

INVENTORY LEVEL MANAGEMENT USING ARENA SIMULATION

A Dissertation submitted in fulfillment of the requirements for the Degree
of

MASTER OF ENGINEERING *in* **Power Systems**

Submitted by

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(Deemed to be University)

2022

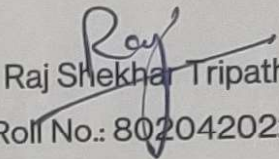
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DECLARATION

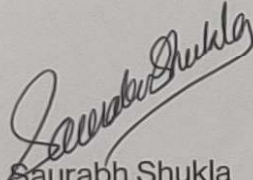
I hereby certify that the work which is presented in dissertation entitled, "Inventory level management using Arena Simulation", in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Power Systems, submitted to Electrical & Instrumentation Engineering Department of Thapar Institute of Engineering & Technology (Deemed to be University) is as authentic record of my own work carried under the supervision of Dr. Saurabh Shukla as internal guide at TIET and Mr. Vinod Siwach as external guide at LGEIL. It refers others researcher's work which are duly listed in the reference section. The matter contained in this dissertation has not been submitted, neither in part nor in full to any other degree to any other university or institute except as reported in text and references.

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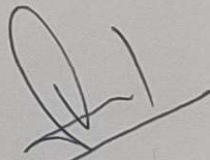
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It is certified that the above statement made by the student is correct to the best of my knowledge and belief.


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ACKNOWLEDGEMENT

I want to express my sincere appreciation to everyone who has helped and motivated me to bring this idea to life.

I owe a debt of gratitude to **Dr. Saurabh Shukla**, my internal faculty guide at **Thapar Institute of Engineering and Technology**, for motivating me and for his unwavering assistance in seeing the project through to its successful conclusion.

I want to express my sincere appreciation to my external guide **Mr. Vinod Siwach, D.G.M. of LGEIL**, for giving me the chance to work in this corporate exposure and for his assistance and direction during this process.

Finally, I want to express my gratitude to my family and friends for their unwavering support and wisdom.

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NOMENCLATURE

UNIF (50, 100) - Standard Uniform Distribution with minimum 50 and maximum 100.

ABSTRACT

In the modern era, businesspersons have shown growing responsiveness of the requirement for precision in the field of inventory control.

Previously, inventories were an indication of wealth; even though inventories are kept in liquidity has directed businesspersons to hold cash and securities. There had been a solid tendency towards holding the means of purchase goods rather than the goods themselves.

Inventories are often referred to as “graveyard” as surplus stock has been principle cause of business failure. Business cycles are influenced in inventories, which are also considered as destabilizing, in fact, there is instability and collapse, which have been the focal point. As a result, almost pathological fear of increasing inventories has developed by businesspersons.

An examine on inventory management of LGEIL is under taken to know how inventories are controlled through the business enterprise and various techniques which are used by the corporation in dealing with the stock effectively. To evaluate the overall performance of inventory many techniques and inventory ratios are used. By means of the study a strive has been made to come to a conclusion with the help of experience derived by the company, arena simulation and with the help of theoretical understanding.

A manufacturing establishment converts raw materials into finished goods (FG), this includes sales cost, conversation cost as well as raw material cost. A manufacturing company has three types of inventory accounts: Raw ingredients, work in progress (WIP), finished goods and indirect material. Manufacturing company fundamental feature is to transform raw material into consumable products. In any company, in any agency, cost of sales within the total of the acquisition cost plus conversation cost of the products that is sold. The manufacturer therefore includes value of goods sold the cost of material and elements used the cost of labour and other cost incurred in manufacturing of goods that are sold. The cost must be obtained by collecting the aggregate numerous elements of manufacturing price.

CHAPTER 1

INTRODUCTION

1.1 About the Internship

My internship was for Room Air Conditioner (RAC) / Water Purifier (WP) - Materials department in LG Electronics Manufacturing, Noida. The internship was completely focused on Inventory Level Management techniques to optimize inventory.

I was working in local materials team. After understanding the theoretical and practical knowledge regarding inventory management, the project started.

1.2 Topic chosen for the study

Study on “Inventory Level Management using Arena Simulation” at LG Electronics India Pvt. Ltd.

Statement of Problem

Inventory management in manufacturing corporations needs inventory for smooth running of production activities. Inadequate stock control will cause stoppage of production and huge losses. A massive quantity of inventory may be stored idle. Since, funds has the cost, the company has to pay huge amount of interest. On the other hand, inadequate inventory will affect the smooth running of production, which results in loss of sales due to not meeting the client requirements on time. Hence, a study is required to analyse and understand the primary problem is to estimate and maintain the optimum level of inventory.

1.3 Need of the Study

In order to maintain various purposes Inventory is must for every organisation. The major component of working capital of any firm or organisation is inventory. Inventory management is an art of controlling the optimum level of inventory in any organisation such that there are no manipulation in the process of production due to insufficient inventory and high level of inventory will result in high carrying cost as well as block up of funds and diminish the organisation profitability. The intension of inventory is to availability if material in adequate quality as and when reduced and to by adopting and analyzing different inventory techniques.

1.4 Objective of the Study

- To apprehend the concept of stock management as a primary approach for a production organization.
- To analyse various inventory models and its application on arena simulation in LGEIL

- To have a look at the mode of inventory management techniques.
- To suggest appropriate measures for the efficient inventory management.

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE REVIEW

The employment of a range of mathematical techniques and strategies to handle general and environmental problems is stressed by Samir K. Srivastava (2007)[1] in his focus on the Green Supply Management, which in many cases suffers from a lack of technological innovation.

The supply chain phases of manufacturing, distribution, and procurement each have their own unique maintenance requirements, as noted by Douglas J. Thomas and Paul M. Griffin in 2007 [2]. In response to the globalisation of the market and the challenges posed by competition, businesses that are growing concentrate on developing supply chains that can swiftly meet client expectations.

Angappa Gunasekaran and Bulent Kobu (2005) [3] state that operating logistics operations successfully, particularly in a cutthroat global economy, requires an effort to assess performance indicators and measurements. A problem for managers in any organisation who wish to make decisions that promote organisational growth is improving performance metrics and measurements.

According to M.T. Melo and S. Nickel (1999) [4], Facility location poses a difficult decision-making problem in supply chain network strategy. supply chain network application to facility location models. Models are employed in the field of supply chain management to support strategic supply chain control decision-making.

Here, Ana Maria Sarmiento and Rakesh Nagi [5] talked about the production-distribution system's integrated analysis. For simultaneous optimization, the proper distribution and production decisions must be made.

A review of publications on inventory control that have appeared in the major logistics channels by Brent D. Williams and Travis Tokar (2008) [6] analyses trends from the literature and offers recommendations for the direction of inventory management.

Imtiaz Ahmeed and Ineen Sultana (2014) [7] discuss inventory in relation to the stuff that is kept or processed. Any company can profit or lose money from unsold inventory. Every organisation has difficulty reducing inventory since the costs associated with rotting and obsolescence can raise costs. This reduces inventory, which increases efficiency.

Mahmut Parla [8] discusses stock issues with unpredictable demand and supply that may be hampered by machinery breakdowns, strikes, and other incidents.

Information on yield management, which focuses on forecasting, overbooking, seat inventory management, and pricing, is provided by Jeffrey I. McGill (1999) [9].

Steven Nahmias (1982) [10] describes an issue with both fixed life and perishable stock, inventory subject to continuous exponential decay, and demand for both single and many items under deterministic and stochastic circumstances.

Timothy L. Urban [11] records concerns with self-space allocation and product collecting. Inventory has to be self-spaced and apportioned in order to prevent loss.

The group that works with integrated inventory models (buyer vendor collaboration), led by Suresh K. Goyal and Yash P. Gupta [12], has changed how to categorise these models.

By describing the various planning models and techniques currently available for warehouse operations, Jinxiang GU, Marc Goetschalckx, and Leon F. McGinnis (2006) [13] discuss the issues associated with planning for warehouse operations, such as receiving, storing, order picking, and shipping. They also discuss how to bridge the gap between academic researchers and warehouse practitioners.

Production scheduling, as described by Stephen C. Graves (1981) [14], may be summed up as organising the available manufacturing resources to meet a certain set of needs. The scheduling problems that occur in manufacturing are briefly described in this article.

Sustainability is becoming a big issue, causing many organisations to place a heavy focus on product recovery and reserve logistics, according to B. Mahadevan, David F. Pyke, and Moritz Fleischmann [15]. The study's main focus is product recovery.

CHAPTER 3

INDUSTRY PROFILE AND COMPANY PROFILE

3.1 Industry Profile

According to preliminary estimates of the gross domestic product for the first quarter of 2021–2022, India's gross domestic product (GDP) for the first quarter of FY22 was Rs. 51.23 lakh crore (US\$ 694.93 billion) at current exchange rates. In the third quarter of FY22, the manufacturing GVA at current prices was predicted to be US\$ 77.47 billion.

The IHS Markit India Manufacturing Purchasing Managers' Index (PMI) stood at 54.9 in February 2022.

In the second quarter of FY22, capacity utilisation in India's manufacturing sector was 72.0 percent, according to a poll done by the Federation of Indian Chambers of Commerce and Industry (FICCI), showing a considerable rebound in the industry.

The Index of Eight Core Industries (ICI) is a production performance index for eight core industries: coal, crude oil, natural gas, processing of petroleum refineries, steel, cement, and electricity generation.

By 2030, India can contribute more than US\$ 500 billion yearly to the global economy and become a major center for manufacturing.

In January 2022, the overall index was 144.4. Growth in the production of coal, crude oil, natural gas, refinery products, fertilisers, steel, cement, and electricity all contributed to this rise.

Natural gas production rose by 11.7 percent, coal by 8.2 percent, steel by 2.8 percent, cement by 13.6 percent and electricity power by 0.5 percent in January 2022. However, crude oil and fertiliser production fell by 2.4 and 2 percent, respectively.

The manufacturing portion of IIP was 138.4 in January 2022.

