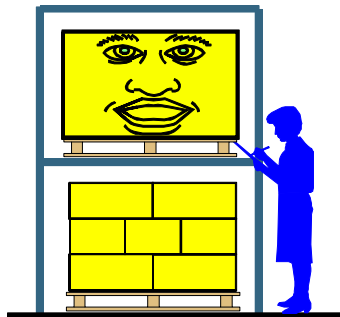


Strategos, Inc.
3916 Wyandotte
Kansas City MO 64111 USA
816-931-1414

Inventory Speaks!

What You Can Learn From Inventory Analysis



By
Quarterman Lee, P.E.
Strategos, Inc.

30 June 2011

Strategos

CONSULTANTS • ENGINEERS • STRATEGISTS

www.strategosinc.com

Inventory Speaks!

What You Can Learn From Inventory Analysis

Introduction

This article is about inventory and how inventory records can point to problems and Root Causes in a manufacturing and/or distribution system. The language of inventory, however, requires interpretation and analysis. Without such analysis is just numbers and text.

At *Strategos*, we find Inventory Analysis useful for a wide range of projects. From Facility Planning and Plant Layout to Process Improvement to Customer Service, inventory has a story to tell. This paper takes an operational rather than financial perspective, e.g., building product, serving customers, filling orders, providing facilities. In this paper we show examples of projects where inventory analysis had a major role.

We normally think of inventory as physical object, i.e., material, parts, subassemblies or products. However, the concepts discussed here generally apply to any form of work-product including paperwork or information stored on a computer disk. Sales orders waiting for review and approval, for example, are a form of inventory.

Why Inventory Matters

Scheduling & Availability

Ultimately, the only reason for holding inventory is to have work-product available when and where machines, people or customers want it. Here are some examples for illustration:

- Home Depot stocks a particular item in the store so that when a customer arrives the item is immediately available. The customer is unwilling to wait for the item and unable to order the item in advance of his/her need. Therefore, it must be in inventory or the sale is lost. Moreover, Home Depot will stock the same item in several nearby stores because the customer is unwilling to travel to that nearby store. Further, the arrival time for customers wanting the particular item is unknown and unpredictable. Hence, the need for Finished Goods (FG) inventory.
- A stock of a particular component is stored in an assembly operation so that when the assembly line needs the part for a particular product, it is readily available. The stock is necessary because it requires time to order and deliver the part and that order-delivery time is unpredictable. In addition, the need for the part is unpredictable since the assembly line schedule changes weekly. Thus the need for Purchased Parts (PP) stock.
- A stock of large machined castings is held after machining and prior to cleaning and deburr. The deburr department is working on a large batch of a different product and is not yet ready to start work on these other castings. It is difficult to schedule the upstream production so that it arrives at deburr exactly when deburr is ready for it. Thus, a queue of jobs is held.

Capital Investment

Inventory devours capital. It is usually the largest or second largest “asset” on the balance sheet and often exceeds the investment in facilities and equipment.

Carrying Cost

Few companies are aware of their true carrying cost, the total annual cost for holding their inventory. This is different from the cost of the inventory itself. The cost of the inventory is a one-time capital investment. Carrying cost recurs annually. Table 1 shows the typical ranges of carrying costs as a percent of the inventory value.

Storage and Handling	4 - 9 %
Insurance and Taxes	1 - 4%
Obsolescence	2 - 5%
Theft and Damage	1 - 4%
Cost of Money	10 - 15%
Total Range	18 - 37%

Table 1 Typical Annual Carrying Cost

Space

Inventory requires space in a warehouse or on the shop floor. This space is costly. It either has been purchased with capital funds or leased with operating funds. It is not unusual to find 50% of a factory used for inventory storage or the aisles to move the material. When new products and processes are under consideration, inventory reduction can create useful space.

Inventory As a Consequence

Eiji Toyoda is credited with the idea that inventory is the result of deficiencies in the manufacturing system and tends to hide those deficiencies. According to legend, Toyoda once asked his lieutenants, “Why do we have inventory?” When they responded with a plethora of reasons, his comment was “Very good, now would you please eliminate those reasons.”



Some of the many causes of inventory are in figure 1. There are probably many more such causes. Figure 1 illustrates the pervasive nature of the inventory issue and why it is so intractable. Almost any difficulty, anywhere in the organization can, eventually, increase inventory. Moreover, the causal chain is often obscure.

There is more discussion of these reasons and the causal chains in our article [“Inventory—Why All the Fuss?”](#) A later article will explore these reasons and the causal chains in more detail.

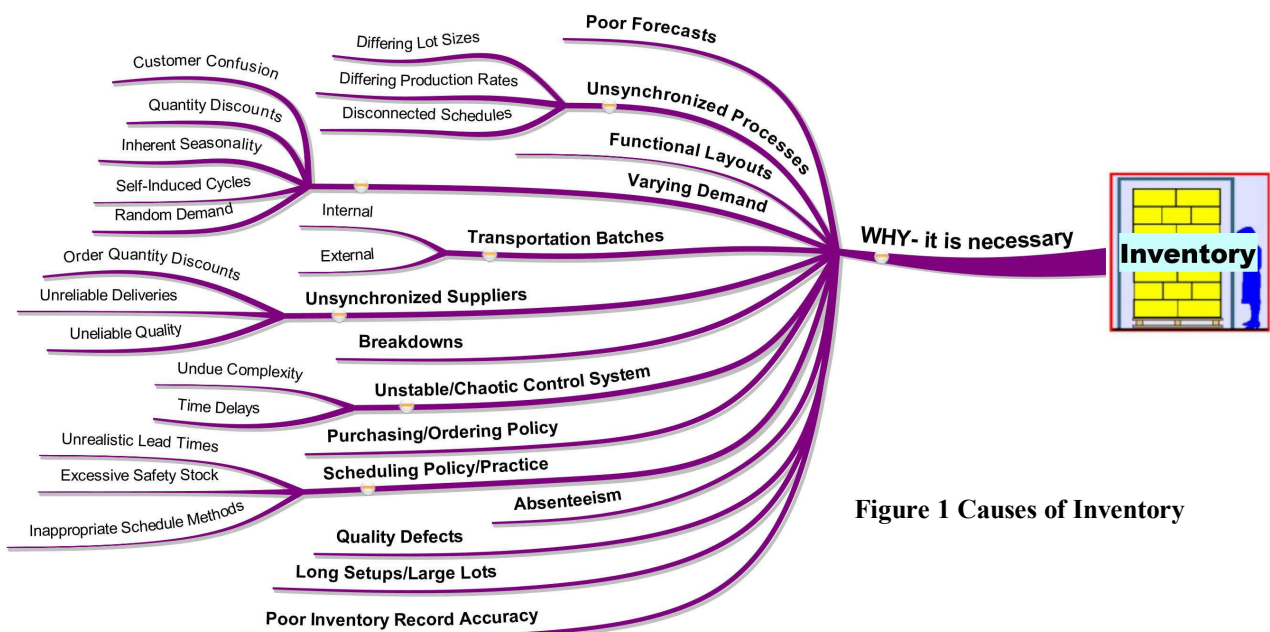


Figure 1 Causes of Inventory

Footprints in the Sand

The various causes of inventory leave a trail in the inventory records. Like footprints in the sand, these records provide clues or hints to the main causes and, thus, to solutions. In most cases, these causes are problems that have created negative effects that are far more serious than a bit of excess inventory. However, these other negative effects have not left a sufficient trail—they are long forgotten and obscured.



Like the trail of footprints, inventory records will not definitively prove or even identify the original problems. Rather, they point the way to further investigation. This is what Inventory Analysis is about.

Inventory Metrics

Dollars or Units?

The most fundamental measure of inventory is Units of Measure (U/M). This may be pieces, gallons, pounds, lineal feet or other unit and varies from SKU to SKU. U/M is most useful for the operational perspective or when examining a particular SKU.

In general, SKUs cannot be aggregated using units of measure unless they are all very similar. For the most part, SKUs are not interchangeable as production components or as items sold to a customer. When analyzing stockouts or history, the individual SKU is important and we often use U/M.

From a financial perspective, the funds invested in inventory are the primary interest. Item-by-item information is less important and there is a need to aggregate all items or various classes of items such as Finished Goods (FG), Work-In-Process (WIP) and Purchased Parts or Raw Materials (PP/RM). To do so, the value of each item is multiplied by the number of items. The sum of various items measures the total inventory in a particular class. Table 2 illustrates.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(12)
ID	SKU#	DESCRIPTION	U/M	ON-HAND	UNIT COST	ON-HAND VALUE	ANNUAL USAGE	ANNUAL COST OF GOODS SOLD	MONTHS ON-HAND	ANNUAL TURN-OVER	GROSS MARGIN	TURN-EARN INDEX
1	A-45768	BODY CASTING	PC	76	\$198.23	\$15,065.48	200	\$39,646	4.56	2.63	30%	78.9
2	A-67324	DRIVE GEAR	PC	5	\$12.34	\$61.71	46	\$568	1.30	9.20	50%	460.0
3	D-45934	BOLT-3/8-20UNFC2.0	PC	326	\$0.27	\$86.72	500	\$133	7.82	1.53	20%	30.7
4	D-88346	WASHER-1/2 ZINC PL	PC	900	\$0.03	\$27.00	200	\$6	54.00	0.22	20%	4.4
5	X-45556	RESIN-PVC	KG	2566	\$67.25	\$172,563.50	66000	\$4,438,500	0.47	25.72	10%	257.2
6	X-85667	COLORANT-BLU	GAL	55	\$59.60	\$3,278.00	110	\$6,556	6.00	2.00	35%	70.0
						\$191,082		\$4,485,409				

Turnover= 23.5

Table 2 Inventory Example

Turnover

The total dollar amount for an item or class of items can be deceptive. Fast moving items may require a larger number on-hand to satisfy customer demand than slow-moving items. Turnover incorporates sales or demand to adjust for this fact.

$$\text{Annual Turnover} = \frac{\text{Annual Sales (\$)}}{\text{Year-End Inventory Value (\$)}}$$

Equation 1 annual Inventory Turnover

This is the most common form of the equation. There are many variations. For our purposes, the variations make little difference as long as there is consistency.

One modification is to use average rather than year-end inventory. This is appropriate where seasonality exists and year-end inventory does not give a true picture. However, year-end inventory is easy to obtain from the balance sheets and average inventory may not be available. Another modification is to use different time periods, say, monthly or weekly. This is useful to identify short-term cycles or medium-term trends.

For distribution and warehouse operations, sales is usually expressed as Cost-of-Goods-sold (COGS) and inventory value as Cost-of-Goods (COG). This is the preferred method. However, there are different inventory valuation methods and the available data may dictate some other valuation.

For manufacturing, the calculation of COG varies between companies. Moreover, the presence of significant Work-In-Process further complicates the situation. For manufacturing, we often substitute sales income as the sales figure rather than COG. This introduces another variable (Gross Margin) but assures consistency. The sales data is usually more available than COG.

Turn-Earn Index

When all SKUs have the same gross margin, turnover is the only measure of inventory efficiency necessary. However, margins may differ between items. When this is the case, the Turn-Earn Index (TEI) helps account for this added variable.

$$\text{Turn-Earn Index} = (\text{Gross Margin (\%)})(\text{Turnover})$$

Equation 2 Turn-Earn Index

Slow-moving items have a bad reputation. In reality, they *can* be a profitable and an important part of the product mix under the following conditions:

- Slow movers are necessary to fill out a product line.
- They do not crowd out fast movers.
- Margins are high enough to justify their storage costs.

The TEI helps to identify those slow-movers that do not meet these conditions. Items with low turns and low margins show a low TEI. Items with slow movement but high margins show a respectable TEI. Items with high turnover and low margins also show a respectable TEI. Generally, the TEI should be above 120.

Figure 2 shows both turnover and TEI for the inventory example of Table 2. Examining turnover for the second SKU (A-67324), a turnover of 9.2 would generally be considered as adequate although it does not compare favorably with SKU #5 with a turnover of 25.7. However, SKU #2 has a high margin that gives it a TEI of 460 that is extremely good.

