CHAPTER II

LITERATURE REVIEW

2.1 General Inventory Management

FLEISHER (1963) described that although individual supermarket stores seem to offer less opportunity for the application of scientific · inventory management techniques than department stores, the central warehouse inventories of supermarket chains are suitable for such applications. Sizable reduction in both inventory investment and stock-outs can be achieved by designing a system incorporating decision rules based on mathematical formulas.

THURSTON (1972) described " safety stock", " reorder point", " economic order quantity", that are now commonplace in the management of parts inventories at manufacturing companies. These terms signify that inventory is being controlled on a statistical basis. Certainly, statistics have important applications in inventory management, but during the past two decades, specialists on inventory and scheduling and line managers alike have gone overboard incurring considerable costs in excessive use of statistically based tools. An alternate approach called " requirements planning" can make very substantial savings.

COLLINS (1984) described the application of a general management perspective to inventory control that focuses on both effectiveness and efficiency of operations. It is predicated upon an articulation of strategic goals and a definition of the role that inventories and inventory control system play in the enhancement of competitive advantage. This means that the task to be accomplished by the inventory control function in support of corporate strategy needs to be specified and communicated in clear, unequivocal terms. To do so requires the identification and resolution of the multiplicity of trade-offs associated not only with investment in inventory but also with the coordination of material flows through the business system. Task definition permits the establishment of appropriate standards of performance, which are consistent with the super ordinate objectives of the enterprise, standards against which actual performance and thus effectiveness can be measured.

HAX and CANDEA (1984) classified the inventory systems into four types; they are pure inventory systems, production-inventory systems, distribution-inventory systems, and production-distribution-inventory systems. The objectives of inventory management system are minimization of the costs incurred in the inventory system, attaining at the same time the customer service level specified by the company policies. An inventory management system can be viewed as being structured of subsystems or modules: the transactions and file maintenance module, the decision rules module, the system integrative module, and the system-management interaction and evaluation module.

MENIPAZ (1984) described the perspective impact of the technological change on our society provides a wide-ranging basis for concerns and opportunities in the area of inventory management and distribution. The advent of microcomputers, programmable controllers, CAD/CAM system, telecommunication equipment, and other high technology products with its supporting hardware/software components, has been paralleled with a significant change in number and practices of distribution outlets. While trying to provide a certain service level by keeping an inventory of items, distribution outlets struggle to keep up with technological obsolescence.

TOMEK (1984) described in the system conception of rationalization the control process the inventory control is inseparable from the production process control. It is mainly the operative planning of supply activity, which is an integral part of operative planning as a whole, which includes sales operative plan, production and supply plan, eventually plans of other auxiliary and attending components. Similarly, inventory control and supply activity control as higher terms, which include employment of other means beside the plan are, to a certain extent, a part of operative production control subsystem, eventually they are in some parts connected with this subsystem.

MAX MULLER (2003) described inventory—Who needs it? All organizations keep inventory. "Inventory" includes a company's raw materials, work in process, supplies used in operations, and finished goods.

Inventory Costs

Inventory brings with it a number of costs. These costs can include:

- Baht
- Space
- Labour to receive, check quality, put away, retrieve, select, pack ship, and account for
- Deterioration, damage, and obsolescence
- Theft

Inventory costs generally fall into ordering costs and holding costs. Ordering, or acquisition costs come about regardless of the actual value of the goods. These costs include the salaries of those purchasing, costs of expediting the inventory, and so on.

The purpose of inventory

Because inventory is considered waste but, in environments where an organisation suffers from poor cash flow or lacks strong control over:

(i) Electronic information transfer among all departments and all significant suppliers

(ii) Lead times

(iii) Quality of materials received

Inventory plays important roles. Some of the more important reasons for obtaining and holding inventory are:

a) Predictability: in order to engage in capacity planning and production scheduling, the company needs to control how much raw material, parts, and subassemblies the company process at a given time. Inventory buffers what the firm needs from what it process.

b) Fluctuation in demand (Bullwhip Effect): a supply of inventory on hand is protection. It is not easy to know how much the company is likely to need at any time, but it still needs to satisfy customer or production demand on time. If the firm can see how customers are acting in the supply chain, surprises in fluctuations in demand are held to a minimum.

c) Unreliability of supply: inventory protects the company from unreliable suppliers or when an item is scarce and it is difficult to ensure a steady supply. Whenever possible unreliable suppliers should be rehabilitated through discussions or they should be replaced. Rehabilitated can be accomplished through master purchase orders with timed product releases, price or term penalties for nonperformance, better verbal and electronic communications between the parties, etc. This will result in a lowering of its on-hand inventory needs.

d) Price protection: buying quantities of inventory at appropriate times helps avoid the impact of cost inflation. Contracting to assure a price does not require actually taking delivery at the time of purchase. Many suppliers prefer to deliver periodically rather than to ship an entire year's supply of a particular stockkeeping unit (SKU) at one time.

e) Quantity discounts: often bulk discounts are available if the firm buys in large rather than in small quantities.

f) Lower ordering costs: if the company buys a larger quantity of an item less frequently, the ordering costs are less than buying smaller quantities over and over again. In order to hold down ordering costs and to lock in favourable pricing, many organizations issue blanket purchase orders coupled with periodic release and receiving dates of the SKUs called for.