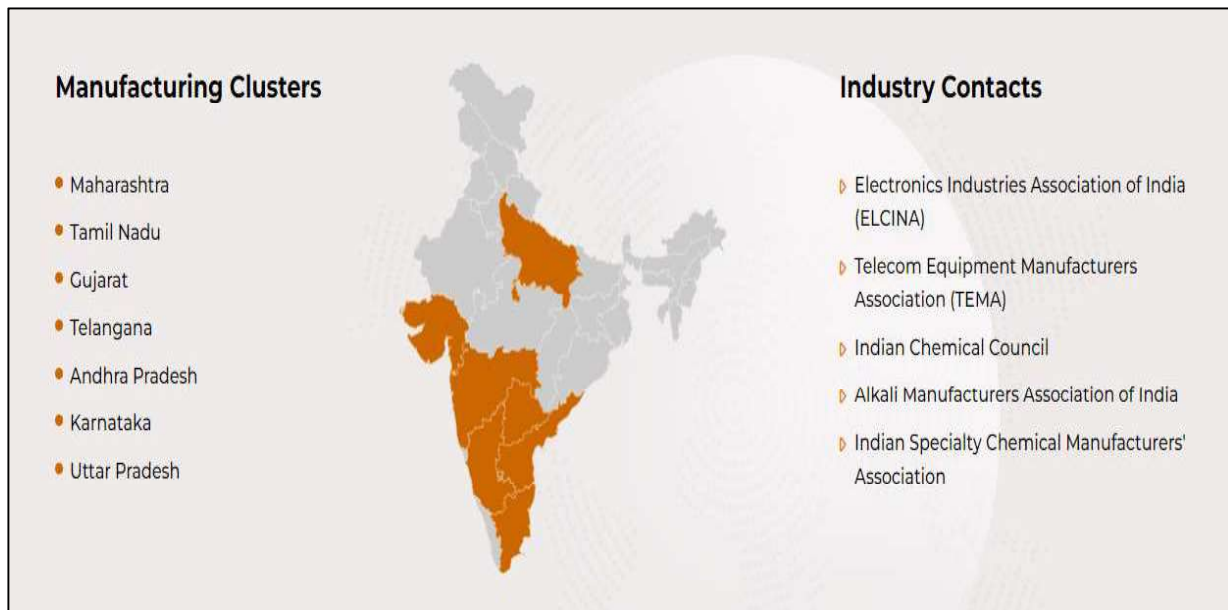


Fig.3.1 Manufacturing Clusters in India

Between April 2021 and February 2022, exports of goods from a few industries—including engineering, petroleum products, gems and jewellery, medications & pharmaceuticals, and chemicals—totaled US\$ 374.05 billion.

With an estimated cost of Rs. 10,683 crore (US\$ 1.45 billion), Prime Minister Mr. Narendra Modi approved the production-linked incentive (PLI) plan in the textile industry in September 2021 for man-made fibre (MMF) garments, MMF fabrics, and 10 segments/products of technical textiles.

15.41 lakh net subscribers were gained by EPFO in September 2021, a 4.05 percent increase from August 2021.

India's market for appliances and consumer electronics (ACE) is anticipated to increase from US\$ 10.93 billion in 2019 to US\$ 21.18 billion in 2025. A PLI programme for white products (ACs and LEDs) valued at Rs. 6,238 crore (US\$ 840.89 million) was approved by the Union Cabinet in April 2021, bolstering the manufacturing sector.

With the expansion of ECLGS and an additional guarantee cover of Rs 50,000 crore (US\$ 6.55 billion) in the Union Budget 2022–23, the MSME sector has benefited.

3.2 Company Profile

Originally known as Gold Star, the company began making radios, TVs, refrigerators, washing machines, and air conditioners in 1958.

The LG Group, from which the abbreviation "LG" was derived, was formed by the amalgamation of two Korean businesses, Lucky and Gold Star. The current catchphrase "Life's good" is a backronym. Before the company's name was changed to LG, electronic products were marketed as Gold Star, while home goods were sold under the Lucky brand. Still seen as a bargain brand is the Gold Star name.

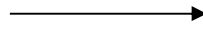
In 1995, Zenith Electronics of the United States was purchased by Gold Star, which had changed its name to LG Electronics.

3.2.1 LG India

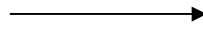
After receiving approval from the Foreign Investment Promotion Board, LG Electronics India Pvt. Ltd., a wholly owned subsidiary of LG Electronics, South Korea, was founded in January 1997 (FIPB). In 1998, LG invested Rs. 500 crores in the construction of a cutting-edge manufacturing facility in Greater Noida, close to Delhi.

This facility manufactures Air Conditioners, Microwave, Refrigerator, Washing Machine and Water Purifier.

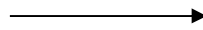




Air Conditioner



Water Purifier



Washing Machine



Fig. 3.2 LG Products Manufactured in Noida

A series of upscale, exclusive showrooms is being established by the company. By the end of the first quarter of this year, LG wants to open 60 premium brand stores.

Currently, there are 83 LG stores in all, 45 of which are shops and 38 of which are exclusive stores. Brand shops will be positioned in the premium market, and customers interested in high-end and premium goods will make up the target market.

In order for the consumer to genuinely experience LG products in his or her own home settings, LG Brand Shoppe goes beyond the idea of a typical exclusive store by providing a more interactive environment and additional lifestyle orientation on display.

With a market share of 27%, LG Electronics India Ltd (LGEIL), the industry leader in consumer durables, is developing a new image. The company will launch a new marketing plan to draw in inspiring and youthful customers throughout India. The business will spend Rs 360 Cr on the exercise.

The firm with the fastest rate of growth in the consumer electronics, home appliances, and computer peripherals sectors is LG Electronics India.

More than 50 lakh households in India are continuously served by LG Electronics' high-quality technological goods at affordable prices. This year, LGEIL is commemorating its 25th birthday.

The largest R&D facility for LG Electronics outside of Korea is located in Bangalore and is named LG Soft India. In order to serve LG Electronics, we at LGSi concentrate on specialised technological fields such as biometrics software, digital video transmission, and mobile application development. We are driven to see LG rank among the top three brands globally by our love of technology, commitment to the company, and excellent workplace culture.

Shin stated that LG Electronics would concentrate on serving the high-end consumer market in order to meet its goal, which will assist increase sales this year. Six (6) percent of LG Electronics' \$42 billion in annual global sales are generated in India. The LG branch in India exports goods to 40 nations.

3.2.2 LG Challenges in India and Overcomes.

When LG entered the Indian market, it experienced the following difficulties:

1. LG's lack of recognition in India..
2. One of the most recent MNCs to enter India (Samsung, Panasonic entered in 1995 in India).
3. Exorbitant import fees.
4. The consumer durables market is characterised by competition from MNCs and local market participants.
5. The Indian consumer's sensitivity to price.

LGEI overcomes these difficulties to become a cutting-edge marketing approach by:

1. Introducing innovative technology into home and consumer electronics.
2. By sponsoring the 1999 World Cup and the 2003 tournament, LG was the first company to make a significant entry into the cricket market.
3. To promote its products, LG enlisted the support of four Indian cricket team captains. LG spent over \$8 million on marketing and advertising for this sport.
4. LG has made use of technology and health advantages to differentiate its product. Golden eye technology is used by CTV. Microwave ovens have the "Health wave system," while air conditioners have the "Health air system".
5. To get around high import taxes at factories in Noida and Pune, LG makes TV refrigerators for the Indian market. Contract manufacture for CTVS has already been started by LGEI in Mohali, Kolkata, and Bhopal. This has enabled LGEI to cut expenses.

3.2.3 Research and Development Potential

In Noida, Bangalore, and Pune, LG maintains research and development facilities. In addition to carrying out R&D for the parent firm and the home market, the three units also do customised R&D for the particular nations to which they export their goods.

Wide distribution networks and regional channels are:

- In India, LG has elected to use the regional distribution system. Each distributor collaborates closely with the business. The stock has rotated more quickly as a result, and the B, C, and D class markets have been better penetrated.
- In addition, LG rotates its inventory rather than dumping it on its channel partners.



Fig. 3.3 LG Soft R&D Office Bangalore

CHAPTER 4

THEORETICAL BACKGROUND

4.1 Material Management

Planning and managing the flow of materials are the responsibilities of the coordination function known as material management. Its primary goals are to deliver the necessary degree of customer service and make the best possible use of the organization's resources. [16]

The company's profit will also increase with complete material flow planning. The goal of material management is to obtain the appropriate amount of supplies of the appropriate quality at the appropriate time, in the appropriate location, and at the appropriate price.

The following are the goals of material management:

- To increase purchasing efficiency.
- To meet demand during the replenishing phase.
- To keep safety stock on hand to prevent stock shortages.
- To stabilize oscillations in consumption.
- To provide reasonable level of customer services.

The fundamental requirements for material management [16-17] are:

- To always have enough supplies on hand.
- To purchase materials at the lowest cost possible while maintaining the required levels of quality and value.
- To reduce the investment in inventory.
- To function effectively.

4.2 Bills of Material (BOM)

Knowing the ingredients required for something is necessary before we can create it. We need a recipe in order to prepare a cake. We require a formula to combine chemicals. We need a parts list in order to manufacture an AC. Recipes, formulas, and parts lists tell us what is required to manufacture the finished product even when the names are different. These are all bills of material. [17-19]

A bill of material is described as "a description of all the subassemblies, intermediates, parts, and raw materials that go into manufacturing the parent assembly stating the amounts of each required to build

as assembly" by the Association for Operations Management (APICS). There are three key elements to remember:

1. The bill of materials lists every component needed to create one unit of the item.
2. There is only one part number for each part or item. One portion only receives a certain number, which is not given to any other part. As a result, the part is the same if a specific number occurs on two separate bills of material.
3. A part's form, fit, or function define it. If any of these things change, the part is no longer the same and needs a new part number.

4.2.1 Uses for Bills of Material

One of the most often utilised papers in a manufacturing organisation is the bill of material. The following are some notable uses:

- Product definition: The invoice lists the parts required to assemble the product.
- Engineering change control: Product design engineers occasionally modify a product's design and the materials employed. These adjustments need to be tracked and managed. The procedure is laid forth in the bill.
- Service parts. The bill of material is used to determine the replacement parts required to fix a damaged component.
- Scheduling: Bills of material specify the materials that must be planned to produce the finished good. To meet the master production schedule, they specify which components must be created or purchased.
- Order entry: When a product (like vehicles) has many alternatives, the order-entry system frequently configures the bill of materials for the finished product. The cost of the item can also be determined by the bill
- Manufacturing: The bill lists the components required to assemble or create a product.
- Costing: Direct material, direct labour, and overhead are often the three components of a

product's cost. The bill includes a system for calculating direct material as well as a framework for tracking direct labour and allocating overhead.

