affected in the short run by product demand and in the long run by utilizing new technology in addition to market demand [10].

Inventory management is among the most important operations management functions as inventory requires a great deal of capital and affects the delivery of goods to customers. Inventory management has an impact on all business functions, particularly operations, marketing and finance. There are however, conflicting inventory objectives within the company. The finance function generally prefers to keep the level of inventories low to conserve capital; marketing prefers high levels of inventories to enhance sales, while operation prefers adequate inventories for efficient production and smooth employment levels. Inventory management works to balance these conflicting objectives and manage inventory levels in the best interest of the company as a whole. In general, the primary purpose of inventories is to uncouple the various phases of operations [11,12].

IV. CURRENT STATUS OF CEMENT INDUSTRY WITHIN LIBYA

The cement industry within Libya is gaining huge attentions during the recent years. Three main companies are running this industry around the country, among of them is the Ahlia Cement Company, producing around 2.5 Million Tones/year. This company owns four large factories located within the western part of the country. The cement produced from these plants is the normal Portland type. Souk El-Khamis Cement Plant is one of the factories which belongs to the Ahlia Cement Company and it struggled from many inventory problems, among of them having a large number of different types of spare parts that require large storage spaces, resulting high cost of inventory items [1, 8].

The eastern part of the country is depending on the production of cement produced by the Libyan Cement Company. This company runs three plants, producing around 2 million tones a year.

The cement industry within Libya needs advanced technologies and techniques to run its plants with a high level of utilization as an evidence the Libyan plants is running their operations at 50% utilization [1, 3].

V. DEVELOPED MODEL

A model for minimizing inventory costs within the supply chain has been developed; it is based on Simpson assumption, where the mechanics of a single stage that operates a base stock policy in the face of bounded demand is described. Graves and Sean Willems practiced two approaches for safety stock placement in a supply chain by means of dynamic programming. The inventory model developed for this study has two types of stock; base and safety stock. Each carries the amount of components that is needed until receiving the required supplies. The model assumes that inventory systems starts with time 0 at month 1 with an initial base stock BS_i for every part, BS_i is calculated, it is found to be equal to the mean value of breakdowns per each month multiplied by its mean value of lead-time. The time spent from ordering a quantity until its delivering is;

$$BS_i = \mu_{BS} * \mu_{LT}$$

Using the calculated data of the base stock, entered by the user of each part, the safety stock can be calculated using the following formula:

$$SS_i = \% BS_i$$

The model was developed to study the state of the customer (end user) in the supply chain as illustrated on Figure 1, representing the flow of data and the processing of these data from the data entry stage until having the outputs. The developed model was also designed to be reliable for any type and amount of spare parts throughout the supply chain, and can accept many variables such as: input order, holding, shortage costs and input safety stock.

There are many types of inventory; here there are four types of inventory and their costs (Base stock, Safety stock, order and shortage costs) in the supply chain. The base stock cost at any part is the amount of inventory on hand multiplied by the holding cost per unit per year; the total base stock cost for the whole chain is equal to the base stock costs for all parts at the beginning of the month.

$$C_{BS} = BS \times C_h$$

The safety stock is determined from the variation of demand during lead time, from the time where placing an order a unit until receiving it. The safety stock cost for any part is the amount of safety stock multiplied by the holding cost per unit for this part; the total safety stock cost for the whole chain is equal to the safety stock costs for all the parts at the beginning of the month.

$$C_{ss} = SS \times C_h$$

Shortage cost occurs when the demand exceeds the supply of inventory on hand for any part; the total shortage cost for the whole chain is equal to the shortage costs for all the parts at the beginning of the month [4], [6],[7].

VI. DATA COLLECTION

Data used for this paper were gathered through one-to one semi-structured interviews and secondary data files. The interviews took place at the factory site with top and middle management levels. The questions for these interviews were prepared according to what is needed to fulfill the requirements for this study. The interviewers (the authors) were trained for this purpose in order to play the job effectively throughout all the sessions. The interviewees were given a choice for not answering in a case of confidentiality reasons. The secondary data used for this paper was obtained from the documented files in the departments of Finance, Maintenance, Production, and Storage.

VII. DATA ANALYSIS AND DISCUSSION

The gathered data were analyzed to ascertain the effect of the input holding cost on the other studied parameters (other related inventory costs). The findings were illustrated in Table 1 and Figure 2. Both shows that using different values as a percentage (25%-200%) of the input holding cost has a direct impact on all the studied costs relatively higher impact on the base stock cost.