In contrast, SKU #5 (X-45556) shows a very good turnover of 25. However, the margin is low on this SKU and the TEI is about half of SKU #2's TEI. Still, a TEI of 260 is quite good. The remaining three SKUs have both a low TEI and low turnover. Here, both the margins and the stock level should get scrutiny. Questions to ask are:

- Can stock levels be lowered?
- Is the margin adequate to cover the cost of storage?
- Are there other good reasons (e.g. filling out product line) to maintain these items?

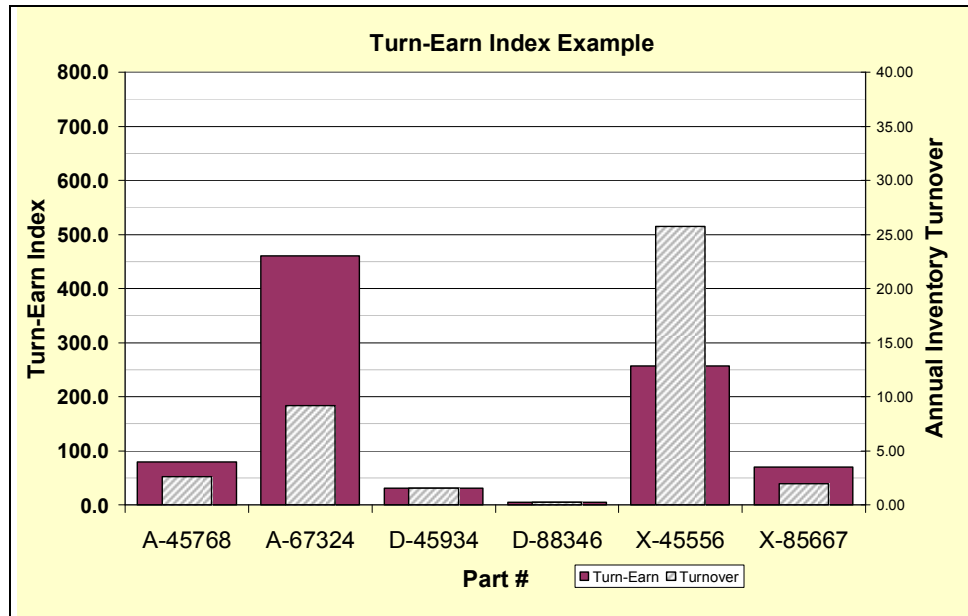


Figure 2 Turn-Earn Index Example

Level of Accuracy

Overall inventory measurements and analyses discussed here rarely require high accuracy for operational purposes. The problems that inventory points to tend to be major (although hidden) problems and small differences in valuation, turnover, TEI or inventory value do not affect major conclusions.

This is not the same as Inventory Record Accuracy, the measure of how many individual records match the physical inventory in count and location. Inventory Record Accuracy (IRA) is very important to operations and does require high accuracy.

Inventory Analysis

An operational inventory analysis uses the previously discussed metrics to identify areas of concern. It points the way to further investigations and possible solutions that improve operations and reduce unnecessary inventory.

There is no fixed format or detailed procedure for an inventory analysis. The format depends on the data available. The precise lines of inquiry depend on the situation as it reveals itself during the investigation. In many ways, it is like Sherlock Holmes investigating a murder. Accordingly, we illustrate the analysis with many examples from past projects rather than a detailed sequence of tasks and outputs.

Much of the data required comes from the inventory management system or an ERP/MRP system. This extraction process requires a person who is familiar with the system, the contents of various databases and the extraction process. In most cases, the data is best extracted to an Excel spreadsheet format. There may be several of these extraction files. Extraction files should include the basic fields such as part#, Description, U/M and On-Hand. There may also be additional fields that will prove useful. These additional fields might indicate a class of item, product line, storage location or other information. When in doubt about the usefulness of a possible extraction field, include it in the extraction file. It is easy to delete fields that prove irrelevant but often difficult to add them in later. Table 2 illustrates.

This process may take some imagination. For example, few inventory systems maintain a history of On-Hand Quantity. However, this can be generated for a particular SKU by combining the current On-Hand with the transaction history for that item.

Product-Volume Analysis (PV)

A PV analysis examines the relative production or sales volume for various products and product groups. The purpose is to understand the product mix and volume. The analysis is helpful for many types of projects including: facilities planning, warehouse design, and process improvement. It often complements the inventory analysis and, since it uses some of the same data, we include it here.

A product-volume analysis answers questions such as:

- What is the current annual, monthly, weekly or daily volume for each item?
- What are the volumes for groups of similar items?
- Will there be significant changes in the relative volumes?
- How will total volume change in the future?
- Are there seasonal (or other) patterns in the volumes?

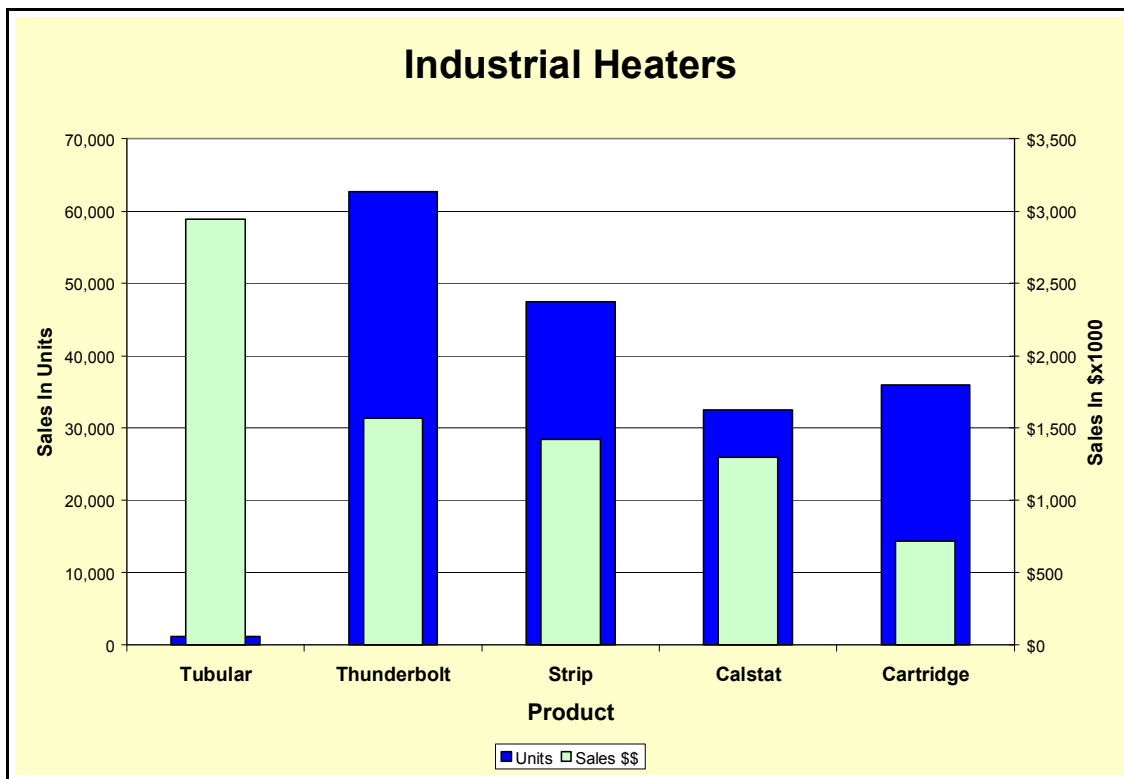


Figure 3 typical Product Profile

Figure 3 shows the current product groups and volumes for a manufacturer of industrial heater modules. One set of bars denotes the dollar value of sales and is ranked by sales dollar volume. The second set of bars denotes units of production. Notice that the tubular heaters rank highest in sales dollars but lowest in production units. This is because they are very expensive and, presumably, have high margins.

Figure 3 is actually not typical. Most firms have a much higher fraction of low-volume products coupled with only a few very high-volume products. This can raise important issues of pricing, overhead allocation and profitability.

Figure 4 came from a plant layout project for a company with two major product lines. It shows the sales history for each line and the total.

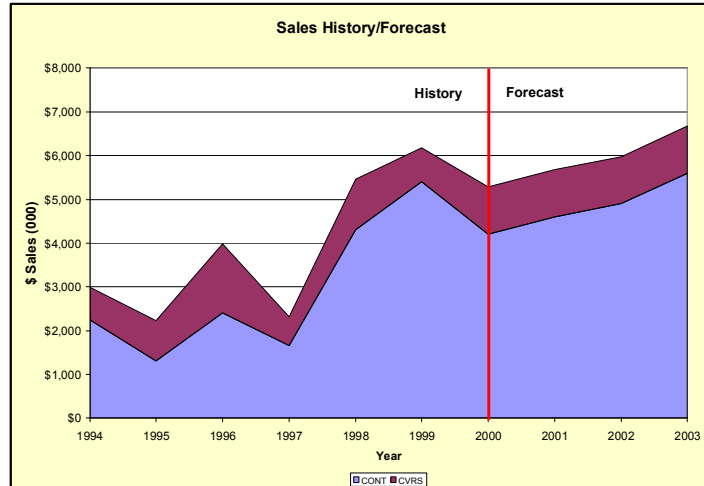


Figure 4 Typical Sales History/Forecast by Product Group

Most of their growth is on the “container” product line and this has important implications for future facility planning, Manufacturing Strategy and business strategy.

Industry Turnover Comparison

Turnover is one of the most important inventory metrics. A firm may track turnover to determine trends, identify anomalies, make decisions and monitor progress. It can also benchmark against others in their industry.

Since turnover is a common financial measurement, financial data sources such as Standard & Poor or Dun & Bradstreet provide such data for specific firms or as industry averages. Several cautions are in order when using such data:

- Two firms are rarely alike in all respects and turnover data may reflect these differences.
- Financial data may come only from public companies and these tend to be larger firms.
- A given industry may have wide turnover variations even from apparently similar firms.
- Turnover data is usually buried in a sea of other financial data and finding it is inconvenient.

One good source of turnover data is the U.S. Census Bureau’s American Factfinder site. The data includes firms of all sizes and is arranged by NAIC code (formerly SIC code). However, calculating turnover from this extremely detailed data is not easy. Strategos has extracted the relevant parts from the Census Bureau data and put it in a convenient form for inventory analysis. A section of this spreadsheet is in figure 5. You may purchase a copy of the manufacturing data at:

http://www.strategosinc.com/articles/manufacturing_inventory_turnover_data.htm

The corresponding wholesale & Distribution data is at:

http://www.strategosinc.com/articles/warehouse_inventory_turns.htm

1) Click on header numbers at far left to expand data outline.
2) Click on (+/-) at left to expand individual sections.

Raw Data Source
2007 Economic Census
U.S. Department of Commerce
Economics & Statistics Administration
U.S. Census Bureau

Average workers reported per year in production

1) Average of reported inventories for Beginning of Year and End of Year.
2) This is not a true average for the entire year and if repetitive seasonality exists, it may cause distortion.
3) Does not include misc inventory unrelated to production such as office supplies.

