THE FIRST STEPS TO INVENTORY MANAGEMENT

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INTRODUCTION

Holding inventory is often interpreted as carrying an asset but also means carrying risk in terms of obsolescence, deterioration and quality faults [1]. In financial terms inventory impacts the balance sheet, cash flow and profit and loss accounts. Operationally inventory affects production efficiencies and on-time delivery. In his book *"The Goal"* Goldratt [2] identifies inventory as a key component for measuring business performance in a manufacturing environment. In short, good inventory management is essential to achieving business objectives and building competitive advantage. Yet the traditional techniques most often used to manage inventory do not always provide optimal solutions. Driven by a greater emphasis on customer service and cost control and the advent of new technologies, inventory management is rapidly moving to a higher level of sophistication.

This paper is the first in a series of three that looks at the alternative options available to optimise inventory held at an aggregate and part level by considering the steps necessary to move towards inventory optimisation. The intent of these papers is to provide a simple guide to enable managers within manufacturing industries to advance their organisation to the next level of inventory management. So, whether you are an experienced inventory manager with a deep understanding of inventory matters working with a sophisticated stock system or a relative beginner in an organisation with no system at all, there should be something of value for you and your organisation here.

The focus of this paper is on the basics and looks at the first steps to inventory management through achieving inventory control and instigating a simple 3-class management system. The second Paper titled 'Professional Inventory Management' introduces further inventory management principles, such as the use of 6 or more classes and the analysis of safety stock that extend the options for managers to improve inventory performance. The third and last paper 'Advanced Inventory Management' looks at K-Curve theory and the impact of system parameters on stock levels. Each paper is structured along similar lines and contains background theory, the requirements for operating at the level under discussion, a worked example using data from the manufacturing industry and a concluding summary.

THE FIRST STEPS TO INVENTORY MANAGEMENT

In this, the first of a three part series, we start with the basic concepts required to achieve inventory control and lay the foundations for a simple 3-class inventory system.

WHAT IS INVENTORY?

All operations keep inventory, which refers to the stored materials that exist within an organisation and applies to raw materials, purchased parts, work in progress and finished goods. The terms inventory and stock are used interchangeably, as is the case here, although by definition inventory is usually referred to in value (pounds, dollars) and stock in quantity (kg, 100s, metre). Inventory primarily arises because of differences in the timing or rate of supply and demand and is used to balance these. Inventory may also occur due to economic batch sizes for an operation, WIP, product seasonality and investment for new product ranges.

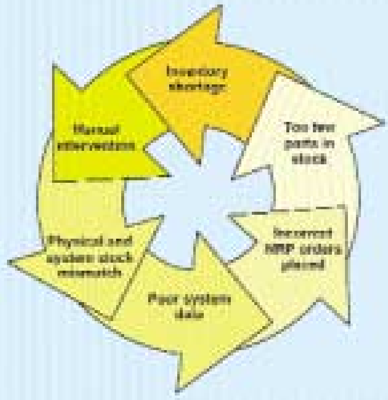
INVENTORY CONTROL, MANAGEMENT AND PLANNING

Inventory control refers to the events or activities that affect inventory during the process of transforming input resources and materials to output goods. Different stock items are however controlled in different ways, for example in an assembly operation nuts and bolts are not treated in the same way as high value, long lead time parts. Control is a necessary step on the road to optimising inventory and requires that relevant business processes are in place to enable materials to be tracked through the system and accurate data records maintained. In this way the quantity and location of physical stock are tied to system data records.

Poor inventory control, often due to manual intervention, leads to self-perpetuating errors, as shown in the typical scenario presented in Figure 1. The resulting vicious circle must be broken before control can be gained.

FIGURE 1

A Typical Scenario Resulting from Poor Inventory Control



Two commonly used measures indicative of good inventory control are:

a) The book to actual stock variances following periodic stocktakes, which should show a cumulative variance of $\leq 5\%$ and ideally decrease over time, and

b) Instances of mis-matched physical stock and system data, which often manifest themselves as a shortage or a zero physical stock when the system shows a certain number of items in stock. Again the instances should show a trend decrease over time.

The use of cycle counting or perpetual physical inventory (PPI) checking to verify that the data records for quantity and location match the physical stock provides information on the level of control achieved and allows targets to be set and monitored.

