Development of an Inventory Policy Based on EOQ Model in a Dyeing Unit: A Case Study

By

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A thesis work submitted to the Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology (BUET), in partial fulfillment of the requirements for the degree Master of Engineering in Advanced Engineering Management (AEM).

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It is hereby declared that this thesis or any part of this has not been submitted elsewhere for the award of any degree or diploma except for publication.

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ABSTRACT

Many firms/industries, whether manufacturing or purchasing, face great challenges in managing inventories. Poor inventory management may result in under-stocking, over-stocking as well as high inventory total cost. The study examines inventory situation at Dyeing unit of Reedisha Knittex Ltd. Gazipur, Bangladesh. For Reedisha two inventory problems, stock-out and overstock occur frequently. The company wants to improve its efficiency and is considering a change in the inventory management. The objectives of this thesis work is to develop inventory management system of Dyeing section by using Economic Order Quantity (EOQ) model that will determine number of units of an item to order at a time and the re-order point (r), that is the level to which stocks of items are allowed to fall before ordering other items, for raw materials. The resulting EOQ for each raw material is compared to the actual ordered quantities so as to see whether there is any relationship between them in operational cost reduction. For variable demand over the period Wagner-Whitin Algorithm is used to determine ordering schedule of the items. By comparing ordering cost and holding cost for each item it is determined when to order and how much to order at a time. The study used cross sectional secondary data from Reedisha Knitex. Excel was used to find EOQ and the re-order point. After doing analysis and calculation of the data, it was concluded that the ordered quantities at Reedisha Knitex Ltd. were not optimal. Therefore, it is recommended that in order to manage inventory effectively, Reedisha needs to employ inventory control methods such as the EOQ model to obtain reasonable ordered quantities for its raw materials.

TABLE OF CONTENTS

Topics	Page
Certificate of Approval	ii
Candidates Declaration	iii
Acknowledgement	iv
Abstract	v
Table of Contents	vi
List of Tables	ix
List of Figures	x
Chapter 1: Introduction	**1-3**
1.1 Introduction	1
1.2 Background of the study	2
1.3 Objectives of the study	3
1.4 Disposition	3
Chapter 2: Literature Review	**4-28**
2.1 Supply Chain Management	4
2.2 Inventory Management	5
2.2.1 Functions of Inventory	6
2.2.2 Types of Inventory	6
2.2.3 Demand Management	7
2.2.4 Demand Forecast	8
2.2.5 Stock Out	9
2.2.6 Safety Stock	9
2.2.7 Inventory Turnover Ratio	10

Topics		Page
2.3	Inventory Cost	12
2.4	Inventory Control System	15
2.5	Methods of Inventory Control	15
	2.5.1 ABC Classification	16
	2.5.2 Fixed Order Quantity Approach (Under the condition of certainty)	18
	Simple Economic Order Quantity Model	18
	2.5.3 Fixed Order Quantity Approach (Under the condition of uncertainty)	19
	2.5.3.1 Adjusted Economic Order Quantity	19
	2.5.3.2 Reorder Point (When to order)	20
	Continuous review model	20
	Periodic review model	23
	2.5.4 Lot sizing Techniques	25
	2.5.4.1 Dynamic Lot Sizing Model (Wagner- Whitin Method)	26
	The Assumptions	27
	The Algorithm	27
	Potential Drawbacks of the Algorithm	28
Chapter 3:	**Research Methodology**	**29-32**
	3.1 Generating the Research Topic	29
	3.2 Deciding the Research Approach	29
	3.3 Choosing the Appropriate Research Strategies	29
	3.3.1 Case Study Strategy	30
	3.3.2 Cross-Sectional Studies	30
	3.3.3 Exploratory, Descriptive and Explanatory Studies	31
	3.4 Data Collection Methods	32

Topics			Page
Chapter 4:	**Case Study**		**33-37**
	4.1	Company Profile	33
	4.2	Production Zone	34
	4.3	Dyes and Chemicals Receiving Process	37
Chapter 5:	**Analysis and Findings**		**40-67**
	5.1	Classifying Inventory (ABC Analysis)	40
		Calculation on ABC analysis	44
	5.2	Selecting Inventory Methods	46
	5.2.1	Economic Order Quantity (EOQ) Model	46
		Calculation on EOQ	47
	5.2.2	The Total Cost Function	49
		Calculation on Total cost for EOQ	50
		Calculation on Total cost for non EOQ	53
	5.2.3	Reorder Points: (How much to Order)	54
		Calculation on Reorder point	56
	5.2.4	Dynamic Lot Sizing Technique (Wagner-Whitin Method)	57
		Calculation on Wagner-Whitin method	67
Chapter 6:	**Conclusion and Recommendation**		**71-72**
	6.1	Conclusion	71
	6.2	Recommendation	72
	6.3	Limitation of the Study	72
References			**77**
Appendices			**79-83**
Appendix 1	Annual consumption report for twenty items in 2013		79
Appendix 2	Questionnaires		83

LIST OF TABLE

Topics		Page
Table 5.1	List of items for ABC analysis	42
Table 5.2	Arrange the items according to % of cost	43
Table 5.3	Summarization of ABC analysis	44
Table 5.4	Determination of Economic order quantity	48
Table 5.5	Determination of Total Cost	51
Table 5.6	Comparison of total cost for EOQ and other than EOQ	52
Table 5.7	Determination of reorder point	55
Table 5.8	Ordering Policy under Wagner-Whitin Method	57
Table 5.9	Summarization of result	70
Table 5.10	Comparison between EOQ Model and Wagner-Whitin Model	70

LIST OF FIGURES

Topics		Page
Figure 2.1	Saving inventory dollar by increasing inventory turns	11
Figure 2.2	What costs go into inventory carrying cost?	14
Figure 2.3	Graphical representation of ABC analysis	17
Figure 2.4	Inventory level in a continuous review model	21
Figure 2.5	ROP with safety stock	22
Figure 2.6	Inventory level in a periodic review model	24
Figure 4.1	Process flow chart of Dyeing Unit	38
Figure 4.2	Organ gram of Dyeing Unit	39
Figure 5.1	Graphic representation of ABC analysis	45
Figure 5.2	Typical representation of ABC analysis	45
Figure 5.3	Inventory usage over time	46
Figure 5.4	Total cost as a function of order quantity	50
Figure 5.5	Reorder point	54
Figure 6	Main Chemical Store of Reedisha Knittex Ltd	73
Figure 7	Stock of Chemical of Felosan NOF	74
Figure 8	Stock of Chemical of Crosoft NBC	75
Figure 9	Stock of Chemical of Leucophor BMB	76

1

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Inventory management is pivotal in effective and efficient organization. It is also vital in the control of materials and goods that have to be held (or stored) for later use in the case of production or later exchange activities in the case of services. The principal goal of inventory management involves having to balance the conflicting economics of not wanting to hold too much stock. Thereby having to tie up capital so as to guide against the incurring of costs such as storage, spoilage, pilferage and obsolescence and, the desire to make items or goods available when and where required (quality and quantity wise) so as to avert the cost of not meeting such requirement. Inventory problems of too great or too small quantities on hand can cause business failures. If a manufacturer experiences stock-out of a critical inventory item, production halts could result. Moreover, a shopper expects the retailer to carry the item wanted. If an item is not stocked when the customer thinks it should be, the retailer loses a customer not only on that item but also on many other items in the future. The conclusion one might draw is that effective inventory management can make a significant contribution to a company's profit as well as increase its return on total assets. It is thus the management of this economics of stockholding, that is appropriately being refers to as inventory management. The reason for greater attention to inventory management is that this figure, for many firms, is the largest item appearing on the asset side of the balance sheet. Essentially, inventory management, within the context of the foregoing features involves planning and control. The planning aspect involves looking ahead in terms of the determination in advance:

- What quantity of items to order;
- How often (periodicity) do we order for them to maintain the overall source-store sink coordination in an economically efficient way?

The control aspect, which is often described as stock control involves following the procedure, set up at the planning stage to achieve the above objective. This may include monitoring stock levels periodically or continuously and deciding what to do on the basis of information that is gathered and adequately processed. Effort must be made by the management of any organization to strike an optimum investment in inventory since it costs much money to tie down capital in excess inventory.

1.2 Background of the Study

The readymade garment (RMG) industry, a very important segment in Bangladesh's manufacturing industry, is playing a critical role in its economic development. The RMG industry plays an important role in satisfying our local demand and also contributes a huge part in our overall export. In 2011-12, amount of export earnings from RMG sector is over USD17.9 billion which is about 77% of total export earnings of this country and it contributes 13% of our total GDP. The RMG industry has played an important role in Bangladesh's economy for a long time. Currently, the RMG industry in Bangladesh accounts for 45 percent of all industrial employment and contributes 5 percent to the total national income. The industry employs nearly 4 million people, mostly women.

The RMG industries have difficulties in matching its supply with production requirements. There are both stock-out of inventoriable items and excess inventory. Both situations impact the profitability negatively. It is considered that the problem results from insufficient control over inventory and volatile demand of some product and another reason is that the lead-time of most products is long about three months at the longest. The root cause of this problem is that industry does not use optimum inventory policy. Optimum order quantity and re-order point need to be determined.

In a composite RMG unit there are six major sections: spinning, weaving/knitting, dyeing, cutting, sewing and finishing. Our focus will be in dyeing unit only as there are all the raw materials are imported from abroad. So, huge amount of dollar value is associated with it. The purpose of this thesis project is to investigate and identify the reasons behind the inefficient inventory management in a Dyeing unit. To do this at first we categorized the item on priority basis and then perform cost analysis of the items. Then we would develop an inventory policy to improve the unit's inventory management based on EOQ model, after examining the relevant theories and understanding the business operational practices.

1.3 Objectives of the Study

The specific objectives of the present research work are as follows:

- To develop an inventory system.
- To find an optimal re-order level to decide when items should be ordered.
- To compare existing inventory cost with the expected inventory cost for the proposed model.

1.4 Disposition

Chapter 1: The first chapter gives an introduction and background of this study. Furthermore it gives an explanation of company's problems. Then the research questions and purpose of this thesis are presented.

Chapter 2: This chapter will explore the different theories and models that are related to the subject of this thesis and can be used for the analysis.

Chapter 3: This chapter will examine different research methods and present what methods are applied to this thesis.

Chapter 4: The authors will present their empirical findings about business practice of the studied company and the major issues that needs to be addressed in their inventory management.

Chapter 5: This chapter will conduct the analysis guided by theoretical framework. The analysis part is based on our empirical findings. Furthermore, the authors will present their suggestions upon the problems identified.

Chapter 6: This chapter carries out the conclusion about the whole thesis and summarizes the implications of the research.

CHAPTER 2
LITERATURE REVIEW

2.1 Supply Chain Management (SCM)

Many theorists have given the definitions for the term supply chain management. One of them that can describe the term supply chain management really well and it seems to cover all related activities is that; Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wise costs while satisfying service level requirements.

As the definition implies, supply chain management has been developed for customers who play the most important role in businesses. Especially in this globalization era, customers, ever more demanding and powerful than before, are seeking for products and services with higher criteria. In order to meet customers' requirements and satisfactions, companies have to be proactive against globalized markets which can be changed and influenced by several factors. With an increase of use of technology like internet, some claim that there is no more geography in business nowadays. Offshore production, collaboration between international companies, and openness of the global market are the significance of the global environment. Supply chain management can therefore be labeled as global supply chain management in today's environment.

Based on the concept of supply chain management, it requires integration of many business components. In 1985, Michael Porter introduced and described his new concept for business management, the value chain. The concept of value chain has developed as a tool for competitive analysis and strategy. It is comprised of inbound and outbound logistics which are the primary components of this business model. The more integrated marketing, sales and production are also the important jigsaws that contribute value to firm's customers.

2.1.1 Push System

Push system is referred when raw materials are stored before production and products are produced to stock before orders are placed. The action is stimulated by demand estimation or demand forecast. Products and information flow the same way, from seller to buyer.

Communication carried out in the supply chain of this approach can be either interactive or non-interactive since customers or buyers do not always response to messages sent by producer or sellers. For example, there is no direct feedback from customers after message in advertisement was sent by vendors through media channels. Push system, typical and traditional, is still widely utilized by many firms in different industries.

2.1.2 Pull System

Pull system, on the other hand, is used in response to confirmed orders. Products are produced after or at production planning stage. Therefore, stock does not contain finished goods, but semi-finished materials. Customers send their requirements and place orders to producers or sellers. The requested product is pulled through the delivery channel. Communication carried out in pull system is usually interactive. Pull model is also widely used inside the same firm, for instance, a department sends an internal order to the other department to manufacturer an item that is needed in their work process.

Pull system includes just-in-time (JIT) which is an inventory strategy to improve business "inventory turnover" by bringing inventory to a minimum. JIT strategy considers inventory as waste, its emphasis therefore is ensure that supplies are delivered at when and to where they are needed.

2.2 Inventory Management

Inventory management is a science primarily about specifying the shape and percentage of stocked goods. It is required at different locations within a facility or within many locations of a supply network to precede the regular and planned course of production and stock of materials. The scope of inventory management concerns the fine lines between replenishment lead time, carrying costs of inventory, asset management, inventory forecasting, inventory valuation, inventory visibility, future inventory price forecasting, physical inventory, available physical space for inventory, quality management, replenishment, returns and defective goods, and demand forecasting. Balancing these competing requirements leads to optimal inventory levels, which is an on-going process as the business needs shift and react to the wider environment.

Inventory control is challenging in business. Managing inventory control can directly affect business performance. The reason for having inventories or stocks is to buffer against demand and supply. Having too much inventory on hand means high holding cost, and having too little leads to a rise in ordering cost. Therefore, inventory management should be well planned in order to achieve the lowest possible total cost.

Even though inventory is considered as a negative impact in business since large proportion of total expenses is generated here, but having inventory is still a must for many kinds of business. Managing and controlling inventory are compulsory practices for firms that seek for profitability. The goals for controlling inventory are minimizing the total cost and maximizing service level by balancing demand and supply. There are several approaches involved in managing inventory. Businesses are characterized by two distinguished systems, push and pull. JIT is a pull system while EOQ (Economic Order Quantity) includes elements of push strategies in proactive manner.

2.2.1 Functions of Inventory

- Economies of scale can be obtained by purchasing large volumes which allows cost reduction of per unit fixed cost. Also, transportation can get economies of scale through utilization by moving larger volume of products.
- Balancing supply and demand is another important reason for having inventory. If supply is seasonal, inventory can help meet demand when materials or products are not available. Vice versa, if there is an occurrence of seasonal demand, firms must accumulate inventory in advance to meet demand in the future.
- Specialization can bring economies of scale to manufacturers by long production run. Instead of producing a variety of products, each plant can produce a product and ship to customers or other warehouse.
- Protection from uncertainties is a primary reason for holding inventory. Having stock on hand can reduce risk of shortage or stock out situation which might lead to lost sales and lack of reliability. Customer can possibly buy products from competitors instead.

2.2.2 Types of Inventory

To accommodate the functions of inventory, firms maintain four types of inventories:

- Raw material inventory
- Work in process inventory
- Maintenance/repair/operating supply (MRO) inventory
- Finished goods inventory

Raw material inventory

Raw material is the basic material that is processed and converted into finished goods. The cost incurred to obtain raw materials that have not yet been placed into production is reported as raw materials inventory in the current assets section of the balance sheet. Examples of raw materials include wood for the manufacturers of cricket bat and steel for the manufacturers of cars.

