

Pull Based Inventory Management

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Introduction

In theory, Materials Resource Planning (MRP) is a relatively simple process. You start with the sales forecast for each of your finished goods. Then you take the Bill of Materials (BOM) for each item and compute how much intermediate and raw materials you need to make the finished goods. You can also predict when you need these materials, based on the predicted sales schedule. This, in turn, leads to a materials-purchasing schedule. This data can then be used to plan your production schedule to make the required intermediate and finished goods. This in-turn can enable you to compute how much labor you need and when.



Unfortunately, life is not that simple. MRP works well if you have long lead times and a good sales forecast. Especially in these turbulent times, this does not apply to many manufacturers. Instead of customers buying large quantities of a small number of items they now want to buy small quantities of a large number of items. Application of Lean methods is eliminating inventory from the supply chain. Customers now want goods delivered Just-in-Time (JIT) rather than buying large quantities of materials and sticking them in a warehouse. Tier 1 manufacturers are driven by the day-to-day purchasing needs or whims of consumers. With JIT this quickly drives these daily variations down to the tier 2 and tier 3 suppliers.

This problem is exacerbated by the trend towards customization. Early in this century, you could have your Ford Model T any color you wanted as long as it was black. Today, no two cars coming off the assembly line are the same. This trend towards a market-size of one is forcing manufacturers to offer a bewildering array of products, all tuned to the needs of specific market segments or customers. In fact many manufacturers are now abandoning the fallacy that they have standard products and instead are focusing on how to rapidly and efficiently ship semi-custom products to each customer.

Pull-Based Inventory Management (PBIM) enables manufacturers to effectively manage their production and inventory in those circumstances where there is no good sales forecast at the finished goods item-number level. PBIM assumes that orders will arrive randomly in real-time for products with a known BOM. It also assumes that suppliers can themselves respond rapidly to orders to replenish raw materials.

How Pull-Based Inventory Control Works

Pull-Based Inventory Management (PBIM) works in a similar manner to MRP except that it is a dynamic real-time process rather than a static once-a-month planning process. PBIM enables manufacturing organizations to minimize the inventory on-hand while ensuring that they do not have stock outs. It basically solves the problem of multiple jobs, arriving at random, placing conflicting demands on limited physical inventory.

A very simple example of the conflicts which PBIM resolves is: "We have 50 brackets in stock and I have two jobs which both require 30 brackets. A production controller checks the stock of brackets needed for the first job, finds adequate stock, and releases the job. Another production controller checks the stock of brackets for the second job, finds there are still 50 brackets there as

30 brackets for the second job, there are only 20 brackets available." While these problems can be manually avoided with simple bills of material, they are very difficult to avoid with multi-level bills that use common parts.

PBIM systems maintain an allocated inventory table for each part. This starts with the current physical inventory level. Whenever a job is entered into the system, its BOM is scanned and a debit is entered in the allocated inventory for each part or material needed. If the allocated inventory for a part falls below a specified level, then PBIM will automatically generate a reorder for a pre-determined economical order quantity. In our example, we would start with 50 brackets. When the first job was entered, the allocated inventory would fall to 20 brackets (50 physical less 30 allocated to the first job). When the second job was entered, this would bring the allocated inventory to -10 brackets, which would trigger an automatic reorder for brackets.

If a part, such as the bracket, is made in-house then PBIM will automatically generate a job to make more brackets. This will cause the allocated inventory levels of material, such as sheets of steel needed to make more brackets, to be adjusted. PBIM propagates demand down all the BOMs until it arrives at purchased materials. In this case it generates purchase requisitions for the needed parts, again in economical order quantities. The parts ordered or being made then appear as credits in the allocated inventory. This is to stop subsequent jobs from generating orders for parts that are already being made or are on order.

When material is pulled from inventory for a job, physical inventory is debited and the corresponding material debit for the job is removed from allocated inventory. Also when parts are received or made they are credited to physical inventory and the corresponding allocated inventory credit is removed.

An important aspect of PBIM is that raw, intermediate, or finished materials are ordered or made in economical order quantities, which are predetermined based on careful studies.

In PBIM we do not allow the factory-floor supervisors to determine how much of each intermediate material to make as they run out. Instead the economical order quantity is decided based on analysis of such factors as machine setup time, average rate of demand, cost of carrying the inventory, and production lead time needed to make the intermediate material from raw goods. When the allocated level of an intermediate material falls below a computed safety-stock level, a job is automatically created by the PBIM system to make an economical quantity of the material.

Usually, the predetermined economical order quantity is specified in terms of a minimum base quantity plus economical increments. This is so that a single job can be initiated to handle a quantity larger than the economical minimum. If a job has been previously initiated, but not yet started, to make the same intermediate part then the additional quantity can be appended to that job if there is an efficiency of scale to be obtained.

Similar principles apply to purchased materials. Orders are placed in predetermined economical quantities. These quantities are determined by trading-off quantity discounts, delivery lead-times, and the cost of carrying the item as inventory.