Manufacturers

Inventory Turnover (Sales/Inventory Ratio)

Inventory Distribution

Productivity

2007 NAICS Code	Description	Prod Workers	Sales (\$000)	Inventory (\$000)	Turnover (Sales/Inventory)	% Raw Materials	% Work In Process	% Finished Goods	Sales per Production Employee (\$000)
126 314	Textile Product Mills	114,168	28,684,974	3,004,896	9.5	39%	16%	46%	261
141 315	Apparel	132,692	24,299,632	2,963,144	8.2	26%	16%	69%	183
176 316	Leather & Allied Product	26,498	5,698,278	923,719	6.2	55%	10%	65%	215
177 3161	Leather & Hide Tanning & Finishing	3,472	1,530,816	117,534	13.0	35%	28%	37%	441
180 3162	Footwear	10,677	1,713,139	307,889	5.6	35%	10%	65%	160
181 31621	Footwear	10,677	1,713,139	307,889	5.6	35%	10%	65%	160
182 316211	Rubber & plastics footwear	1,902	483,865	51,942	9.3	30%	10%	60%	254
183 316213	Men's footwear (not athletic)	5,117	799,200	183,133	4.4	36%	8%	56%	156
184 316214	Women's footwear (not athletic)	2,931	352,699	62,330	5.7	33%	14%	52%	120
185 316219	Other footwear	727	77,375	10,485	7.4	51%	14%	35%	106
186 3169	Other Leather & Allied Product	12,349	2,454,323	498,296	4.9	36%	5%	69%	199
192 321	Wood Product	417,471	102,001,662	11,623,698	8.8	41%	18%	41%	244
215 322	Paper	321,937	176,018,245	14,962,988	11.8	49%	9%	42%	547
245 323	Printing & Related Support Activities	454,598	103,216,636	6,320,363	16.3	46%	24%	31%	227
261 324	Petroleum & Coal Products	68,272	606,004,340	36,249,027	16.7	30%	25%	44%	8,876
271 325	Chemical	463,802	722,493,722	68,015,265	10.6	30%	21%	49%	1,558
330 326	Plastics & Rubber Products	662,001	211,531,166	20,543,188	10.3	40%	11%	49%	320
360 327	Nonmetallic Mineral Product	365,928	127,239,683	11,844,566	10.7	38%	12%	51%	348
401 331	Primary Metal	344,662	267,851,366	32,836,436	7.9	40%	30%	30%	748
442 332	Fabricated Metal Product	1,179,280	346,104,298	42,766,931	8.1	38%	28%	34%	293
509 333	Machinery	739,449	347,930,344	51,300,892	6.8	38%	28%	34%	471
579 334	Computer & Electronic Product	497,895	395,409,844	44,223,138	8.9	38%	39%	23%	794
624 335	Electrical eqpt/Appliance/Components	296,191	129,270,659	14,541,565	8.9	42%	23%	35%	436
660 336	Transportation eqpt	1,081,651	734,244,498	76,790,115	9.6	28%	55%	17%	679
713 337	Furniture & Related Product	388,495	84,989,575	7,888,373	10.8	46%	17%	37%	219
785 339	misc	416,630	145,839,426	19,752,324	7.4	33%	16%	62%	361

Figure 5 sample of Stategos Manufacturing Inventory Turnover Data

Within an industry, the industry average turnover reflects “average,” almost a definition of mediocrity. There are often, however, a few firms that turn their inventory much faster than the average—perhaps 5-10 times faster. This is shown in figure 6. Do not assume that because a firm is near the industry average that it is “OK.” Average may be very poor performance compared to what is possible.

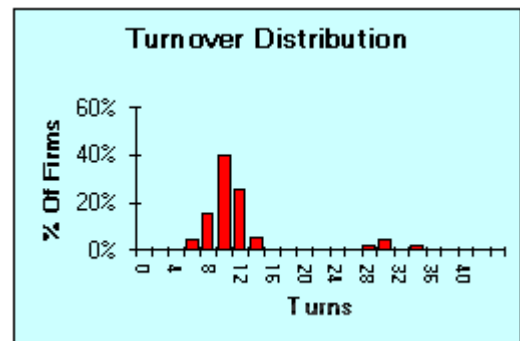


Figure 6 Typical Turnover Distribution

Production Stage Analysis

Another helpful analysis is to determine the percentage of total inventory held at each production stage. Inventory is attracted to problems. Where there is inventory, there are problems.

In warehousing and distribution operations, a production stage analysis does not apply because there is only the one stage—Finished Goods. For manufacturing or for supply chain analyses a production stage analysis can point to significant problems and, eventually, to solutions.

The distribution of inventory between RM, WIP and FG is shown for the various categories in figure 5. In the absence of industry averages, common sense applies. For example, does it make sense for a manufacturer of Made-To-Order equipment to have significant Finished Goods inventories?

A manufacturer of large specialty valves for refineries, paper mills and other process plants had an inventory distribution as shown in figure 7. This did not, at first glance, seem out of order. However, the company produced only custom-built valves, made to order. There should be no FG inventory other than a few items waiting on the dock for shipment.

Valve Specialty Company

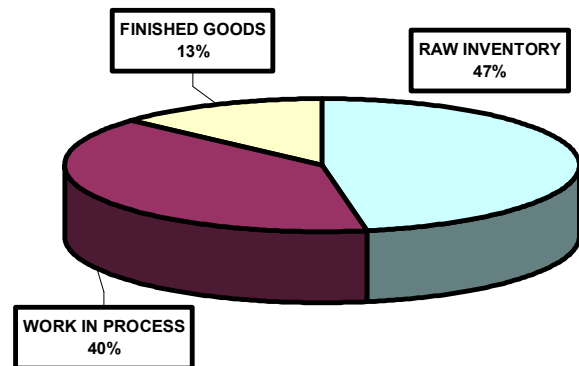
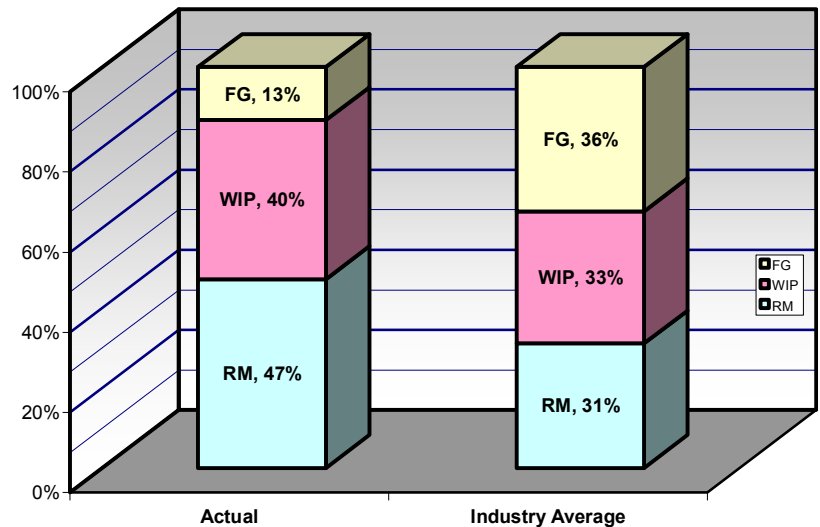


Figure 8 compares the company’s inventory distribution to a general industry average. Other firms in the industry had about equal parts RM and WIP with a bit more FG. However, these other firms built many of their products for stock so the FG stock would be expected.

Figure 7 Inventory Distribution for Specialty Valve

The relative proportions of WIP & RM were in line with industry averages but the FG stock did not make sense. Further investigation showed that most of this inventory consisted of items on an order that were waiting for completion of other items so the complete order would ship together.

Valve Specialty company



This raised the question of why all items on an order were not scheduled for completion at the same time. The answer was parts shortages on Purchased items. Scheduling put products on the schedule that had parts available and others went on hold until parts came in, even if some were on the same order. This approach kept production busy but did not help the customers or the inventory situation.

Figure 8 Industry Distribution Comparison

What first appeared to be an inventory problem, and then a scheduling problem, when followed to the root cause, was actually a supplier/purchasing problem.

Data Acquisition

Acquiring the data for the various parts of an inventory analysis is rarely difficult. Some data comes from previous year-end financial statements. Most of the charts that follow derive from a current dump of inventory status. Table 3 shows a small part of the Excel file used for many of the following charts. It is from a project with a distributor of replacement parts for off-road vehicles. We will call the company V-Parts for confidentiality reasons.

Part #	Part Desc	Current OH	Usage YTD Used	Usage YTD Sold	Usage Total	Location	\$ Value	Months On Hand
821003	SPINDLE - LEFT	0.00	0	0	0	STOCK	19.15014	#DIV/0!
00700100733	KEY, LOCK PIN FOR STEER AXLE	2.00	346	2	348	SAM134	0.1416	0.05
00700100733	KEY, LOCK PIN FOR STEER AXLE	71.00	346	2	348	B021	0.1416	1.84
00700100733	KEY, LOCK PIN FOR STEER AXLE	71.00	346	2	348	B021	0.1416	1.84
00700100733	KEY, LOCK PIN FOR STEER AXLE	1214.00	346	2	348	J201	0.1416	31.40
00700100733	KEY, LOCK PIN FOR STEER AXLE	1214.00	346	2	348	J201	0.1416	31.40
00700100734	Thrust Bearing	1.00	346	11	357	SAM136	1.3452	0.03
00700100734	Thrust Bearing	1.00	346	11	357	SAM136	1.3452	0.03
00700100734	Thrust Bearing	1.00	346	2	348	SAM136	1.3452	0.03
00700100734	Thrust Bearing	1.00	346	2	348	SAM136	1.3452	0.03

Table 3 Current Data for V-Parts, Inc.

Obsolete Part Numbers

A firm's database is often clogged with obsolete part numbers. Such was the case with V-Parts. Figure 9 was generated by locating all parts with no On-Hand Stock and zero usage for the previous nine months.

It is possible that some of these part numbers are not truly obsolete but this quick analysis was a good estimate. The part numbers are candidates for deletion or archiving.

It is also possible that some part numbers are obsolete but there is still inventory on-hand. These are identified in the following analysis and are candidates for liquidation.

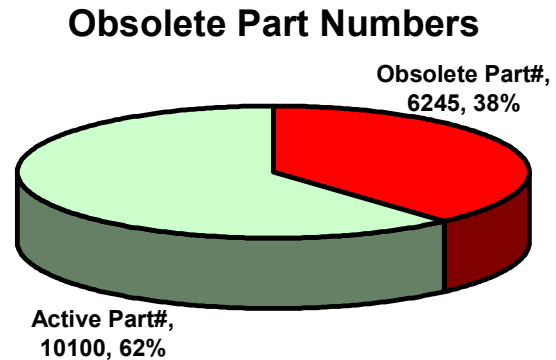


Figure 9 V-Parts Obsolete Numbers

Dead/Slow-Moving

A common cause of excess inventory and low turnover is the presence of many items that sell slowly or not at all. These slow-moving, dead and obsolete items usually have much larger stocks than necessary. The TEI is one way to identify this slow moving inventory. Another method is to rank items by months-on-hand. That is the current on-hand quantity divided by monthly average usage.

Figure 10 charts the "Months On-Hand" for each item in the inventory. This is for a distributor of off-road vehicle repair parts. For most items, the desired quantity was 1-6 months usage. This translates to 2-12 inventory turns.

The figure shows that only about 25% of the 8600 active items were in the desired range. About 13% had more than a two-year supply. Another 20% or so were likely to result in stockouts.

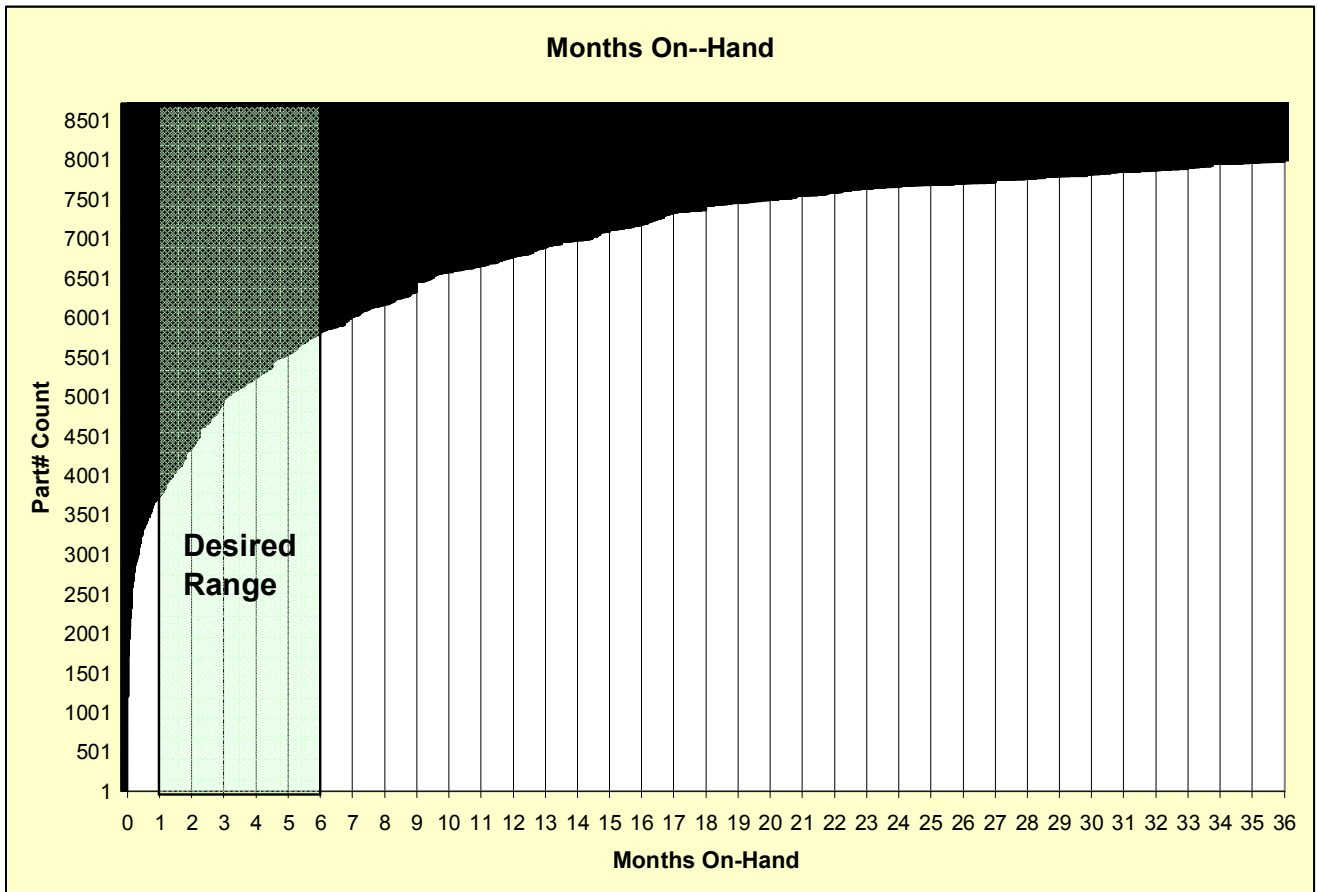


Figure 10 Months On Hand Inventory for V-Parts

Figure 11 is from a project with a distributor of industrial equipment replacement parts. This company had large overstocks on many different items.