Work-in-process inventory:

The units that remain incomplete at the end of a period are known as work-in-process inventory. These units need the addition of more materials, labor or manufacturing overhead to be completed in the coming period. Like raw materials, work-in-process inventory is reported in the current assets section of the balance sheet.

Maintenance/repair/operating supply (MRO) inventory:

MRO supplies are necessary to keep machinery and processes productive. They exist because the need and timing for maintenance and repair of some equipment are unknown. Although the demand for MRO inventory is often a function of maintenance schedules, other unscheduled MRO demands must be anticipated.

Finished goods inventory:

Finished goods are completed but unsold goods. The total cost incurred to complete these unsold goods are reported as finished goods inventory along with raw materials and work-in-process inventory in the current assets section of the balance sheet.

2.2.3 Demand Management

Demand management may be thought of as "focused efforts to estimate and manage customers' demand, with the intention of using this information to shape operating decision." Inventory Management deals essentially with balancing the inventory levels. Inventory is categorized into two types based on the demand pattern, which creates the need for inventory. The two types of demand are Independent Demand and Dependent Demand for inventories.

Independent Demand

An inventory of an item is said to be falling into the category of independent demand when the demand for such an item is not dependent upon the demand for another item. Finished goods Items, which are ordered by External Customers or manufactured for stock and sale, are called independent demand items. Independent demands for inventories are based on confirmed Customer orders, forecasts, estimates and past historical data**.**

Dependent Demand

If the demand for inventory of an item is dependent upon another item, such demands are categorized as dependent demand. Raw materials and component inventories are dependent upon the demand for Finished Goods and hence can be called as Dependent demand inventories.

2.2.4 Demand Forecast

The sales forecast is particularly important as it is the foundation upon which all company plans are built in terms of markets and revenue. Management would be a simple matter if business was not in a continual state of change, the pace of which has quickened in recent years. It is becoming increasingly important and necessary for business to predict their future prospects in terms of sales, cost and profits. The value of future sales is crucial as it affects costs profits, so the prediction of future sales is the logical starting point of all business planning.

Sufficient data result in more effective forecasts. The traditional way to forecast demand is to refer to the historical record of demand. All forecasting techniques are characterized by the fact that the more data are observed, the more we modify the estimates of the average demand and demand variability, and the more accurate these predictions can be (Simchi-Levi et al., 2004). Of course, forecasts are never completely accurate. Indeed, the following rules of forecasting hold:

- The forecast is always wrong. It is very unlikely that actual demand will exactly equal forecast demand.
- The longer the forecast horizon, the worse is the forecast. A forecast of demand far in the future is likely to be less accurate than a forecast of near-future demand.
- Aggregate forecasts are more accurate.

2.2.5 Stock-out

A stock out or **out-of-stock** (OOS) event is an event that causes inventory to be exhausted. While out-of stocks can occur along the entire supply chain, the most visible kinds are retail out-of-stocks in the fast moving consumer goods industry (e.g., sweets, diapers, fruits). Stock outs are the opposite of overstocks, where too much inventory is retained. Out-of-stock inventory does not necessarily indicate that a seller is doing poorly, and in fact, it can be a good sign for the business if inventory is managed well. Out-of-stock inventory is sometimes called backordered inventory if orders are placed for an item before the new inventory supply arrives. Out-of-stock inventory also sometimes happens because of business or manufacturing problems regardless of the market. For instance, a bad snow storm might delay a shipment or a robot on an assembly line might break down.

Advantages

An advantage of out-of-stock inventory is that it allows the seller to continue doing business even if he physically does not have the item he is selling. For instance, he can alert buyers of the out-of-stock status and then let them purchase the item on backorder, provided he knows he can get more of the item. This can save seller money, because he does not need to reprint advertisements; instead of removing and adding every out-of-stock inventory item on a website, he can just note the change in status. Having out-of-stock inventory sometimes means that a seller is doing well, as he is able to sell the entire inventory he has on hand.

Disadvantages

Handling out-of-stock inventory can complicate the inventory tracking process, as customers may continue to place orders for items the seller has yet to receive. The seller also has to deal with inquiries about the out-of-stock items, such as when the seller expects to have more of the item. Additionally, listing an item as out of stock sometimes costs a seller a sale, as buyers opt not to backorder and simply go to another vendor who does have the item readily available.

2.2.6 Safety Stock

Safety stock is the stock held by a company in excess of its requirement for the lead time. Companies hold safety stock to guard against stock-out. The term Safety stock (also called **buffer stock**) is used by logisticians to describe a level of extra stock that is maintained to mitigate risk of stock outs (shortfall in raw material or packaging) due to uncertainties in supply and demand. Adequate safety stock levels permit business operations to proceed according to their plans. Safety stock is held when there is uncertainty in demand, supply, or manufacturing yield; it serves as an insurance against stock outs. The amount of safety stock an organization chooses to keep on hand can dramatically affect their business. Too much safety stock can result in high holding costs of inventory. In addition, products which are stored for too long a time can spoil, expire, or break during the warehousing process. Too little safety stock can result in lost sales and, thus, a higher rate of customer turnover. As a result, finding the right balance between too much and too little safety stock is essential. Safety stock is calculated using the following formula:

Safety Stock = (Maximum Daily Usage − Average Daily Usage) × Lead Time

Lead time is the time which supplier takes in ordering the items.

Safety stock may be calculated in another way.

Safety Stock, SS = $\boldsymbol{z\sigma_L}$

Where, z = Number of standard deviations for a specified service probability

σ_L = Standard deviation of usage during lead time

2.2.7 Inventory Turnover Ratio

The inventory turnover ratio is an efficiency ratio that shows how effectively inventory is managed by comparing cost of goods sold with average inventory for a period. This measures how many times average inventory is "turned" or sold during a period. In other words, it measures how many times a company sold its total average inventory dollar amount during the year. A company with $1,000 of average inventory and sales of $10,000 effectively sold its 10 times over.

This ratio is important because total turnover depends on two main components of performance. The first component is stock purchasing. If larger amounts of inventory are purchased during the year, the company will have to sell greater amounts of inventory to improve its turnover. If the company can't sell these greater amounts of inventory, it will incur storage costs and other holding costs. The second component is sales. Sales have to match inventory purchases otherwise the inventory will not turn effectively. That's why the purchasing and sales departments must be in tune with each other. The inventory turnover ratio is calculated by dividing the cost of goods sold for a period by the average inventory for that period.

Inventory Turnover =Cost of Goods Sold/Average Inventory

Cost of goods sold figure is obtained from the income of a business whereas average inventory is calculated as the sum of the inventory at the beginning and at the end of the period divided by 2. The values of beginning and ending inventory are obtained from the sheets at the start and at the end of the accounting period.

Inventory turnover ratio is used to measure the inventory management efficiency of a business. In general, a higher value of inventory turnover indicates better performance and lower value means inefficiency in controlling inventory levels. A lower inventory turnover ratio may be an indication of over-stocking which may pose risk of obsolescence and increased inventory holding costs. However, a very high value of this ratio may be accompanied by loss of sales due to inventory shortage. Inventory turnover is different for different industries. Businesses which trade perishable goods have very higher turnover compared to those dealing in durables. Hence a comparison would only be fair if made between businesses of same industry.

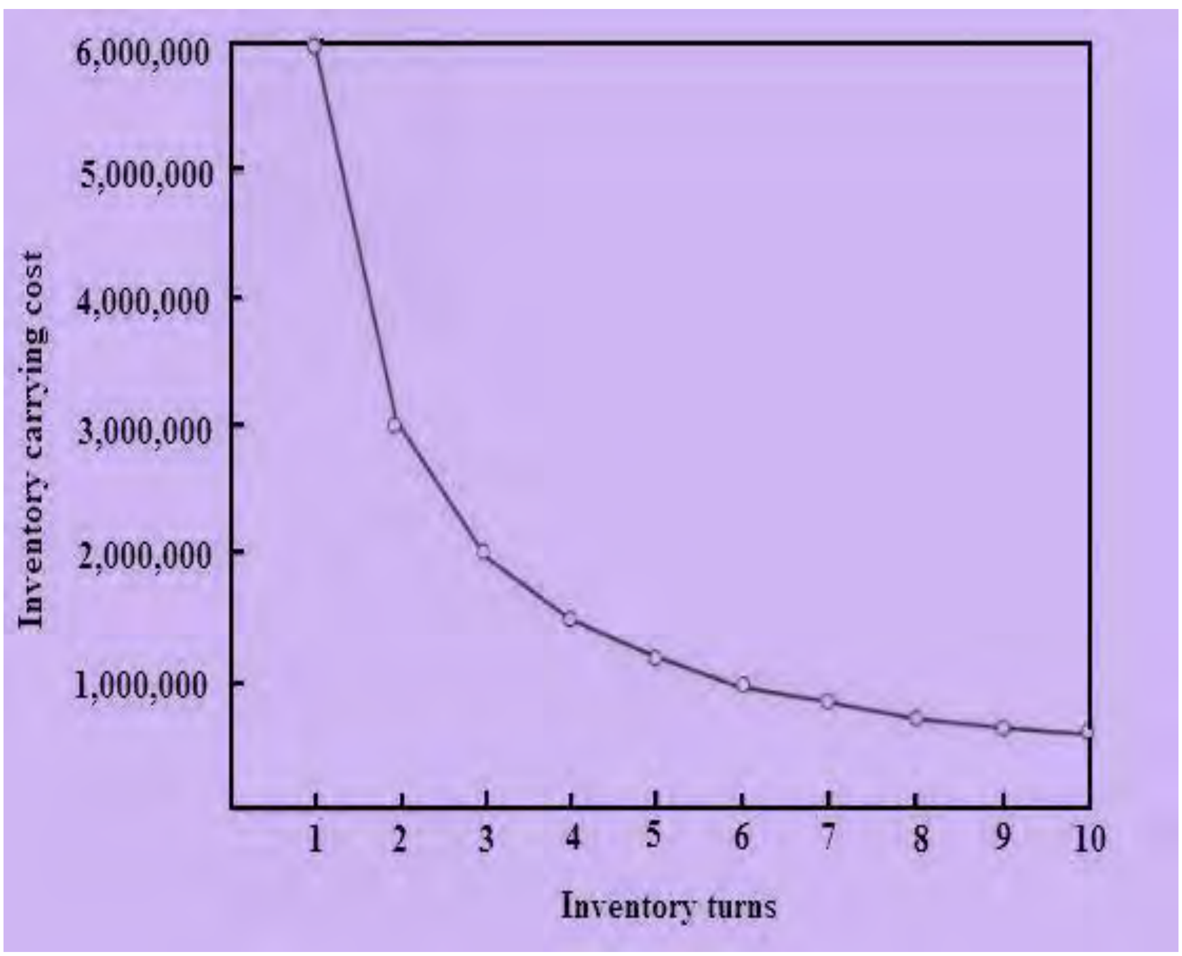


Fig: 2.1: Saving inventory dollar by increasing inventory turns

2.3 Inventory Costs

Inventory costs are the costs related to storing and maintaining its inventory over a certain period of time. Typically, inventory costs are described as a percentage of the inventory value (annual average inventory, i.e. for a retailer the average of the goods bought to its suppliers during a year) on an annualized basis. They vary strongly depending on the business field, but they are always quite high. It is commonly accepted that the carrying costs alone represent generally 25% of inventory value on hand. Inventory is associated with three major costs as follows.

- **Ordering Cost (also called setup cost):**
- **Holding Cost (also called carrying cost)**
- **Stock out (also called shortage cost)**

Ordering Cost:

The ordering cost (also called setup costs, especially when producers are concerned), or cost of replenishing inventory, covers the friction created by orders themselves, that is, the costs incurred every time you place an order. These costs can be split in two parts:

- **The cost of the ordering process itself**: it can be considered as a fixed cost, independent of the number of units ordered. It typically includes fees for placing the order, and all kinds of clerical costs related to invoice processing, accounting, or communication.
- **The inbound logistics costs**, related to transportation and reception (unloading and inspecting). Those costs are variable. Then, the supplier's shipping cost is dependent on the total volume ordered, thus producing sometimes strong variations on the cost per unit of order.

There are ways to try to minimize those costs, more precisely to determine the right trade-off of carrying costs vs. volume discounts, thus essentially balancing the cost of ordering too much and the cost of ordering too less (basically, a smaller inventory typically leads to more orders, which means higher ordering costs, but is also implies lower carrying costs).

Holding or Carrying Cost:

There are costs associated with holding all inventories, and the costs go beyond the expenditure of the inventory investment, inventory carrying costs form an interesting concept, representing both accounting costs and economic costs. Accounting costs are explicit and call for a cash payment. Economic costs are implicit, not necessarily involving an outlay but rather an opportunity cost.

Inventory Carrying Cost in Summary

Total inventory carrying cost can be estimated at …..

Types of Cost	Percentage
Cost of money	6% - 12%
Taxes	2% - 6%
Insurance	1% - 3%
Warehouse Expenses	2% - 5%
Physical Handling	2% - 5%
Clerical & Inventory Control	3% - 6%
Obsolescence	6% - 12%
Deterioration & Pilferage	3% - 6%
Total	**25% - 55%**

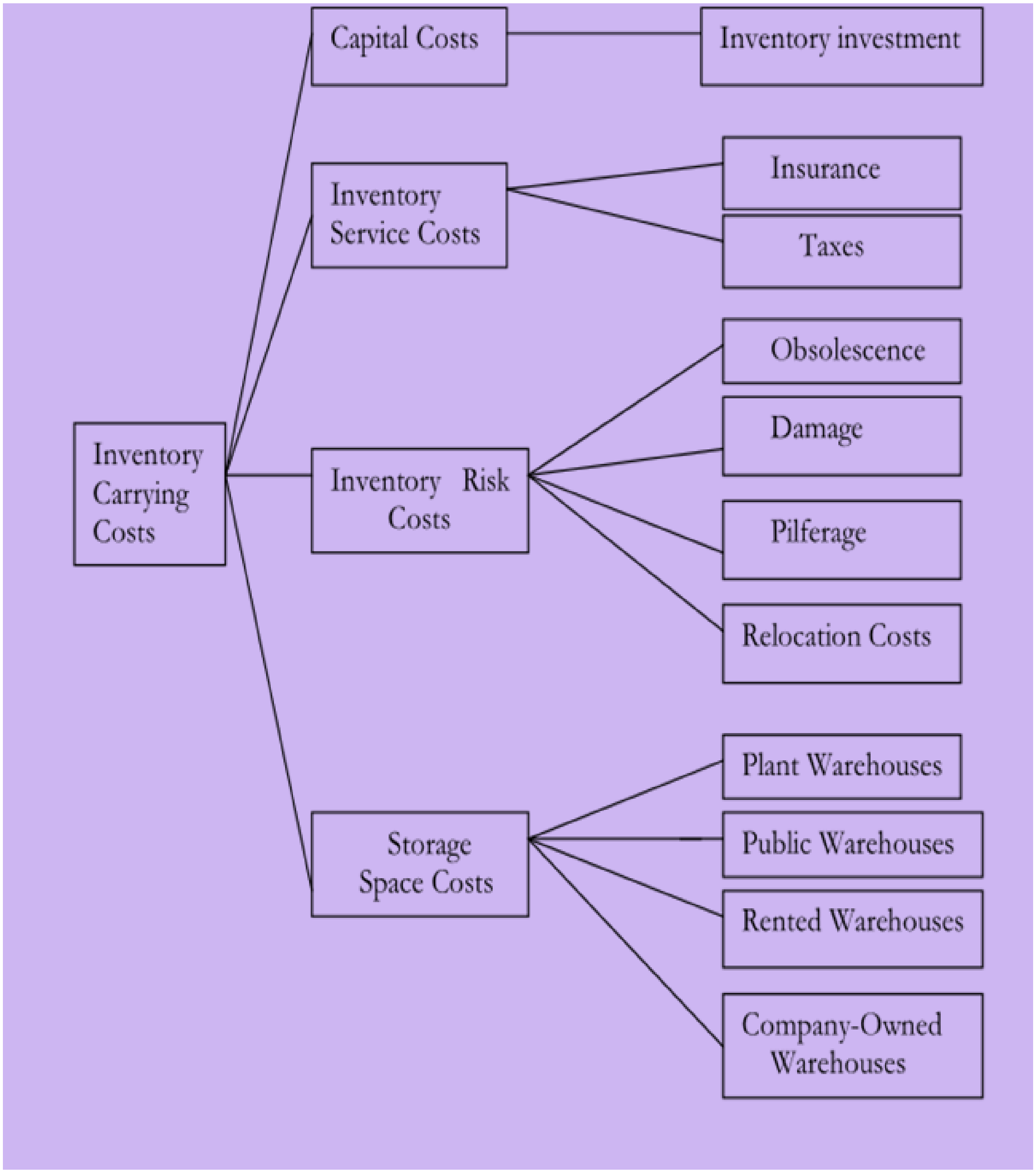


Figure 2.2: Components of inventory carrying cost
Source: Goldsby t al., 2005

2.4 Inventory Control System

An inventory system is a structure for controlling the level of inventory by determining how much to order (the level of replenishment) and when to order. There are two basic types of inventory system:

1. Continuous or fixed order quantity system (Q system)
2. Periodic or fixed time period system (P system)

Continuous inventory system:

- In a continuous inventory system (alternatively referred as a perpetual system or fixed order quantity system) a constant amount is ordered when inventory declines to a predetermined level, referred to as the reorder point.
- This fixed order quantity is called the economic order quantity.
- The inventory level is closely and continuously monitored so that management always knows the inventory status.
- However, the cost of maintaining a continual record of the amount of inventory on hand can also be a disadvantage of this type of system.