Experience has shown that the economical order quantities under PBIM tend to be smaller than are used in a traditional make-to-order system. Also inventory levels and WIP are significantly lower and stock-outs are virtually eliminated provided that the allocated (not physical) inventory safety-stock levels are chosen appropriately.

Similar principles can be applied to finished goods. Typically there are two cases with finished goods:

1. The safety stock level is set to zero. Finished goods are only made when a customer order is received. The pull on this zero inventory from a customer order causes a job to be initiated to

then these are stored in inventory to be reused for the next order.

2. The safety stock is set at a level where customer orders can be quickly filled without stock-outs. Jobs are automatically initiated to refill the finished goods inventory.

Determining Safety Stock Levels

In many cases, the determination of safety stock levels of frequently used raw and intermediate materials is amenable to statistical analysis. By monitoring the use of each material we can determine a running average rate of use of the material. Then the average safety stock needs to be $U \times N$, where U is the average rate of use and N is the number of days to replenish the item.

There are often significant variations in the rate of use of materials. We can obtain a running estimate of the standard deviation of the rate of use. Then we can set the safety stock at the average level plus one, two or three sigma of variation, all multiplied by N . By choosing one, two, or three sigma we are choosing a probability of stock-out of approximately 16%, 2%, or 0.1%. The level to choose will depend on a trade-off between the cost of carrying the inventory and the economic impact of a stock-out.

In practice, the safety stock levels are often best set by monitoring and graphing the use of each part. You will see the inventory level fluctuating over time. The whole graph moves up and down as we change the safety level. Choose the safety level so that there is a comfortable margin at the lowest point in the graph, if you don't want stock-outs.

Job Prioritization and Scheduling

In a pure PBIM system, there is no direct relationship between inventory and orders. Orders place a material demand on the PBIM system. The PBIM system orders materials and initiates jobs to provide the materials needed to fulfill the orders. When the finished goods are available, then the order can be picked, packed, and shipped.

In reality, some orders are more important than others and some have to be delivered before others. In PBIM we can use the principle of inheritance to set job priorities. Basically an order has a delivery date and a priority, which we can translate into a numerical importance. When this creates a pull on finished goods inventory, it usually creates a job to make the needed finished goods. This job will inherit its importance and due date from the order. In a PBIM system, we typically have an estimate of how long each job step will take to perform. Thus given the job information, we can compute when the materials are needed for the job. The material requisition inherits the job's importance and the delivery date on which the material is needed for the job. This in turn creates another job or purchase requisition. In the case of the purchase requisition, we have an estimate of the lead time to get replacement material, which leads us to a date by which we need to place the purchase order.

Under PBIM, each job in the plant inherits its due date and priority from the order it serves. If a job serves multiple orders then it inherits the highest priority and the earliest due date. At each stage of the manufacturing process, when there is a conflict for resources, the jobs with the highest priority and those closest to being late are worked on first.

Sometimes this priority scheme is modified to include the customer name. Some plants have one or two major customers who are always given highest priority. In this case the jobs also inherit the most important customer name, so they can be given a high priority when scheduling work center operations.

PBIM and MRP

PBIM does not require a sales forecast. It simply works with the orders as they arrive to manage materials and jobs. It does require accurate tracking of inventory and of jobs on the factory floor. It works very well to efficiently run those plants that make many variations on a basic product

them and ship them in rapid response to customer orders.

PBIM is a short-term management tool. It works best where orders have lead times of a few days to a few weeks. Its weakness lies in handling long-lead-time materials. If it takes three months to get specialized materials then there is a danger with PBIM that there will be a stock out with a three month wait to ship the order.

Where there are long lead-time material items then MRP based on sales forecasts will provide a forecast for when long lead materials need to be ordered and in what quantities. When these materials are ordered, the POs should be entered into the PBIM system as allocation credits, with the appropriate due dates. This will enable PBIM to handle its short-term material planning fully integrated with longer-term material buys.

The same principle applies to materials to be delivered on a schedule from another manufacturing plant. These are entered into the PBIM system as future allocations that turn into real materials when they are delivered.

PBIM does not replace MRP but rather it complements the long term MRP planning function to handle the day-to-day influx of orders. Where there is no long-term planning then a PBIM system can be used by itself.

Case Study

A jewelry manufacturer in Rhode Island implemented a BellHawk® PBIM system about a year ago. This jeweler makes earrings for several major retail chains. Replenishment orders are received daily from the retail chains based on purchases made by their customers the previous day. The jeweler typically has 5 working days to make and ship the replacement finished goods. A typical product has a five level BOM and there are many thousand raw, intermediate, and finished goods part numbers.

Before implementing a PBIM system, this manufacturer was using a classical make-to-order scheme with levels of intermediate material inventory being established by production supervisors.

In the first year of PBIM operation, in which the sales were essentially the same as the prior year, they achieved a reduction in WIP inventory of 60%. They also saved over \$200,000 by eliminating overtime that had previously been required to expedite the shipment of goods on time. Finished goods are now typically shipped one or two days ahead of their due date and cancelled orders due to late shipments have been eliminated. The pace of work is now much more ordered and everyone is much happier.

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