With consistent and rational purchasing policies, overstock items should have no additional open work orders or purchase orders. It is often easy to check for open orders. In this case, we found that 12% of all overstocked items also had open purchase orders that would increase the overstock even further.

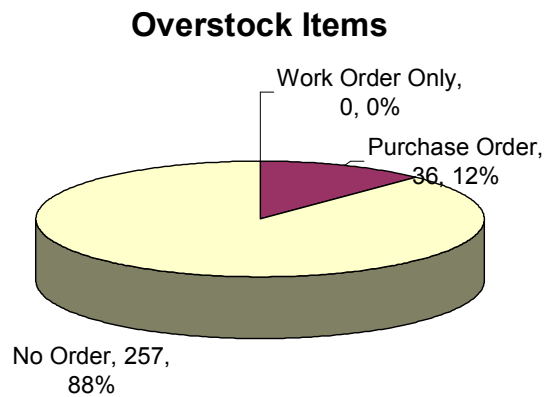


Figure 11 Replenishment of Overstock Items

Stockouts

Stockout rate is the percentage of items that cannot be supplied from existing stock. Many software packages can report on stockouts and help track the stockout rate. In the absence of such reporting, the stockout rate can be deduced from on-hand records and usage records.

For V-Parts, we looked for parts with less than .08 months or about two days usage available. As figure 12 shows, about 20% of active parts are at or near stockout.

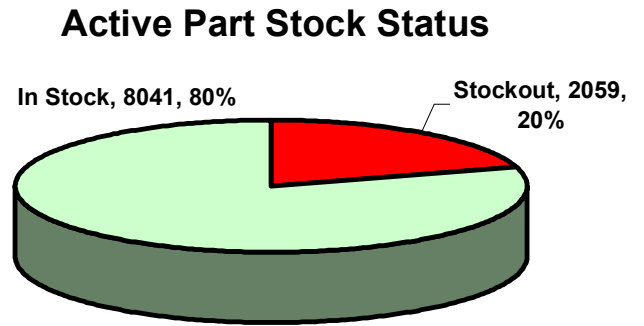


Figure 12 V-Parts Stock Status

The equipment distributor from figure 11 also had many items that were in stockout or eminent stockout. A rationalized replenishment system would have open purchase or work orders for such items. However, a comparison in figure 13 shows that 96% of their stockout items had no open orders.

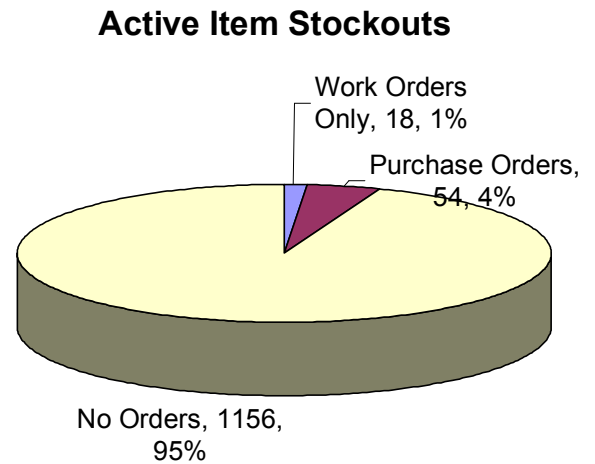


Figure 13 Replenishment of Stockout Items

Inventory Record Accuracy

Inaccurate inventory records create many problems in scheduling, customer service and purchasing. It is a principle cause of low turnover. The Strategos website has a large section on [Inventory Record Accuracy](#).

The data collected for the analyses shown here has some limited information that may lead to a deeper investigation of IRA. Negative On-Hand balances from table 3 are definitive inventory errors. Figure 14 shows that, of the active items at V-Parts, 1% have negative balances. Negative balances are only one of several types of errors and the easiest to identify and remove. With 1% of active items showing negative balance, the total error rate may be on the order of 10%-25%. For V-Parts, this line of inquiry should definitely be pursued.

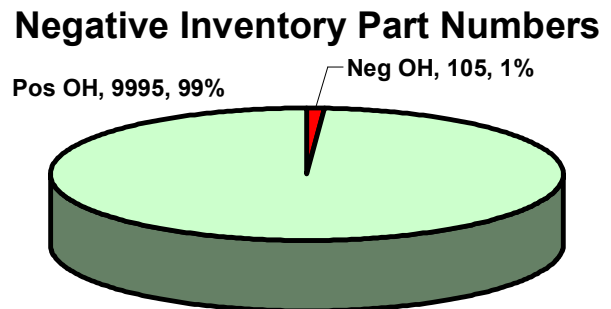


Figure 14 Negative Inventory at V-Parts

Short Term Historical analysis

In this analysis, Months-On-Hand are plotted on a monthly or weekly basis for 1-2 years. This is usually done for several representative individual items. The intent is to discover any hidden patterns in the inventory situation. Such patterns might be from seasonal demand or unusual buying patterns.

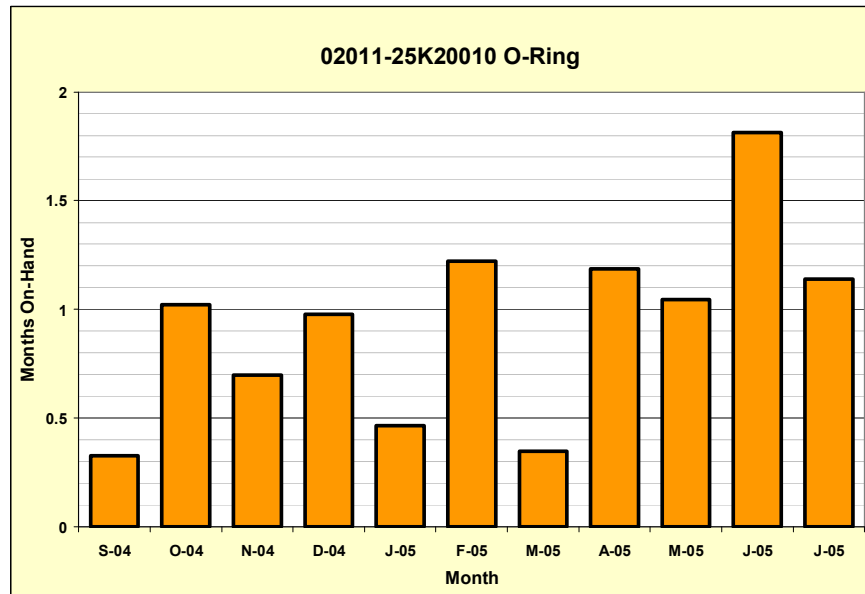


Figure 15 V-Parts short Term History

For the O-ring of figure 15, the pattern appears normal. OH balances range from about two weeks to one month. There may be a general trend towards increasing on-hand balances and this should be watched or investigated.

Figure 16 shows how a simple ReOrder Point (ROP) system is supposed to work. The On-Hand level starts at a particular level, say 100 units. Over time, withdrawals are made to satisfy demand and the OH level decreases. When the OH level reaches a pre-determined level, shown by the dashed line, a purchase order or work order is created. It requires time to fill the order and during that time, the OH level continues to drop. When the order arrives, the OH level returns to the maximum point and the cycle repeats. An additional "Safety Stock" is supposed to compensate for variations in demand or replenishment.

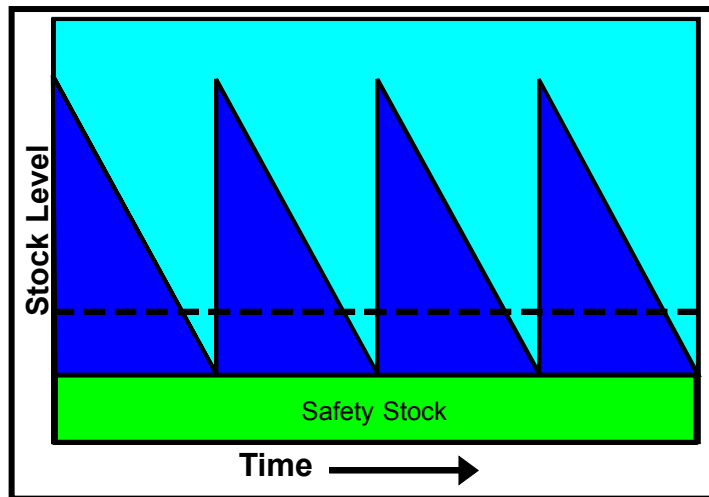


Figure 16 Theory of ReOrder Point

There are many discrepancies between theory and practice with ROP. Few of these systems operate with the clockwork regularity shown in figure 16. A short-term historical analysis can determine whether ROP (or some other system) is operating within reasonable limits.

For example, figure 17 shows the On-Hand level of four distinct products for a manufacturer of sheet metal duct fittings. In this project, the control system used a simple ROP approach. Demand was reasonably steady although there was some known seasonality.

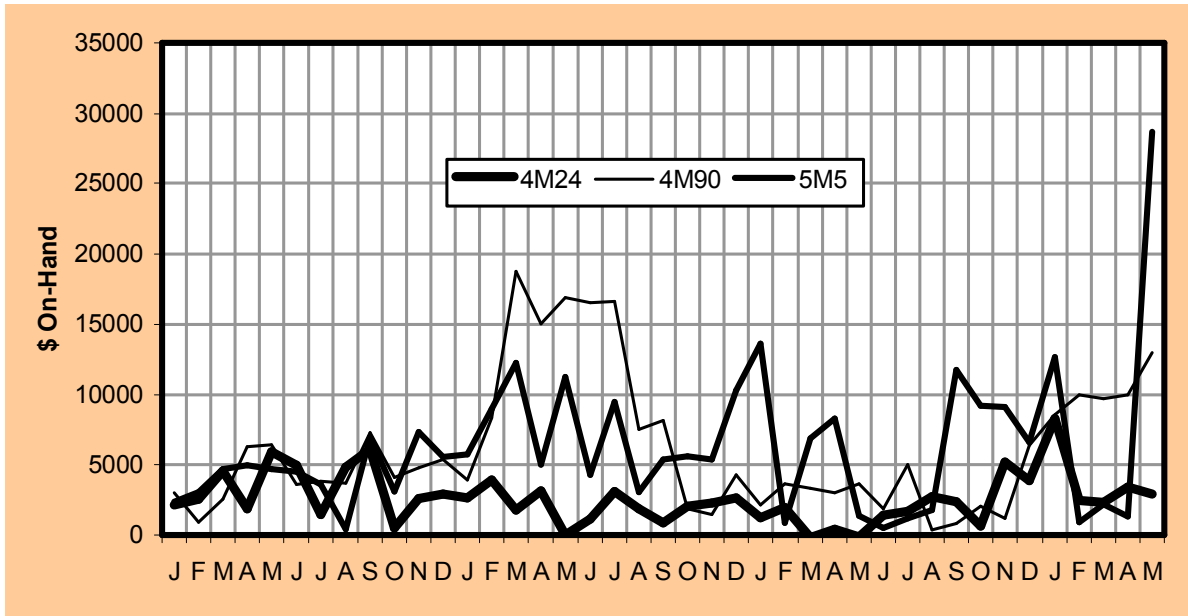


Figure 17 History Showing Chaotic Effects

A brief glance at figure 17 makes it clear that there is not particular pattern over the three plus years of this study. Moreover, the four parts have patterns that only roughly coincide with each other. This is an example of the chaos that can be generated entirely within the system, even when demand is perfectly constant. There is more on this topic at the Strategos web page “Stabilizing Production Scheduling” at http://www.strategosinc.com/lean_scheduling.htm.