Periodic Inventory System

- Fixed time period system. An order is placed for a variable amount.
- The inventory level is not monitored at all during the time interval between orders.
- It has the advantage of requiring little or no record keeping.
- It has the disadvantage of less direct control after a fixed passage of time

2.5 Methods of Inventory Control

Many approaches are used in order to control inventory. Choosing a method to use in business must be carefully considered and analyzed based on its comprehensiveness. In a textile industry, there are several methods employed to control inventory and to facilitate procurement's policy. Each method has different objectives and procedures. Selecting and utilizing methods of inventory control depends on feasibility and suitability. Several factors are involved in making decision regarding utilization of inventory methods such as, budget, technology and personnel. Methods of inventory control are summarized as follows:

2.5.1 ABC Classification

ABC analysis is one the most widely used tool for materials management. It is also known as Paretos Law or "80–20 Rule". This classification has been conducted and developed by Vilfredo Pareto, an Italian philosopher and economist. He observed that a very large percentage of total national income and wealth was concentrated on a small percentage of population. This rule of thumb expresses that 80 % of total value is accounted by 20 % of items. This analysis is considered a universal principle. It is therefore widely used in many situations of businesses.

- Class A represents 20 % of materials in inventory and 70 % of the inventory value.
- Class B represents 30 % of materials in inventory and 20 % of the inventory value.
- Class C represents 50 % of material in inventory and only 10 % of inventory value.

According to ABC classification, it suggests that the more analysis should be applied to materials with high inventory value. Class A should be most extensively handled and Class C is analyzed little. Advantage of ABC classification is that controlling small numbers of items amounting to 10-20 % will result in the control of 75-80 % of the monetary value of the inventory held.

If items in the inventory are not classified, managing and handling materials would be very expensive since equal attention is given to all items. Having classified the inventory, different levels of control can be assigned to items in the different classes.

Very strict control procedures should be used with A items and the controller should have great authority. Inventory held in safety stock should be very low or none compensated with more frequent order placements. Consumption control and product movement should be reviewed regularly – weekly or daily. Number of sources for high valued items should be increase in order to ensure good supplier performance and reduction in lead time. Purchases of items should be centralized.

Class B can be controlled by middle management. Low safety stock policy is applied to this class with quarterly or monthly orders. Past consumption can be used a basis for calculating order quantity. There should be two or four reliable suppliers to ensure that lead time is reduced.

Power can be delegated to user department to determine stock level. Class C items do not need to be highly controlled. Since the items have the lowest value compared to the class A and B, orders can be placed at a greater volume to take advantage of quantity discount. Rough estimates are sufficient to manage class C materials.

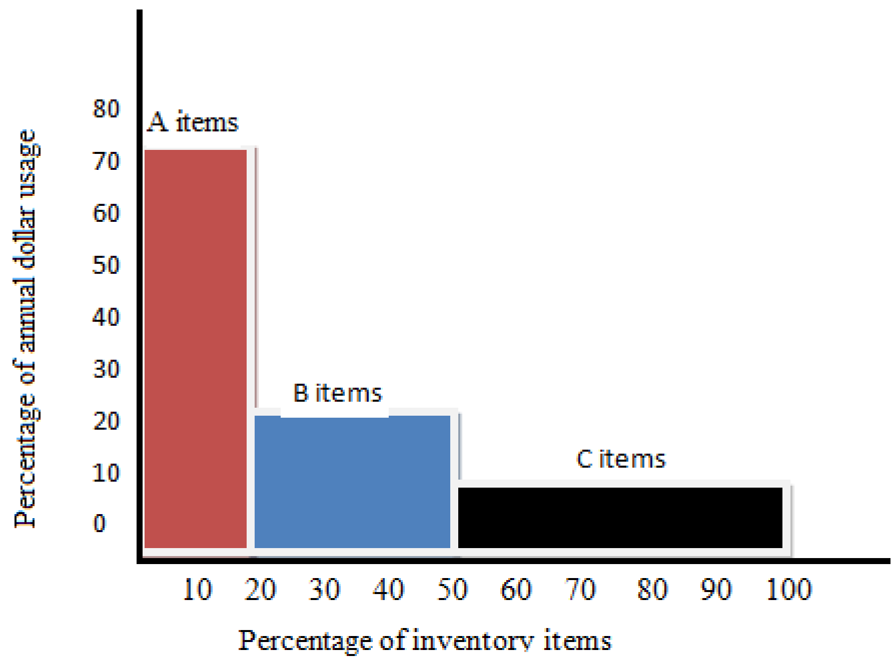


Figure 2.3: Graphical representation of ABC Analysis
Source: Own prepared

Benefits and Pitfalls of ABC Analysis:

Onwubolu et al. stated that the advantage of dividing inventory items into classes allows policies and controls to be established for each class. Policies that may be based on ABC analysis include the following:

- The purchasing resources expended on supplier development should be much higher for individual A items than C items.
- A items should have tighter physical inventory control; perhaps they belong in a more secure area, and perhaps the accuracy of inventory records for A items should be verified more frequently.
- Forecasting A items may warrant more care than forecasting other items.

Better forecasting, physical control, supplier reliability, and an ultimate reduction in safety stock can all result from inventory management techniques such as ABC analysis.

But Fuerst argued that there are also some pitfalls of ABC analysis:

- Although an item is classified as a C item, this does not necessarily mean that this item can (or should) be eliminated from the product mix. For example, a retail establishment may not be able to eliminate a particular item even though it is a C item because customers expect to be able to purchase that item in that store.
- In manufacturing endeavors, a stock-out of a C item may cause serious delays in the completion for a finished product.
- Some inventory situations do not lend themselves to classification. If the inventory situation does not reasonably reflect the underlying basis of the ABC technique-the "important few" and the "trivial many"-then such a technique should not be employed.

2.5.2 Fixed Order Quantity Approach (Under the Condition of Certainty)

Under the condition of certainty when lead time and demand are certain, fixed order quantity approach can be applied to determine order quantity. As the name implies, order is placed at a fixed quantity which is calculated based on product cost and its demand characteristics. Inventory carrying and ordering costs are the main components of this equation.

Simple Economic Order Quantity Model (How much to order)

Economic Order Quantity (EOQ) is one of the most popular formulas used for calculating quantity of order placement. EOQ is formulated to get trade-off point on basis of regular relationship between ordering cost and carrying cost. Before employing this method to determine an order quantity, there are several assumptions that should be taken into account as follows:

- There is a continuous, constant, and known demand rate.
- The lead time cycle is known and constant.
- The constant purchase price is independent of the amount ordered.
- Transportation costs are constant no matter the amount moved or the distance traveled.
- There is no inventory in transit.
- All inventory parts are independent of each other.
- The planning horizon is infinite.
- There is no limit of the amount of capital available.

The formula for basic EOQ is given as

$$\text{EOQ} = \sqrt{\frac{2RA}{vw}}$$

Where:

EOQ= Economic order quantity

R= Ordering cost per order

A= Annual demand for the product

w= Annual inventory carrying cost expressed as a %age of the product's cost

v= Average cost or value of one unit of inventory

According to Coyle, Bari & Langley, some may feel that simple EOQ model is too simplistic and it might lead to consequent inaccurate result. However, they have mentioned that the simple EOQ method is chosen to use instead of the complex one for several reasons:

- Adopting more complex analysis would cost more since demand variation is so small.
- Data is too limited to formulate sophisticated methods for firm that just develops inventory models.
- Changes in input variables will not significantly affect simple EOQ"s result.
- It is also suitable for products with constant price or discount is not offered.

2.5.3 Fixed Order Quantity Approach (Under the Condition of Uncertainty)

An existence of uncertainties seems to be a very common and regular situation in business. Uncertainty includes change in demand, damage during transportation and delay delivery, for example. If there is an uncertainty of demand, EOQ therefore has to be adjusted to buffer against uncertain business atmosphere. Reorder point (ROP) also needs to be taken into account when both demand and lead time vary. ROP calculation is not anymore straightforward when there is an occurrence of delay in delivery and fluctuation in demand.

2.5.3.1 Adjusted Economic Order Quantity

In a business environment, fluctuation in demand is a common situation. Since uncertainty in demand seems to be the situation encountered the most, EOQ model should be fixed to cope with this uncertainty. As the emphasis of this adjusted formula is demand, the other assumptions applied to simple EOQ therefore still exist.

$$Q = \sqrt{\frac{2RAG}{vw}}$$

Where:
Q= Order quantity

R= Ordering cost per order

G= Expected stock out cost per cycle (expected shorts in units*stockout cost per unit)

A= Annual demand for the product

w= Annual inventory carrying cost expressed as a %age of the product's cost

v= Average cost or value of one unit of inventory

2.5.3.2 Reorder Point (When to order)

The reorder point (ROP) is the level of inventory which triggers an action to replenish that particular inventory stock. It is normally calculated as the forecast usage during the replenishment lead time plus safety stock. In the EOQ (Economic Order Quantity) model, it was assumed that there is no time lag between ordering and procuring of materials. Therefore the reorder point for replenishing the stocks occurs at that level when the inventory level drops to zero and because instant delivery by suppliers, the stock level bounce back. Continuous review and periodic review are two main types of models for companies to decide when to order. In continuous review model inventory should be reviewed every day. Then management makes the decision whether the company needs to order more. And different from the continuous review policy, the periodic review is the policy in which the inventory is reviewed at regular intervals, and an appropriate quantity is ordered after each review. Simchi-Levi et al. (2004) also mention that both of the above two models have a common basis, which is the concept of inventory position. The inventory position in real time is the actual inventory at the facility plus items ordered by the company but not yet arrived minus items that are back ordered.

Continuous Review Model

This inventory review model is characterized by two parameters-the reorder point (ROP) "s" and the order-up-to level "S". Whenever the inventory position is at or below the reorder point "s", an order should be placed to increase the inventory level to the order-up-to level "S" (Simchi-Levi et al., 2004). Figure 2.4 shows the inventory level in a continuous review model.

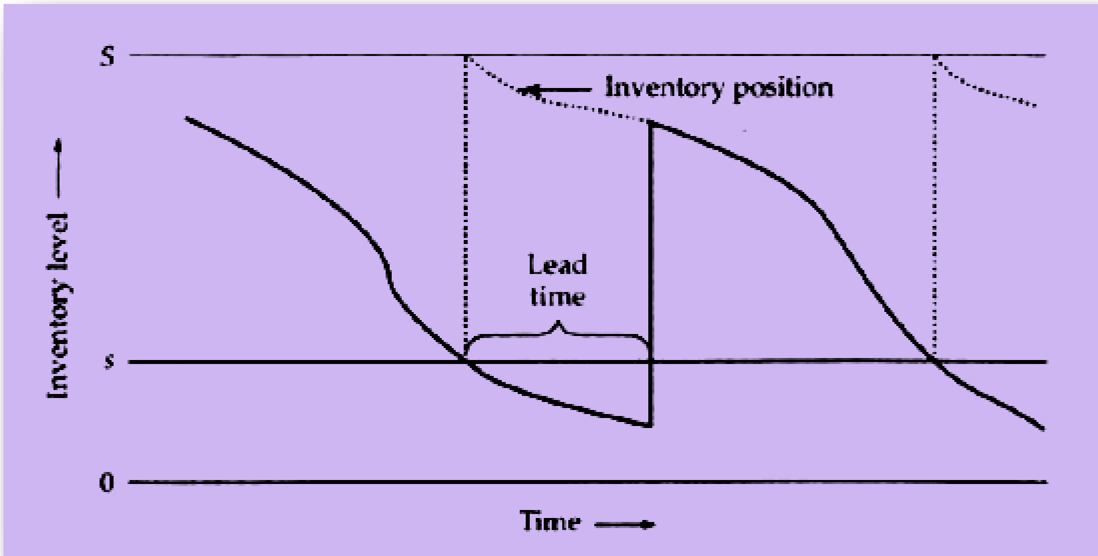


Figure 2.4: Inventory level in a continuous review model
Source: Simchi-Levi et al., 2004

The reorder point (ROP) system determines when to place orders based on the number of component units on hand. The reorder point consists of two components. The first is the average demand during lead time, and the second is the safety stock. The safety stock is the amount of inventory that the company needs to keep at the warehouse and in the pipeline to protect against deviations from average demand during lead time. ROP is calculated using lead time, average demand, and safety stock. Lin (1980) suggested if demand has no seasonal fluctuation, and the supplier's lead time is reliable, the reorder point is just the demand during lead time (DDLT) plus a small amount of safety stock. Following above mentioned, the formula can be described as:

ROP = Cycle Stock + Safety Stock
= Demand during lead time + Safety Stock

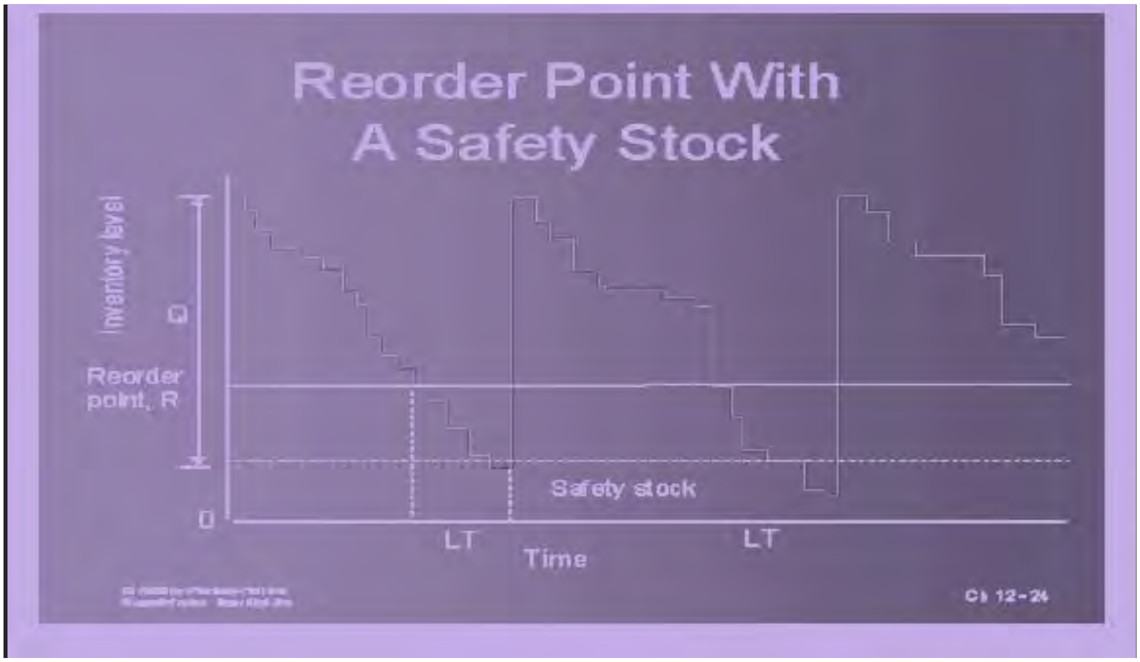


Fig 2.5: ROP with Safety Stock
Source: Http://www.usfca.edu/villegas/classes/984-307/307ch12/sld024.htm

Cycle Stock

Cycle stock is the estimate quantity of an item that will be sold or used during the time that takes until the new order arrives from the supplier (lead time). When lead time and demand are known and constant, firms can simply calculate cycle stock by multiplying daily demand by lead time in days.