Achieving inventory control is a precursor to inventory management, which is concerned with the means used to balance conflicting organisational objectives on the overall level of stock held, and to determine optimal inventory levels for each item. These conflicting objectives include achieving manufacturing efficiencies, a high level of customer service and low procurement costs and drive some parts of the business to increase inventory and other parts to decrease it. For example, sales are primarily concerned with delivery of the desired product in the best time frame to satisfy customer demand, and therefore encourage the business to keep finished goods stocks high. Production want all parts to be available to keep line efficiency high and run large batch sizes, again increasing inventory. Purchasing order large batches of materials to achieve better cost breaks once again increasing inventory. On the other hand, product development may want to keep inventory low to hasten the introduction of new products and senior management will want to decrease inventory as it ties up cash flow.

Often the business swings from one extreme to the other without achieving a desirable balance. In one common scenario customer demand, manufacturing efficiencies and low procurement costs lead to untenably high stock levels that result in high carrying costs and large write-offs for obsolescence. Another scenario is at the other extreme where stock levels are low resulting in poor service levels and missed sales, manufacturing efficiencies suffer due to lack of parts and material costs are high. These issues and their associated costs must be managed and inventory planning attempts to reconcile the discrepancies between supply and demand and strike a working balance between the carrying costs, opportunity costs and stock out costs. Similarly, operational efforts, such as just in time (JIT), try to match supply and demand and can succeed in reducing inventory levels. One aspect of inventory planning, demand forecasting accuracy, is critical to achieving optimal inventory levels due to its impact on buffer stock as will be seen in the second paper.

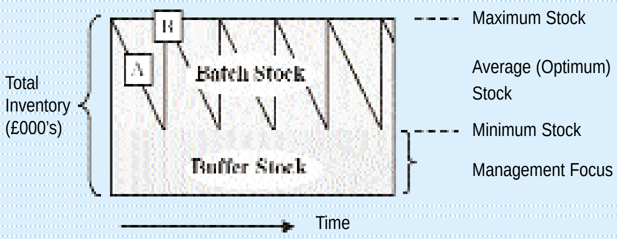
Inventory control, management and planning are key to improving inventory performance and are the responsibility of all employees who have an impact on inventory whether through forecasting, ordering, receiving, quality assessment, storage, distribution or use in manufacture. Educating staff on the impact of their actions, setting targets, measuring and communicating performance are thus essential activities in the optimisation process.

DEFINITION OF TERMS

For our purposes here total inventory is considered as composed of two separate, but related components: batch stock and buffer stock (Figure 2).

FIGURE 2

A Simple View of Inventory



Most people are familiar with **Batch Stock** (or cycle stock) as the stock ordered on a regular basis to meet demand and allow operations to cope with not making all products simultaneously. Batch stock cycles at their simplest are represented by the familiar saw-tooth pattern although in practice this can look much more irregular than shown in Figure 2. Inventory decreases gradually based on demand (point A) and rises sharply as incoming orders are delivered (point B). As previously mentioned, total inventory is measured in value.

Buffer Stock (or safety stock) is often the main focus of management attention due to its relationship to customer service levels. It is used to compensate for uncertainties in the timing and volume of supply and demand and often builds through over-production in response to poor availability with the intent to safeguard against future shortages. Buffer stocks are discussed in more detail in the second and third papers.

Another useful measure of inventory is the **Annual Usage Value (AUV),** which at a part level is given by the average (on an annualised basis) cost of the item multiplied by its annual use (in singles). For example, an item with an average annual cost of £2.50 and an annual use of 40,000 will have an AUV of £100,000. As will be seen later, knowing the AUV allows the **Average Inventory** to be calculated at the aggregate level. This is the sum of the buffer stock and batch stock at part level at a point in time and at this stage no further distinction is made between the two as this is dealt with in the further articles.

A measure related to AUV is the **Daily Going Rate (DGR).** This is equal to the AUV divided by the number of working days and gives an average demand per day figure.