Long-Term Historical Analysis

There may be long-term inventory trends and this analysis can show them. Construct a graph with overall inventory turns for the previous 5 years or more. This information can come from the year-end financials.

Figure 18 is typical of the first stage of historical analysis. Depending on the results, more detail may clarify the historical situation. Figure 3 shows a definite downward trend in turnover. The year-to-year changes have probably not attracted management’s attention because they are relatively small and there are always good reasons for increased inventory. However, in the longer-term context, this trend should be addressed.

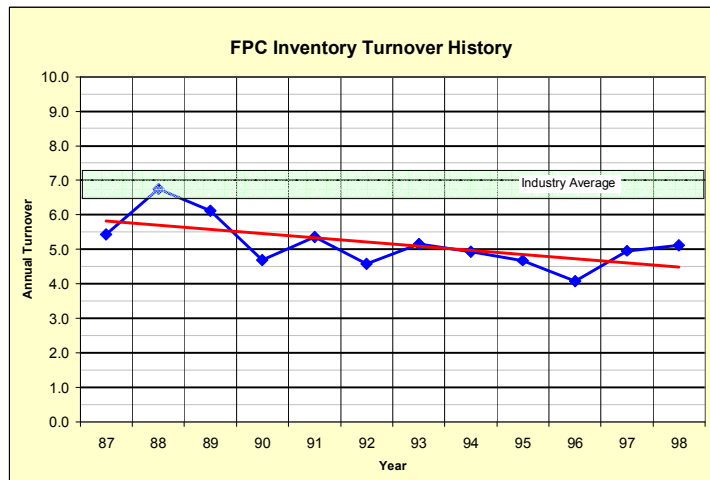


Figure 18 typical Long-Term Historical Analysis

Integrated Paper Mill Example

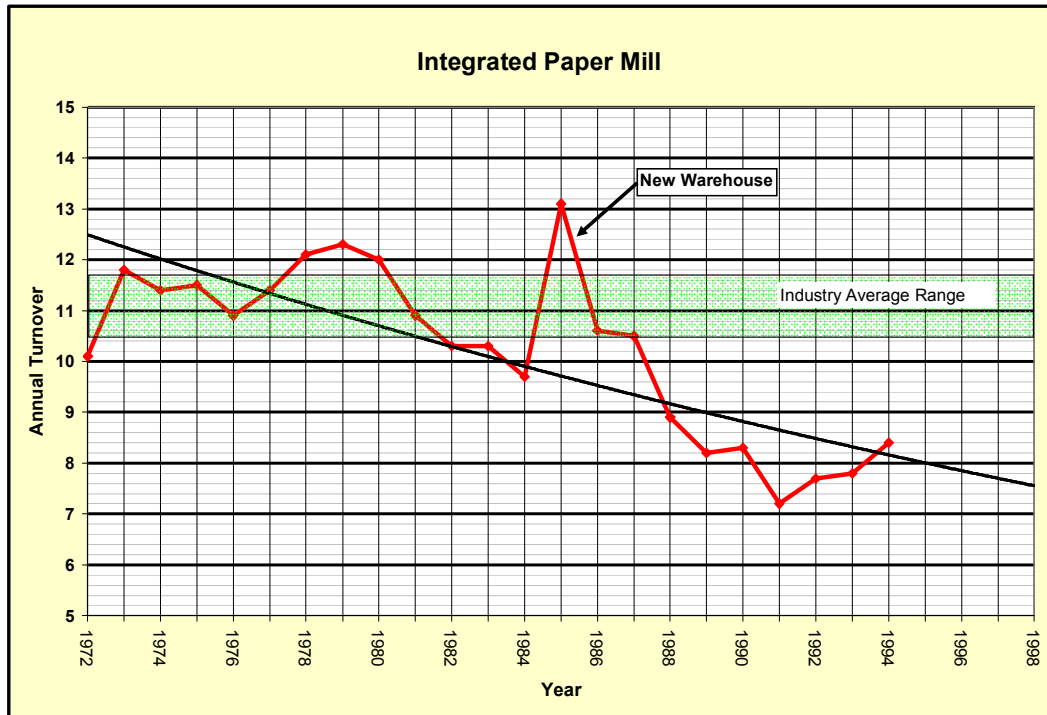


Figure 19 Historical Turnover Analysis of Integrated Paper Mill

The example of figure 19 was taken from a site-planning project for an integrated paper manufacturer. The site featured a pulp mill, paper mill and converting operations. The original purpose of this particular chart was to assist in planning storage requirements 10-20 years into the future. This example illustrates some of the findings and clues that emerge from a long-term inventory history.

From the start of the data in 1972 until about 1980 overall inventory turns were relatively steady and within the normal range for this industry. The company began specializing in more exotic, custom-designed products and these products began to proliferate after 1980. However, the Manufacturing Strategy was not in place to cope with this proliferation. The result was an increase in inventory reflected by decreasing turns.

A crisis arose about 1985 when the company had exhausted storage space and limited the amount of inventory. With increasing sales and limited inventory, turnover rose sharply. A new warehouse was built and turnover resumed its downward trend. By the time of this project, turnover was well below industry average. This chart helped clarify an important strategic issue: would the company continue on the same path building more and more storage space or would it develop the equipment and layout that would stabilize inventory growth?

Fluid Products Corporation (Specialized Pump Manufacturing)

The client in this project was an old firm with a long history. They built large, highly specialized pumps and certain critical fittings and controls to match those pumps. The objective of the project was a new plant layout that emphasized Cellular Manufacturing. Of necessity, material storage played a large role in this layout project.

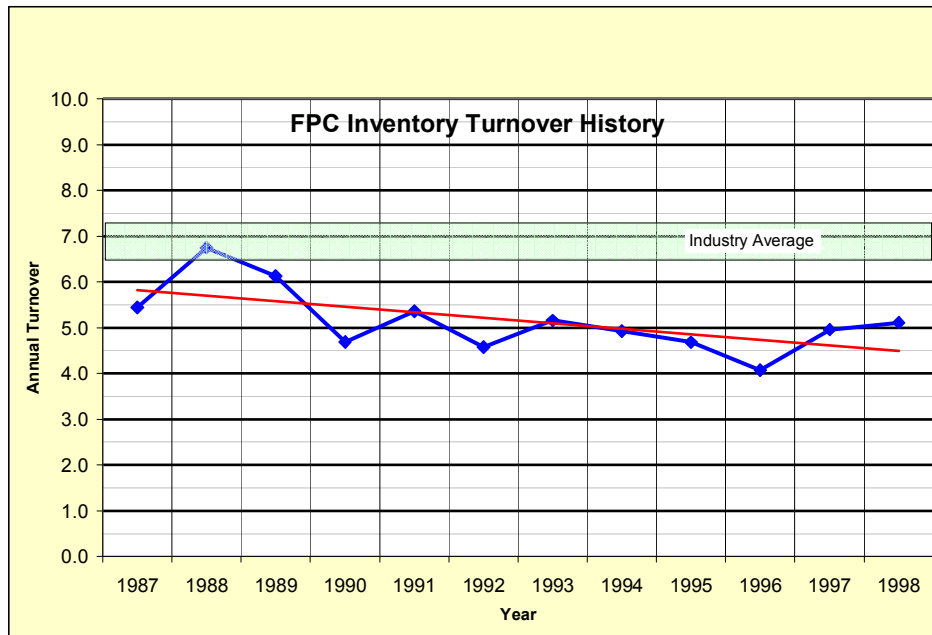


Figure 20 Historical Turnover Analysis

A long-term historical analysis, figure 20, brought forth two major conclusions:

- There was a downward trend in turnover that had persisted for at least eleven years and probably much longer.
- At the beginning of this period, turnover was near the lower bounds of industry averages but by the time of the study had fallen significantly below those averages.

From figure 20 it was evident that inventory was increasing faster than sales. The next reasonable question was “where is this inventory going?” Figure 21 and figure 22 provide the answer. Figure 21 shows that 82% of the current inventory is in WIP. Figure 22 shows that the growth of inventory has been almost entirely in WIP.

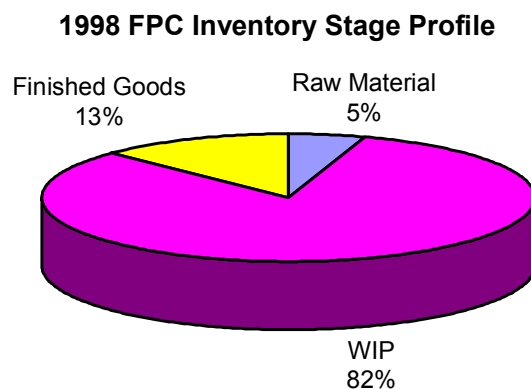


Figure 21 Inventory Profile by Production Stage

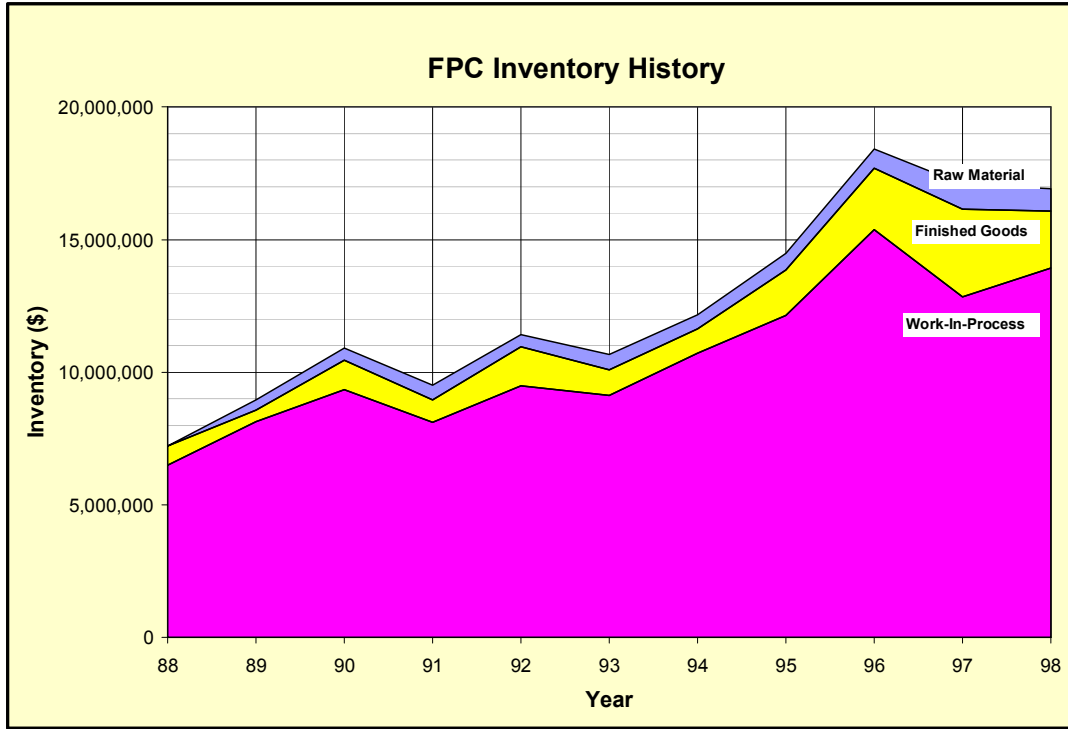


Figure 22 Inventory History by Production Stage

Figure 23 shows how the relative proportions of FPC's production stage inventory compares with industry averages. Since there were few industry groups that fitted FPC's products exactly, the proportions shown in figure 23 are approximate. This approximation makes little difference, as it is clear that FPC's WIP is significantly out of line with other companies.