The extensive use of the bill of material in manufacturing is demonstrated by this, albeit incomplete, list. Almost every division of the business will use the bill at some point. It's crucial to keep material bills accurate and up to date. Once more, the computer is a fantastic instrument for centrally keeping and updating invoices.

Figure 4.1, which illustrates what is included in a BOM, can be used as an example.

Single pane Window 500mm x 500mm						
BoM level	Part #	Description	Qty	Units	Unit Cost	Cost
1	756	Window framing	1	4	\$3.00	\$12.00
1	95	Brackets	1	4	\$0.75	\$3.00
1	PRS045	Rubber seal	2	metre	\$0.50	\$1.00
2	342	Glass pane	1	1	\$9.50	\$9.50
2	LB8579	Safety label	1	1	\$0.10	\$0.10
3	GH098	Hinges	2	1	\$2.25	\$4.50
3	GS664	Screws	8	10	\$4.95	\$3.96
3	587	Latch	1	1	\$2.20	\$2.20
3	588	Latch hook	1	1	\$0.88	\$0.88
4	GS660	Screws for latch and hook	6	10	\$4.95	\$2.97
5	812	Protective wrap	1.5	metre	\$0.65	\$0.98
6	XYZ123	Cardboard box 600mm x 600mm	1	1	\$1.00	\$1.00
6	LB7487	Box label barcode	1	1	\$0.10	\$0.10
Total number parts			27.5	Total costs		\$42.19

Fig.4.1 Example of BOM content

4.3 Material Requirements Planning Process (MRP)

A method for figuring out the materials and parts required to make a product is called material requirements planning (MRP). It consists of three main steps: listing the materials and components already present, deciding which more are required, and then planning for their manufacture or acquisition. [17]

MRP, which is generally carried out through specialised software, aids in ensuring that the proper inventory is accessible for the manufacturing process precisely when it is required and at the lowest cost. MRP increases industrial processes' productivity, adaptability, and efficiency as a result. It can increase worker productivity, enhance product quality and lower material and labour costs in factories.

Additionally, MRP enables businesses to adapt more swiftly to escalating demand for their goods, avoiding production snags and inventory stockouts that could cost those clients, ultimately resulting in revenue growth and stability. [20]



Fig.4.2 Material Requirement Planning (MRP)

MRP determines the necessary materials and when they will be needed during the manufacturing process using data from the bill of materials (BOM), inventory data, and the master production schedule.

The majority of businesses utilise MRP to keep track of and manage all of these dependencies and to determine how many items will be required by the dates listed in the master production schedule. MRP is an inventory management and control system for ordering and monitoring the materials required to manufacture a product, to put it another way.

4.3.1 MRP in Manufacturing

MRP is crucial to a manufacturing operation's efficacy, productivity, and ultimately profitability.

Manufacturers are unable to meet customer demand for products at the best price and quality if they lack the necessary raw materials and components. They will also be less able to change production in response to changes in demand. [21-23]

By removing the majority of the uncertainty surrounding inventory and cutting down on the time required to manage it, MRP can also improve the efficiency and predictability of the final stages of production, such as assembly and packaging.

MRP is helpful in both discrete manufacturing, where the finished goods are discrete, countable items like bolts, subassemblies, or automobiles, and process manufacturing, where the finished goods are bulk items like chemicals, soft drinks, and detergent that cannot be separated into their component parts or counted separately.

4.3.2 Benefits of MRP

- Slashed lead times for customers to boost satisfaction.
- Lower costs for inventory.
- Effective inventory management and optimization — By purchasing or producing the right kind of inventory, businesses can reduce the risk of stockouts and the detrimental effects they have on customer satisfaction, sales, and income, without spending more money on inventory.
- Enhanced manufacturing productivity through precise production planning and scheduling that maximises the usage of personnel and machinery.
- Enhanced work productivity.
- More affordable product prices.

4.4 Forecasting

Inventory forecasting is a technique for estimating inventory levels for the future. In order to handle your purchase orders more effectively, it also helps to keep track of sales and demand. A good inventory management tool can boost sales for your business and cut wasteful expenses. [17]

4.4.1 Benefits of Forecasting

- Reduces stockouts: Because they result in lost sales revenue. By precisely estimating future demand, inventory forecasting assists you in avoiding this. With this knowledge, you may decide

how many units to order and when to refill.

- Lowers the cost of holding inventory: Inventory forecasting aids in overall inventory control. Because you just order what you require and have on hand, rather than ordering too much, it aids in inventory storage space management. As a result, less unnecessary storage space is needed and associated expenses are lower.
- Inventory forecasting identifies which products are not selling or are selling more slowly, which reduces product waste. Using this information, we can make plans to repurpose these items or combine them with more products that are profitable. This improves revenue and frees up warehouse space. [24]

4.5 Inventory

According to FERD HANSUM “Inventory is an idle source of any kind offered that, such resources possess some monetary value”. [25]

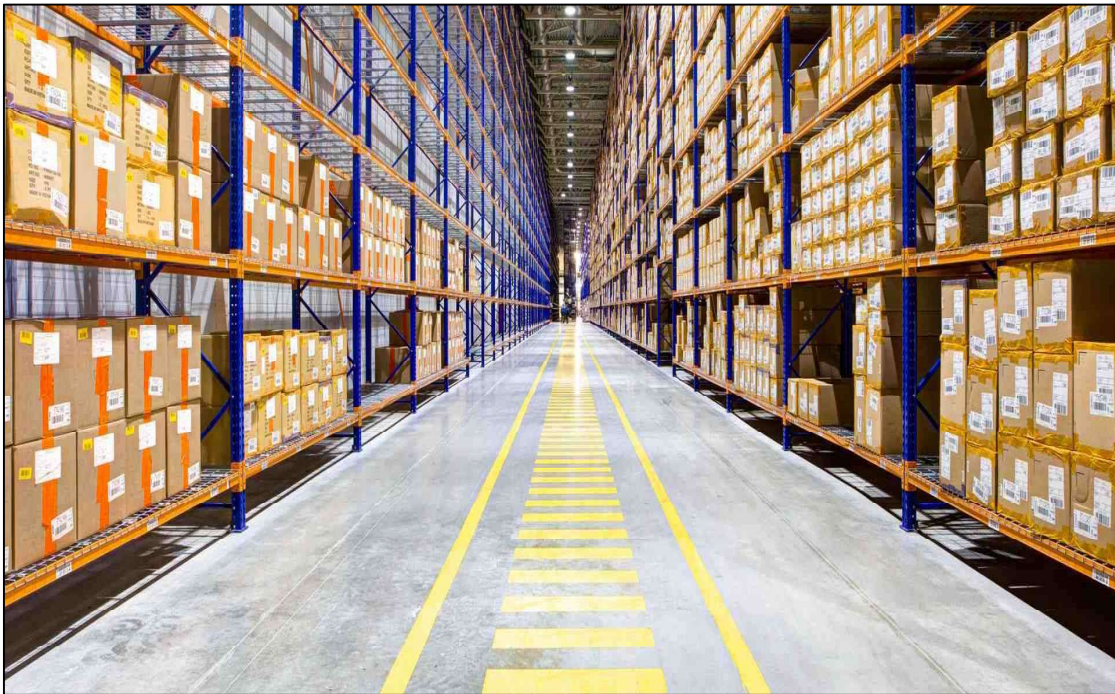


Fig. 4.3 Warehouse Inventory Management

In accordance to accounting principles board, Inventory means the blend of those items of tangible personal property which:

1. Intend for transaction everyday course of organisation

2. Happen in the process of producing for such sales.
3. Are to become presently consumed within the manufacturing of goods or perhaps services to be obtainable for sale.

4.6 Inventory Management

Inventory management have been described as “systematic control and regulation of purchase, safe keeping system and procedures which usually will minimize total expenditure relative to inventory decision and related function. [26-29]

Inventory control defined, as “systematic control and regulation of purchase, storing and consumption of materials are such a way so as to uphold uniform flow of production and at the same time evading unnecessary investment in inventories.

4.6.1 Nature of Inventory

- By manufacturing process, raw materials could be converted in to finished goods. For further production, raw components are procured and warehoused.
- Work-in-progress is semi-finished goods.
- Finished goods inventories are finished goods, which is usually ready for sale. Therefore inventories serves as a linkage between production and consumption of goods.

4.6.2 Purpose of Inventory Management

- Inventory management assist with in sales forecasting
- To meet companies predetermined goals
- Sales and procedure planning
- Material requirement and production planning

4.6.3 Motives of Holding Inventory

- For transaction motive, that facilitates non-stop manufacturing and well-timed accomplishment of sales order.
- Precautionary motive which necessities the retaining of inventories to satisfy the irregular variation in demand and supply of material.

- Speculative motive, which incorporates preserving inventories for taking benefit of price variations, saving in the ordering costs and quantity discount etc.

4.6.4 Prominence of Inventory Management

Inventory management talks about the manner of coping with the stock of finished goods, semi-finished goods and raw materials by the industry. If the inventory managed is maintained well any firm can bring down the cost and increase the revenue.

How a great deal one must capitalize inventory management? The reaction to this question realize upon the quality and value inventory proportion of total asset. Importance of stock management varies industries to industries. As an instance, an automobile dealer has very high inventories, on occasion as excessive as 50% of total asset. However, within the hotel industry it may be 2% to 5% of total asset.

4.6.5 Need of Holding Inventory

The query coping with inventories arises when the company hold inventories. Enterprise have to preserve adequate inventory to make sure smooth and interrupted production. It is very expensive to maintain inventories then the question arises why do companies hold inventories?

The precise benefits from retaining inventory

- Avoiding loss in sales: When the products are not available to the clients, this cannot be taken as the breathing space for not holding inventories. This could occur due to absence of inventory then the customers will shift to company's competitors.
- Gaining quantitative discounts: If the company is, purchasing goods in bulk suppliers might give discounts. Buying goods on bulk with discounts will reduce the cost of goods sold and there by contributing to margin, profit.
- Accomplishing well-organized production runs whenever a firm set up worker and machines to produce item, start-up charges are incurred. Those are absorbed as manufacturing begins. The longer the run, the smaller the cost to being producing the goods, the longer runs involves lower costs are compared to frequent setups.
- Checking the seasonality of materials

In agro, based industries certain materials are available only in particular season. When the season ends, company should take the risk of storage of materials.