Cycle stock = (Annual demand/ no of working days in a year) × Lead time in days

$$= \frac{A}{N} \times L$$

Where

A= Annual demand of the Product

N= No. of working days in a year

L= Lead time

Safety Stock

Safety stock is added to the method of ROP to reduce risk when a delay in delivery and fluctuation in demand during lead time take place. When comparing to cycle stock, safety stock is a bit trickier to calculate since there are several methods to determine safety stock.

Results from different methods can vary. It therefore depends on how much we would want to have on hand during the replenishment cycle.

A simple method is used to determine safety stock is:

Safety stock = (Maximum usage – Average usage)* Lead time.

However, this method might give an exaggerating result if there is a big gap between maximum usage and average usage. One can end up holding too much inventory on hand more than required. This formula is thus suitable for items whose demand rate is more constant. Another way to determine safety stock which is a bit more sophisticated than the previous one is standard deviation method. The equation of determining safety stock is as follow:

Safety Stock = z_α×STD×√L

Where

α = service level

z = No. of std. deviation for a given cycle service level

STD = standard deviation of daily demand

L= lead time

ROP = Cycle Stock + Safety Stock

$$\mathbf{ROP} = \frac{A}{N} \times L + z_\alpha \times STD \times \sqrt{L}$$

Periodic Review Model

In many real situations, the continuous review is generally not practical. The more popular way is that the inventory is reviewed periodically, at regular interval. For example, the inventory level may be reviewed at the end of each month and an order may be placed at the same time. The review period can be set according to the company's actual situation. Since the inventory levels are reviewed at a periodic interval, the fixed cost of placing an order is a sunk cost and hence can be ignored.

Since fixed cost does not play a role in this review model, one parameter for inventory is the base-stock level. The company determines a target inventory level, the base-stock level, and each review interval point the inventory position is reviewed, and the replenishment order is placed for an amount large enough to bring the inventory level back to the base-stock level. Figure 2.6 illustrates the inventory level in a periodic review model.

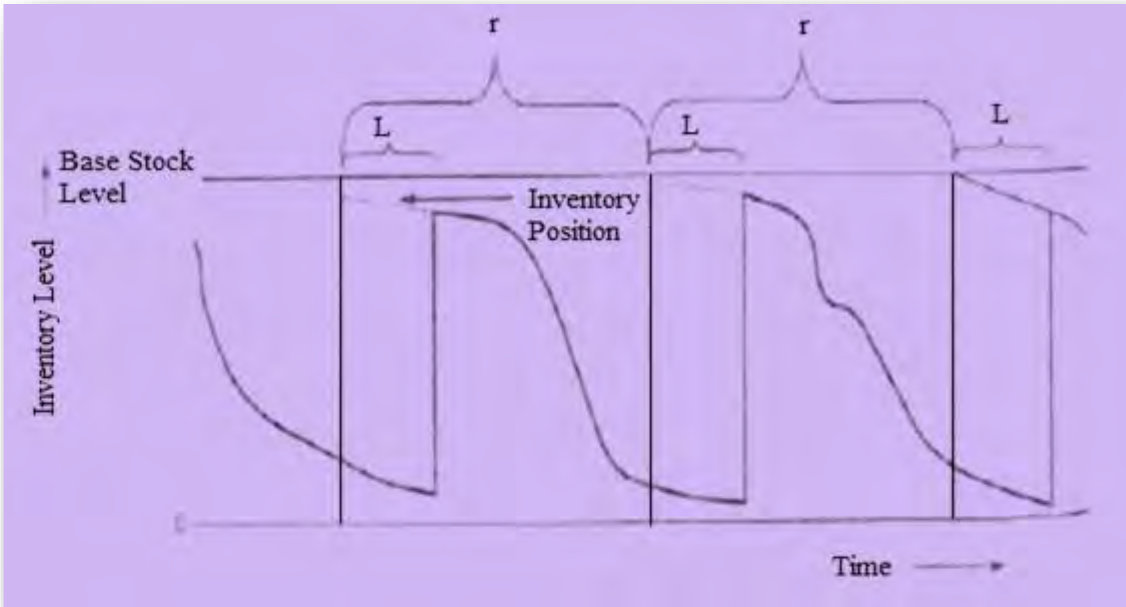


Figure 2.6 Inventory level in a priodic review model
Source: Simchi Levi et al., 2004

The base-stock level consists of two components: (1) average demand during an interval of time equal to the review period plus the lead time and (2) safety stock, which is the amount of inventory that the company needs to cover deviations from average demand during the same period (Simchi-Levi et al., 2004). It is difficult to determine the appropriate safety stock level, as it is affected by a variety of characteristics, like the service level. The service level is a critical factor in relation to safety stock determination. If a higher service level is desired, more safety stock will be required. Also, if demand is highly variable (frequently much higher or lower than average), it is also important to hold more safety stock. Similarly, if lead time is long, more safety stock is needed to guard against possible stock-outs during lead time.For periodic review model, reorder point

ROP = $\frac{A}{N} \times (r + L) + z_{\alpha} \times STD \times \sqrt{r + L}$

Where,

A/N=Demand per day L= Lead time

r = length of review period STD= Standard deviation

2.5.4 Lot Sizing Techniques:

The techniques used for determine lot size to minimize total holding and setup costs when demands are not equal in each period. There are a variety of ways to determine lot sizes. Methods include:

1. **Economic Order Quantity (EOQ)**
2. **Periodic Order Quantity (POQ)**
3. **Lot for Lot**
4. **Part period Balancing (PPB)**
5. **Wagner- Whitin Algorithm (WWA)**

1. Economic Order Quantity (EOQ): The method computes the EOQ based on the average demand over the period and orders in lots of this size. Enough lots are ordered to cover the demand.

2. Periodic Order Quantity (POQ): It translates the EOQ into time units (number of periods) rather than an order quantity. The POQ is the length of time an EOQ order will cover rounded off to an integer. For example, if the demand rate averages 100 units per period and EOQ is 20 units per order then POQ is 100/20 = 5 periods.

3. Lot for Lot: It is the traditional way of ordering exactly what is needed in every period. This is optimal if set up costs are zero.

4. Part Period Balancing (PPB): It is a more dynamic approach to balance setup and holding cost. PPB uses additional information by changing the lot size to reflect requirements of the next lot size in the future. PPB attempts to balance setup and holding cost for known demand.PPB develops an Economic part period (EPP), which is the ratio of setup cost to holding cost.

5. Wagner-Whitin Algorithm (WWA): It is a dynamic programming model that adds some complexity to the lot size computation. It assumes a finite time horizon beyond which there are no additional net requirements. Wagner-Whitin finds the production schedule which minimizes the total costs (holding +setup).

2.5.4.1 Dynamic Lot Sizing Technique– WAGNER-WHITIN METHOD

The dynamic lot-size model in inventory theory is a generalization of the economic order quantity model that takes into account that demand for the product varies over time. The model was introduced by Harvey M. Wagner and Thomson M. Whitin in 1958. Dissatisfied with the "square root formula" to find the economic lot size under the assumption of steady-state (constant) demand, Wagner and Whitin (1958) developed an elegant forward algorithm based on dynamic programming principles to make optimal lot size decisions.

The problem considered by Wagner and Whitin is the N periods problem with no backorders when the assumption of constant demand is dropped i.e. when the amounts demanded in each period are known but are different– and furthermore, when inventory costs vary from period to period. Their 1958 paper is considered a classical and had been cited innumerable times in the lot-sizing literature. Their model formulation permits the determination of optimal lot sizes for a single item when demand, inventory holding charges and setup costs vary over N periods of time.

The solution provided by the Wagner and Whitin algorithm (WWA) is considered the benchmark or standard against which other lot-sizing rules or heuristics are judged. Notwithstanding the fact of providing an optimal solution to the discrete lot-sizing problem, the WWA has been considered by many as an impractical approach. Many researchers indicate that the algorithm is difficult to use due to the dynamic programming nature of the procedure and other limitations such as computational time, computer memory and misunderstanding of its complexity (Evans 1985; Heady and Zhu 1994; Jacobs and Khumawala 1987; Saydam and McKnew 1987; Boe and Yilmaz 1983).For practitioners in general, the WWA is considered more as a philosophy of problem solving than as a technique for lot-sizing decisions.

The Assumptions:

- The demand rate is given in the form of D(j) to be satisfied in period j (j = 1,2, --------N) where the planning horizon is at the end of period N. Of course demand rate may vary from one period to the next, but it is assumed known.
- The entire requirements of each period must be available at the beginning of that period. Therefore a replenishment arriving part -way through a period cannot be used to satisfy that periods requirements. It is cheaper, in terms of reduced carrying costs, to delay its

arrival until the start of the next period. Thus replenishments are constrained to arrive at the beginning of periods.

- The unit variable cost does not depend on the replenishment quantity. In particular, there are no discounts in either the unit purchase cost or the unit transportation cost.
- The cost factors do not change appreciably with time. In particular inflation is at a negligibly low level.
- The item is treated entirely independently of other items, that is, benefits from joint review or replenishment do not exist or are ignored.
- The replenishment lead time is known with certainty (a special case being zero duration) so that delivery can be timed to occur right at the beginning of a period.
- No shortages are allowed.
- The entire order quantity is delivered at the same time.

The Algorithm:

The algorithm is an application of dynamic programming a mathematical procedure for solving sequential decision problems. The computational effort, often prohibitive in dynamic programming formulations, is significantly reduced because of the use of two key properties (derived by Wagner and Whitin) that the optimal solution must satisfy.

Property 1: Replenishment only takes place when inventory level is zero.

Property2: There is an upper limit to how far before a period j we would include its requirements, D (j), in a replenishment quantity. Eventually the carrying costs become so high that it is less expensive to have replenishment arrive at the start of period j than to include its requirements in replenishment from many periods earlier.

Potential Drawbacks of the Algorithm:

As mentioned earlier, the Wagner-Whitin algorithms guaranteed to provide a set of replenishment quantities that minimize the sum of replenishment plus carrying cost out to a specified horizon. In general, the algorithm has received extremely limited acceptance in practice. The primary reasons for this lack of acceptance are as follows:

- The relatively complex nature of the algorithm makes it more difficult for the practitioner to understand than other approaches.
- There is a possible need for a well defined ending point for the demand pattern. Such an ending point is not needed when there is at least one period whose requirements exceed A/vr.
- A related issue is the fact that the algorithm is often used in conjunction with MRP software. Because MRP typically operates on a rolling schedule, the replenishment quantities chosen should not change when new information about future demands become available. Unfortunately the Wagner-Whitin approach does not necessarily have this property

The necessary assumption is that replenishment can be made only at discrete intervals. This assumption can be relaxed by subdividing the periods. However, the computational requirements of the algorithm go up rapidly with the number of periods considered.

CHAPTER 3
RESEARCH METHODOLOGY

[In this chapter, the authors will examine different research methods and present what methods are applied to this thesis.]

The research process usually includes formulating and clarifying a topic, reviewing the literature, choosing a strategy, collecting data, analyzing data and writing up. The research process is not strictly sequential in reality; the researcher often needs to revisit each stage many times in order to refine the ideas.

3.1 Generating the Research Topic

The authors decided to make the thesis a research project based on practical work, and a specific company needed to be accessed to collect empirical data for the research project. Somehow the authors managed to find a company that showed their initial interest in supporting the business management research project. The research project, given this topic, is particularly of practical relevance for the company.

3.2 Deciding the Research Approach

According to Saunders et al. (2003) there exist two types of research approach: one is the deductive approach, in which the researcher develops certain theories and/or hypotheses and design a research strategy to verify the hypotheses; the other is inductive approach, in which the researcher collects data and develops theories as a result of the data analysis.

Considering the research questions and purpose of the thesis the authors choose the deductive approach as the legitimate approach to be used. The authors conducted a range of relevant theories review, proposed some hypotheses, such as the implications gained from the relevant theories would help to improve the management of the researched company and how to improve, and tested the hypotheses by concluding that they really worked.

3.3 Choosing the Appropriate Research Strategies

Saunders et al. (2003) present that eight strategies can be used in the research work: experiment; survey; case study; grounded theory; ethnography; action research; cross-sectional and longitudinal studies; exploratory, descriptive and explanatory studies.

3.3.1 Case Study Strategy

Robson defines case study as 'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence'. The researcher must be alert to the need for multiple sources of evidence. 'All evidence is of some use to the case study researcher: nothing is turned away.' (Gillham (2000) gave us the following list of six main evidences.

1. Documents. These can be letters, policy statements, regulations and guidelines. They provide a formal framework to which a researcher may relate the informal reality.

2. Records. These are the evidences that go back in time but may provide a useful longitudinal fix on the present situation. These may well be stored in computer files.

3. Interviews. This is an inadequate term for the range of ways in which people can give you information.

4. Direct observation. It is used mainly when a researcher needs to be more systematic in how he or she observes.

5. Participant observation. This is the more usual sort in a case study-where a researcher is 'in' the setting in some active sense-perhaps even working there but keeping the ears and eyes open, noticing things that they might normally overlook.

6. Physical artifacts. These are things made or produced. Sometimes this kind of evidence is most important when a researcher is doing a multiple case study.

As to our research project, we investigated the current situation of inventory management in Reedisha Knitex by using multiple sources of evidence, for instance, the interviews with the top manager and other related staff at dyeing section of Reedisha, and monthly consumption report for twenty sample items. When we were visiting at Reedisha, we conducted direct observation on warehousing operation and the information system.

3.3.2 Cross-Sectional Studies

Cross-sectional research can be interpreted as the study of a particular phenomenon at a particular time. In this sense our thesis project is a cross-sectional research as the case study conducted in Reedisha knitex Ltd. was based on interviews and observations over a short period of time less than three months.