GITMAN (2000) described that inventory is a necessary current asset, which permits the production-sale process to operate with minimum of disturbance. Like accounts receivable, inventory represents a significant investment for most firms. For the average manufacturer, it accounts for about 42 percent of current assets and about 18 percent of total assets. In addition, he illustrated the importance of turning over inventory quickly to reduce financing costs.

Inventory as an Investment

Inventory is an investment in the sense that it requires that the firm tie up its money, thereby giving up certain other earning opportunities. In general, the higher a firm's average inventories, the larger the money investment and cost required; the lower its average inventories, the smaller the money investment and cost required. When evaluating planned changes in inventory levels, the financial manager should consider such changes from a benefit-versus-cost standpoint.

BOWERSOX, CLOSS, and COOPER (2003) explained that the general concept of an integrated supply chain is typically illustrated by a line diagram which links participating firms into a coordinated competitive unit.

Supply chain management consists of firms collaborating to leverage strategic poisoning and to improve operating efficiency. For each firm involved, the supply chain relationship reflects strategic choice. A supply chain strategy is a channel arrangement based on acknowledged dependency and relationship management. Supply chain operations require managerial processes that span across functional areas within individual firms and link trading partners and customers across organizational boundaries.

Logistics, in contrast to supply chain management, is the work required to move and position inventory throughout a supply chain. As such, logistics is a subset of and occurs within the broader framework of a supply chain. Logistics is the process that creates value by timing and positioning inventory; it is the combination of a firm's order management, inventory, transportation, warehousing, materials handling, and packaging as integrated throughout a facility network. Integrated logistics serves to link and synchronise the overall supply chain as a continuous process and is essential for effective supply chain connectivity. While the purpose of logistical work has remained essentially the same over the decades, the way the work is performed continues to radically change.

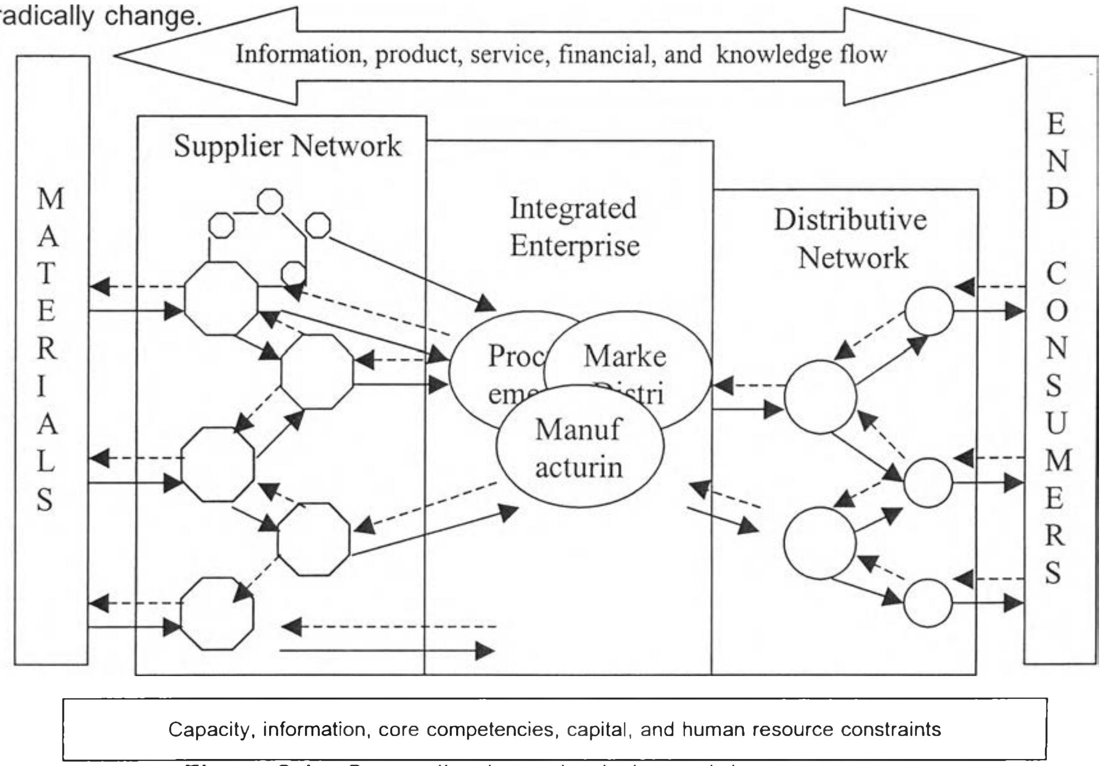

Figure 2.1 : *Generalised supply chain model*

2.2 Ordering Policy

FABRYCKY (1967) described an inventory of a single item maintained to meet demand. When the total number of units on hand and on order is depleted to a specific level, action is initiated to procure a replenishment quantity from a single predetermined source. The objective is to determine the procurement level and the procurement quantity, in the light of system and cost parameters, so that the sum of all costs associated with the process will be minimized. It is assumed that the demand rate and the procurement lead time are deterministic and time invariant. Demand and lead time are assumed to be independent of each other and independent of the procurement level and the procurement quantity. Models are derived under these assumptions for the purchase alternative and for the manufacture alternative. Individual models are then extended to illustrate the effect of a price discount schedule, a manufacturing progress function, and a warehouse restriction.

