Decision Support System for Brick Production Factory using Economic Production Lot Size Model

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Abstract

In this paper, an economic production quantity model is developed for a production–inventory system where the demand rate increases with time; the production rate is finite and adjustable in each cycle over an infinite planning horizon. The model is formulated taking the demand rate as a general increasing function of time and the optimal production policy is obtained for the special case of a linearly increasing demand rate. In manufacturing sectors, it is important to make plans for producing products with costs effective and on the other hand, to meet the customer demands. A procedure to find approximately the minimum total cost of the system over a finite time horizon is suggested. This paper describes the work done on the development of a decision support system for brick production factory using an economic production lot size problem. The decision support system thus developed for inventory control is expected to assist brick production manager in decision making regarding production plan and to minimize total variables cost for inventory over a specified time period.

Keywords: Inventory; production; lot size; decision making;

1. Introduction

Decision support systems (DSS) are a type of information system whose principal objective is to support a human decision maker during the process of arriving at a decision. Developers of DSS systems and applications now benefit from a wide range of useful languages, tools and environments. DSS systems are everywhere.

Once an item is setup to produce, we may want to produce **a** large batch or lot size so as to cover demand over a number of future periods and hence defer the next time when the item will be setup and produced. But it will cost highly the setup and inventory costs. Small batch size or lot size will cost highly the holding costs and inventory costs [4]. Therefore, an organization will need to make a decision for maintaining the right balance between high and low inventory to minimize cost.

The lot-sizing problem is to determine the relative frequency of setups so as to minimize total variables cost for inventory over a specified time period. The economic lot size is a direct relationship between the inventory cost and the setup cost [3].

This paper intends to help brick production factory's management in control and decision making to reduce costly inventory overheads, to list which customers are paid with their target date and to make better decisions with Decision Support System using Economic Production Quantity Model (EPQ).

The rest of the paper is organized as follows. We present the related work in section2. In section 3, we describe the motivation of the system. The briefly discussion of Theoretical Background including Decision Support Systems and Economic Production Quantity Model (EPQ) can be seen in section 4. In section 5, we depict the system architecture of our system. The detailed implementation of the system is described in section 6. And, section 7 concludes our paper with future works.

2. Related Work

Wagner, H.M, Whitin, TM [7] described the Dynamic Version of the Economic Lot Size Model to minimize cost of a solution for periods 1… t. This implies that the problem can be divided into two smaller sub-problems and the least cost solution v (T-1) is optimal for the first sub-problem (periods 1,…,T-1).

Just in time actually is a well-developed philosophy for managing inventories. The focus of the just-in-time philosophy is an avoiding waste wherever it might occur in the production process. One form of waste is unnecessary inventory. Others are unnecessary large setup costs, unnecessary long lead times, production facilities that are not operational when they are needed, and defective items. Minimizing these forms of waste is a key component of superior inventory management. Companies that plan JIT to meet their needs often benefit in profitability, productivity, and customer satisfaction. Production on demand reduces inventory, eliminates waste, ships faster, and pleases customers."

Manufacturing cycle time determination for a multi-stage economic production quantity model treats the manufacturing cycle time as a function of the lot size in a multi-stage production system. Using this functional relationship to determine the magnitude of the work-in-process inventory[1].

3. Background Theory

3.1. Decision Support System

Decision support systems (DSS) deals with the design and the use of cognitively compatible computerized systems for assisting the managers in taking more effective decisions concerning semi-structured and unstructured tasks[8].

DSS essentially consists of three components or modules. They are

i. Database management module;
ii. Knowledge or model management module; and
iii. Dialog or user interface module.

A very promising aspect of a DSS is its ability to integrate data access and decision models. It does so by imbedding the decision models in an information system, which uses the database as the integration and communication mechanism between models. Figure 1 shows a schematic view of this subsystem.

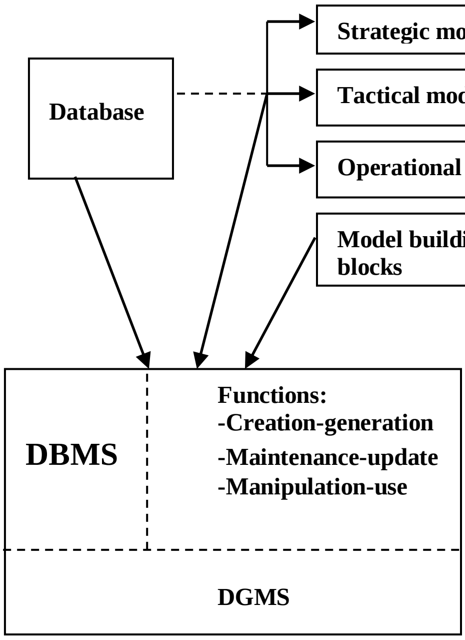

Figure 1. Schematic view of subsystem

3.1.1. Features of Proposed DSS

The proposed DSS aim at helping the decision-makers (i.e., production manager) and users in effective management of inventory[5]. More specifically, the system will help in:

- Forecasting the requirement of fast and slow moving items.
- Monitoring the inventory positions.
- Finding lot size.
- Finding safety cost.