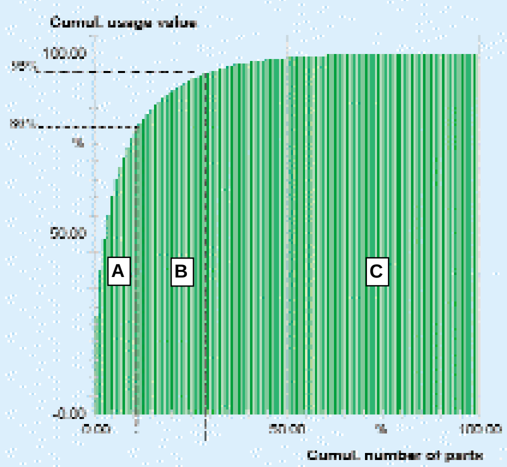
SIMPLE STOCK CLASSIFICATION

Assuming that a good degree of inventory control has been achieved, as measured by stock variance or shortage instances, the first step in inventory management is to categorise the different items of stock, in short a classification system. There are many tools and methods for classifying inventory using different bases (value, volume, seasonality etc.) however the most common means of classifying stock is the **ABC** technique.

ABC classification uses a Pareto distribution of cumulative Annual Usage Values, such as that shown in Figure 3, to assign parts to each of three classes. For the traditional 3-class system, parts with cumulative annual usage values from 0% to between 75 – 85% are typically categorised as Class 'A' items,

FIGURE 3

Example of a Pareto Curve ABC Classification



from 75% to between 85%- 98% as ‘B’ items and the remainder to 100% as ‘C’ items. The setting of the class boundaries in percentage terms is critical to the overall inventory value but often these boundaries are set by reference to previously used values or by feel. This may in part be due to the lack of ready information available on the impact of different boundary points. In this way those familiar with the 80:20 rule would tend to set the ‘A’ class boundary at 80%.

Once all items have been allocated to a class an order frequency compatible with the business cycle is set, typically in our 3-class system this is weekly for ‘A’ class items, monthly or 4-weekly for ‘B’ class and bi-annually or annually for ‘C’ class.

The 3 classes may also be treated in different ways for the method of ordering, for example class C items may be ordered on a Kanban (two-bin) basis, class B by MRP and class A through a JIT system.

The average inventory (as Figure 2) I_A, I_B, I_C, for each class is given by:

$I_A = \frac{1}{2}\ AUV_A + F_A$ [1] AUV = annual usage value = annual demand x unit cost

F = order or delivery frequency p.a. = no. of working days ÷ batch days

Alternatively using DGR;

$I_A = \frac{1}{2}\text{Batch Days}_A \times DGR_A$ [2] Batch days = no. of days between orders

DGR = Daily Going Rate = AUV ÷ no. of working days

Summing the average inventory for each class from equation [1] and repeating for different class boundaries gives a possible range of total inventory values. In each case the number of batches or orders required per class can also be calculated by multiplying the number of parts per class by the order frequency. In this way inventory can be managed at the aggregate level through targeting a desired overall stock holding and the resources required to manage inventory in terms of the numbers of orders that need to be placed, deliveries received, inspections carried out and stock put away. At the class level the order frequency and means of ordering can be decided while at part level an assessment can be made on how individual parts should be ordered and managed.

A WORKED EXAMPLE OF AN ABC CLASSIFICATION

An ABC classification can be easily conducted using a spreadsheet programme such as Lotus 1-2-3 or Microsoft Excel. The only data requirements are a list of all stock items by part number, their unit cost and annual usage quantity.
The steps required are:

1. Import data into the spreadsheet. Often this is best accomplished through a flat text file.

2. Add columns for AUV, Cumulative AUV, Cumulative AUV as % of Total AUV and calculate:

   a. AUV for each item (AUV = unit cost x annual quantity usage) and sort in descending order of value

   b. Cumulative AUV for each item

   c. % Cumulative AUV. Note that this is equivalent to the y-axis of the Pareto distribution shown in Figure 3. A Pareto graph can be drawn by plotting the cumulative % of parts along the x-axis.

3. Decide break points in percentage terms of cumulative AUV for each class (the example below starts with A=80%, B=90%, C=100%) and assign an order frequency to each class (the example below uses A=5 working days, B=20 working days, C=250 working days, based on a 5 day working week and a 250 day working year). Calculate:

   a. Average inventory per class and total average inventory (class inventory is derived from 0.5 x (sum of AUV for class/Frequency of orders)

   b. Number of parts per class

   c. Orders per annum per class and total orders.

4. Vary the parameters for class boundaries and order frequency per class to arrive at alternative scenarios for average inventory and total orders.