HOYT (1973) described the B.F.I. (Business Factor Indices) order point technique that allows management the opportunity to identify and emphasize the success factors. The resultant effect will be one of maximizing the advantages that a company possesses. In practice, B.F.I. order points best fit the individual needs of business in a way that "standard" order points have been unable to do. Top management involvement in the derivation of the matrix of business factor indices has led to an awareness of the value and contribution of the materials function to company objectives. The traditional order point calculation is as below.

Order Point = Expected Usage + Safety Stock

Safety Stock = Serviced Level Desired * Deviation from Expected Usage

$$= \frac{Tolerable\ - Stcokouts}{Exposures} * \text{Mean Absolute or Standard Deviation}$$

= Safety Factor * Adjusted MAD or SD

and the B.F.I. order point calculation is as below:

Order Point = (Dem. * LT) + (Dem.* LT) (D% + V% + E% + L%)

Where, Dem = Average historical demand over a reasonable period or the forecasted demand (expected demand)

LT = The "normal" current replenishment lead time

D = The effect the shortage of the items will have on profit or production

V = The dollar value of the item

E = The deviation of demand from average usage

L = The lead time and lead time variation in replenishing the stock

OSAKI (1977) described an ordering policy in which a working item can be replaced by an item supplied by order with lead time and discussed the optimum ordering policy minimizing the expected cost per unit time for an infinite time span. It assumed that an item for each replacement can be supplied by order with lead time. That is, only by order can we obtain an item for each replacement after a lead time. The policy is when we should order an item for each replacement.

THOMAS and OSAKI (1978) considered a generalized ordering policy in which a spare unit for replacement can be delivered only by order after a constant lead time. Introducing the costs for ordering, shortage and holding, the expected cost per unit time in the steady-state is derived. Discussing the optimal ordering policy which minimizes the expected cost, it is shown in a main theorem that the optimal policy is reduced to either one of two typical ordering policies depending on some conditions. Further discussing a similar ordering policy with varying lead time, it is shown that the optimal policy must be either to replace the operating unit, as soon as the ordered spare is delivered, or not to replace it unit it fails.

KRUPP (1982) described many environments where management deems safety stock to be justified; an example would be make-to-stock environments where customers will not tolerate backorders, and failure to provide product on demand results in a lost sale and potential customer dissatisfaction. In such circumstances, the use of statistical techniques (MAD, standard deviation, smoothing models, etc.) is a common basis on which to base safety stock calculations. A major problem in the use of such methods is the inability of classic statistical safety stock formulae to guard against imbalanced inventories and/or sudden changes in environment. The assumptions are:

1. A time-phased inventory planning technique (such as MRP or Time Phase Order Point) is used to plan inventory replacement.
2. Forecasts as provided by Marketing and/or other sources are time phased.

BRUGGEMAN (1985) described the general framework of a maintenance resource planning system and covered some specific characteristics (Master Maintenance Scheduling, Bills of Maintenance and Safety stocks in spare parts planning) of the maintenance planning that require some specific amendments to the existing software. It was argued that the general framework of existing manufacturing resource planning systems can be applied and used for planning maintenance resources.

GREENE (1987) described the units sold of next period can be calculated by forecasting method, Brown's Exponential Smoothing, and some programmes can easily get the data such as STATGRAPHICS. The order point, or the cumulative gross requirements, includes provision for a safety stock to manage the trade-off between customer service and the investment in inventory. Safety stock (Fig. 2.1) can always be expressed as kσ pieces, where k is a safety factor that might vary over time in a selling season and σ is the standard deviation of errors in forecasting demand over a lead time. Its value may also vary over time in a seasonal industry or where there are significant promotions. The standard deviation is computed (and revised at regular internals) in the forecasting procedures. The safety factor k can be computed from any of several alternative decision rules. And described the concept of the economic order quantity (EOQ) is to balance the expected cost of acquisition for stock against the expected costs to hold the stock. And the base case of EOQ model is:

$$Q = \sqrt{\frac{2AS}{rv}} = \sqrt{\frac{2CpD}{Ch}}$$

where,

S = annualized usage (pieces per year), to continue at same rate for an indefinitely long time

Q = quantity delivered stock (pieces), delivered all at the same time

v = unit value (dollars per pieces), the same at any time in future for for any reasonable order quantity

A = acquisition cost (dollars per order), applies to each product individually; sometimes called setup cost.

r = carrying charge (dollars per dollar per year), applies to extended value of working stock, at unit cost v