3.3.3 Exploratory, Descriptive and Explanatory Studies

(1) Exploratory studies

An exploratory study is conducted when not much is known about the current situation, or no information is available on how similar problems or research issues have been solved in the past that exploratory studies are particularly useful if the researcher seeks to clarify his understanding of a problem. There are three major ways of conducting exploratory research:

- A search of the literature;
- Talking to experts in the subject;
- Conducting focus group interviews.

Our thesis research is obviously not an exploratory study according to the above explanation of exploratory studies.

(2) Descriptive studies

A descriptive study is undertaken in order to ascertain and be able to describe the characteristics of the variables in certain situation, and to understand the characteristics of organizations that follow certain routine practice. The aim of a descriptive study, therefore, is to provide the researcher with a profile or to describe the relevant aspects of the phenomenon from an individual, organizational, industry-oriented, or other perspective.

The descriptive study strategy was used in the chapter of empirical findings to clarify and elaborate the case study context, which included the company organizational structure, the functions performed in-house, the outsourcing functions, the business operational process, and the physical facilities.

(3) Explanatory studies

According to Saunders et al. (2003) a study that establishes causal relationships between variables may be termed explanatory study; the key issue here is to study a situation or a problem in order to explain the relationships between variables.

As the authors recognized there are a number of issues associated with the inventory control problem in Reedisha Knitex Ltd. that are actually affecting each other, we did not pursue a simple cause-and-effect approach to the problem discussion and the suggested solutions to the problem.

3.4 Data Collection Methods

We collected primary data mainly through in-depth interviews with the head of the dyeing unit of the company and through non-participant observations in the fieldwork, such as looking into the information system, visiting the warehouses, and observing the operational process of warehouse activities. E-mails also were used to send out questions and get responses and other data from the same interviewees. We prepared the interview questions in advance and also raised unprepared questions of relevance when interacting with the interviewees during the conversations. We used semi-structured and unstructured interviews approach to all the interviews that were conducted. Using unstructured interview approach gave the authors greatest flexibility in picking up as many clues as we could to draw a clear picture of the facts. While semi-structured interview approach was applied to the later stage of data collection actions, which assisted us in keeping focus on identified questions and digging deeper into the questions, however, concurrently, allowed a certain degree of flexibility during the interview.

We also gathered the product catalogue of the company as the secondary data for the thesis project. But we decided not to collect the historical commercial documents, for instance, the invoices that are most frequently used in the company's business activity, since we considered these documents as small pieces of a puzzle and they were too many to collect and form the whole picture for outside researchers. Instead we acquired the relevant information from the manager through in-depth interviews.

Purposive sampling is very useful for researchers. We collect 2013 daily chemical consumption report for twenty sample items, which were selected through purposive sampling. The consumption report also is the secondary data and was retrieved from the company's information system. We set the criteria for sampling as listed: they should be "alive" which means they are ordered frequently, and they should have different unit price-low, medium, and high. All the primary and secondary data collection in the company was under the permission of the manager and without any offence in ethical rules during the whole research process.

CHAPTER 4
CASE STUDY

4.1 Company Profile

Reedisha Knitex Ltd. a 100% export oriented composite knit textile unit established with the commitment to cater the global needs for knit and casual clothing. The project has employed the State -of –A technology in its every piece of investments. Aiming at the context of the changing global demand pattern, international environment on trade specially the withdrawal of quota system and GSP and the availability of craftsmanship in the country, the project encompassed the knitting, dyeing and processing of fabrics and readymade garments production to be available from one stop service. The project ensures sampling to supply of finished RMG all from one source, ensuring in time delivery and complying quality. The machines and equipment's setup for these projects are procured from world class brand, names renowned for their high quality, product integrity and dependable production.

The project is established in 2003, but the manpower engaged in the projects to carry out the day to day business are all highly skilled, purely professional, vastly experienced, The unique combination of organized Managerial and technical team in one hand and latest, advanced and balanced technology on the other hand made the project one of the top to be referred in this field in the country. The best use of continuous development of human resources by providing them International Standard Environment and equal opportunity is the keys for achieving comprehensive competence in all the level of the Organizational Hierarchy.

Reedisha Knitex Ltd. has been established with the objective and vision to cater the needs of 21st century of worldwide knit apparels market from one stop service being committed to on time delivery, short lead time, quality assurance, price affordability and social accountability. RKL already achieved Worldwide Responsible Apparels Production (WRAP) certificate in April 2007.

Project Location

The project is located in Dhanua, Sreepur under the district of Gazipur, about 55 kilometer distance from the international airport of Dhaka Bangladesh. A well developed road communication is there to reach the factory from the Airport as well as from the Dhaka city. The Head Office of the project is located in the heart of Dhaka city in Tejgaon Industrial area. RKL is established in a 25 acres land premises and in 415000 square feet total industrial building area.

Total space and manpower position:

a) **Manpower Total: 5020 People**

Garments: 3700 People

Quality: 450 People

Knitting & Dyeing: 500 People

Admin, Store, Maintenance, Security & others: 370 People

b) Total Space: 3, 91,338 SFT

Garments Factory Area: 2, 22,564 SFT

Dyeing Area: 48,610 SFT

Knitting Area: 31,500 SFT

Printing Area: 10,250 SFT

Space for Store, Utility, Security, Admin Effluent Treatment Plant and others:78,414 SFT.

4.2 Production Zone

The production zone of the company is occupied six sections

- Knitting section
- Dyeing section
- Finishing section
- Garments section
- Embroidery section
- Printing section

- **Knitting Section:**

Reedisha Knitex Ltd. is one of the world-class pioneers in the knitting and processing of stretch fabrics for use in manufacturing sportswear, active wear, performance wear, body wear, intimate apparel and swim wear. Reddish's Fabrics and RMG are performed on specialized and highly technologically advanced Knitting, Dyeing and Finishing machineries. The processing of fabrics that contains stretch yarns require precision technology, special conditioning and consistently clean machinery and constant maintenance over and above the standards of the units.

The Unit has the strength to produce various types of Fabrics, like: Single Jersey, Pique and Double Pique, Lacoste, Waffle, Rib, Inter Lock, Fleece, Design Interlock, Feeder Stripe, Engineering Stripe, Lycra attachment, Flat Knit Collar & Cuff making with half jacquard design. All above fabric are lycra Knitting.

Knitting Production capacity: 16,000 kg of Gray Fabrics per Day

- **Dyeing Section:**

The process of dyeing to produce the most reliable color quality and steadfastness is a very sensitive and sophisticated process on any fabrics. Especially the stretch fabrics require the level require the level of sophistication in the dyeing process. The quality of our dyeing equipment coupled with the high precision skill of our dyeing plant operators have enabled us to excel in this very complex process. To meet the worldwide demand trend the unit has the combination of Tubular and Open Width fabrics processing.

Fabric Product Range:

The plant has the facilities to process 100 % Cotton, Cotton Blend, T/C, Viscose, Acrylic, elastic etc. fabrics. The Dyeing and finishing machines are of Computer controlled having highly sophisticated and advanced Technology of German, USA and UK.

Dyeing Production capacity: 16,000 kg of Fabrics per Day

- **Finishing Section:**

Reedisha Knitex Ltd. has amassed a highly successful prows of finishing based on process scientific methods, collective experience and accumulated expertise, because finishing is not only by its notional implications, but is also of crucial importance. Finishing is one of the most critical stages in the final performance of fabrics. Our most latest and state-of-the-art finishing technology is constantly updated to meet our fabric-specific requirements for quality, standardization and performance.

- **Garments Section:**

Reedisha's acquired mileage is ensured from the fact that its consumption of fabrics comes entirely from its own making. Good fabrics help tailoring good apparel for the demanding buyers of the world. Our range of apparel includes T-shirt, Polo shirt, Ladies-wear, Sports-wear, Tank-Tops and Children's wear, Sacket, Trousers etc. The support for printing, embroidery and washing are organized from associated projects.

Present Garments Production capacity:

Garments Production Per Month: 1,800,000 pieces

Garments Production Lines: 59 Lines.

Garments Factory Area : 2, 22,564 SFT

- **Embroidery Section**

The Embroidery section of Reedisha Knitex Limited has two sets of 9 colors Embroidery machine within 20 heads each.

Production Capacity : 10,000 pcs per day.

Manpower : 40 People

Embroidery Plant Area : 1200 sft

- **Printing Section**

The Printing Unit of Reedisha Knitex Limited has the strength to produce various types of Garment Printings like Pigment Print, Rubber Print, Discharge Print, Plastisol Print, High Density Print, Flock Print, Foil Print, Puff Print, Crack Print, Gel Print, Glitter Print, Sticker Print, Stone Setting, Metalic Print etc.

Printing Plant Area: 12000 sft.

Manpower: 212 people

Production Capacity: 50,000 pcs per day

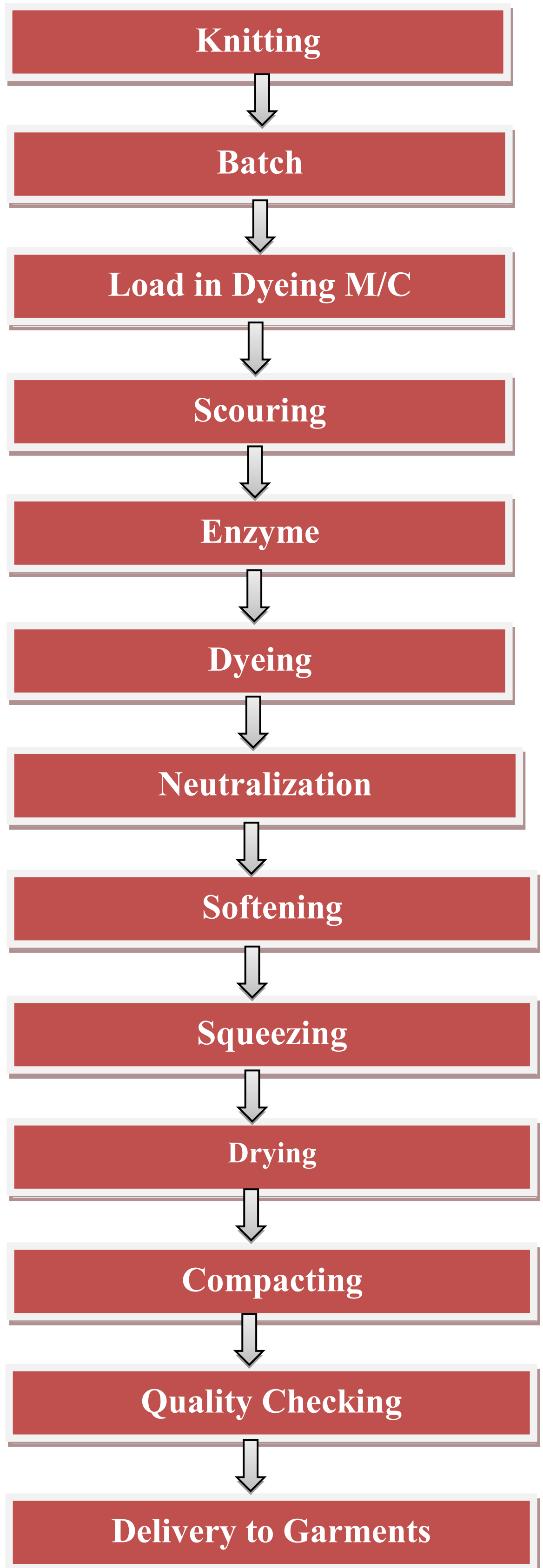
4.3 Dyes and Chemicals Receiving Process of Reedisha Knitex :

Reedisha Knitex Ltd is a 100% export oriented fully knit composite factory & one of the leading textile & garments factory of the country. It has all the unit of textiles under one roof. It only imports raw cotton & Dyes & Chemicals from foreign countries. It has all the units for processing from raw cotton to finished garments. Dyeing unit is back process of garments. Here fabrics are dyed at different shades & finished & delivery to garments. For processing fabrics different types of dyes & chemicals are used in dyeing.

There are almost 30 chemicals and 20 dyes are used in dyeing section. Almost all of the chemicals are imported from abroad. The chemicals are mainly imported from India, China, Singapore, Germany, Thailand, Belgium, Srilanka. Lead time for all the chemicals is 90 days. The materials are ordered through L/C opened. Safety stock for every chemical for 3-4 months is maintained here. Here chemicals are imported for 3-6 months projection basis. Chemicals required for 3-4 months calculated first, then per day average requirement is calculated. The chemicals required for 3-6 months calculated & inform the purchase manager. He then contacts with local agent, negotiates about current price & open L/C against the respective supplier. As per L/C rule supplier reaches the chemical through ship to Chittagong sea port. Then Reedisha authority sends C & F agent to Chittagong sea port. He contacts with custom authority & finishes all the formalities chemicals are imported to factory by truck or cavered van.

When the truck enters into factory gate, security authority receive products & give a number that is Gate Receive No(GRN).Then security & store authority counts the drum & quantity & unload by loader. The loaders transport chemicals to main godown or ware house. Then the listed chemicals are registered in a book that is called Material Receive Report(MRR) & put entry into computer. Batch card is maintained for every types of chemicals & lot wise receiving date is recorded there. Here FIFO is maintained for well management of chemicals that is First In First Out.

Figure 4.1: Process Flow Chart of Dyeing Unit



CHATER 5
ANALYSIS AND FINDINGS

As explained previously regarding the encountered problems of inventory control in the Dyeing section of Reedisha Knitex, reorder point and order quantity are the most common issues for inventory management. Identifying and analyzing these problems lead to the practical solutions. Several inventory control methods can be utilized to determine reorder point and order quantity. However, before selecting any approach to use, dyes chemical inventory must be first classified. In order to improve inventory performance of the dyeing section, action plan can be divided into two phrases–classifying dyes inventory and selecting inventory control methods.

Classifying inventory must be performed when handling great number of product types. Several classification models can be used to group the inventory. One of the most common and effective approaches is ABC model that categorizes product based on its value. Having classified the inventory, the next step is to select inventory control methods. In order to put the right method in the right place, it must be remembered that different methods serve different purposes and they require different levels of management.

In conclusion, activities that must be performed to solve the problems about ROP and order quantity are inventory classification and selection of inventory control methods. However, it is important to note that the result in this final thesis does not necessarily provide the final solution for dyes inventory control, but some possibilities to improve dyes inventory control in a dyeing unit of textile industry.

5.1 Classifying Inventory (ABC Analysis)

The ABC analysis provides a mechanism for identifying items that will have a significant impact on overall inventory cost while also providing a mechanism for identifying different categories of stock that will require different management and controls. The ABC analysis suggests that inventories of an organization are not of equal value. Thus, the inventory is grouped into three categories (**A, B, and C**) in order of their estimated importance. According to Onwubolu et al. (2006), classifying inventory items into A, B, C categories should follow several steps:

- Determine annual quantity usage of each item.

- Multiply the annual quantity usage of each item by the cost of the item to obtain the total annual value usage of each item.
- Add the total value usage of all items to get the aggregate annual value inventory expenditure.
- Divide the total annual value usage of each item by the aggregate annual inventory expenditure to obtain the percentage of total usage for each item.
- List the items in rank order by percentage of aggregate usage.
- Review annual usage distribution and classify items as A, B, or C.

Management policies for ABC Categorization:

Managing all the inventories will take personal time and costs money. ABC classification shows that not all the inventories need to control with equal attention. ABC analysis for prioritization allows the management to decide which items require most effort in controlling.

- A items should have tight inventory control under more experienced management. Re-orders should be more frequent.
- B items require medium attention for control. An important aspect of class B is the monitoring of potential evolution toward class A or, in the contrary, toward the class C.
- C items require minimum attention and may be kept under simple observation. Re-ordering is less frequent.