For individual items in stock, the system specifically takes into consideration the consumption rate, criticality and contribution to inventory of individual.

3.1.2. Database Management Module

Database is the most important part of a decision support system, as models work on data and produce decision suggestions. Database is accessed, i.e., data is stored and retrieved through use-interfaces. In the resent work database has been created using Microsoft SQL Server.

3.1.3. Model Management Module

Models provide the analysis capabilities for a DSS. Using a mathematical representation of the problem, algorithm processes are employed to generate information to support decision making.

3.4.3. User Interface Module

This is interface between the user and the system, which are in the form of screens or forms. A decision support system is not complete without a comprehensive and friendly user interface. In the present work all user interfaces have been prepared in Microsoft Visual Studio 2005.

3.2. Economic Production Lot Size Model

Inventory is any stored resource used to satisfy a current or future need (raw materials, work-in-process, finished goods, etc.). Inventory represents as much as 50 percent of invested capital at some companies and excessive inventory levels are costly. At the same time, insufficient inventory levels lead to stock outs. And so we learned Inventory Planning and Control for maintaining the right balance high and low inventory to minimize cost. The inventory planning and control process consists of the following steps:

i. Planning on what inventory to stock and how to acquire it;
ii. Forecasting parts/products demand;
iii. Controlling inventory levels; and
iv. Feedback measurements to revise plans and forecasts;

For inventory planning and control, we consider two models: deterministic models and stochastic models. Deterministic models are models where the demand for a time period is known, whereas in stochastic models the demand is a random variable having a known probability distribution. Economic lot sizing is under deterministic model. The characteristics of deterministic model is following:(1) all parameters and variables are known or calculated with certainly, (2) inventory demand is known and continuous, (3) constant replenishment lead time, (4) regular ordering pattern[3].

Economic lot sizing is a well-known problem in the area of production and operations management, as it has a variety of applications. For example, the economic lot-sizing problem is the core problem in aggregate production planning in MRP systems. The economic lot-sizing problem is defined as follows: Given the demand, unit production cost, and unit inventory holding cost for a commodity, and given production capacities and set-up costs for each time period over a finite, discrete-time horizon, finds a production schedule that satisfies demand at minimum cost. This model assumes a fixed and a variable component of production costs.

Economic production lot size model is also known as economic production quantity (EPQ) model. Economic production lot size model's variables costs are annual holding cost and annual set-up costs. The inventory is reached maximum when every production cycle is finished and it is changed with time[5]. Large setup times to be large batch size and increase in inventory cost and potential loss for products becoming obsolete.

Figure 2 shown the inventory level as a function of time.

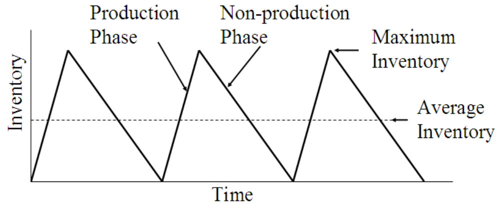

Figure 2. Range in inventory level as a function of time

3.2.1 Notations and Assumptions

Notations

Q* = Optimal production quantity (or EPQ)
C_o = Setup cost
C_h = Holding cost
D = Annual demand
P = Annual production rate
d = Daily demand rate
p = Daily production rate

Assumptions

- Demand occurs at a constant rate of D items per year.
- Production rate is P items per year (and P>D).
- Holding cost, Ch per item in inventory per year.
- Purchases costs per unit are constant.
- Setup time (lead time) is constant.
- Planned shortages are not permitted.