Figure 4 presents a snapshot of an analysis using data from the manufacturing industry with initial parameters set as described above. For reference the Pareto distribution of the stock in our example is about 80/10, ie. 10% of the parts represent about

FIGURE 4

Example Spreadsheet Analysis for an ABC Stock Classification

PART NUMBER	UNIT COST	ANNUAL USAGE	AUV	CUMULATIVE AUV	CUMULATIVE % AUV	CLASS	CUMULATIVE # OF PARTS	CUMULATIVE % OF PARTS
xxxxxa	4.17	200,230	833,047	833,047	1.33%	A	1	0.01%
xxxxxb	22.30	34,924	767,481	1,602,528	2.56%	A	2	0.02%
xxxxxc	7.06	76,415	541,015	2,143,543	3.42%	A	3	0.04%
xxxxxd	6.59	82,009	540,490	[illegible]	[illegible]	A	4	0.05%
xxxxxe	9.68	46,305	448,231	3,128,114	4.99%	A	5	0.06%
xxxxxf	13.47	33,150	451,578	3,579,692	5.68%	A	6	0.07%
xxxxxg	[illegible]	5,206	388,739	3,968,431	6.30%	A	7	0.08%
xxxxxh	21.40	17,540	376,025	4,325,376	6.90%	A	8	0.10%
xxxxxi	23.12	16,001	369,936	4,695,312	7.49%	A	9	0.11%
xxxxxj	97.81	3,918	366,101	5,061,313	8.07%	A	10	0.12%
xxxxxk	37.02	9,885	365,019	5,427,132	8.65%	A	11	0.13%
xxxxxl	87.96	3,968	349,173	5,776,345	9.21%	A	12	0.14%
xxxxxm	3.66	83,115	305,103	6,081,860	9.70%	A	13	0.16%
xxxxxn	99.89	2,990	298,716	6,380,176	10.17%	A	14	0.17%
xxxxxo	67.53	4,578	290,850	6,671,026	10.64%	A	15	0.18%
xxxxxp	1.35	333,384	236,269	6,907,295	11.08%	A	16	0.20%
xxxxxq	4.22	51,448	270,258	7,218,099	11.50%	A	17	0.21%
xxxxxr	55.08	4,825	268,640	7,486,742	11.94%	A	18	0.22%
xxxxxs	[illegible]	9,806	266,854	7,753,596	12.36%	A	19	0.23%

Class	Boundary	% Parts
A	80%	12.1%
B	90%	21.3%
C	100%	100.0%

Working Days per annum 250

CLASS	AUV	Order Days	Frequency p.a
A	50,182,968	5	50
B	6,271,486	20	12.50
C	[illegible]	250	1
Total	62,713,389		

CLASS	Av. Inventory	# Parts	# Orders
A	501,830	779	38,950
B	250,979	599	7,488
C	3,137,967	5,079	5,079
Total	3,890,577	6,457	51,517

FIGURE 5

Impact of Alternative Class Boundaries (± 3%) for ABC Stock Classification

Class	Boundary	% Parts
A	83%	14.1%
B	93%	26.6%
C	100%	100.0%

Working Days per annum 250

CLASS	AUV	Order Days	Frequency p.a
A	52,047,658	5	50
B	6,271,356	20	12.50
C	4,394,374	250	1
Total	62,713,389		

CLASS	Av. Inventory	# Parts	# Orders
A	520,477	910	45,500
B	250,854	809	10,113
C	2,197,187	4,738	4,738
Total	2,968,518	6,457	60,351

Class	Boundary	% Parts
A	77%	10.5%
B	87%	17.6%
C	100%	100.0%

Working Days per annum 250

CLASS	AUV	Order Days	Frequency p.a
A	48,275,637	5	50
B	6,278,138	20	12.50
C	8,159,614	250	1
Total	62,713,389		

CLASS	Av. Inventory	# Parts	# Orders
A	482,756	675	33,750
B	251,126	464	5,800
C	4,079,807	5,318	5,318
Total	4,813,689	6,457	44,868

The box on the left shows the impact of increasing the class boundary for A and B class parts by 3% i.e. from 80% to 83% and 90% to 93% respectively. The box on the right shows the effect of decreasing the boundaries by 3%

80% of the annual usage value. A further business measure, turnover, can be derived as follows:

Turnover = AUV ÷ Average Inventory

Alternative scenarios can easily be prepared (see Figure 5) by varying the class boundaries to give a range of values. An analysis of this sort aids understanding at the aggregate, class and part levels. At the aggregate level the overall average inventory carried and the number of orders processed can be derived. Assigning an inventory carrying cost gives an indication of the cash tied up in stock and is often a stimulus to action. Similarly if there is an agreed cost for order processing (a notoriously difficult figure to derive [3]) an overall cost can be assigned to these activities. Setting financial targets for overall inventory and order processing resources allows the costs calculated to be assessed in the context of the financial requirements of the business and can initiate debate on the desired inventory and resource level.