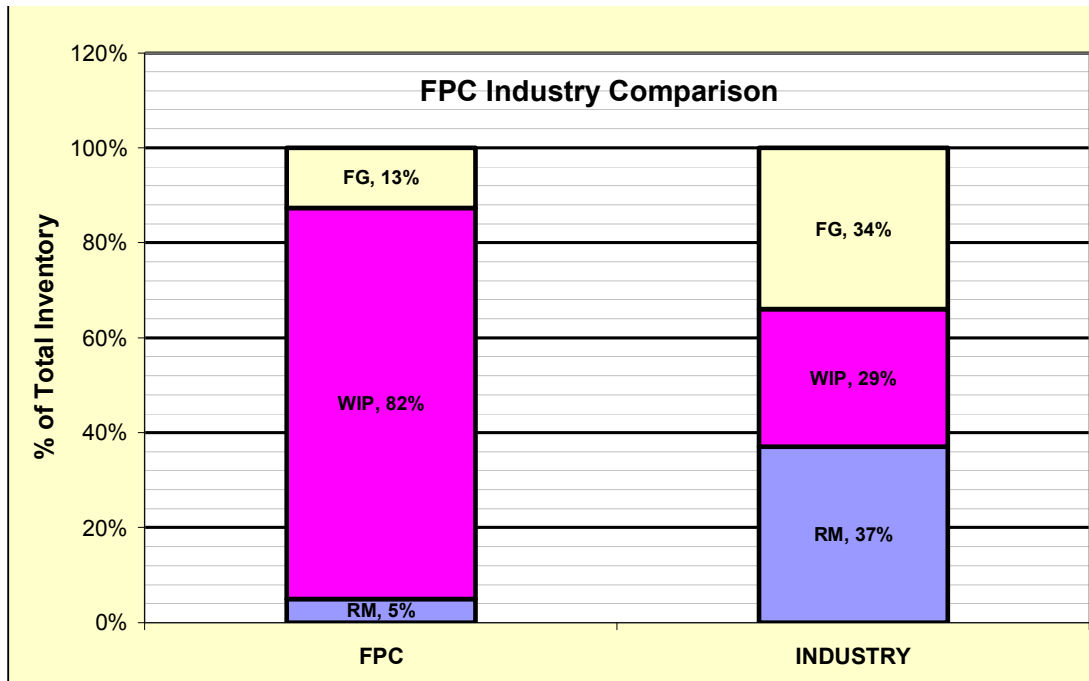


Figure 23 FPC Inventory Proportion Comparison

Three distinct product lines existed. Figure 24 shows the inventory associated with each product line. The Valve product and Pumps represented the majority of the inventory. However, valves were a highly seasonal product and much of that inventory was in Finished Goods. We might have displayed the data differently, for example, calculating turnover by product line. However, it seemed clear to everyone at this point that pump WIP was the primary culprit and that the amount of this inventory was extremely high.

1998 FPC Product Inventory Profile

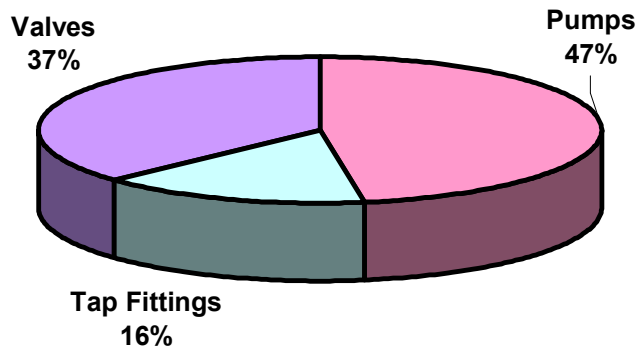


Figure 24 Inventory Distribution by Product

When the proportion of WIP is too large, it indicates problems on the shop floor or the scheduling and support systems for the shop. Material flow diagrams and process charts verified the casual, visual observation that confusion reigned on the shop floor and material movement was excessive, confused and erratic. This, in turn, necessitated complex scheduling and other elements that amplified the negative effects.

How did this situation develop? The root causes of this problem were in the firm's Manufacturing Strategy or rather their lack of Manufacturing Strategy. Decades prior to this project, the company operated with functional machining departments. Equipment was simple and small-scale but required highly skilled machinists.

As the firm grew, each functional department became more specialized, more inward-looking and more disconnected from the others. Then, Numerical Control machining was introduced. These machines were expensive and required high utilization to show profitability. Schedules were arranged to load the new NC machines, scheduling became more complex and queues grew to ensure that the NC machines always ran. WIP increased accordingly.

Midwest Machinery Parts (Industrial Distribution)

The firm marketed and distributed replacement parts for a particular type of industrial equipment. They imported the majority of these SKUs from China. Most SKU's came as finished product, ready for sale. Some arrived as semi-finished product that was completed in MMP's own shop according to customer specifications. We will emphasize primarily those aspects of the project involving the inventory analysis and what it reveals.

Figure 25 shows MMPs overall inventory turnover for the previous four years. Earlier history was unavailable.

Turnover based on COG and COGS was 3.1 in 2007. It dropped to 2.0 in 2009, rose to 3.0 in 2010. However, recent additions to inventory indicated another drop in turnover was imminent.

This turnover is way below average for the industry. In fact, very few distributors in any industry have a turnover less than 2.5. Moreover, MMP's turnover appears to be worsening.

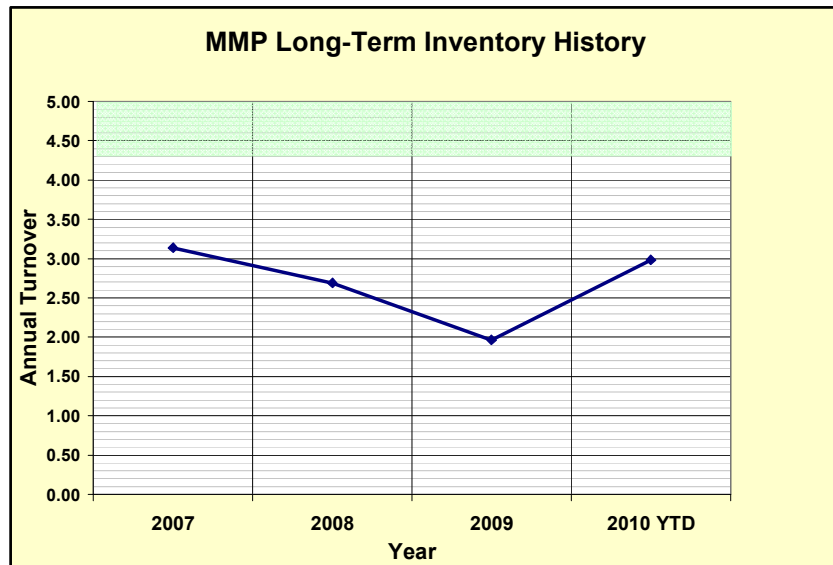


Figure 25 MMP Long-Term Inventory Turnover

Product-Volume Analysis

Figure 26 show MMP's product lines and volumes for the previous 6-months. The green bars represent dollar volume at COG. The blue bars represent unit volume. The chart shows that the FKT product group represents 74% of total sales volume and a similar portion of unit volume. Casual observation indicated that the vast majority of inventory was the FKT product.

For this reason, we decided to focus the remainder of the study on FKT products. Most of the data, charts and tables that follow figure 26 include only those FKT products.

Figure 27 is the P-V chart for the 1112 FKT parts. About 100 items account for 75% of FKT sales volume. The remaining 1000 or so items represent only 26% of sales. Figure 28 examines the highest volume 100 items to reveal more detail. Here we see that **only about 10 part numbers account for 42% of all FKT sales.**