3.2.2 Formulation of the EPQ Model

The EPQ model determine how much to product at one production cycle. In many cases, inventory arrives gradually. The economic production quantity model assumes inventory is being produced at a rate of p units per day. There is a setup cost each production begins. We calculate the annual setup costs with the following formula.

$$C_0 = (D/Q)\, C_o \qquad (1)$$

And we calculate the annual holding costs is

$$C_h = [1/2\ Q^* \ (1\text{-}d/)] * C_{h.} \qquad (2)$$

As in the EOQ model, at the optimal quantity Q* we should have

$$(D/Q)\, C_o = [1/2\ Q^* \ (1\text{-}d/)] * C_{h.} \qquad (3)$$

Rearranging to solve for Q*,

$$Q^* = \sqrt{(2DCo/[Ch(1-d/p)])} \qquad (4)$$

3.2.3 Numerical example and discussion

Brick Production Factory No (1) has been using production runs (has 365 business days per year) of 100,000 bricks, 10 times per year to meet the demand of 1,000,000 bricks annually. And so their annual production rate is 6,000,000 units and their annual demand is 1,000,000 units. The cost of one item for holding in factory is 10% of the manufacturing cost of 1 kyat per brick, and the machine setup cost for one cycle is 5,000 kyat. Therefore, we obtain P=6,000,000, D=1,000,000, Ch = 0.10 and Co= 5,000.

Economic production lot size model's variables costs are annual holding cost and annual set-up costs. And so, TC, the total variable cost is

$$\begin{aligned} TC &= \text{(Holding costs)} + \text{(Setup costs)} \\ &= [1/2\ Q^* \ (1\text{-}d/)] * C_{h.} + (D/Q)\, C_o \qquad (5) \\ &= 0.416\, Q + 5{,}000{,}000{,}000/Q \end{aligned}$$

Thus, we should known Q to calculate the total annual variable cost. The optimal production lot size Q* is

$$Q^* = \sqrt{(2DCo/[Ch(1-d/p)])}$$

= 346,410 units

How much is the brick production factory losing annually by using their present production schedule? The total cost of current schedule is 54,167 and the total cost of optimal lot size schedule is 28,868. Therefore, the production factory saves 25,299 and so the EPQ to be minimize the total inventory cost.

4. System Architecture

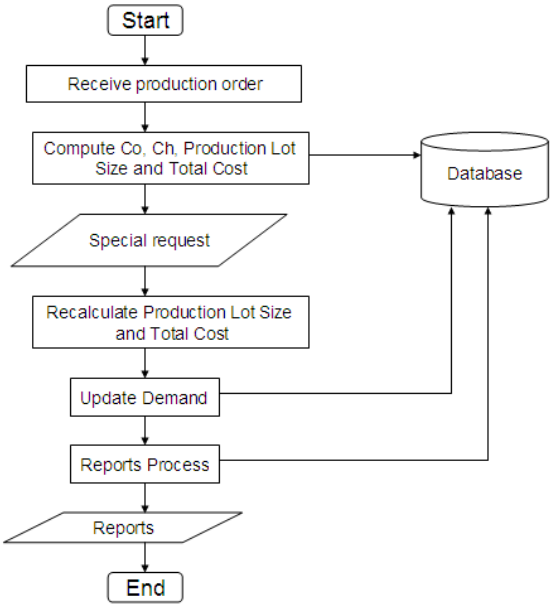

Figure 3. Flowchart of the System Architecture

The architecture of the system is shown in Figure 3. It consists of three computations: first entering setup cost and holding cost per item and compute annual setup and holding cost, second calculate the optimal lot size with the annual production rate, annual demand rate, annual holding cost and annual setup cost, third deciding the customer issue order ratio for the optimal lot size.

At the third part, we look the customer order whether ad-hoc (government order) is received. If not, we issue the bricks to the ordered customer with their permit date within the lot size. If the customer orders include the ad-hoc, update the annual demand and we calculate the optimal lot size with the changed demand again and we issue the bricks to the ad-hoc demand and the ordered customer within the lot size. The last customer is reached to another production cycle and waits the lot size of that cycle.

4.1. Database Design

This system is implemented with Microsoft SQL Server and the relationships between the tables for Customer, Customer Order, Economic Production Quantity (EPQ), Production Cycle, Customer Order Receive, and Customer Order Issue are shown in Figure 4.