The overhead costs associated with the inventories are

- **Material costs:** Those are the expenses of buying the goods including carrying and handling costs.
- **Ordering costs:** Ordering costs are those cost with preparation of purchase ordered and follow up actions taken by the purchase department, transportation of materials ordered from scrutiny and handling at the warehouse for string.
- **Carrying cost:** These costs includes insurance, hire or depreciation in warehouse, salaries of store keeper, security personnel's financing cost of money locked up in inventories, spoilage, tax and many others

4.6.6 Techniques of Inventory Management

- **Fixation of levels:** Materials are maintained within the stores by using different level namely maximum level; re-order level, minimum level and danger level by a tool. Those levels are fixed taking into consideration of cost, nature of raw material, lead time storage space many others.

[30]

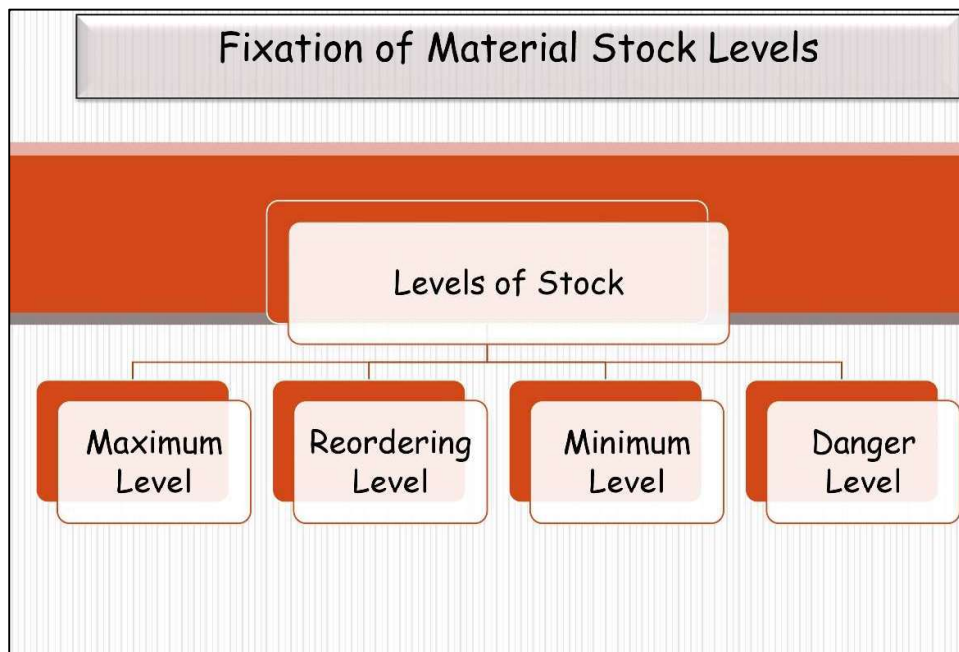


Fig.4.4 Fixation of Levels

- **ABC analysis:** Materials are graded as A,B,C wherein material “A” grade are costlier in its value but less in number where as materials with “C” grade are cheaper value but more in number . Grade “B” materials are mild in value and mild quantity of such objects are maintained. [30-31]

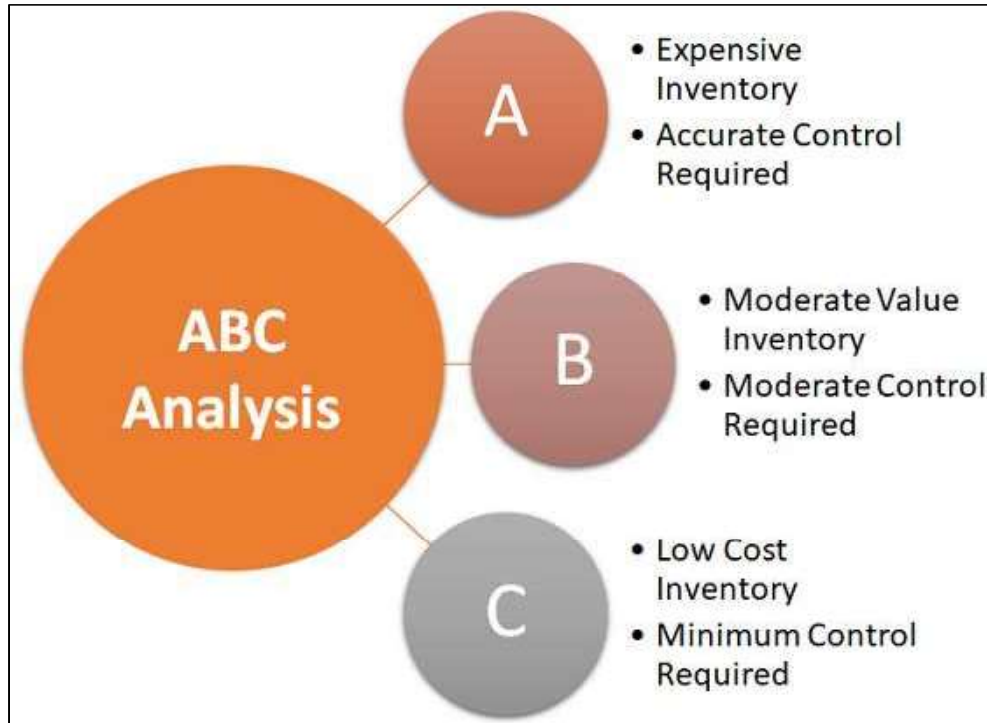


Fig.4.5 ABC Analysis

- **VED analysis:** materials are labelled into vital, essential, desirable components. Much significance is given to vital as well as desirable. [30]

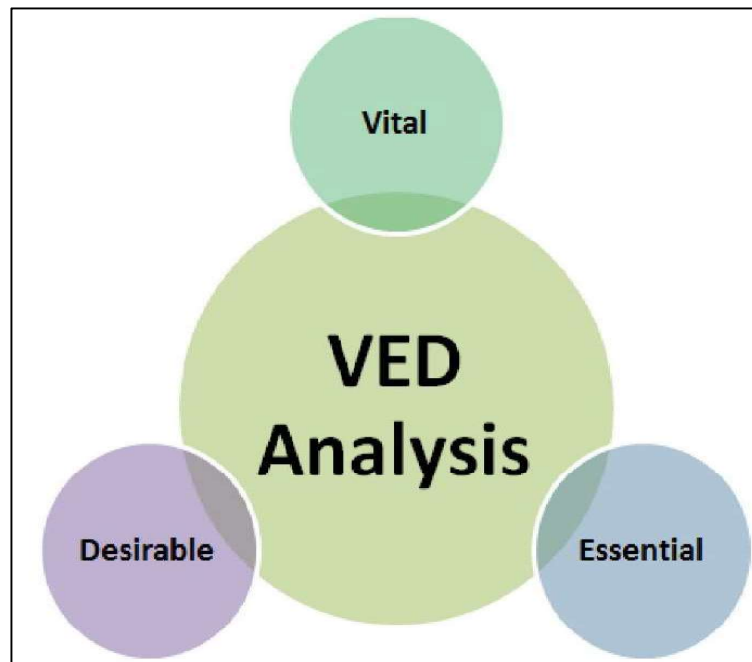


Fig.4.6 VED Analysis

- **FSN analysis:** Under this technique, materials are grouped according to the movement. Fast transferring materials are stored in massive quantity to meet the necessities. Sluggish moving materials are hardly ever very less as they rarely required. [30]

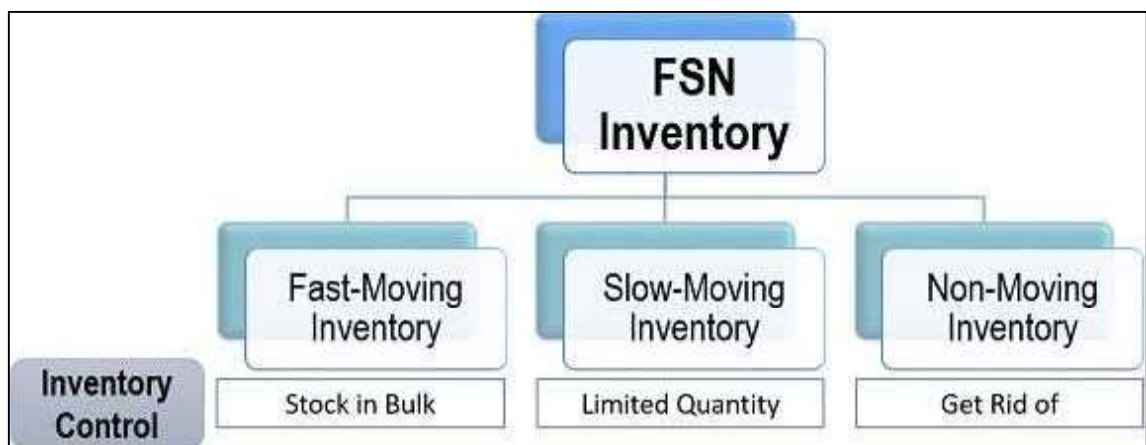


Fig.4.7 FSN Analysis

- **Economic order quantity (EOQ):** this technique is related to purchase of raw materials. The firm has to decide lot to be bought on every replenished. [32-33]