ABC analysis of inventory leads to certain benefits in form of guidance to the manager about level of control for each type of item, which are summarized in Table below.

Activity	**Group A**	**Group B**	**Group C**
Monitoring	Very Strict	Strict	Moderate
Safety stock to be kept	Low	Medium	High
Level of control for issue	Tight	Moderate	Low
Estimates of requirement	Very Accurate	Moderately Accurate	May be low
Frequency of Purchase	Most frequent	Less frequent	Least frequent
Turn over	Maximum	Medium	Least
Management involvement	Top level	Middle level	Lower level

Table 5.1: Items for ABC Analysis

SL No.	Product Name	Annual Demand (kg)	Unit Cost (tk.)	Total Cost	% of Cost
1	Acetic Acid	137587	70	9631090	4.6
2	Neutracid	20505	92	1886460	0.9
3	Bio Polish Al	72751	326	23716826	11.2
4	CWS	227910	182	41479620	19.6
5	Caustic Soda	152056	35	5321960	2.5
6	Cibafix ECO	13352	395	5274040	2.49
7	Felosan NOF	111739	185	20671715	9.8
8	Secho SQD	70563	104	7338552	3.5
9	H2O2	207789	28	5818092	2.8
10	Hydrose	14320	64	916480	0.43
11	Leucophor BMB	702	650	456300	0.22
12	Optavon 4UD	95329	111	10581519	5
13	Croscolor ARI	4167	290	1208430	0.6
14	Salt Glubar	2592752	11	28520272	13.5
15	X MEN	73028	225	16431300	7.8
16	Lubatex ECS	141990	68	9655320	4.6
17	Soda Ash	510689	18	9192402	4.4
18	Cros Color ADM	23257	285	6628245	3.14
19	Crosprep PBS	5051	295	1490045	0.71
20	Permol R	63739	80	5099120	2.4
	Total	4539276		211317788	

Table 5.2: Arrange the items according to % of cost from higher to lower value

SL No.	Product Name	Annual Demand (kg)	Unit Cost (tk.)	Total Cost	% of Cost	Cumulative %	Classify
4	CWS	227910	182	41479620	19.60	19.60	A
14	Salt Glubar	2592752	11	28520272	13.50	33.10	A
3	Bio Polish Al	72751	326	23716826	11.20	44.30	A
7	Felosan NOF	111739	185	20671715	9.80	54.10	A
15	X MEN	73028	225	16431300	7.80	61.90	A
12	Optavon 4UD	95329	111	10581519	5.00	66.90	A
1	Acetic Acid	137587	70	9631090	4.60	71.50	B
16	Lubatex ECS	141990	68	9655320	4.60	76.10	B
17	Soda Ash	510689	18	9192402	4.40	80.50	B
8	Secho SQD	70563	104	7338552	3.50	84.00	B
18	Cros Color ADM	23257	285	6628245	3.14	87.14	B
9	H_2O_2	207789	28	5818092	2.80	89.94	B
5	Caustic Soda	152056	35	5321960	2.50	92.44	B
6	Cibafix ECO	13352	395	5274040	2.50	94.94	C
20	PERMOL R	63739	80	5099120	2.40	97.34	C
2	Neutracid	20505	92	1886460	0.90	98.24	C
19	Crosprep PBS	5051	295	1490045	0.70	98.94	C
13	Croscolor ARI	4167	290	1208430	0.60	99.54	C
10	Hydrose	14320	64	916480	0.40	99.94	C
11	Leucophor BMB	702	650	456300	0.20	100.00	C
	Total	4539276		211317788			

Calculation:

1. Calculation on % of Volume:

Total no of items = 20

No. of class A items = 6

% of class A items = $\frac{6}{20} \times 100$

= 30%

No .of class B items = 7

% of class B items = $\frac{7}{20} \times 100$

= 35%

No. of class C items = 7

% of class C items = 7/20 × 100

= 35%

2. Calculation on % of Cost:

Total cost of 20 items = tk. 211317788

Cost of class A items = tk. 141401252

% cost of class A items = $\frac{141401252}{211317788} \times 100$

= 66.90%

Cost of class B items = tk. 53585661

% cost of class B items = $\frac{53585661}{211317788} \times 100$

= 25.36%

Cost of class C items = tk. 163330875

% cost of class C items = $\frac{163330875}{211317788} \times 100$

= 7.80 %

Table 5.3: Summarization of ABC analysis

Category	No. of items	% of items in Inventory	Total value (tk)	% of total value
A	4,14, 3,7,15,12	30%	235642393	66.90%
B	1,16,17,8,18,9,5	35%	80262458	25.36%
C	6,20,2,19, 13,10,11	35%	35005790	7.80%
Total	20	100	350910641	100%

% of items in Inventory	% of total value in tk.
30%	66.90%
35%	25.36%
35%	7.80%
100	100%

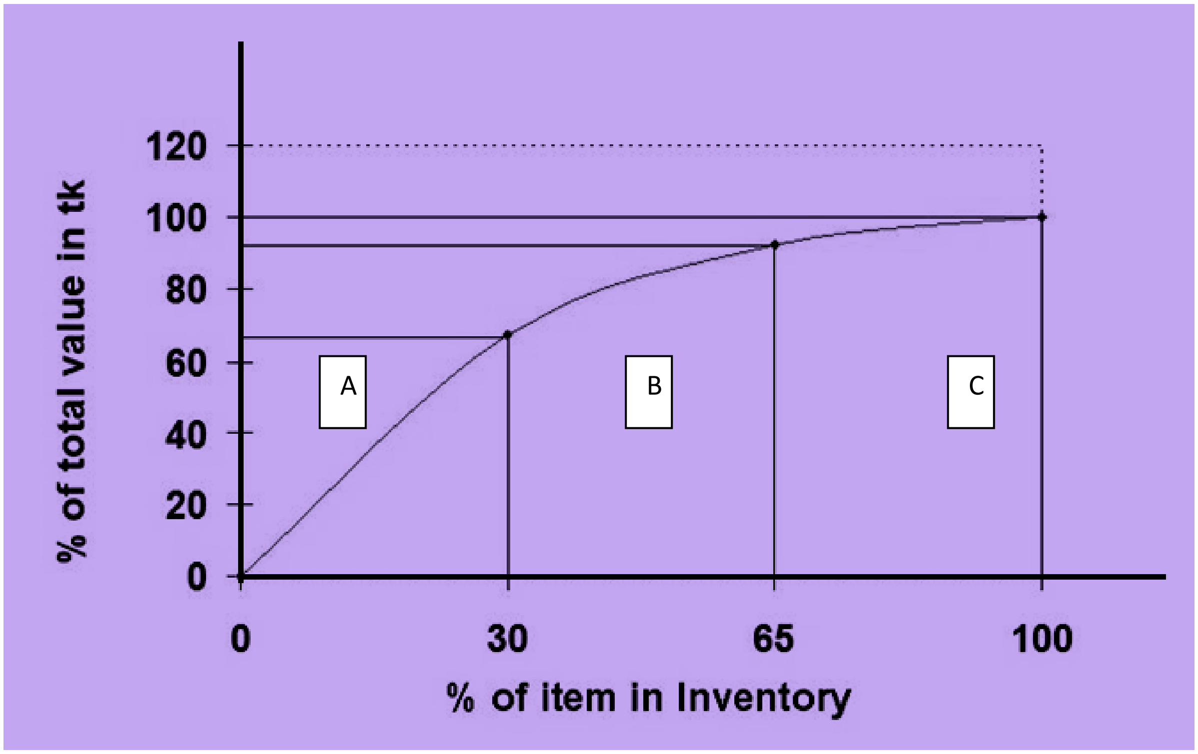


Figure 5.1: Graphic Representation of ABC Analysis

Source: Own Prepared

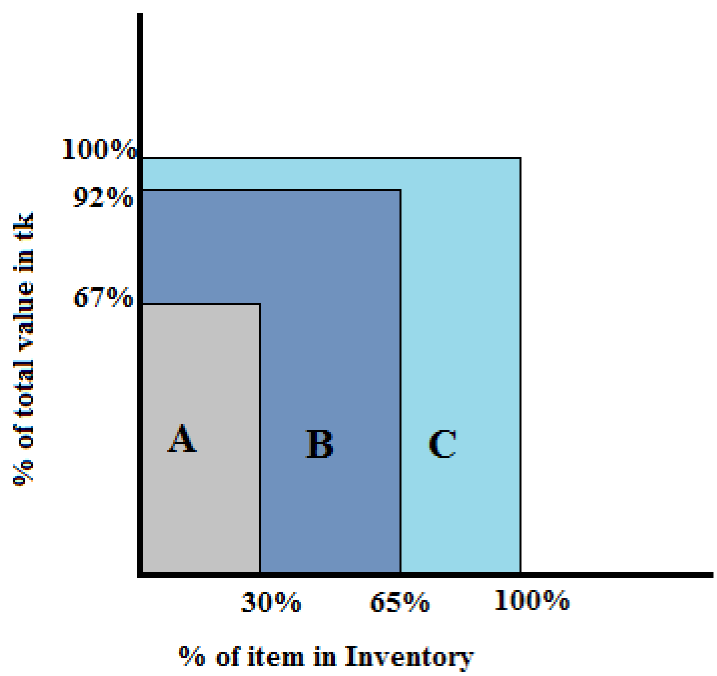


Figure 5.2: Typical representation of ABC analysis
Source: Own prepared

5.2 Selecting Inventory Methods

5.2.1 Economic Order Quantity (EOQ) Model: (When to Order)

Economic order quantity is the order quantity that minimizes total inventory holding costs and ordering costs. It is one of the oldest classical production scheduling models. The framework used to determine this order quantity is also known as Wilson EOQ Model or Wilson Formula. The model was developed by Ford W. Harris in 1913, but R. H. Wilson, a consultant who applied it extensively, is given credit for his in-depth analysis.

EOQ applies only when demand for a product is constant over the year and each new order is delivered in full when inventory reaches zero. There is a fixed cost for each order placed, regardless of the number of units ordered. There is also a cost for each unit held in storage, commonly known as holding cost, sometimes expressed as a percentage of the purchase cost of the item.

We want to determine the optimal number of units to order so that we minimize the total cost associated with the purchase, delivery and storage of the product. The required parameters to the solution are the total demand for the year, the purchase cost for each item, the fixed cost to place the order and the storage cost for each item per year. The number of times an order is placed will also affect the total cost.

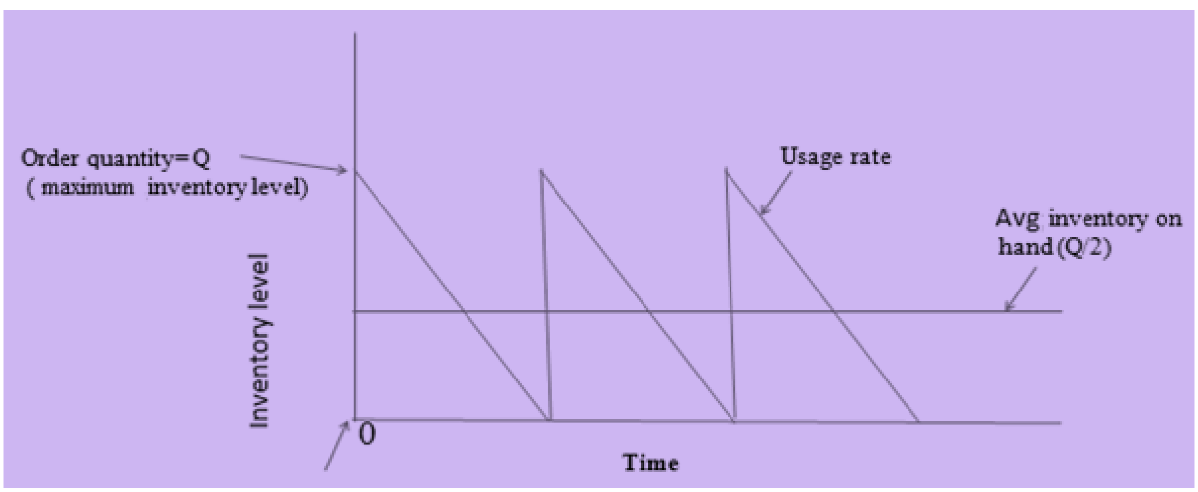


Figure 5.3: Inventory usage over time
Source: Own prepared

Underlying Assumptions:

- The ordering cost is constant.
- The rate of demand is known, and spread evenly throughout the year.
- The lead time is fixed.
- The purchase price of the item is constant i.e. no discount is available
- The replenishment is made instantaneously; the whole batch is delivered at once.
- Only one product is involved.

EOQ is the quantity to order, so that the sum of ordering cost and holding cost is at its minimum. These costs will be equal to one another at the minimized cost point.

EOQ= Q* = $\sqrt{\frac{2RA}{vw}}$

Variables

v= Purchase price, unit production cost

Q= Order quantity

Q*= Optimal order quantity

A= Annual demand quantity

R= Fixed cost per order, setup cost (*not* per unit, typically cost of ordering and shipping and handling. This is not the cost of goods)

H= vw = Annual holding cost per unit, also known as carrying cost or storage cost

Calculation: Sample item Felosan NOF

EOQ= Q* = $\sqrt{\frac{2RA}{vw}}$

Here,
Annual demand A = 111739 kg
Ordering cost per order R = Tk. 3500
Holding cost H= vw= tk. 2.78

Economic order quantity = Q* = $\sqrt{\frac{2RA}{vw}}$

$= \sqrt{\frac{2 \times 3500 \times 111739}{2.78}}$

= 16774 kg

Table 5.4 : Determination of Economic Order Quantity

SL No.	Product Name	Annual Demand, (A)	Unit Cost, (v)	Demand per day, ($\bar{A}$)	ROP= ($\bar{A}$*L)	Holding cost, vw	EOQ = $\sqrt{(2RA/vw)}$
4	CWS	227910	182	660.61	59455	2.73	24174.00
14	Salt Glubar	2592752	11	7515.22	676370	0.17	331655.00
3	Bio Polish Al	72751	326	210.87	18979	4.89	10205.00
7	Felosan NOF	111739	185	323.88	29149	2.78	16774.00
15	X MEN	73028	225	211.68	19051	3.38	12298.00
12	Optavon 4UD	95329	111	276.32	24868	1.67	19990.00
1	Acetic Acid	137587	70	398.80	35892	1.05	30286.00
16	Lubatex ECS	141990	68	411.57	37041	1.02	31216.00
17	Soda Ash	510689	18	1480.26	133223	0.27	115066.00
8	Secho SQD	70563	104	204.53	18408	1.56	17794.00
18	Cros Color ADM	23257	285	67.41	6067	4.28	6167.00
9	H2O2	207789	28	602.29	54206	0.42	58849.00
5	Caustic Soda	152056	35	440.74	39667	0.53	44814.00
6	Cibafix ECO	13352	395	38.70	3483	5.93	3970.00
20	PERMOL R	63739	80	184.75	16628	1.20	8952.00
2	Neutracid	20505	92	59.43	5349	1.38	10199.00
19	Crosprep PBS	5051	295	14.64	1318	4.43	2825.00
13	Croscolor ARI	4167	290	12.08	1087	4.35	2590.00
10	Hydrose	14320	64	41.51	3736	0.96	10218.00
11	Leucophor BMB	702	650	2.03	183	9.75	710.00
	Total	4539276					

5.2.2 The Total Cost Function

The single-item EOQ formula finds the minimum point of the following cost function:

Purchase cost: This is the variable cost of goods.