Cp = set-up cost, order cost

Ch = holding cost per period

D = average demand per period

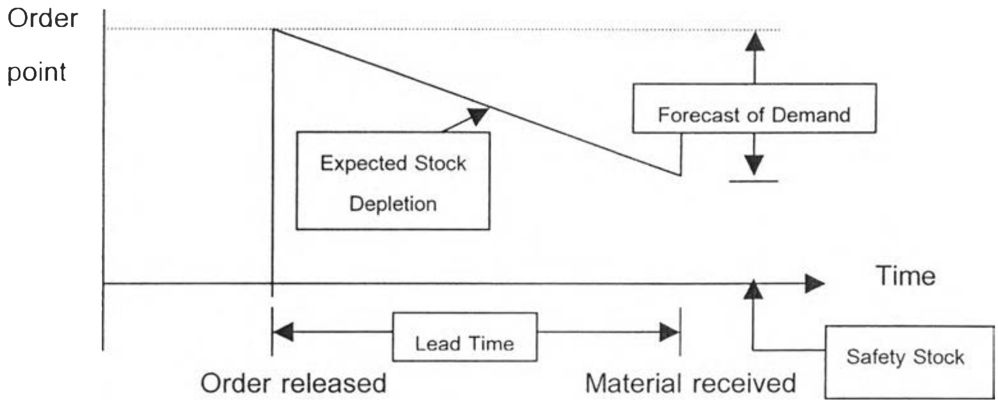

Figure 2.2 : *Safety Stocks and Order Point*

Forecast = Sum of forecasts for each month in lead time

Safety stock = (safety factor) x (standard deviation over lead time)

= Order point

2.2.1 ABC Analysis

RIGGS (1981) described the division of inventory into three classes according to dollar usage is known as ABC analysis. The usage rating for each item is the product of its annual usage and its unit purchase or production cost. The typical pattern of dollar usage is depicted in figure 2.2. The A class, on which attention is concentrated, includes high-value items whose dollar volume typically accounts for 75 to 80 percent of the material expenditure while representing only 15 to 20 percent of the quantity volume. The proportions are reversed in passing from A to C items. For A items, order quantities and order points are carefully determined. For B items, EOQ and reorder level calculations are conducted and the variables are reviewed quarterly or semiannually. For C items, no formal calculations are made and the reorder quantity is usually a 1- or 2- year supply.

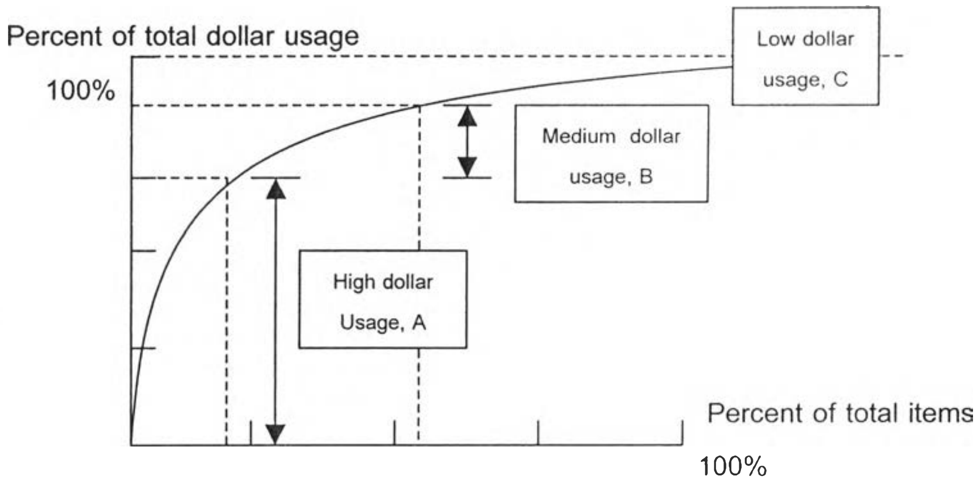

Figure 2.3 : *Distribution of Supply Expenditures with Respect to Quantity Supplied*

RIVERS (1982) described the ABC inventory categorization techniques as commonly applied to both Component Part Inventories and to Finished Goods Inventories. However, it is not commonly understood that the use of the ABC assignment is necessarily different between the two types of inventory when used in conjunction with an MRP system. Finished Goods Inventory Policies can be augmented with ABC Classification. Prior to assigning ABC indicators, objectives and approaches must be developed, discussed and agreed to. Once in place, constant review and management are necessary. With carrying costs becoming more significant as the economy matures, a programme that does not strive for improvement and better utilization of money, materials, and man power will soon meet with disfavor and disillusionment, ultimately to be discarded.

WILLIS and SHIELDS (1990) described all component parts and materials are essentially classified as either A or C. Class A parts, being high cost and most vulnerable to availability delays, are MRP scheduled and then kanban-pulled through the plant. Class C parts, being low cost wide availability type items, are reorder point controlled. Class B is reversed for a special group of replacement parts that are used infrequently to maintain older products and are neither reorder point nor kanban managed. The underlying goals with any material management system are simplicity and effectiveness. The ABC method can help achieve both objectives.