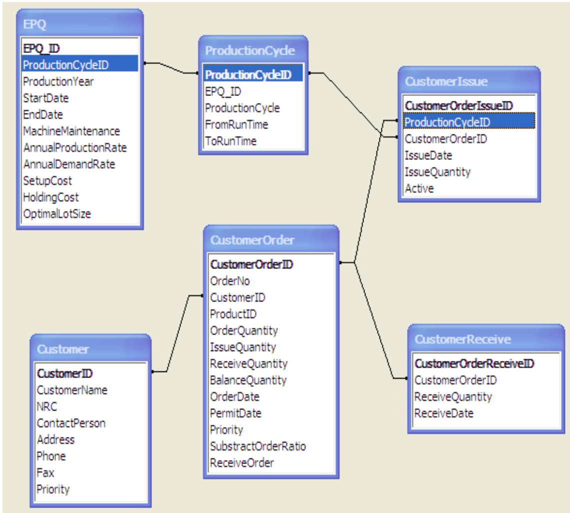

Figure 4. Database Table Design

5. Implementation

In this system, customer and customer order is the user input. Figure 5 shows the Customer Form for the customer information of the brick production factory.

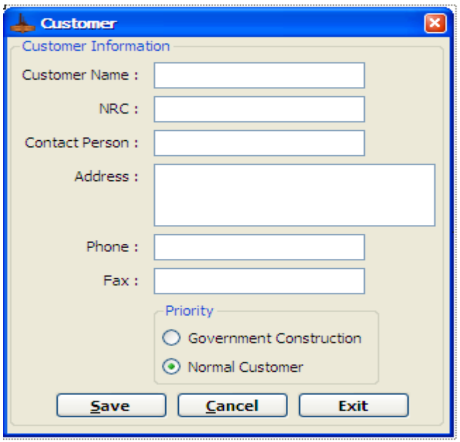

Figure 5. Customer Entry Form

The user input the custome name, number, contact person name, phone number, fax number and chooses the customer type. There are two customer types: government construction and normal customer.

Then, the customer can start order with customer order form. The user types the customer name and then clicks the search bottom. This bottom load the customer required information of first customer form and then choose the product type. There are two product types: brick-8 and brick-10. And type the order quantity and order date. The permit date of normal customer is the start date of production year. The government construction's permit date is the same of their order date. This is ad-hoc. Figure 6 shows the customer order form.

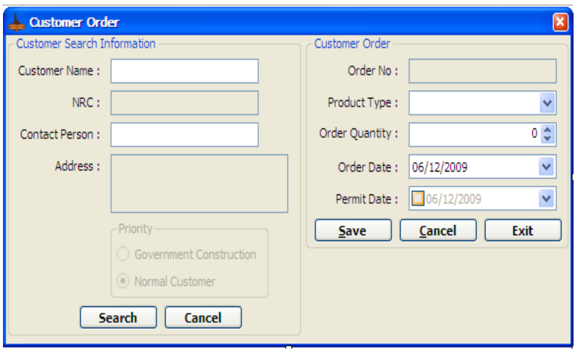

Figure 6. Customer Order Form

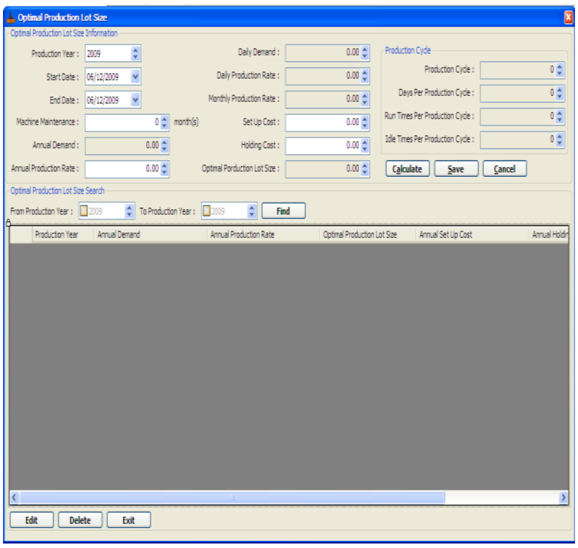

Figure 7. Economic Production Quantity Calculate Form

After the customer order entry, the annual demand is received and then accepts the setup cost, the holding cost and we can now calculate the optimal lot size with the economic production quantity form. After we calculated the lot size, divide the lot size for the customer order and we get the customer issue list which customer will receive the order with the issue date. Figure 8 shows the customer issue form after EPQ is received.