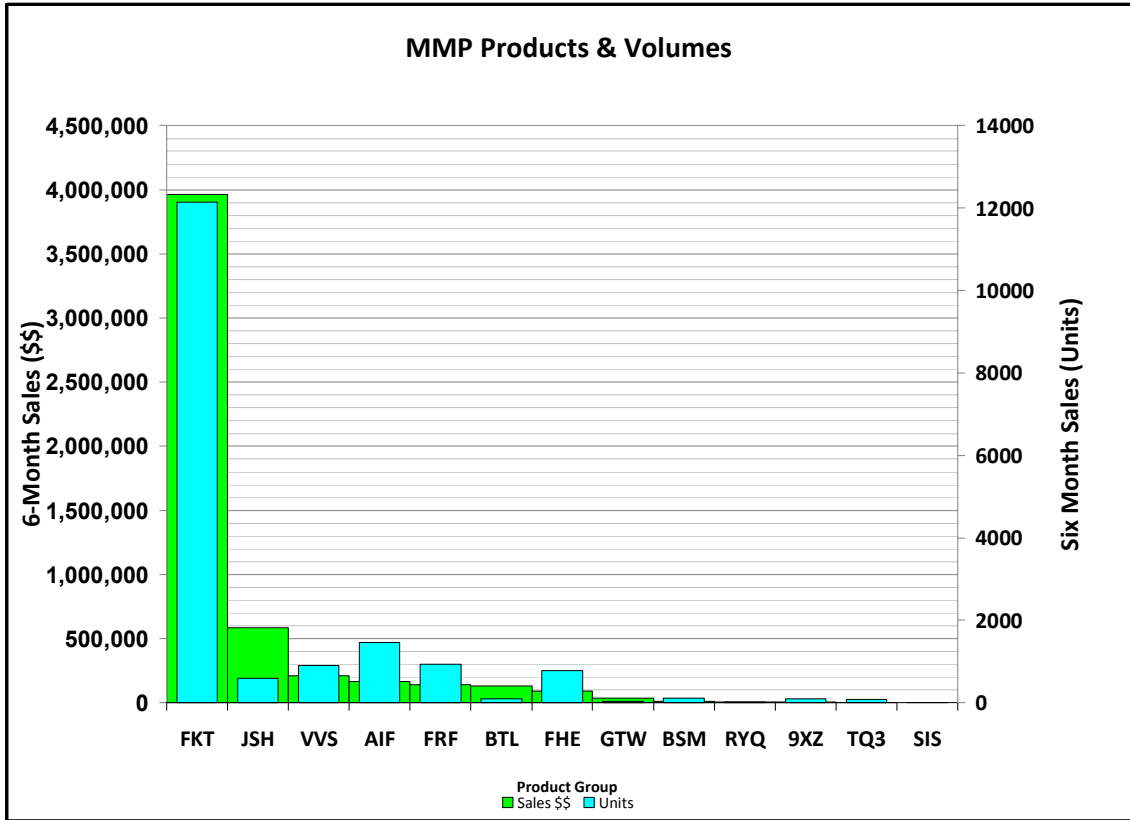


Figure 26 MMP Product-Volume Analysis

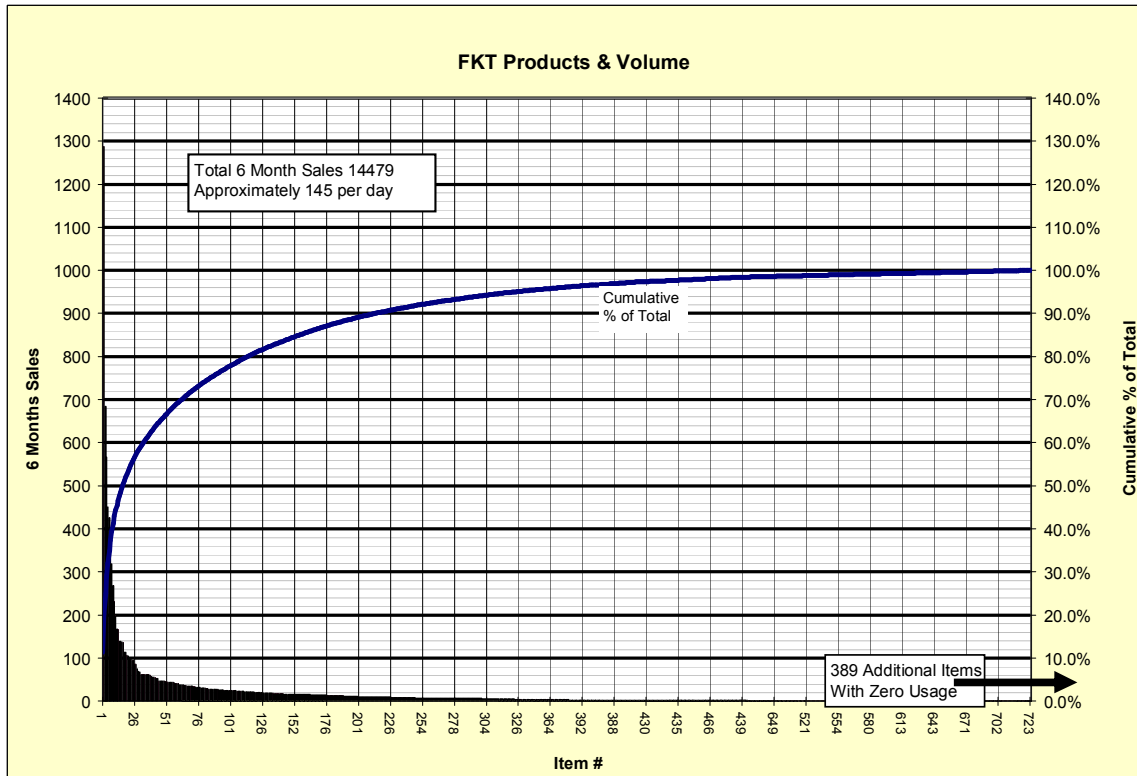


Figure 27 Product-Volume FKT Only

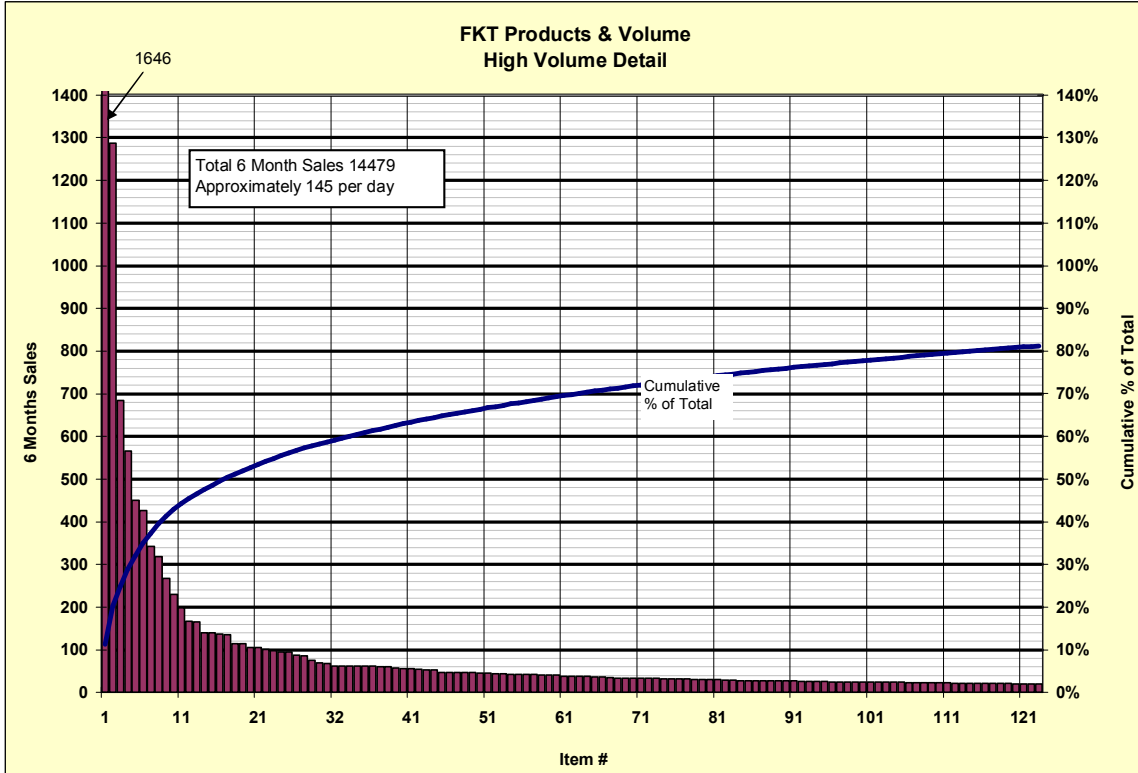


Figure 28 Product-Volume Detail FKT

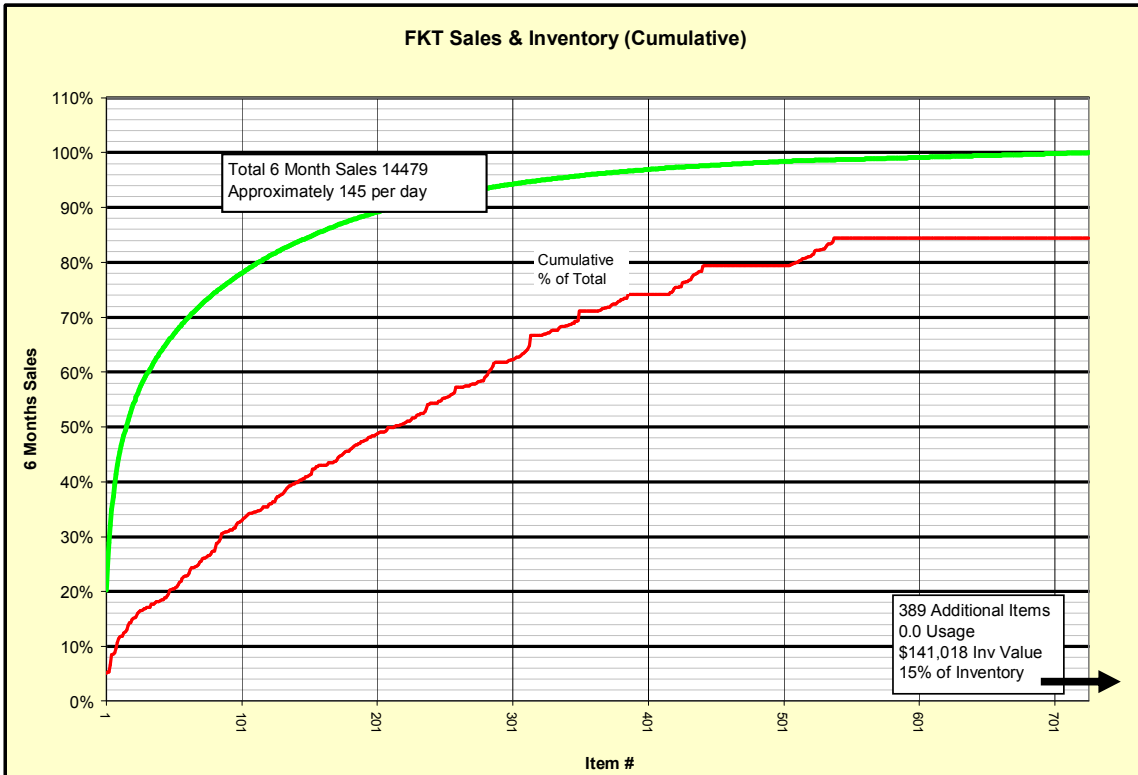


Figure 29 FKT Sales & Inventory Cumulative

Usage of Inventory Funds

Figure 29 is similar to figure 27. Individual part numbers are on the X-axis and are ranked, left to right, by sales volume. The actual part number is not shown due to space constraints on the diagram. The upper curve (green) shows the cumulative percentage of total sales for each part number. The lower (red) line shows corresponding cumulative inventory for those part numbers.

In an ideal situation, inventory level for a part would reflect the sales for that part, the inventory turns would be identical for all parts and the two graphs would coincide. In practice, slower moving parts usually have higher variability, more inventory is required to compensate for the variability and turns are lower. The cumulative inventory curve would fall slightly below the cumulative sales curve in the left portion of the graph but would gradually rise to meet it.

The continued gap on the right of this graph is the result of dead inventory. It represents about \$141,000 of inventory with zero sales during the six-month study period. The gap at the left of this graph indicates that too much inventory is dedicated to slow moving items and probably insufficient inventory to fast moving items.

Sales Orders

We analyzed the sales orders during this six-month period to profile the size and types of orders. The results, on average are:

- 36.4 Orders per Day
- 3.4 FKT Items per Order
- 1.5 Line Items per Order
- \$1134 per Order

The overall conclusion is that MMP's's orders typically consist of a large number of small orders, probably going mostly to the replacement market. On rare occasions, large orders appear.

Short-Term History

A short-term history was compiled from a spreadsheet maintained by the Accountants. It reflected total daily inventory as entered into the inventory control system from January through June. The blue line in figure 30 shows this daily value while the narrow green line is a 31-day moving average. The patterns provoked several important questions:

- **What was creating the steady decline from January through mid-April?**
- **What created the sudden, periodic, short-term increases?**

The decline in inventory originated with a management edict to reduce inventory in the face of falling sales. After 2-3 months, shortages developed and purchasing increased orders. However, it required 60 days or more to build and ship the replenishment material. When these larger orders started arriving in May, inventory increased again.

The sudden, periodic increases resulted from the arrival of shipments from China. Orders were placed one per month (maybe) and consisted of 20-25 containers. These were all scheduled to arrive simultaneously. The red arrows indicate arrival dates.

It would require as much as two weeks to unload and receive such a large number of containers and this is why the increases are not instantaneous. When a shipment arrived, most other operations were shut down and there was a lot of commotion and confusion during receiving. After receiving, it might take several more weeks to put the material in its proper position and this created even more confusion.

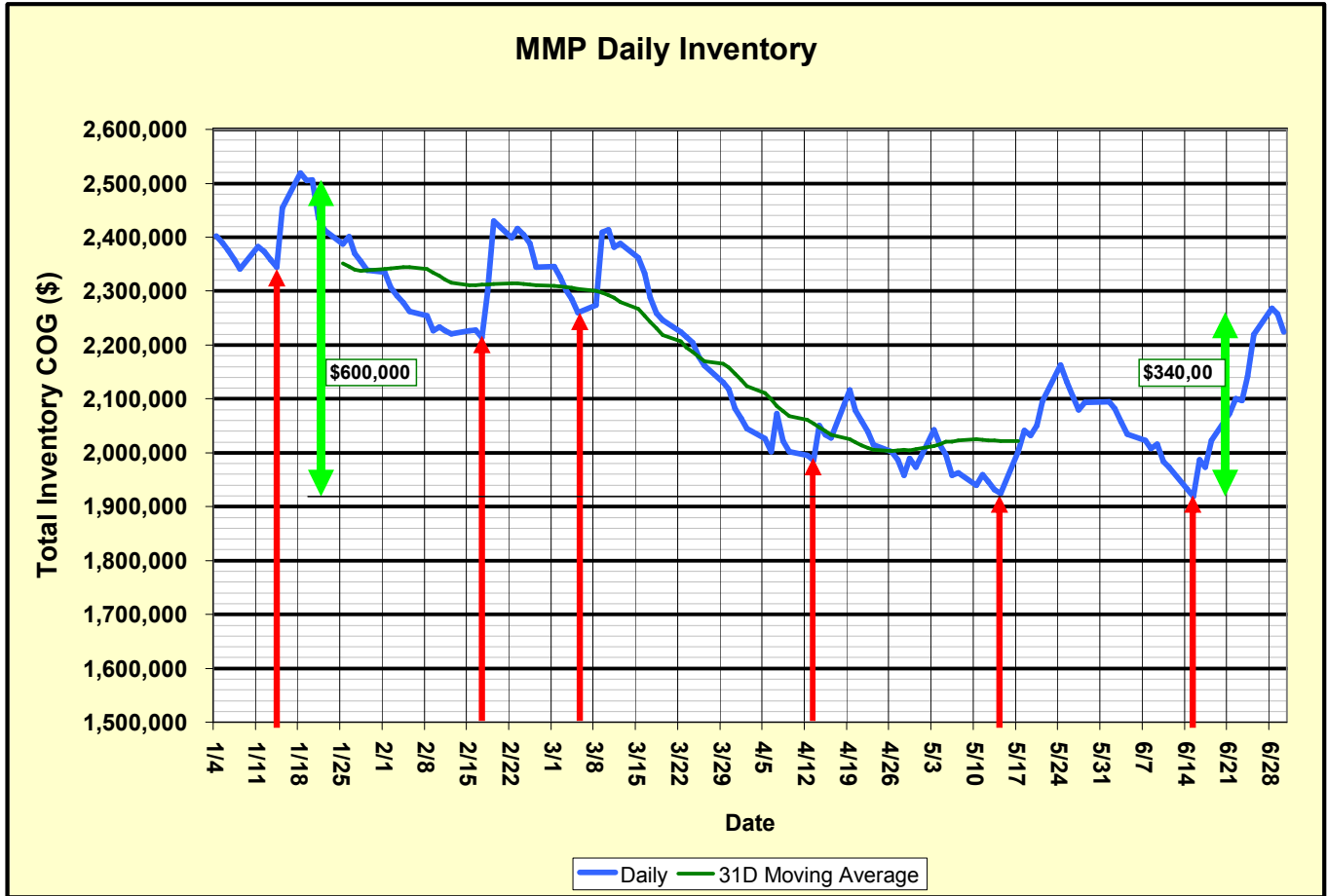


Figure 30 MMP Overall Inventory History

Obsolete Parts

Figure 31 shows that of the 5870 part numbers, 2770 or 47% show no usage activity during the six-month period of the study. There are several possible reasons for zero usage:

- Part # may be obsolete and superseded by a different part#.
- There were no orders.
- The part was out of stock, unavailable for sales and the sales were lost—hence no usage.