SCABOROUGH and ZIMMERER (1996) described that the most viable option for inventory management is a partial inventory control system for the small business owner with limited time and money. Too many managers apply perpetual inventory control systems universally across every item maintained in stock when a partial control system would be much more practical. Partial inventory systems minimize the expense involved in analyzing, processing, and maintaining records, a substantial cost of any inventory control system. The ABC method is one such approach, focusing control efforts on that small percentage of items that accounts for the majority of the firm's sales. The typical ABC system divides a firm's inventory into three major categories:

A items: those items that account for a large dollar usage volume

B items: those items that account for a moderate dollar usage volume

C items: those items that account for a low dollar usage volume

The dollar usage volume that an item accounts for measures the relative importance of that item in the firm's inventory. Value is not necessarily synonymous with high unit cost. In some instances a high-cost item that generates only a small dollar volume can be classified as an A item. But, more frequently, A items are those that are low-cost and high-volume by nature.

The initial step in establishing an ABC classification system is to compute the annual dollar usage value for each product (or product category). Annual dollar usage value is simply the cost per unit of an item multiplied by annual quantity used.

The next step is to arrange the products in descending order based on the computed annual dollar usage value. They can be divided into appropriate classes by applying the following rule:

A items: roughly the top 15 percent of the items listed

B items: roughly the next 35 percent

C items: roughly the remaining 50 percent

The purpose of classifying items according to their value is to establish the proper degree of control over each item held in inventory. Clearly it is wasteful and inefficient to exercise the same level of control over C items as A items. Items in the A classification should be controlled under a perpetual inventory system with as much detail as necessary. Analytical tools and frequent counts may be required to ensure accuracy, but the extra cost of tight control for these valuable items is usually justified. The manager should not retain a large supply of reserve or safety stock because this ties up excessive amounts of money in inventory, but the manager must monitor the stock closely to avoid stockouts and lost sales. Weekly or even daily inspections may be required to control A items properly.

Control of B items should rely more on periodic control systems and basic analytical tools such as EOQ and reorder point analysis. The manager can maintain large levels of safety stock for these items to guard against shortages, and can afford monthly or even bimonthly merchandise inspections. Because B items are not as valuable to the business as A items, less rigorous control systems are required.

C items typically comprise a minor proportion of the small firm's inventory value and, as a result, require the least effort and expense to control. These items are usually large in number and small in total value. The most practical way to control them is to use uncomplicated records and procedures. Large levels of safety stock for these items are acceptable because the cost of carrying them is usually minimal. Substantial order sizes often enable the business to take advantage of quantity discounts without having to place frequent orders. The costs involved in using detailed record-keeping and inventory control procedures greatly outweigh the advantages gleaned from strict control of C items.

One practical technique for maintaining control of these "nuts and bolts" C items is the two-bin system. In this process the owner simply keeps two separate bins full of material or merchandise. The first bin is used to fill customer orders, while the second bin is filled with enough safety stock to meet customer demand during the lead time. When the first bin is empty the owner places an order with the vendor large enough to refill *both* bins. During the lead time for the order, the manager uses the safety stock in the second bin to fill customer demand. A variation of this technique is the level control system. Here the manager fills the bin with the usual amount of safety stock and marks the level with a brightly colored line. When the supply of material reaches the colored line, he or she orders enough stock to refill the bin.

When storage space or the type of items does not suit the two-bin system, the owner can use a tag system. Based on the same principle as the two-bin system, which is suitable for many manufacturers, the tag system applies to most retail, wholesale, and service firms. Instead of placing enough inventory to meet customer demand during lead time into a separate bin, the owner marks this inventory level with a brightly colored tag. When the supply is drawn to the tagged level, the merchandise is reordered.

In summary, total inventory costs are reduced when the small business manager spends time and effort controlling items that represent the greatest inventory value. Some inventory items require strict, detailed control techniques, while others cannot justify the cost of such systems. Because of its practicality, the ABC inventory system is commonly used in industry. In addition, the technique is easily computerized, speeding up the analysis and lowering its cost. Table 2.1 summarises the use of the ABC control system.

Table 2.1 : *ABC Control Features*

A Items	B Items	C Items
1. Monitor closely and maintain tight control	1. Maintain moderate control	1. Maintain loose control
2. Based on forecasted requirements	2. Based on EOQ calculations and past experience	2. When level gets low, reorder
3. Keep detailed records of receipts and disbursements	3. Use periodic inspections and control procedures	3. No records required
4. Low levels of safety stock	4. Moderate levels of safety stock	4. High levels of safety stock
5. Frequent monitoring of schedule changes	5. Periodic checks on changes in requirement	5. No checks on requirements

2.3 Inventory Information System

GREENE (1987) proposes the inventory control system follows a basic cycle regardless of the firm's size. It begins by determining the production needs and is completed by filling the customer's order. Records and information will flow from similar sources, although the timing, accuracy, frequency, and completeness will be a function of the firm's size and its reliance on data processing systems. The basic information is contained on several records:

1. The Part Master Record: this includes a description of the part and of the planning and ordering rules – such as the lot size, manufacturing and cumulative lead times, planner codes, source codes, standard costs of material, labour, and burden and inventory balances for on-hand, in-inspection, in-transit, and floor stock.