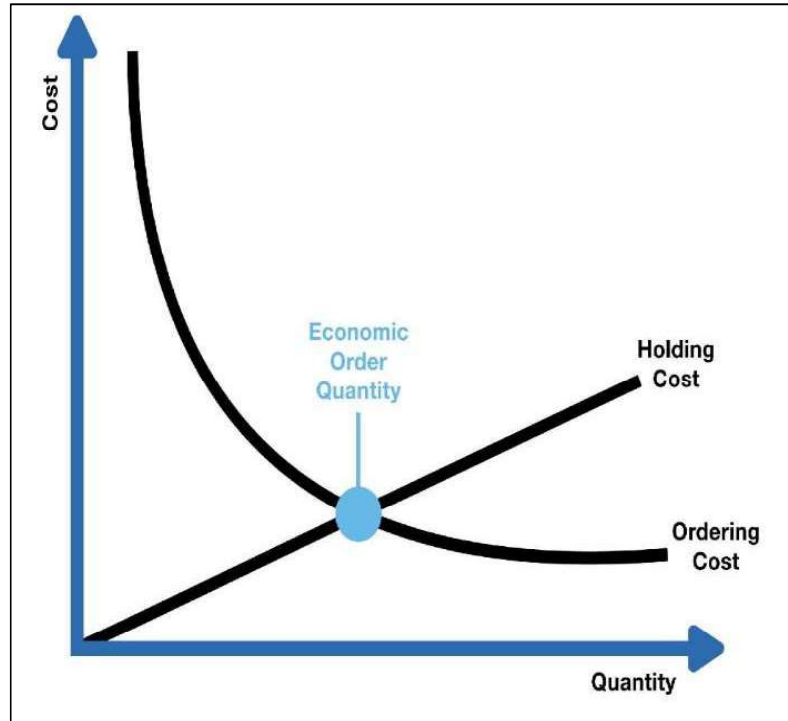


Fig.4.8 Economic Order Quantity

4.7 Classification of materials in LGEIL

Components of inventory –

1. Raw materials (RM)
2. Goods in Transit (GIT)
3. Work in Progress (WIP)
4. Finished Goods (FG)
5. Tools and Consumables (IDM)
6. Machinery spares and replacement parts (MAZE)

4.8 Reorder Point

In order to avoid running out of stock, the reorder point indicates when you should order more inventory. It typically results in the acquisition of a defined quantity of replenishment stock. The replenishment inventory should arrive at the reorder point right as the remaining on-hand inventory is being used up, assuming that the purchasing procedure and supplier fulfilment go as expected. As a result, there are no delays in the production and fulfilment processes, and the overall amount of inventory on hand is reduced. [34-35]

The reorder point's fundamental formula is-

$$(\text{Average daily usage rate} \times \text{Lead time}) + \text{Safety stock} = \text{Reorder point}$$

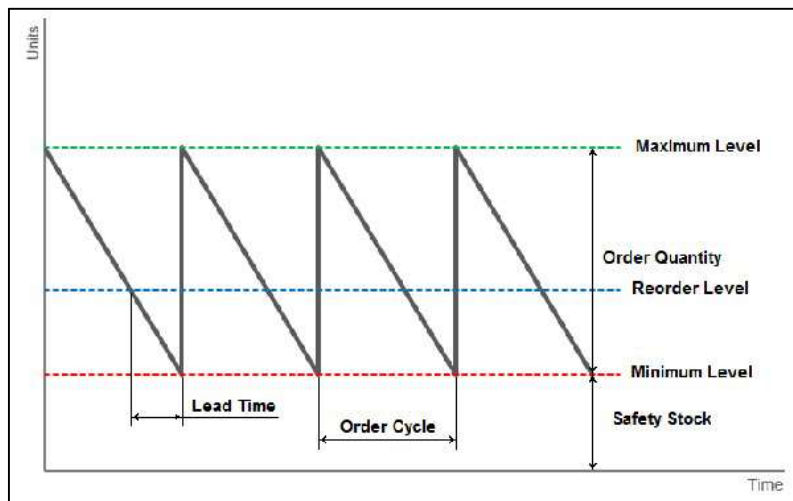


Fig.4.9 Reorder Point

4.9 Lead Time

The lead-time in inventory management is the period of time between placing and receiving an order to replenish inventory. The quantity of stock a corporation must maintain at any given time is impacted by lead-time. [34-35]

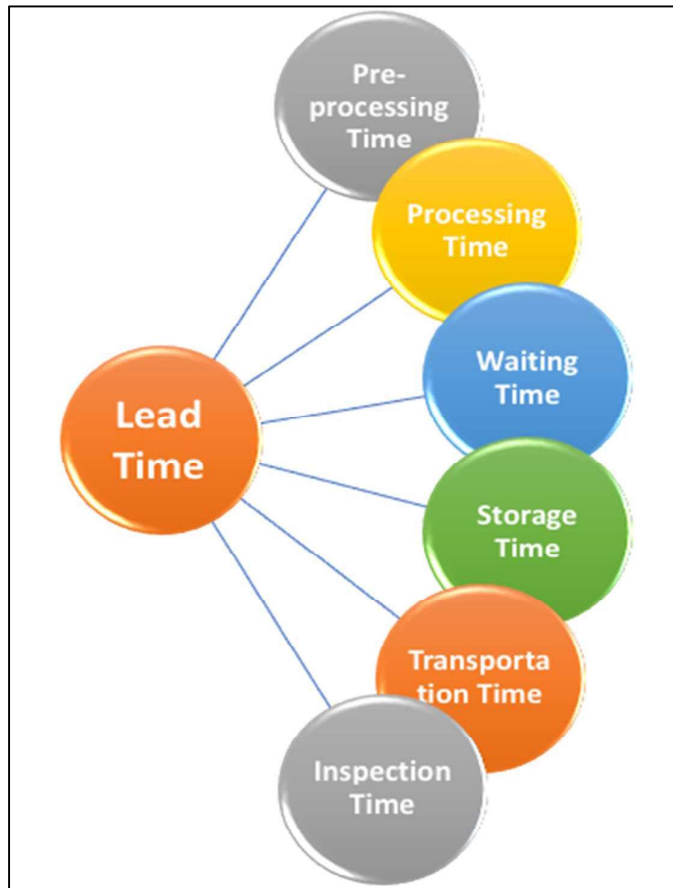


Fig.4.10 Lead Time

CHAPTER 5

SIMULINK MODEL AND INITIAL VALUES

5.1 Methodology

We have simulated two models, Demand management and production management model in Arena Simulation Software based on which we have optimized the inventory level.

Plan, demand, inventory level, and reorder point are all taken into consideration while determining the results. Furthermore, we contrasted the sales and lost sales. Problems, presumptions, and the Arena model are all presented in this section. Inventory management is critical throughout the supply chain, just as it is when determining sales at the retailer's end because demand varies according to seasonal trends. Several techniques, including forecasting, neuro-fuzzy analysis, and consulting supply chain professionals, are used to predict customer demand. The same techniques are used to anticipate the lead-time.

The Simulink model is shown as below.

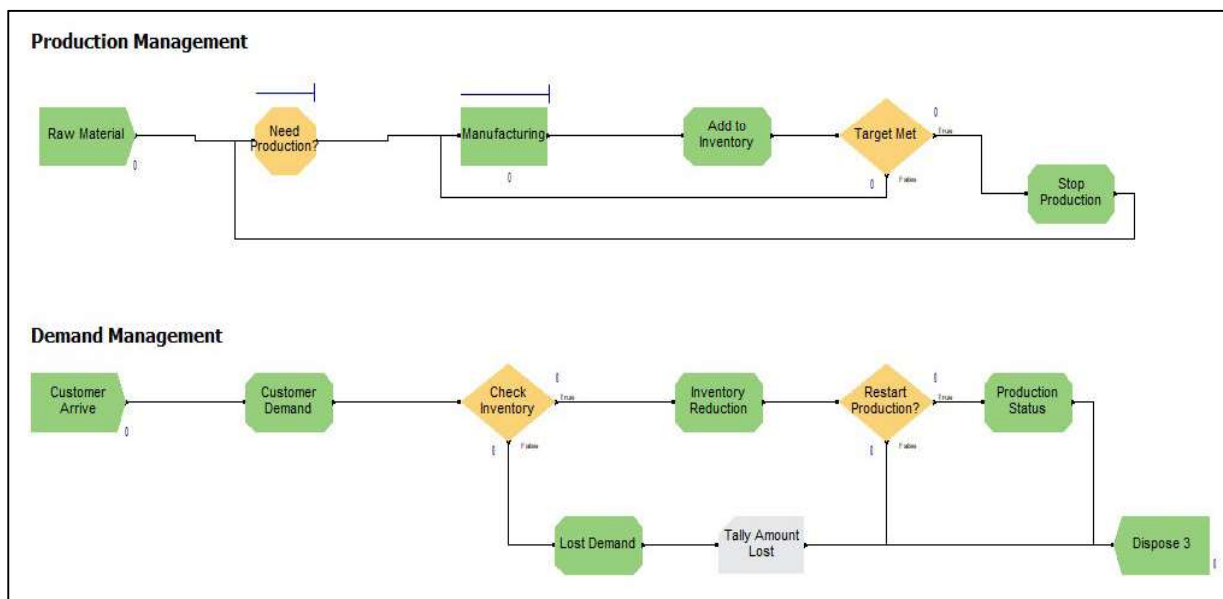


Fig.5.1 Simulink Model

5.2 Production Management

Production Management includes “Raw material” as Create, then hold comes named “need production?” to check whether the production is required or not. When production is required then “manufacturing” process comes into sequence. After manufacturing process, inventory level increases. When the inventory is increased, the decide factor comes into action as “Target Met”. If the logic is True, then production is stopped else if False, again the Manufacturing process begins.

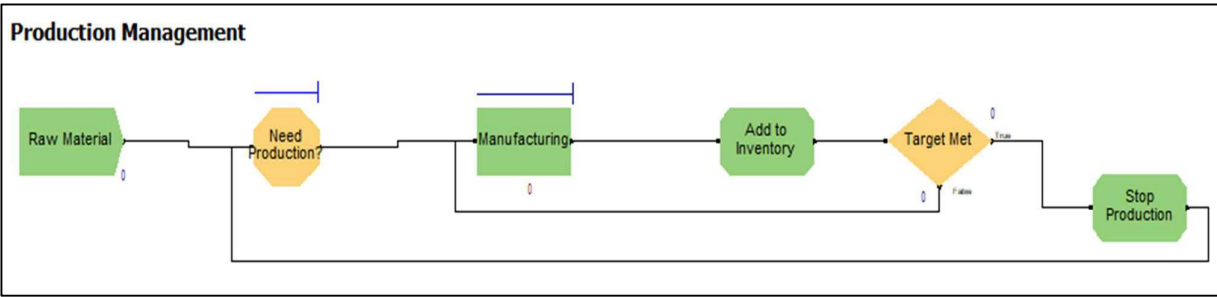


Fig.5.2 Production Management

This continuous process keeps on going as per the demand comes.