At the class level the means of handling items in each class can be assigned recognising that A class items are likely to have high value and/or high volume while C class parts are likely to be low value and/or low volume items. Options for changing the order frequency and class boundaries exist and these should be examined in the context of the discussions above due to their impact on overall inventory and number of orders. The examples in Figure 5 are a good illustration of the impact of changing the class boundaries by 3% in either direction. Comparison with the starting position in Figure 4 reveals significant differences in the overall inventory and order levels.

The changes are summarised in Figure 6 and require some explanation. Taking the scenario where A & B class boundaries are increased by 3% (Delta 1 box in Figure 6) moves 341 parts from class C into class B and 131 from class B into class A. The parts as previously are allocated to each class on the basis of their AUV, which has not changed per part or in total but has changed for each class. Shifting the class boundary has two effects:

1. The average inventory per class and the total average inventory change
2. The number of orders per class and the total system orders change.

In our example the total inventory decreases by €0.92m or 23.7% while the number of orders increases by 8,834 or 17.1%. The reason for this is that a greater number of parts are now classified as either 'A' or 'B' and hence ordered more frequently (increasing the number of orders). With more frequent orders the average inventory required to satisfy demand before the next order cycle decreases.

At part level the analysis helps identify grossly overstocked or understocked materials and highlights the highest annual usage value parts, which require the most attentive management.

FIGURE 6

Impact of Alternative Class Boundaries (± 3%) for ABC Stock Classification Compared to the Starting Conditions with Boundaries of A=80%, B=90%, C=100%.

Delta 1 (+3%)

Class	Δ Boundary	Δ # Parts	Δ % Parts	Δ AUV
A	3%	131	[illegible]	[illegible]
B	3%	210	35.1%	[illegible]
C	0%	-341	-6.7%	[illegible]

Class	Δ Av. Inventory	Δ % Av. Inventory	Δ # Orders	Δ % Orders
A	[illegible]	[illegible]	[illegible]	[illegible]
B	-129	[illegible]	[illegible]	35.1%
C	[illegible]	-30.0%	-341	-6.7%
Total	[illegible]	-23.7%	8,834	17.1%

Delta 2 (-3%)

Class	Δ Boundary	Δ # Parts	Δ % Parts	Δ AUV
A	-3%	-104	-13.4%	[illegible]
B	-3%	[illegible]	[illegible]	[illegible]
C	0%	239	4.7%	[illegible]

Class	Δ Av. Inventory	Δ % Av. Inventory	Δ # Orders	Δ % Orders
A	[illegible]	[illegible]	[illegible]	-13.4%
B	146	0.1%	[illegible]	[illegible]
C	[illegible]	30.0%	239	4.7%
Total	[illegible]	23.7%	[illegible]	-12.8%

Understanding that the A parts carry a significant value and impact to the business allows for more focused attention to be given to these parts and in this way the ABC classification and analysis serves to help gain inventory control and then to manage inventory.

Using different values for boundaries allows a planned approach to optimising inventory to be made. The large change in total inventory (-23.7%) and number of orders (+17.1%) from a small (+3%) change to the class boundaries highlights the sensitivity of using an ABC class methodology and the dangers of using a potentially sub-optimal standard boundary setting, such as 80% for A class. Setting boundaries should be approached with caution!

SUMMARY OF THE FIRST STEPS TO INVENTORY MANAGEMENT

This article has looked at the basics of and first steps to achieving inventory management beginning with inventory control:

Step 1 Inventory Control

Instigate appropriate business processes, minimising manual intervention

Tie system data on stock location and quantity to physical stock. Insist on accurate data records

Set targets and measure the degree of control through inventory variances (book to actual) and instances of physical inventory shortfalls

Educate staff.

Step 2 Basic Inventory Management

Classify inventory using a 3-class ABC system based on Annual Usage Value

Determine appropriate order frequency and order means for each inventory class

Try different class boundaries and analyse the results at aggregate, class and part level and take appropriate action.

In the next paper ‘Professional Inventory Management’ we introduce the concept of overage, look at what happens when the number of classes is increased and the impact of safety stock on overall inventory and service levels.

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