2. Bill of Materials: this record contains the product structure by the relationships of the part number. By describing the successive single-level relationships, the entire multilevel product structures are described for all assemblies and subassemblies. This information can then be manipulated to determine the number of components required at each level to produce the final product. Conversely, the parent products that use a given component can also be determined.
3. Engineering-Change Records: these contain past, present, and future engineering changes to the bills of materials. These changes are effective as of a given date, parent serial number, or order number; they may be changes in the quantity of a component per parent of may be the substitution of one component for another. This information is used to plan and execute changes in the product structure by making changes in the components required to build a parent. Information is retained for some specified period to provide a complete record of the part's engineering evolution.
4. Routing Records: these contain the manufacturing-process information used to make a part. They relate the processes for the part in the sequence in which they take place as well as the special tools and time required. This time may be subdivided into move, queue, setup, and run times expressed in hours, with adjustment factors for efficiency, shifts worked, crew size, so fourth. This information is used to route manufacturing orders through the production facility and to plan the labour and machine time that will be required to attain the production schedule.
5. Routing-Change Records: these contain past, present, and future versions of the routing for any given part. They are used to change the routing on the date, the serial number, or the order's effective date. The process and/or routing changes can include the substitution of one operation for another, a change in the setup or runtime for a part, etc. This information is used to plan and execute changes in the processes used to manufacture a part.

SANTICHAI (1998): in chapter three of this dissertation, it included the POS system, an important component, which was used to capture high volume sales data. This system was generally used in many retail businesses such as department stores, supermarkets, convenience stores, etc. However, the system will be implemented in a different way because of the different types of requirements between businesses.

Retail Information System

A computer system may help the firm to achieve their goals in many fields. The key success of using computer systems in retail businesses is that the flow of information is appropriate and timely. Computers improve accuracy and control, ensure that business transactions are performed accurately, and allow management to control information. For these reasons, this type of retail information system is applied to many retail businesses. It consists of several functions. Figure 2.4 is one of the examples of a retail information system. The POS system is an important component which is used to capture high volume sales data.

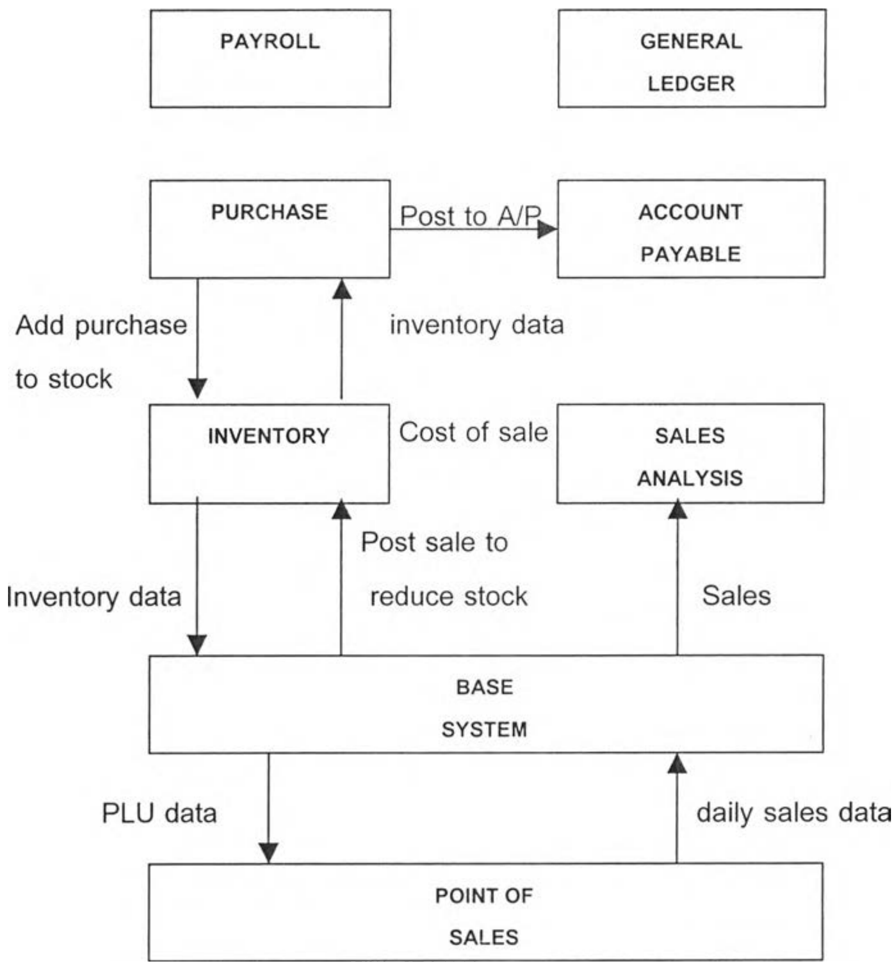

Figure 2.4 : *Retail Information System*

POS Hardware Configuration

Point of Sales (POS) has many different functions: scanning merchandise and credit and debit card equipment. A POS hardware configuration usually consists of many different types of electronic equipment as shown in figure 2.5 i.e. customer display, POS printer, monitor, keyboard, cash drawer, and bar-code scanner.