Annual purchase cost= Unit price × Annual demand quantity.

= v × A

Ordering cost: This is the cost of placing orders: each order has a fixed cost R, and we need to order A/Q times per year.

Annual Ordering cost = Fixed order cost × no. of order

= R × A/Q

Holding cost: This is the cost for holding one unit of inventory for one year. The average quantity in stock (between fully replenished and empty) is Q/2.

Annual Holding cost = Holding cost for one unit × Average inventory

= H × Q/2

Total cost = Annual purchase cost + Annual ordering cost + Annual holding cost

TC = (Annual Demand × Unit Cost) + (No. of Order × Ordering Cost) + (Avg Inv × Holding Cost)

TC = (A×v)+($\frac{A}{Q}$×R) +($\frac{Q}{2}$×H)

To determine the minimum point of the total cost curve, partially differentiate the total cost with respect to Q (assume all other variables are constant) and set to 0:

$$0 = -\frac{RA}{Q^2} + H/2$$

Solving for Q gives Q* (the optimal order quantity):

$$Q*^2 = \frac{2AR}{H}$$

Therefore Economic Order Quantity

$$\mathbf{Q^* = \sqrt{\frac{2RA}{H}}}$$

Q* is independent of v; it is a function of only R, A, H

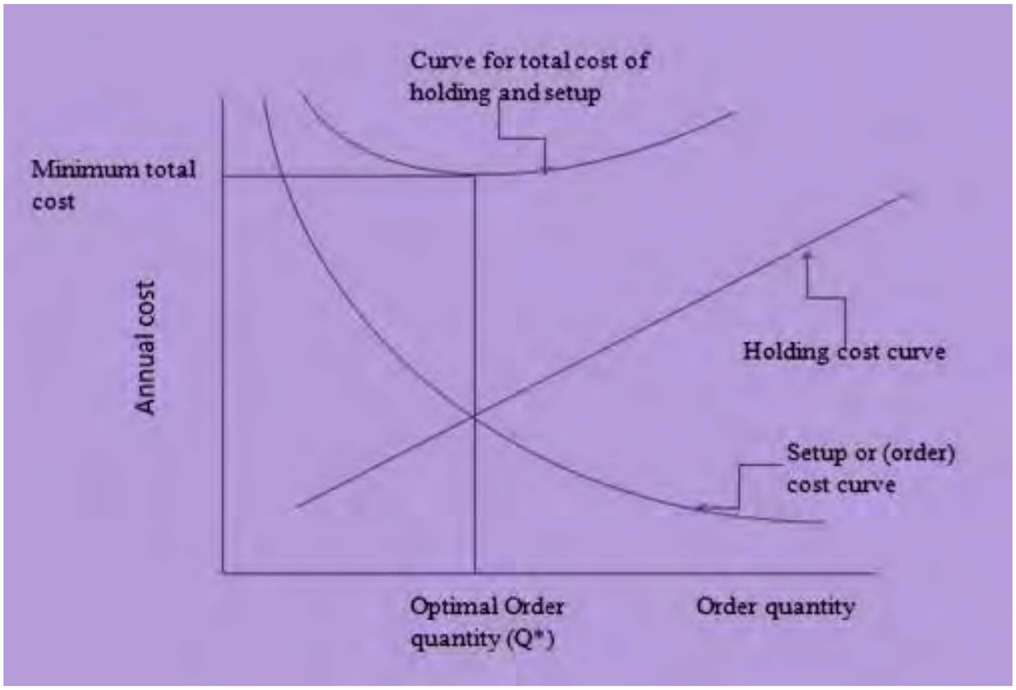


Figure 5.4: Total cost as a function of order quantity
Source: Own prepaed

Calculation: Sample item Felosan NOF

TC = (A×v) + ($\frac{A}{Q*}$×R) + ($\frac{Q*}{2}$×H)

Here,

TC= Total Cost

A = Annual Demand = 111739 kg

v = Unit Cost = Tk 185

Q = Order Quantity

Q* = Economic Order Quantity = 16774 kg

R = Ordering Cost per Order = Tk. 3500

H = Holding Cost = Tk. 2.78

Total cost = TC= $(111739 \times 185) + (\frac{111739}{16774} \times 3500) + (\frac{16774}{2} \times 2.78)$

= (20671715 + 24500 + 23315.86)

= Tk. 20719531

Calculation: Sample item Felosan NOF (Total cost for non EOQ Quantity)

Total Cost = (Annual Demand × Unit Cost) + (No. of Order × Ordering Cost) + (Avg. Inventory × Holding Cost)

$$TC = (A\times v) + (\frac{A}{Q}\times R) + (\frac{Q}{2}\times H)$$

Here

Annual demand, A = 111739 kg

Unit cost, v = tk. 185

Order Quantity, Q= 23400 kg

Ordering cost per order, R= tk. 3500

Holding cost per unit per year= tk. 2.78

For Q= 23400 kg,

$$TC= (111739\times185) + (\frac{111739}{23400}\times 3500) + (\frac{23400}{2}\times 2.78)$$

$$= (20671715 + 16713.10 + 32526)$$

$$= Tk.\ 20720954.1$$

The difference between total cost for Q= 23400 kg and for Q*= 16774kg is (2072095410 – 20719531) = Tk. 1423.10 which is greater than EOQ quantity.

If order quantity Q = 12200 kg

$$TC = (111739\times185) + (\frac{111739}{12200}\times 3500) + (\frac{12200}{2}\times 2.78)$$

$$= (20671715 + 325905.42 + 16598)$$

$$= Tk.\ 21014578.42$$

The difference between total cost for Q = 12200 kg and for Q* = 16774kg

= (21014578.420 – 20719531) = Tk. 295047.42 which is greater than EOQ quantity.

So optimal order quantity Q= 16774kg is appropriate, which minimizes total cost for holding inventory.

5.2.3 Reorder Point :(How much to Order)

The simple EOQ model assumes that receipt of an order is instantaneous. i.e. it is assumed:

1. A firm will place an order when the inventory level for that particular item reaches zero
2. It will receive the ordered items immediately.

The time between placement and receipt of an order, called lead time or delivery time can be as sort as a few hours or as long as months. Thus, when to order decision is usually expressed in terms of a reorder point (ROP) i.e. inventory level at which an order should be placed. The reorder point is given as

ROP = (Demand per day) * (Lead time for a new order in days)

= a * L

This equation for ROP assumes that demand during lead time and lead time itself is constant. The Demand per day is found by dividing the annual demand, A by the number of working days in a year.

$$\mathbf{a} = \frac{A}{Number of working\ days\ in\ a\ year}$$

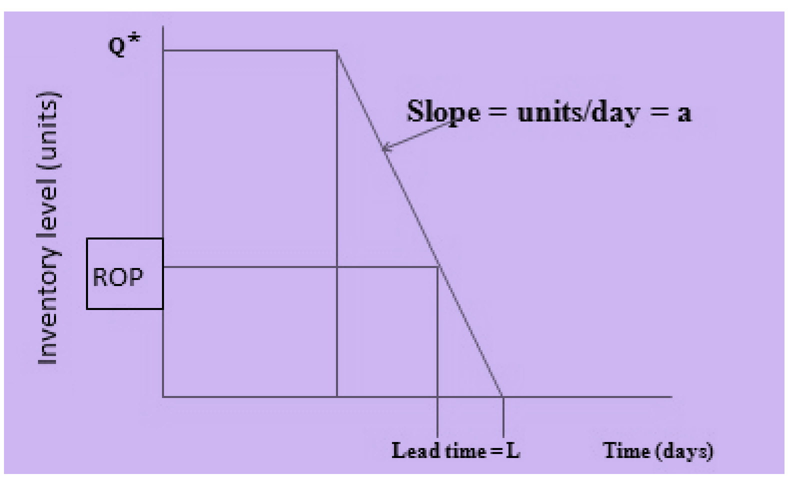


Figure 5.5: Reorder point
Source: Own prepared

Table 5.7: Determination of Reorder Point

Sl No.	Product Name	Annual Demand (A)	Unit Cost (v)	Demand per day, ($\bar{A}$)	ROP ($\bar{A}$*L)
4	CWS	227910	182	660.61	59455
14	Salt Glubar	2592752	11	7515.22	676370
3	Bio Polish Al	72751	326	210.87	18979
7	Felosan NOF	111739	185	323.88	29149
15	X MEN	73028	225	211.68	19051
12	Optavon 4UD	95329	111	276.32	24868
1	Acetic Acid	137587	70	398.80	35892
16	Lubatex ECS	141990	68	411.57	37041
17	Soda Ash	510689	18	1480.26	133223
8	Secho SQD	70563	104	204.53	18408
18	Cros Color ADM	23257	285	67.41	6067
9	H2O2	207789	28	602.29	54206
5	Caustic Soda	152056	35	440.74	39667
6	Cibafix ECO	13352	395	38.70	3483
20	PERMOL R	63739	80	184.75	16628
2	Neutracid	20505	92	59.43	5349
19	Crosprep PBS	5051	295	14.64	1318
13	Croscolor ARI	4167	290	12.08	1087
10	Hydrose	14320	64	41.51	3736
11	Leucophor BMB	702	650	2.03	183

Calculation: Sample item Felosan NOF

No. of working days in a year = (365-20) = 345 days

Carrying rate, w = 0.015 per unit per year

Ordering cost per order, R = tk. 3500

Lead time, L = 90 days

Annual demand, A = 111739 kg

Reorder Point = Demand per day × Lead time

$$\textbf{ROP} = \frac{\boldsymbol{Annual\ demand}}{\boldsymbol{No.\ of\ working\ days\ in\ a\ year}} \times \text{Lead time}$$

$$= \frac{A}{345} \times L$$

$$= \frac{111739}{345} \times 90$$

= 29149 kg

5.2.4 Dynamic Lot Sizing Technique (Wagner-Whitin Method)

Table 5.8 Determination of ordering policy under Wagner-Whitin method

Class A Item:

4. Crosoft NBC (CWS)

Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**Unit Price (tk)**
Demand(kg)	25527	17704	31010	12779	16381	12346	182
Month	**July**	**August**	**Sept.**	**October**	**Nov**	**Dec**	
Demand(kg)	23432	7726	26513	15368	26800	1225	
Total (kg)						227910	

Sl No	**Month**	**Order Quantity (kg)**
1	January	12779
2	Feb	28727
3	April	31158
4	June	41881
5	August	39125
Total	No of order= 5	153670

14. Salt Glubar

Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**Unit Price (tk)**
Demand(kg)	200597	311957	177116	294928	138818	137286	11
Month	**July**	**August**	**Sept.**	**October**	**Nov**	**Dec**	
Demand(kg)	205293	129454	339364	156439	226500	275000	
Total (kg)						2592752	

Sl No	**Month**	**Order Quantity(kg)**
1	Jan	433746
2	March	472033
3	June	339364
4	July	382939
5	Sept	275000
Total	**No of order= 5**	**1903082**

3. Biopolish Al

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	6487	5018	5538	6534	7714	7265	326
Month	**July**	**August**	**Sept.**	**October**	**Nov**	**Dec**	
Demand(kg)	7596	3744	5646	5510	4750	6950	
Total (kg)						72751	

Sl No	Month	Order Quantity (kg)
1	Jan	14248
2	March	18605
3	June	11156
4	August	11700
Total	**No of order=4**	**55709**

7. Felosan NOF

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	9491	6921	8447	8330	9653	10897	185
Month	July	August	Sept.	October	Nov	Dec	
Demand(kg)	11945	7189	9925	7820	10440	10680	
Total (kg)						111739	

Sl No	Month	Order Quantity (kg)
1	January	17983
2	March	22842
3	May	17114
4	July	18260
5	Sept	10680
Total	**No. of order= 5**	**86879**

15. X MEN

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	3843	3538	4456	3594	6153	3285	225
Month	July	August	Sept.	October	Nov	Dec	
Demand(kg)	5603	6313	7604	5118	13080	10440	
Total (kg)						73028	

Sl No	Month	Order Quantity (kg)
1	January	9747
2	March	8888
3	May	13917
4	July	18198
5	Sept	10440
Total	**No of Order = 5**	**61190**

12. Optavon 4UD

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	6922	5660	7858	8098	7480	9209	111
Month	**July**	**August**	**Sept.**	**October**	**Nov**	**Dec**	
Demand(kg)	9040	6582	8596	7734	7800	10350	
Total (kg)						95329	

Sl No	Month	Order Quantity (kg)
1	Jan	8098
2	Feb	16689
3	April	9040
4	May	15178
5	July	25884
Total	**No of Order= 5**	**74889**

16. Lubatex ECS

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	12372	8862	10752	9361	12180	9563	68
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	16295	10565	12917	11330	11880	15912	
Total (kg)						141990	

Sl No	Month	Order Quantity (kg)
1	Jan	31104
2	April	39777
3	July	54042
Total	**No of Order = 3**	**124923**

1. Acetic Acid

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	7144	7424	9776	8031	11288	18145	70
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	6624	16483	8791	7653	19388	8750	
Total (kg)						**137587**	

Sl No	Month	Order Quantity (kg)
1	Jan	19319
2	March	24769
3	May	16483
4	June	16444
5	Aug	28138
Total	**No of order = 5**	**105153**

17. Soda Ash

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	60984	47289	62313	49355	38192	29441	18
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	32743	29831	39782	32559	44700	43500	
Total (kg)						**510689**	

Sl No	Month	Order Quantity (kg)
1	January	87547
2	March	62184
3	May	56344
4	July	60068
5	Sept	43500
Total	**No of order = 5**	**309643**

8. Secho SQD

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	4689	3902	7944	5324	5161	5875	104
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	10924	5072	6919	5537	3648	5568	
Total (kg)						**70563**	

Sl No	Month	Order Quantity (kg)
1	January	16360
2	April	15996
3	June	12456
4	August	9216
Total	**No of Order= 4**	**54028**

18. Croscolor ADM

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	2895	1917	2199	714	1201	2120	285
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	2181	981	1840	1229	2600	3380	
Total (kg)						**23257**	

Sl No	Month	Order Quantity (kg)
1	Jan	4035
2	April	3162
3	June	3069
4	Aug	5980
Total	**No of order= 4**	**16246**

9. H_2O_2

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	11538	16112	27019	9822	16804	22611	28
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	13202	22415	13209	14259	19530	21270	
Total (kg)						**207789**	

Sl No	Month	Order Quantity (kg)
1	January	26625
2	March	35813
3	May	35624
4	July	33789
5	Sept	21270
Total	**No of order = 5**	**153121**

5. Caustic Soda

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	9607	8146	30984	8046	12974	10723	35
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	11149	11119	11032	8377	9900	20000	
Total (kg)						**152056**	

Sl No	Month	Order Quantity (kg)
1	January	21020
2	March	21872
3	May	22151
4	July	18277
5	September	20000
Total	**No of order= 5**	**103320**

6. **Cibafix Eco**

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	749	797	924	692	884	704	395
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	1499	890	1535	1638	1090	1950	
Total (kg)						**13352**	

Sl No	Month	Order Quantity (kg)
1	January	2280
2	April	3924
3	July	2728
4	September	1950
Total	**No of order= 4**	**10882**

20. Permol R

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	3884	3763	4562	5456	6841	4512	80
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	7392	2769	5296	7384	5760	6120	
Total (kg)						63739	

Sl No	Month	Order Quantity (kg)
1	January	5456
2	Feb	11353
3	April	10161
4	June	12680
5	August	11880
Total	No of order= 5	51530

3. Neutracid

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	1630	1339	1087	1558	1795	747	92
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	900	1670	2035	2024	3200	2520	
Total (kg)						20505	

Sl No	Month	Order Quantity (kg)
1	January	4100
2	April	2570
3	June	4059
4	August	5720
Total	No of order= 4	16449

19. Crosprep PBS

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	995	451	721	360	361	360	295
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	480	1200	4702	255	120		
Total (kg)						**5051**	

Sl No	Month	Order Quantity (kg)
1	January	1081
2	April	1680
3	June	4702
4	July	375
Total	**No of order= 4**	**7838**

13. Croscolor ARI

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	813	800	601	400	45	300	290
Month	**July**	**Aug**	**Sept**	**October**	**Nov**	**Dec**	
Demand(kg)	400	800	5018	179		25	
Total (kg)						**9381**	

Sl No	Month	Order Quantity (kg)
1	January	745
2	April	1200
3	June	5018
4	July	204
Total	**No of order= 4**	**16246**

10. Hydrose

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	1203	932	499	733	1096	2199	64
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	1509	879	1064	1105	1300	1800	
Total (kg)						**14319**	

Sl No	Month	Order Quantity (kg)
1	January	1829
2	March	3708
3	May	3048
4	August	3100
Total	**No of order= 4**	**16246**

11. Leucophor BMB

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	120	70	97	49	58	51	650
Month	July	Aug	Sept	October	Nov	Dec	
Demand(kg)	5	84	20	46		100	
Total (kg)						**702**	

Sl No	Month	Order Quantity (kg)
1	January	49
2	February	114
3	May	150
4	September	100
Total	**No of order= 4**	**413**

5.2.4.2 Calculation: Sample Item Felosan NOF:

Month	Jan	Feb	March	April	May	June	Unit Price (tk)
Demand(kg)	9491	6921	8447	8330	9653	10897	185
Month	July	August	Sept.	October	Nov	Dec	
Demand(kg)	11945	7189	9925	7820	10440	10680	
Total (kg)						111739	

Required Data:

1. **Ordering Cost:**

Ordering cost = Fixed cost + Transportation cost

Fixed cost = Tk. 3500/- per order

Transportation cost: from Chittagong port to factory warehouse

Truck rent for 17 ton= 17000 kg truck is 21000 tk.