5.3 Moving Average

For stationary time series, averaging techniques are typically helpful (the series, which fluctuates around a central value with no apparent pattern). An average of "n" consecutive measurements of demand constitutes a moving average of order "n". This approach provides each observation the same amount of weight. When there is no seasonality or pattern in the data, it is typically used. It can be mathematically represented as:

$$F_{t+1} = \frac{(y_t + y_{t-1} + y_{t-2} + \dots + y_{t-n+1})}{n}$$

$$F_{t+1} = \frac{\sum_{i=t-n+1}^t y_i}{n} \tag{1}$$

n = no. of terms in moving average

Moving average with $n = 3, 6, 9$ was used after historical data for the company was studied. Figure (4.3) following shows the anticipated numbers for moving average together with the fluctuation in demand.

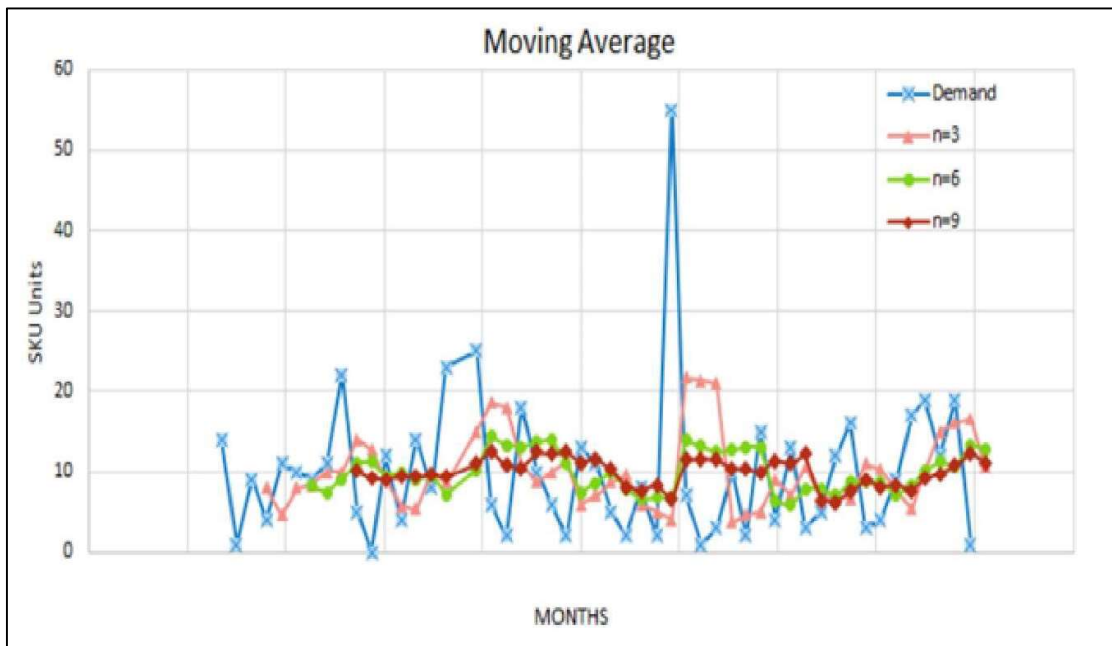


Fig.5.3 Moving Average

The forecast is smoother the higher the value of "n" but as it averages over a longer time period, it also begins to lag. A lower value of "n" makes it easier for the forecast to adapt to change.

The exponential smoothing mathematical formula is:

$$F_{t+1} = \alpha y_t + (1 - \alpha)F_t \quad (2)$$

F_{t+1} = Forecast for next period

α = Smoothing Constant

y_t = Demand in current period

F_t = Forecast in current period

Between 0 and 1 is the Smoothing Constant. " α " cannot have a value of 0 or 1. For stable predictions with smoothed random changes, a smaller value of " α " is desirable. When we want the forecasts to be sensitive to significant random changes, a bigger " α " is employed. The forecasting method chooses " α " based on the value providing the lowest mean square error.

$$y = a + bx$$

y = Dependent Variable

x = Independent Variable

a = Constant

b = Slope of the line

Demand d_t and t are the dependent and independent variables, respectively, in demand forecasting.

$$d_t = a + bt + \varepsilon_t \quad (3)$$

Finding the lowest root mean square error leads to the values of a and b . The formula for the squared error total is:

$$\sum_{t=1}^n \varepsilon_t^2 = \sum_{t=1}^n (d_t - a - bt)^2 \quad (4)$$

The above statement is reduced and solved for a , b in order to determine the values of a and b . It gives:

$$a = \frac{\sum_{t=1}^n d_t - b \sum_{t=1}^n t}{n} \quad (5)$$

$$b = \frac{n \sum_{t=1}^n t d_t - \sum_{t=1}^n d_t \sum_{t=1}^n t}{n \sum_{t=1}^n t^2 - (\sum_{t=1}^n t)^2} \quad (6)$$

To determine future values of the demand for various values of time period t , these values can be substituted in the equations above.

5.4 Demand Management

In demand management, customer arrives with plan as create block and following process will take place:

1. The plan is assigned as the customer demand according to which the inventory is checked by the decide block.
2. Inventory is checked by the decide block logic.
3. If True, then the material will be used and the Inventory reduction will take place else if false, Lost demand which leads to lost customers and lost amount.
4. After Inventory level is reduced, then the inventory level will be checked and will be decided whether the production needs to be restarted or not.
5. Now the decide block named “Restart production” logic will check if Inventory level is less than equal to reorder point. When the condition satisfies then the production demand will generate as per the requirement and when it does not meet the condition then the process will dispose.

Using this continuous process we can find the optimum value of inventory level, customer lost and amount lost.

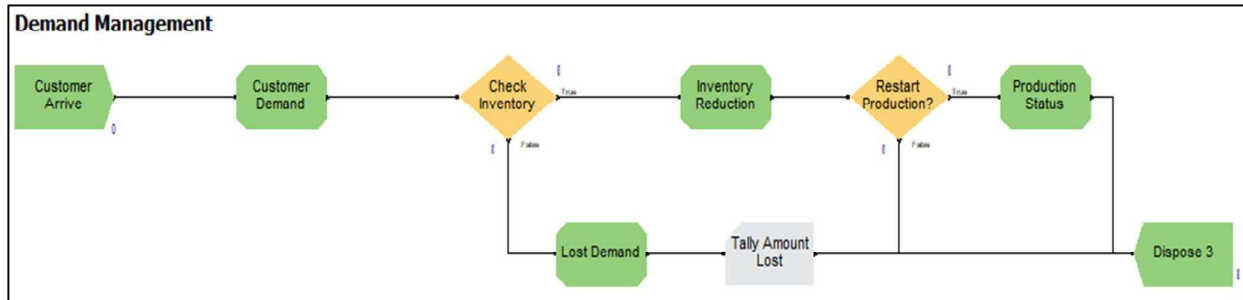


Fig.5.4. Demand Management

5.5 Model Variables

The model variables are as follows:

Table: 5.1- Model Variables

S.No.	Name	Data Type
1	Demand	Real

2	Inventory	Real
3	Production	Real
4	Target Stock	Real
5	Batch Size	Real
6	Reorder Point	Real
7	Total Customers	Real
8	Demand Met	Real
9	Lost	Real
10	Amount Lost	Real

5.6 Initial Model Values

Initial model values of the Simulink model is provided in table 4.2 below.

Table: 5.2- Initial Parameters of Model

S.No.	Initial Parameters	Value
1	Demand	UNIF(50,100)
2	Customer Arrive	UNIF(3,7) Hrs
3	Inventory	250
4	Entity per Arrival	1
5	Target Stock	500
6	Batch Size	5
7	Reorder Point	100
8	Manufacturing Resource	UNIF(10,20)min
9	Demand Met	0
10	Lost	0
11	Amount Lost	0
12	Production Status	1

5.7 Model Block Conditions

We have applied conditions in order to get the optimum inventory level. The conditions used in the

model blocks are as follows:-

Table: 5.3- Assignment Blocks Condition with Model

S.No.	Block Name	Assignments	Condition
1	Add to Inventory	Inventory	Inventory + Batch Size
2	Stop Production	Production	0
3	Customer Demand	Demand	UNIF(50,100)
		Total Customers	Total Customers + 1
4	Inventory Reduction	Demand Met	Demand Met + Demand
		Inventory	Inventory - Demand
5	Lost Demand	Lost	Lost + 1
6	Manufacturing Resource	Amount Lost	Amount Lost + Demand
7	Production Status	Production	1

5.8 Limitation of the Simulation

Here we have a limitation in finding out the result with the current model. With the model simulated in this project, we can only optimize the inventory level for the product, which uses single quantity of a material only. Since, some materials are there which requires two or greater than two quantity (≥ 2) per product, for example – screws.

CHAPTER 6
SIMULATION RESULTS

6.1 Resulting graphs

Based on the Simulation model, the resultant graphs obtained below are of different time span for inventory level.

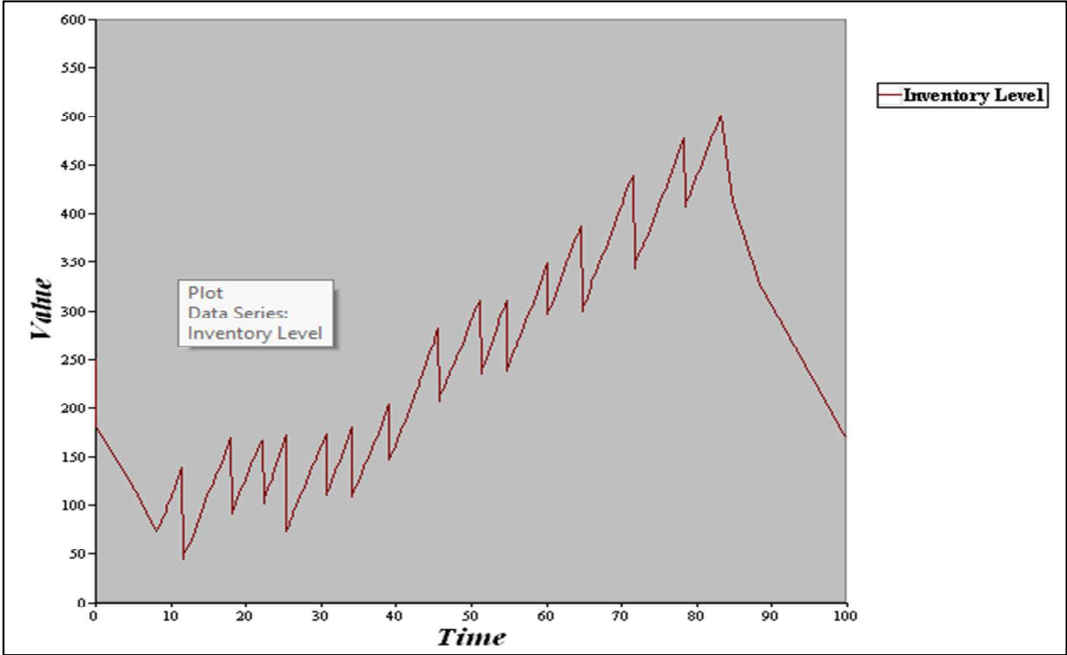


Fig.6.1 Inventory Level Plot (0 to 100 hrs)