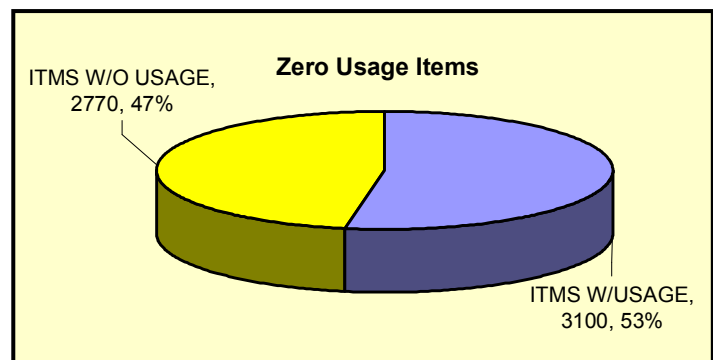


Figure 31 Zero Usage Part#s

Stockouts & Slow Movers

With the present supply chain, an OH level of 1-6 months might be considered a “normal” or target inventory level. Improvements to the supply chain and reordering system will reduce this significantly and target levels of 1-3 months should be attainable.

Figure 32 displays the results of an aging study of the FKT inventory. This study includes any part numbers that a) have usage during the six-month period or b) have on-hand inventory. We considered that any item with more than 6-months of inventory was overstocked and any item with 0.1 month or less as a stockout.

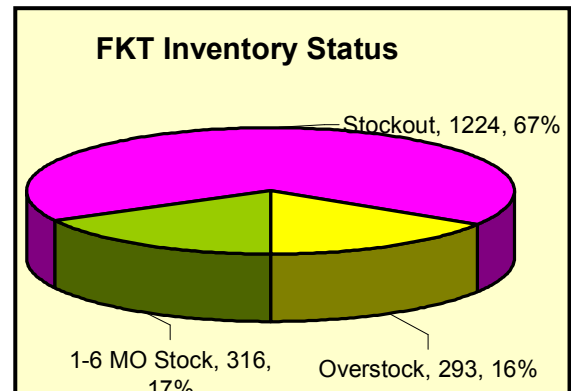


Figure 32 FKT Inventory Status

Figure 32 shows an astounding 67% stockout rate. If these stockouts include high-volume, popular items it indicates a very large loss of sales. If stockouts are concentrated in slow-moving items, it may not be as serious.

To check on this, we segregated the highest-volume 100 parts and looked at the stockout rate separately. Figure 33 shows the results. **The stockout rate on these items that make up 74% of sales was 57%.** We then examined the 1000 lowest volume parts, figure 34. These slow moving parts had a stockout rate of only 22%.

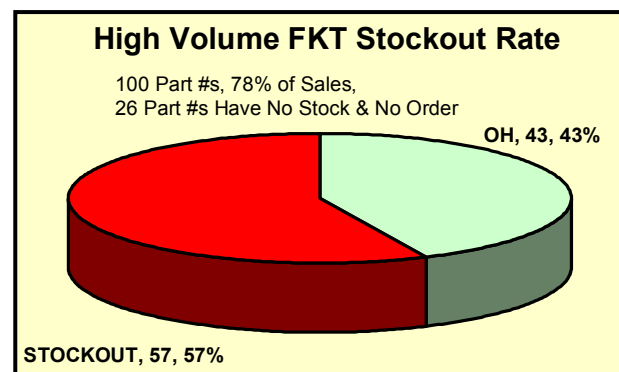


Figure 33 Stockouts- High Volume FKT

These stockout rates are extremely high by almost any standard. It appears, in addition, that MMP had put their working capital into slow-moving parts rather than the fast movers.

Clearly, there was something very dysfunctional in the purchasing and replenishment system and/or replenishment policies. By the time this study was finished, it became clear that **there were no replenishment policies**—no guides or rationale for the purchasing department. Further, there was no identified method or system for tracking stock and determining what to order or when.

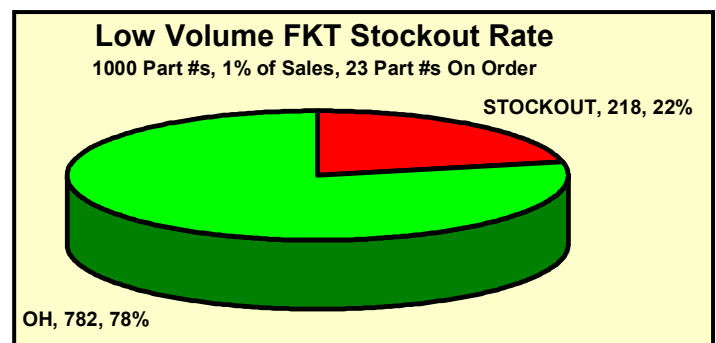


Figure 34 Stockouts-Low Volume FKT

Short-Term Historical Analysis

Item #1254-44 was MMP's sixth largest selling item with an annual volume of \$99,792. It was typical of the high volume parts. We constructed a short-term history using the current On-Hand and a transaction history report. The objective was to identify patterns in sales and replenishment that might give insight into the algorithms used for re-ordering and replenishment. Figure 3 shows this chart.

On 1/1 the inventory was 420 pieces or about a five month supply at the average sales rate of 2.6 per day. No significant replenishments were arrived until 5/21. It may be that the management decision to reduce overall inventory in the face of falling sales at the start of the year was partly responsible for this non-replenishment.

On 4/6, the Midwest DC was out of stock. Since this DC accounted for 76% of total sales, total stock at all DCs remained constant because very little was sold from the East and West coast DCs. However, this eliminated any further sales from the Midwest DC. It appears that no replenishment orders were placed until the Midwest DC's stockout or, at least, until the stock level was very low. Since it takes about 60 days to build and ship the product, new product did not start arriving until 5/21.

The replenishment orders that started arriving on 5/21 were very large. Inventory increased rapidly as these orders arrived until the end of the study on 9/12. At this time, there were more than 500 units in stock and even more units in transit and due to arrive shortly. All this on an item that sold, on average, 2.6 per day.

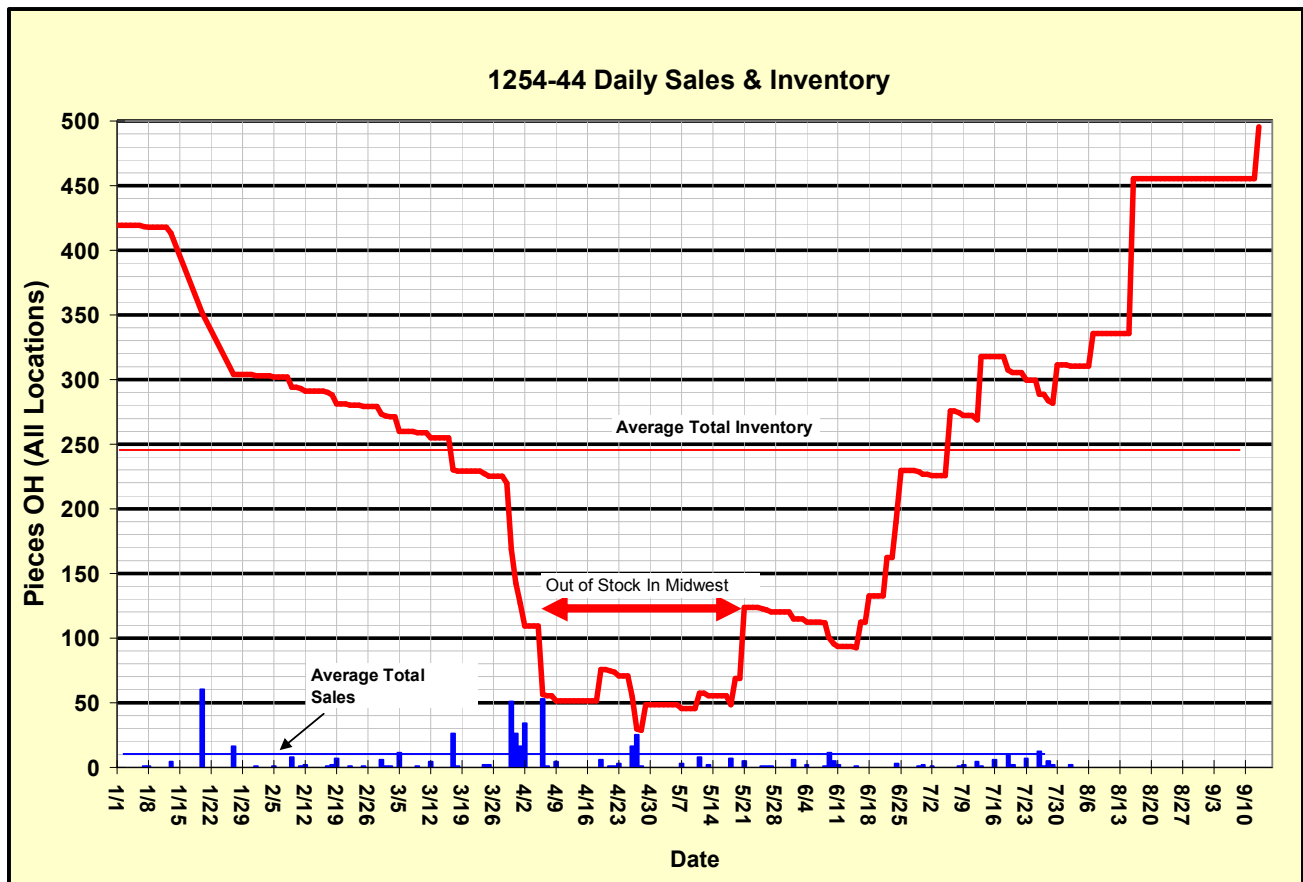


Figure 35 Sales & Inventory History—Part# 1254-44

Accomplishments of The MMP Inventory Analysis

The inventory analysis was not the entire story for this project. Additional work was necessary to identify root causes and develop solutions and recommendations. The inventory analysis did accomplish the following:

- Established that overall inventory was 2-3 times larger than normal.
- With all of this excess inventory, customer service was poor and significant sales were lost.
- Inventory was concentrated on the wrong items.
- Inventory levels for individual items were erratic and varied greatly.
- Replenishment policy and practice was dysfunctional.
- Much additional information and many insights developed indirectly from the gathering of data and discussions.
- Set the stage for a strategic analysis of their operations based on customer needs.

Summary

Inventory analysis is a valuable tool for many types of improvement projects because inventory reflects shortcomings in the system; it covers up problems. Inventory records contain information that, properly interpreted, can lead to improvements in many manufacturing and distribution processes.

The data required for an inventory analysis is often readily available. It requires only formatting, visualization and interpretation.

Every analysis is different, however, in some respects. A degree of experience and intuition helps immensely. Skills with spreadsheets and database managers are also necessary for a good analysis.

Inventory speaks. It has a story to tell. Is anyone listening?