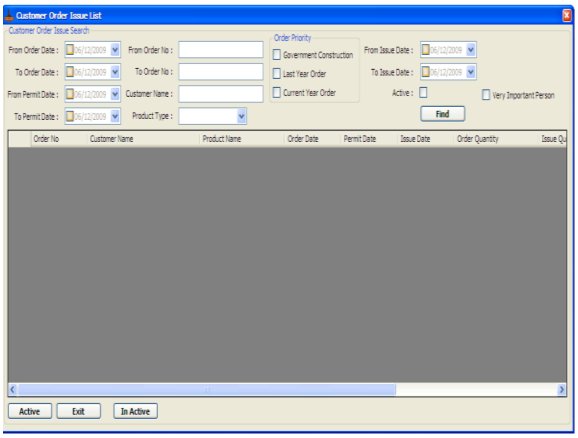

Figure 8. Customer Issue Form

Customer issue form includes customer name, product type, order date, permit date, issue date, order quantity and issue quantity. This issue list is produced for the production manager to know which customer will receive with their issue date. This list is not sure. In the form, the issue date is surely accepted when the Active bottom is clicked. And the customer receive form is worked in issue date. The customer receive form is entered for really receiving of customer order by customers. Figure 9 shows the customer receive form.

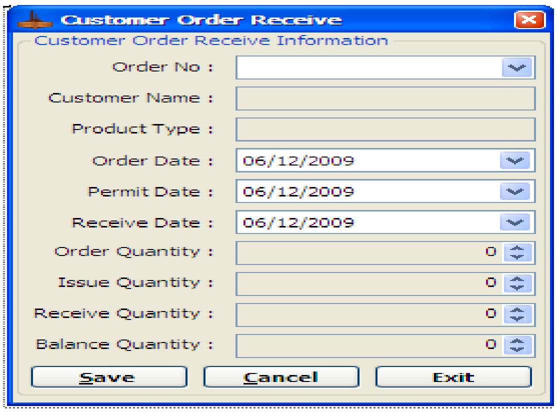

Figure 9. Customer Receive Form

The user chooses the order number and then other required information is loaded from the database with the order number. The balance quantity is received from the different of issue quantity and receives quantity.

In this system includes three report: comparison of lot size and inventory cost, the demand report with production year, the customer list of received order.

6. Report

Comparison of lot size and inventory cost report, the manager can be compared the calculated lot size and other batch size. The row of this report is production lot size and the column is total variable cost. The total variable cost can be changed by the changes of production lot size. But the calculated lot size of the economic production lot size model to be minimized the inventory cost. Figure 10 shows the comparison report.

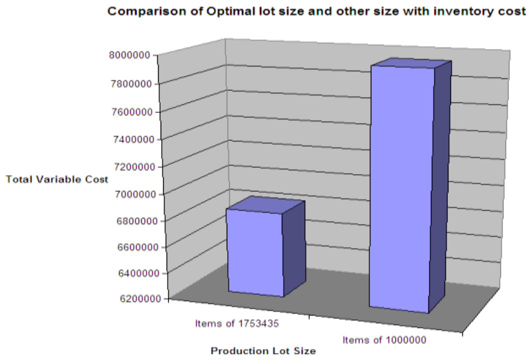

Figure 10. Comparison of Optimal lot size and other size with inventory cost

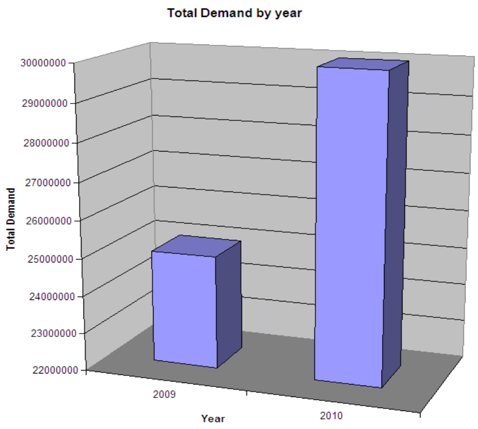

Figure 11. Demand Report with production year

Figure 11 shows the annual demand with the production year. And the customer received list is displayed the customer who has been entered the customer received form.

System specification is Pentium 4, CPU 3.0 GHz, 2.00 GB RAM running Windows and Microsoft .Net. The required software is Microsoft SQL Server 2005 and Visual Studio 2005 and later.

7. Conclusion

This paper presents a decision support system for production-inventory by using economic production lot size model. The classical economic production quantity (EPQ) model is generalized by considering a relationship between the setup cost and the production run length. This paper proves that the uses of lot-sizing model are better than current policy without computation. The system was tested with different demand and inventory costs(setup cost, holding cost and inventory variable costs) It is also possible that the system's performance will improve an organization's needs to get the production processes, to become better performance, higher efficient, more effectiveness, and better retrieval as manual are used. It can be flexible for any Production System. The overall experience from this paper is a very positive one.

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