Figure 2.5 : *POS Hardware Configuration*

POS System Operation

The operation of the POS system can be different in each business. It is dependent on the requirements or policies of the individual business. However, the core operation may be similar to the following.

1) *Business Transaction Register*

Every product in the store will be registered in a database. It may consist of product description, package size, price, taxation rate, discount rate, and so on. Each package must have the product identification, generally in the form of a barcode, which is printed or labeled on the package. Whenever a customer needs to buy the product, the cashier can process sales activity by using equipment such as barcode reader or scanner to identify the item. The product description and price will be called from the database and automatically displayed on the monitor. This process simplifies the procedure for the cashier who will not need to key the price, and reduces both working procedures and the possible mistakes from the price key-in process. Furthermore when the price of the product is changed, there is unessential to adjust the price tag on the typical package. The price of the product is changed in the database so the pricing mistakes can be reduced at the cash register from using outdated prices.

2) *Daily Sales Report*

On each day, at the completion of sales activity, the system will automatically generate daily sales reports in the main computer. It will not disrupt service time of the POS at the sales area. The reports will be either printed from the printer or displayed on the monitor. The report may customized the requirements of the users. It can report sales of individual items which is unable to do ordinarily in the process of cash register.

3) *Sales Data Transmission*

When daily sales reports are complete, the sales data will be sent to other applications such as inventory control systems, sales analysis systems, *accounting* systems, and so fourth.

4) *Financial Report*

The financial reports will be made to display net income and financial status of the store. The find out represented in the report will be used as a guideline to improve financial performance of store.

Advantages of the POS System

The POS system in the market place, which is used in retail businesses may be expected to generate benefits as follows.

1) *Store Performance*

The POS system will provide the itemized information requirements. The use of this information will help the store to improve both service level and inventory level. Service level of an inventory in this case is defined as the proportion of time the item is available in the store, and the inventory level is the average quantity level of that item over time.

2) *Service Quality*

The implementation of POS system in the store will increase the speed of service at the selling point and the accuracy of the price key-in will be better than using traditional calculators or electronic cash register machines. These will enhance to improve and increase customer satisfaction.

3) *Image and Brand Loyalty*

The use of modern equipment will help to create a positive image of the store. The customers will be inclined to think that the company is trying to improve quality of service for them. The brand loyalty will be improved as well.

4) *Strategic Management Tool*

By using the POS system, the management can obtain a picture in a short period allowing for faster responses to changing market conditions.

BOWERSOX, CLOSS, and COOPER (2003) described the logistical interfaces that the efficient and effective coordination of manufacturing strategy with the procurement of materials and components ultimately relies on logistics. Resource input must be procured and made available when needed for manufacturing operations. Whether the manufacturing strategy is MTO, ATO, or MTP, logistics links the supplier base with manufacturing processes. Clearly, the more seamless the interface, the better the opportunity is for achieving lowest cost of ownership and, ultimately, lowest total cost of manufacturing. Such operations only emerge when there is high-level supplier integration in both operations and in design. Just-in-time, Materials Requirements Planning, and Design for Logistics represent three approaches to achieving desired coordination.

Just-in-Time (JIT)

This technique has received considerable attention and discussion in recent years in every functional area related to supply chain management. Sometimes referred to as just-in-time production, often called just-in-time purchasing, and frequently referred to as just-in-time delivery, the goal of JIT is to time-phase activities so that purchased materials and components arrive at the manufacturing or assembly point just at the time they are required for the transformation process. Ideally, raw material and work-in-process inventories are minimized as a result of reducing or eliminating reserve stocks. The key to JIT operations is that demand for components and materials depends on the finalized production schedule. Requirements can be determined by focusing on the finished product being manufactured. Once the production schedule is established, just-in-time arrival of components and materials can be planned to coincide with those requirements, resulting in reduced handling and minimal inventories.

The implications of JIT are numerous. Obviously, it is necessary to deal with suppliers who have high and consistent levels of quality, as their components will go directly into the finished product. Absolutely reliable logistical performance is required and eliminates, or at least reduces, the need for buffer stocks of materials. JIT generally requires more frequent deliveries of smaller quantities of purchased inputs, which may require modification of inbound transportation. Clearly, to make JIT work, there must be very close cooperation and communication between a manufacturer's purchasing organization and suppliers. In JIT operations, companies attempt to gain the benefits of backward vertical integration but avoid the formal tie of ownership. They achieve many of the same ends through coordination and process integration with suppliers.

Originally, JIT was applied to manufacturing processes characterized as MTP since the effective functioning of the system is dependent upon a finalized production schedule. However, as manufacturing strategies have evolved with more emphasis on flexibility, reduced lot-size production quantities, and quick changeovers, JIT concepts have evolved to accommodate ATO and MTO manufacturing as well. In many situations, lead suppliers are used by manufacturers to sort, segregate, and sequence materials as they flow into assembly operations. The goal is to reduce handling and facilitate continuous JIT.