So, per kg cost = $\frac{21000}{17000}$ = tk. 1.2/kg

Transportation cost may vary according to the volume of goods. It can be divided into the following range:

Volume range (kg)	Per unit truck rent (tk.)
1-15000	1.2
15001-30000	1.1
30001-45000	1.0
45001-60000	0.95

2. **Holding Cost:**

Holding cost = Unit cost * holding rate

Holding rate per unit per year = 0.25%

= 0.025

Holding rate per unit per month = 0.025/12 = 0.0025 = 0.002

3. **Lead time**

Lead time = Time between placing order and received order = 90 days

Calculation:

1. For demand of the month of April = 8330 kg, place order in the month of January.

Ordering cost = (monthly demand * per unit transport cost) + Fixed Cost

= (8330 * 1.2) + 3500

= Tk. 13496/-

Holding Cost = Zero

Quantity ordered in January = 8330 kg

2. For demand of the month of May = 9653 kg, place order in the month of January or February

If order place in January, holding cost, hc= (9653*.002*185) = tk. 3572/-

If order place in Feb , ordering cost, oc = (9653*0.1) + 3500 = tk. 4465/-

hc<oc, so place order in the month of January = 9653 kg

3. For demand of the month of June = 10897 kg, place order in the month of January or March

If order place in January, holding cost for two month, hc= (10897*.002*185*2) = tk. 8064/-

If order place in March , ordering cost, oc = (10897*0.1) + 3500 = tk. 4590/-

oc<hc, so place order in the month of March = 10897 kg

4. For demand of the month of July = 11945 kg, place order in the month of March or April

If order place in March, holding cost for one month, hc= (11945*.002*185) = tk. 4420/-

If order place in April , ordering cost, oc = (11945*0.2) + 3500 = tk. 5889/-

hc<oc, so place order in the month of March = 11945 kg

5. For demand of the month of August = 7189 kg, place order in the month of March or May

If order place in March, holding cost for two month, hc= (7189*.002*185*2) = tk. 5320/-

If order place in May , ordering cost, oc = (7189*0.1) + 3500 = tk. 4219/-

oc<hc, so place order in the month of May = 7189 kg

6. For demand of the month of September = 9925 kg, place order in the month of May or June

If order place in May, holding cost for one month, hc= (9925*.002*185) = tk. 3672/-

If order place in June , ordering cost, oc = (9925*0.1) + 3500 = tk. 4493/-

hc<oc, so place order in the month of May = 9925 kg

7. For demand of the month of October = 7820 kg, place order in the month of May or July

If order place in May, holding cost for two month, hc= (7820*.002*185*2) = tk. 5787/-

If order place in July , ordering cost, oc = (7820*0.1) + 3500 = tk. 4282/-

oc<hc, so place order in the month of July = 7820 kg

8. For demand of the month of November = 10440 kg, place order in the month of July or August

If order place in July, holding cost for one month, hc= (10440*.002*185) = tk. 3863/-

If order place in August , ordering cost, oc = (10440*0.1) + 3500 = tk. 4544/-

hc<oc, so place order in the month of July = 10440 kg

9. For demand of the month of December = 10680 kg, place order in the month of July or September

If order place in July, holding cost for two month, hc= (10680*.002*185*2) = tk. 7903/-

If order place in September, ordering cost, oc = (10680*0.1) + 3500 = tk. 4568/-

oc<hc, so place order in the month of September = 10680 kg

Table 5.9: Summarization of result

From above calculation, the results are summarized as below:

Month of Order	Ordering Quantity (kg)
January	(8330 + 9653) = 17983 kg
March	(10897 + 11945 = 22842 kg
May	(7189 + 9925) = 17114 kg
July	(7820+ 10440) = 18260 kg
September	10680 kg
Total no of order = 5	**Total Order Quantity = 86879 kg**

Table 5.10: Comparison Between EOQ Model and Wagner- Whitin Model

SL No.	Terms	EOQ Model	Wagner- Whitin Model
1	Annual Demand(kg)	111739	111739
2	Unit Cost(tk.)	185	
3	Order Quantity(kg)	16744	17376(avg)
4	No of order	7	5
5	Annual ordering cost(tk.)	24500	37050
6	Annual holding cost(tk.)	23316	42600
7	Total cost(tk.)	47816	79650

From the above table, it is found that for inventory management EOQ model is more appropriate than Wagner-Whitin Model. Total cost for holding inventory for one year is less than WW model. Quantity per order and no. of order is also appropriate. For developing inventory situation of dyeing unit of Reedisha Knitex Ltd. EOQ model may apply.

CHAPTER 6
CONCLUSION & RECOMMENDATION

6.1 Conclusion

From the above study it is found that in most of the cases industry does not follow the modern inventory management system. The company selected for our research work is Reedisha Knitex Ltd. Here raw materials are ordered through experience or when inventory levels become low in the warehouse. They keep three month stock of the raw materials and then place order for the next lot. As a result the company faces the problem of overstocking or under stocking. If consumption of chemicals for any month is lower than the expected rate or much higher than the company has to meet the demand domestically or by rented from another company which carries a huge expense for the company. Again all raw materials need not review in the same manner. By doing ABC analysis we categorize the items and give different level of control to different items.

Therefore, the company needs a formalized inventory system to minimize operational costs. If the Economic Order Quantity model is objectively used, with the aid of some judgment by the management, holding costs and ordering costs will become low. The use of this model will help the company to know the exact amount of raw materials to order and when to place new orders for each raw material.

From Wagner-Whitin Model it is found that by comparing ordering cost and holding cost for a particular month, we can determine whether place order in that month or next month. By applying the model we can minimize the number of order and thus total cost of maintaining inventory become optimal.

By comparing EOQ model& Wagner-Whitin model it is found that EOQ model is more appropriate for inventory cost reduction. From reorder point calculation it can be determined when next order place.

6.2 Recommendations

Since there is no formal inventory control system employed by Reedisha Knitex Ltd, to manage inventories for its raw materials, some aspects need to be improved in order to minimize the raw materials inventory costs. The following are recommended:

1. A large company like Reedisha Knitex Ltd. should improve their ways of keeping records about purchasing and the daily consumption of the raw materials. If possible, the company should computerize these systems.

2. Lack of awareness on the quantitative techniques of managing inventories indicates that storekeepers and supplies staff are lacking some business management skills, therefore these staff should be undergoing on job training about stores and supplies management to improve their knowledge and competence in the field.

3. It is also suggested that periodic review where inventory are reviewed in a regular interval may be the appropriate policy for the company to solve the 'when to order' problem.

6.3 Limitation of the Study:

Due to restriction of some departments as per company policy required data collection is not possible. Also it was so difficult to collect data from all available department and sections alone within limited time.

Economic order quantity calculation is based on some assumption. Here demand is assumed to be constant over the period. But in practice demand is variable during the period. Most of the company does not calculate inventory carrying cost. The standard rule of thumb for inventory carrying cost is 25% of inventory value on hand.

This research is built on comparison between existing activities and estimated activities. Due to the assumptions connected with estimations, the results could be questionable in terms of its credibility. However, our viewpoint is that the estimations are based on a solid investigation therefore the study is relatively convictive.

Figure 6: Main Chemical Store of Reedisha Knittex Ltd.

Figure 7: Stock of Chemical of Felosan NOF

Figure 8: Stock of Chemical of Crosoft NBC

Figure 9: Stock of Chemical of Leucophor BMB

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Appendix 1 - Annual consumption report for twenty items in 2013

1. CWS

January	**February**	**March**	**April**	**May**	**June**	**Unit price**
25527	17704	31010	12779	16381	12346	Tk. 182
July	**August**	**September**	**October**	**November**	**December**	
23432	7726	26513	15368	26800	12325	
				Total =	**227910 kg**	

2. Salt Gluber

January	**February**	**March**	**April**	**May**	**June**	**Unit price**
200597	311957	177116	294928	138818	137286	Tk. 11
July	**August**	**September**	**October**	**November**	**December**	
205293	129454	339364	156439	226500	275000	
				Total =	**2592752 kg**	

3. Biopolish AL

January	**February**	**March**	**April**	**May**	**June**	**Unit price**
6487	5018	5538	6534	7714	7265	Tk. 326
July	**August**	**September**	**October**	**November**	**December**	
7596	3744	5646	5510	4750	6950	
				Total =	**72751 kg**	

4. Felosan NOF

January	**February**	**March**	**April**	**May**	**June**	**Unit price**
9491	6921	8447	8330	9653	10897	Tk. 185
July	**August**	**September**	**October**	**November**	**December**	
11945	7189	9925	7820	10440	10680	
				Total =	**111739 kg**	

5. X MEN

January	**February**	**March**	**April**	**May**	**June**	**Unit price**
3843	3538	4456	3594	6153	3285	Tk. 225
July	**August**	**September**	**October**	**November**	**December**	
5603	6313	7604	5118	13080	10440	
				Total =	**73028 kg**	

6. Optavon 4UD

January	February	March	April	May	June	Unit price
6922	5660	7858	8098	7480	9209	Tk. 111
July	**August**	**September**	**October**	**November**	**December**	
9040	6582	8596	7734	7800	10350	
				Total =	**95329 kg**	

7. Acetic Acid

January	February	March	April	May	June	Unit price
7144	7424	9776	8031	11288	18145	Tk. 70
July	**August**	**September**	**October**	**November**	**December**	
6624	16483	8791	7653	19388	8750	
				Total =	**137587 kg**	

8. Lubatex ECS

January	February	March	April	May	June	Unit price
12372	8862	10752	9361	12180	9563	Tk. 68
July	**August**	**September**	**October**	**November**	**December**	
16295	10565	12917	11330	11880	15912	
				Total =	**141990 kg**	

9. Soda Ash

January	February	March	April	May	June	Unit price
60984	47289	62313	49355	38192	29441	Tk. 18
July	**August**	**September**	**October**	**November**	**December**	
32743	29831	39782	32559	44700	43500	
				Total =	**510689 kg**	

10. Secho SQD

January	February	March	April	May	June	Unit price
4689	3902	7944	5324	5161	5875	Tk. 104
July	**August**	**September**	**October**	**November**	**December**	
10924	5072	6919	5537	3648	5568	
				Total =	**70563 kg**	

11. Cros Color ADM

January	February	March	April	May	June	Unit price
2895	1917	2199	714	1201	2120	
July	**August**	**September**	**October**	**November**	**December**	Tk. 285
2181	981	1840	1229	2600	3380	
				Total =	**23257 kg**	

12. H_2O_2

January	February	March	April	May	June	Unit price
11538	16112	27019	9822	16804	22611	
July	**August**	**September**	**October**	**November**	**December**	Tk. 28
13202	22415	13209	14259	19530	21270	
				Total =	**207789 kg**	

13. Caustic Soda

January	February	March	April	May	June	Unit price
9607	8146	30984	8046	12974	10723	
July	**August**	**September**	**October**	**November**	**December**	Tk. 35
11149	11119	11032	8377	9900	20000	
				Total =	**152056 kg**	

14. Cibafix Eco

January	February	March	April	May	June	Unit price
749	797	924	692	884	704	
July	**August**	**September**	**October**	**November**	**December**	Tk. 395
1499	890	1535	1638	1090	1950	
				Total =	**13352 kg**	

15. Permol R

January	February	March	April	May	June	Unit price
3884	3763	4562	5456	6841	4512	
July	**August**	**September**	**October**	**November**	**December**	Tk. 80
7392	2769	5296	7384	5760	6120	
				Total =	**63739 kg**	

16. Neutracid

January	February	March	April	May	June	Unit price
1630	1339	1087	1558	1795	747	Tk. 92
July	**August**	**September**	**October**	**November**	**December**	
900	1670	2035	2024	3200	2520	
				Total =	**20505 kg**	

17. Crosprep PBS

January	February	March	April	May	June	Unit price
995	451	721	360	361	360	Tk. 295
July	**August**	**September**	**October**	**November**	**December**	
480	1200	4702	255	120		
				Total =	**7838 kg**	

18. Cros Color ARI

January	February	March	April	May	June	Unit price
813	800	601	400	45	300	Tk. 290
July	**August**	**September**	**October**	**November**	**December**	
400	800	5018	17		25	
				Total =	**9381 kg**	

19. Hydrose

January	February	March	April	May	June	Unit price
1203	932	499	733	1096	2199	Tk. 64
July	**August**	**September**	**October**	**November**	**December**	
1509	879	1064	1105	1300	1800	
				Total =	**14320 kg**	

20. Leucophor BMB

January	February	March	April	May	June	Unit price
120	70	97	49	58	51	Tk. 650
July	**August**	**September**	**October**	**November**	**December**	
5	84	20	46		100	
				Total =	**702 kg**	

Appendix 2 Questionnaires

Proposed Interview Questions for Reedisha

Company Information:

1. Please state the company's background.
2. What is the company's organization structure?
3. How many suppliers do you have and where they are located?
4. What kind of customers do you have?
5. How many different kinds product do you have?

Operation Process:

1. What are the payment terms between the company and suppliers from different areas?
2. What is your company's purchase order process?
3. When do you know you should place new order? And how much do you know to order?
4. Did you set the forecast for most items to help you to determine the new order?
5. Did you set the safety stock for each item?
6. Who arrange the logistics for customers and what kind of trade term is used between the company and customers?
7. Please show us some shipping documents?

Information System:

1. When does the company start to use information system to involve into daily operation?
2. What kind of information system do you have?
3. What functions you are using of your information system?