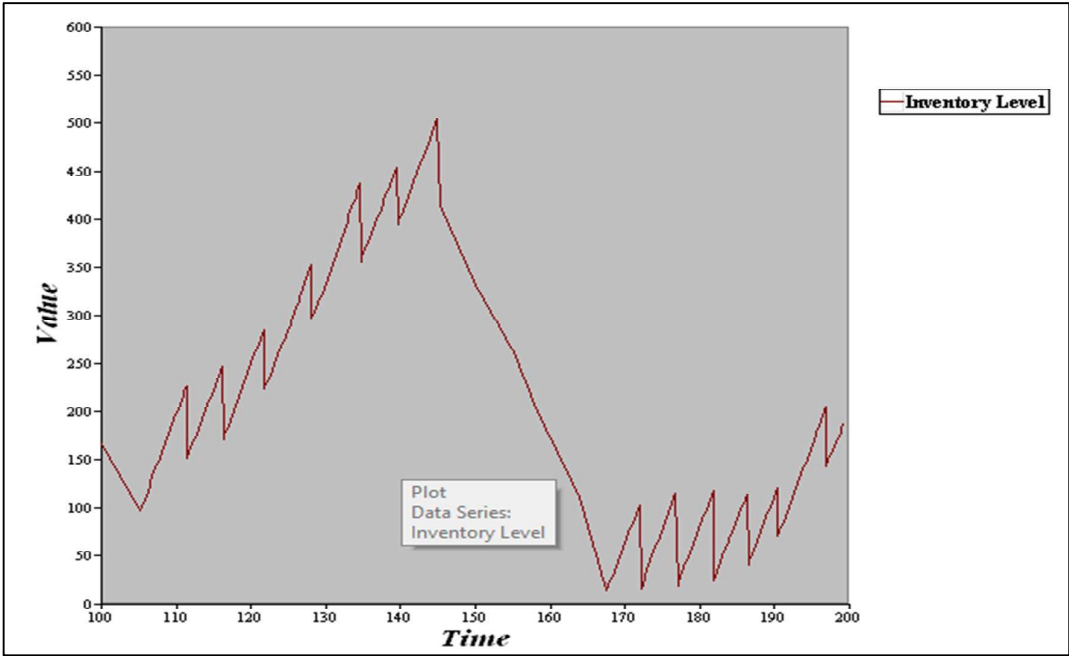


Fig.6.2 Inventory Level Plot (100 to 200 hrs)

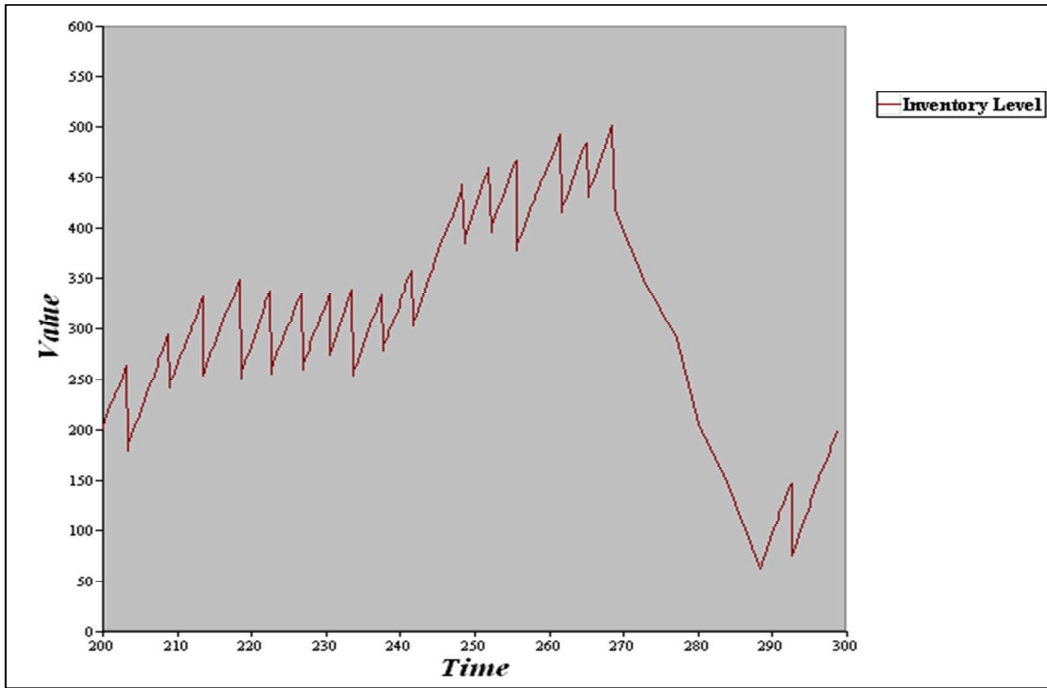


Fig.6.3 Inventory Level Plot (200 to 300 hrs)

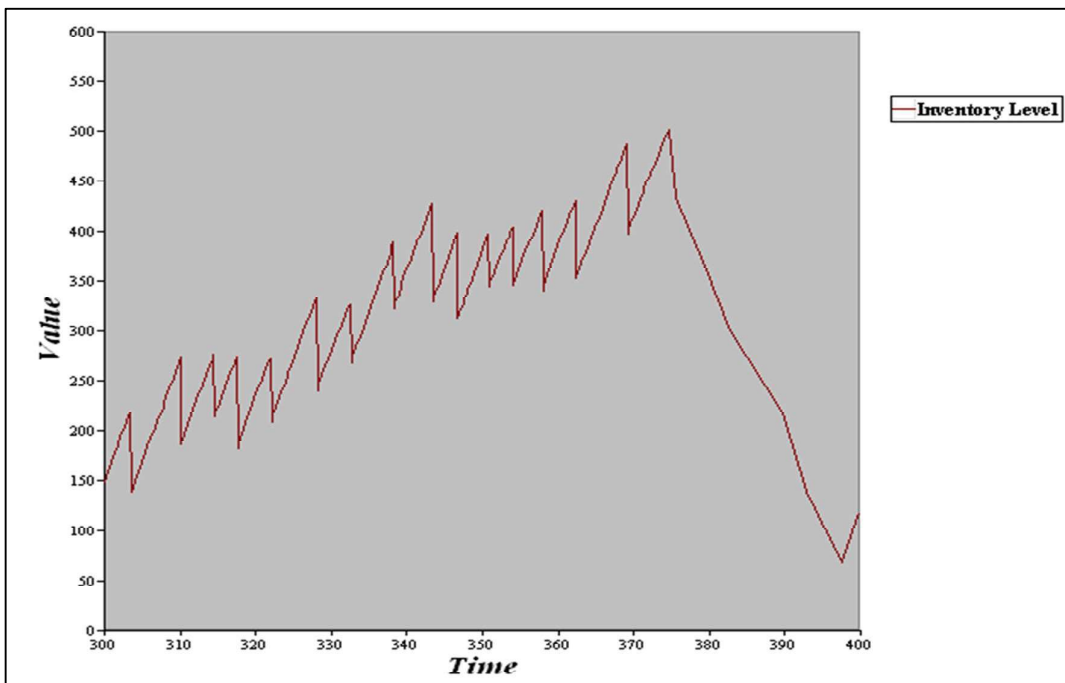


Fig.6.4 Inventory Level Plot (300 to 400 hrs)

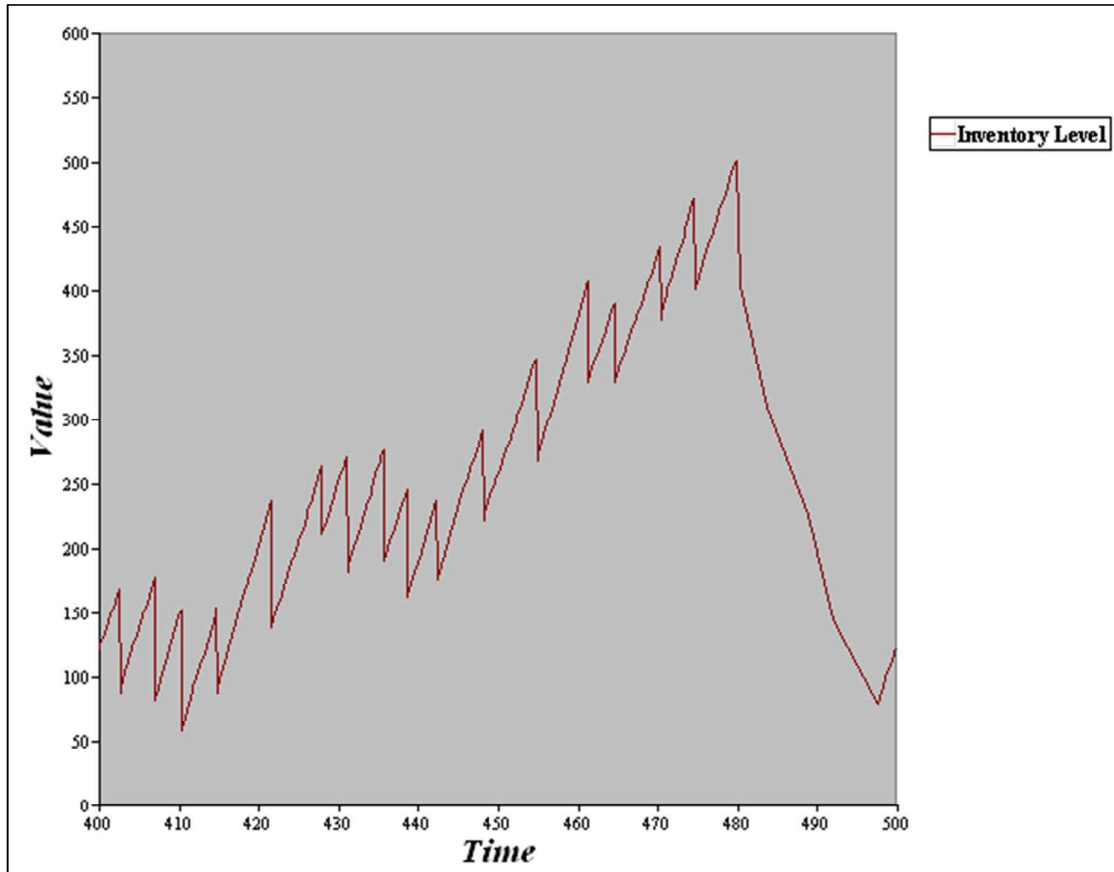


Fig.6.5 Inventory Level Plot (400 to 500 hrs)

6.2 Results

The results are obtained from the simulink model given in fig. 4.1, using Process Analyser (PA) tool of Arena Simulation Software. This PA uses the Simulink model and gives solution for the different scenarios for the same simulink model at the same time. Responses includes Lost (lost customers), amount lost and Inventory level.