TABLE I
THE EFFECT OF INPUT HOLDING COST ON ALL OTHER COSTS

Input Holding Cost (%)	Base Stock cost (LD)	Safety Stock cost (LD)	Order cost (LD)	Shortage cost (LD)	Total cost (LD)
0.25	2595	1384	12723	1458	18160
0.5	3919	2048	15462	2097	23528
0.75	6906	3713	11621	1278	23518
1	9850	4129	11733	1135	26847
1.25	15061	6814	12871	1042	35787
1.5	16616	7051	13365	1151	38183
1.75	17440	7148	14100	1359	40047
2	18728	10444	14384	1596	45152

Table II, shows the calculated values of increasing levels of all the studied costs based on using different percentage rates of the real amounts of safety stock. The Table shows relatively higher increase in the safety stock cost, whereas the other costs show small increase in their values. Surprisingly, the table shows that the optimum quantity of the safety stock of 30% gave the minimum total cost of the model. Therefore changing base stock amounts have an effect on the total cost, showing its best value at 30%.

TABLE II
EFFECT OF INCREASING SAFETY STOCK ON ORDER COSTS

Percept Quantity	Base Stock cost (LD)	Safety Stock cost (LD)	Order cost (LD)	Shortage cost (LD)	Total cost (LD)
0.15	11478	1781	14193	1901	29353
0.2	11170	1974	14776	1627	29547
0.25	11288	3077	13049	1306	28720
0.3	9897	4447	12031	1126	27501
0.35	12567	6254	13806	1484	34111
0.4	12284	6883	11049	1640	31856
0.45	10303	9543	12689	1355	33890
0.5	11888	10070	13123	1436	36517

Further investigation has been applied to examine the validity of the developed model, comparing the actual data of the used system with the obtained results from the developed model. The holding, order, shortage and total costs obtained by the two systems are illustrated in Table III.

TABLE III
COMPARISON BETWEEN ACTUAL DATA AND SIMULATED DATA

The Used System	Holding cost (LD)	Order cost (LD)	Shortage cost (LD)	Total cost (LD)
Actual	52601	7136	7455	67192
Simulated	12304	13565	1523	27392

Table IV and Fig. 1, present a comparison between the results from the developed model and the actual used data obtained from the factory. The results show a reduction of about 60% from the total actual costs, giving strong evidence that the developed model is reliable and valid for implementation within this factory.
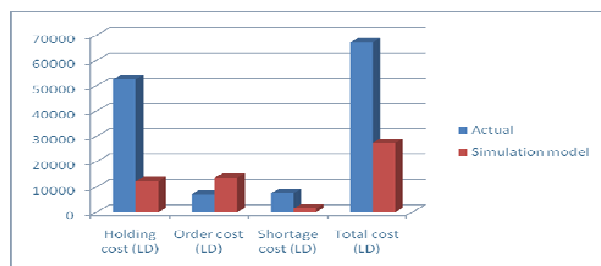

Fig. 1 Comparison between actual and simulated data

Table V, shows some suggested key elements as a way forward that might help for eliminating waste as presented by JIT philosophy. These elements may work as a complete system to eliminate activities that do not add any values throughout the entire manufacturing and storage operations.

TABLE V
SHOWS SUGGESTED JIT KEY-FACTORS

Key-element	Area of implementation
Eliminate all waste	Related departments/sections
Continuous improvement	Related departments/sections
Reduce set-up times	Areas where applicable
Scheduling & job sequences	Areas where applicable
Kanban as a control system	Areas where applicable
Multifunctional skills training	Related departments/sections
Total quality management	Related departments/sections
Quality circles	Related departments/sections
Preventative maintenance	Related departments/sections

VIII. CONCLUSIONS

This study is the most recent to study the inventory and storage costs within the cement industry in Libya. Considering the supply chain as an integrated handling and supplying processes wherein materials transferred and stored as an inventory items, then delivered to customers (end user). So, the objective of this paper was to find a new optimum quantity which minimizes the customer inventory costs and to investigate the economic performance of the supply chain under this new condition through developing a model that can be used for this purpose.The proposed model determines the amount of base stock and safety stock to be located at each item of different types of spare part for the supply chain to achieve a minimum total cost, including the base stock, safety stock, order and shortage cost. Souk El-Khamis Cement Plant (end user) for which the model was developed, and can be modified to accept any number of different types of spare parts upon the requirements of the manufacturing process within the plant. The overall findings show that the increase in the input order, holding and shortage costs lead to an increase in the total cost. Furthermore, increasing the input of the safety stock leads to a change in the total cost. That could be as a result of changing the cost of total base stock and order cost effects for all inventory items. The optimum quantity of the safety stock, which found to be with a minimum effect on the total cost of inventory items was found at the level of 30% from its actual value. Finally, a comparison of the actual system that was used in the plant with the result obtained by the developed model was performed, and noted that results obtained by the developed model is much less than the actual costs that used in the reality. Furthermore, the paper suggests a way forward for eliminating the waste as suggested by JIT philosophy, which considered as anything that does not add more values. These suggestions might help in reducing the inventory costs throughout the studied supply chain.

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