Some organization, seeing the benefits of JIT systems and recognizing the benefits of supplier integration, have gone so far as to bring their suppliers' personnel into their production plants. The supplier personnel are empowered to use the customer's purchase orders, have full access to production schedules, and have responsibility for scheduling arrival of materials. Originally introduced by the Bose Corporation, the term JIT II has been applied to these efforts to reduce lead times and cost.

Requirements Planning

In complex manufacturing organizations a process known as Materials Requirement Planning (MRP) is frequently used to aid in the interface between purchaser and supplier. MRP systems attempt to gain benefits similar to those of JIT, minimize inventory, maintain high utilization of manufacturing capacity, and coordinate delivery with procurement and manufacturing activities. Implementation of MRP systems requires a high level of technological sophistication. Software applications such as advanced planning and scheduling systems have been developed to deal with the complexity of information required, such as lead times, quantities on-hand and on-order, and machine capacities for literally thousands of materials across multiple manufacturing locations.

Design for Logistics

The logistics interface with procurement and manufacturing, as well as with engineering marketing, can be greatly enhanced by incorporating a concept known as Design For Logistics into the early phases of product development. The objectives of JIT and MRP are to minimize inventories and handling, with materials and components being ready for assembly or transformation, as they are needed. How a product is designed and design of the components and materials themselves can have a significant impact on this process. In particular, product packaging and transportation requirements need to be incorporated into the design process. Furthermore, product and component design must have consideration of transportation and internal materials handling methods to ensure that cost-efficient, damage-free logistics performance can be achieved. Similar design considerations must be made for the finished product itself.

E-Commerce and Procurement

The explosion in technology and information systems is having a major impact on the procurement activity of many major companies. Much of the actual day-to-day work in procurement has traditionally been accomplished manually with significant amounts of paperwork, resulting in slow processes subject to considerable human error. Applying technology to procurement has considerable potential to speed the process, reduce errors, and lower cost related to acquisition.

Basic Electronic Procurement

Probably the most prevalent use of electronic commerce in procurement is **Electronic Data Interchange (EDI)**. EDI, as the term implies, is simply the electronic transmission of data between firm and its supplier. This allows two or more companies to obtain and provide much more timely and accurate information. There are many types of data being transmitted directly, including purchase requisitions, purchase orders, purchase order acknowledgement, order status, and tracking and tracing information. The explosion in EDI usage during the late 1990s was a direct recognition of its benefits, including standardization of data, more accurate information, more timely information, shortening of lead times with associated reductions in inventories, and reduced TCOs.

At its most basic level, EDI is a major component of integration between buyers and sellers. At least in theory, buyers can communicate quickly, accurately, and interactively with suppliers about requirements, schedules, orders, invoices, and so forth. It provides a tool for transparency between organizations, which is needed to integrate processes in the supply chain.

Another basic application of electronic commerce in procurement has been the development of electronic catalogues. In fact, making information available about products and who can supply them is a natural application for computer technology. Electronic catalogues allow buyers to gain rapid access to product information, specifications, and pricing. When tied to EDI systems, electronic catalogues allow buyers to quickly identify and place orders for needed items. Many companies have developed their own online electronic catalogues and efforts have also been devoted to developing catalogues containing products from many suppliers, which will allow buyers to compare features, specifications and prices very rapidly. These tools potentially can bring significant savings in procurement, especially for standard items for which the primary criterion is purchase price.

The Internet and B2B Procurement

The real excitement in procurement related to e-commerce is the development of the Internet as a B2B tool. Even more so than in the business-to-consumer realm, the Internet and the World Wide Web are expected to have a major impact on how businesses interact with one another. As early as 1996, several major organizations, including General Motors and Wal-Mart, announced that suppliers who were not capable of conducting business via the Internet would be eliminated from consideration. Estimates of the future for B2B e-commerce vary even more wildly than business-to-consumer, but at least one respected authority predicts B2B Internet transactions could reach over $ 1 trillion by 2005.

One advantage of the Internet relative to traditional EDI is that it overcomes some of the technical issues of compatibility of computer systems, which is required in EDI. The Internet itself provides, capability for buyers and sellers to exchange files and information easily. General Electric created a "Trading Process Network" that turned a once completely manual process for producing custom-designed parts into an electronic system. The system sends requests for quotation along with drawings and specifications to vendors worldwide. GE reports that the system has reduced acquisition costs significantly and perhaps more importantly, reduced cycle times by as much as 50 percent.

In a supply chain management context, the link between a company and its external suppliers is critical. It provides for the integration of materials and resources from outside the organization into internal operations. Procurement is charged with the responsibility of ensuring that this transition is accomplished as efficiently and as effectively as possible. Much of the concern in procurement is focused on the logistical interface between the organization and its supply base. Ultimately, the purpose of procurement is to integrate material flow in accordance with manufacturing requirements.