Desired response should have ZERO Lost customers, ZERO Amount Lost and Minimum Inventory for all particular cases.

We have simulated for many different cases by changing the reorder point and keeping the Target stock constant for particular cases. Batch size is common for all cases equal to five.

- **Case- I: Target Stock = 500**

In this case, target stock is 500 and batch size is equal to five. Now the resulting values for different reorder points are provided in the table 6.1 below.

Table: 6.1- Responses for Case-I

S	Scenario Properties			Controls			Responses		
	Name	Program File	Reps	Batch Size	Reorder Point	Target Stock	Lost	Amount Lost	Inventory
1	Scenario 1	14 : Model-	1	5.0000	50.0000	500.0000	1075.000	82319.401	50.091
2	Scenario 2	14 : Model-	1	5.0000	100.0000	500.0000	2.000	189.482	435.875
3	Scenario 3	14 : Model-	1	5.0000	150.0000	500.0000	0.000	0.000	425.862
4	Scenario 4	14 : Model-	1	5.0000	200.0000	500.0000	0.000	0.000	270.562
5	Scenario 5	14 : Model-	1	5.0000	250.0000	500.0000	0.000	0.000	432.286
6	Scenario 6	14 : Model-	1	5.0000	300.0000	500.0000	0.000	0.000	502.945
7	Scenario 7	14 : Model-	1	5.0000	350.0000	500.0000	0.000	0.000	449.473
8	Scenario 8	14 : Model-	1	5.0000	400.0000	500.0000	0.000	0.000	440.559
9	Scenario 9	14 : Model-	1	5.0000	450.0000	500.0000	0.000	0.000	500.210

In response table 6.1, we have taken nine different scenarios having different reorder point of step size 50. As per the requirement, we have least desired value of scenario-1 having 50 reorder point as the lost customers are way too high than the other scenarios. Whereas in scenario-4, having 200 reorder point we get the most desired value which has ZERO Lost customers, ZERO Amount Lost and LEAST Inventory.

Hence in Case-I, scenario – 4 has optimum inventory level of 270.562.

- **Case- II: Target Stock = 450**

In this case, target stock is 450 and batch size is equal to five. Now the resulting values for different reorder points are provided in the table 6.2 below.

Table: 6.2- Responses for Case-II

	Scenario Properties			Controls			Responses		
	S	Name	Program File	Reps	Batch Size	Reorder Point	Target Stock	Lost	Amount Lost
1	Scenario 1	14 : Model-	1	5.0000	50.0000	450.0000	1355.000	103965.655	77.827
2	Scenario 2	14 : Model-	1	5.0000	100.0000	450.0000	3.000	291.480	415.183
3	Scenario 3	14 : Model-	1	5.0000	150.0000	450.0000	0.000	0.000	375.507
4	Scenario 4	14 : Model-	1	5.0000	200.0000	450.0000	0.000	0.000	259.146
5	Scenario 5	14 : Model-	1	5.0000	250.0000	450.0000	0.000	0.000	307.440
6	Scenario 6	14 : Model-	1	5.0000	300.0000	450.0000	0.000	0.000	431.280
7	Scenario 7	14 : Model-	1	5.0000	350.0000	450.0000	0.000	0.000	364.458
8	Scenario 8	14 : Model-	1	5.0000	400.0000	450.0000	0.000	0.000	359.555
9	Scenario 9	14 : Model-	1	5.0000	450.0000	450.0000	0.000	0.000	392.150

Similarly, in response table 6.2, we have taken nine different scenarios having different reorder point of step size 50. As per the requirement, we have least desired value of scenario-1 having 50 reorder point as the lost customers are way too high than the other scenarios. Whereas in scenario-4, having 200 reorder point we get the most desired value which has ZERO Lost customers, ZERO Amount Lost and LEAST Inventory.

Hence, in Case-II, scenario – 4 has optimum inventory level of 259.146.

- **Case- III: Target Stock = 400**

In this case, target stock is 400 and batch size is equal to five. Now the resulting values for different reorder points are provided in the table 6.3 below.

Table: 6.3- Responses for Case-III

	Scenario Properties			Controls			Responses		
	S	Name	Program File	Reps	Batch Size	Reorder Point	Target Stock	Lost	Amount Lost
1	Scenario 1	14 : Model-	1	5.0000	50.0000	400.0000	791.000	60822.429	189.536
2	Scenario 2	14 : Model-	1	5.0000	100.0000	400.0000	5.000	470.736	103.282
3	Scenario 3	14 : Model-	1	5.0000	150.0000	400.0000	0.000	0.000	204.770
4	Scenario 4	14 : Model-	1	5.0000	200.0000	400.0000	0.000	0.000	271.638
5	Scenario 5	14 : Model-	1	5.0000	250.0000	400.0000	0.000	0.000	363.448
6	Scenario 6	14 : Model-	1	5.0000	300.0000	400.0000	0.000	0.000	373.605
7	Scenario 7	14 : Model-	1	5.0000	350.0000	400.0000	0.000	0.000	362.052
8	Scenario 8	14 : Model-	1	5.0000	400.0000	400.0000	0.000	0.000	360.770

In response table 6.3, we have taken eight different scenarios having different reorder point of step size 50. As per the requirement, we have least desired value of scenario-1 having 50 reorder point, as the lost customers are way too high than the other scenarios. Whereas in scenario - 3, having 150 reorder point we get the most desired value which has ZERO Lost customers, ZERO Amount Lost and LEAST Inventory.

Hence, in Case-III, scenario – 3 has optimum inventory level of 204.77.

- **Case- IV: Target Stock = 350**

In this case, target stock is 350 and batch size is equal to five. Now the resulting values for different reorder points are provided in the table 6.4 below.

Table: 6.4- Responses for Case-IV

	Scenario Properties			Controls			Responses		
	S	Name	Program File	Reps	Batch Size	Reorder Point	Target Stock	Lost	Amount Lost
1	Scenario 1	14 : Model-	1	5.0000	50.0000	350.0000	673.000	52516.903	75.813
2	Scenario 2	14 : Model-	1	5.0000	100.0000	350.0000	5.000	460.154	160.751
3	Scenario 3	14 : Model-	1	5.0000	150.0000	350.0000	0.000	0.000	244.703
4	Scenario 4	14 : Model-	1	5.0000	200.0000	350.0000	0.000	0.000	200.967
5	Scenario 5	14 : Model-	1	5.0000	250.0000	350.0000	0.000	0.000	222.799
6	Scenario 6	14 : Model-	1	5.0000	300.0000	350.0000	0.000	0.000	302.331
7	Scenario 7	14 : Model-	1	5.0000	350.0000	350.0000	0.000	0.000	259.687

In response table 6.4, we have taken seven different scenarios having different reorder point of step size 50. As per the requirement, we have least desired value of scenario-1 having 50 reorder point, as the lost customers are way too high than the other scenarios. Whereas in scenario - 4, having 200 reorder point we get the most desired value which has ZERO Lost customers, ZERO Amount Lost and LEAST Inventory.

Hence, in Case-IV, scenario – 4 has optimum inventory level of 200.967.

- **Case- V: Target Stock = 300**

In this case, target stock is 300 and batch size is equal to five. Now the resulting values for different reorder points are provided in the table 6.5 below.

Table: 6.5- Responses for Case-V

	Scenario Properties			Controls			Responses		
	S	Name	Program File	Reps	Batch Size	Reorder Point	Target Stock	Lost	Amount Lost
1	Scenario 1	14 : Model-	1	5.0000	50.0000	300.0000	864.000	67196.817	13.301
2	Scenario 2	14 : Model-	1	5.0000	100.0000	300.0000	7.000	610.823	229.422
3	Scenario 3	14 : Model-	1	5.0000	150.0000	300.0000	0.000	0.000	173.237
4	Scenario 4	14 : Model-	1	5.0000	200.0000	300.0000	0.000	0.000	212.013
5	Scenario 5	14 : Model-	1	5.0000	250.0000	300.0000	0.000	0.000	304.578
6	Scenario 6	14 : Model-	1	5.0000	300.0000	300.0000	0.000	0.000	303.678

In response table 6.5, we have taken seven different scenarios having different reorder point of step size 50. As per the requirement, we have least desired value of scenario-1 having 50 reorder point, as the lost customers are way too high than the other scenarios. Whereas in scenario - 3, having 150 reorder point we get the most desired value which has ZERO Lost customers, ZERO Amount Lost and LEAST Inventory.

Hence, in Case-V, scenario – 3 has optimum inventory level of 173.237.

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 Conclusion and Future Work

After examining the data, we may draw the conclusion that using arena simulation software, we can quickly achieve the ideal inventory level with minimal safety stock or reorder points. So, in order to improve the relationship with the client, it is up to the buyer to select the right quantity of inventory, reorder point, and safety stock.

We can infer from the simulation findings that the buyer will have better outcomes in situations where demand fluctuates if they use the arena simulation model for the reorder point, safety stock, and order quantity.

While inventory level management is a difficult system, using Arena Software to simulate it provides us with a good answer rather than trying to address it in real time using conventional methods.

Simulated models are only capable of maximising the inventory level for products that employ a single quantity of a given resource. We can think of products that use two or more (>2) quantities of material for future development. Regardless of the amount of quantities used in a single product, simulating and optimising the inventory level will be intriguing.

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