Solving the Wandering Bottleneck Problem

Many manufacturers find managing the logistics of order and product flow extremely difficult. It seems that every day is spent chasing production bottlenecks and trying to solve them. The problem of the "wandering bottleneck" is particularly troublesome, since it is so difficult for production managers to identify the root cause of the problem. Typically, they give up trying to solve the problem and end up living with poor delivery performance and low productivity because "that's the way things work."

There are three causes of the wandering bottleneck:

1. Management policy
2. The production process has process variation
3. The market mix (product & volume) fluctuates

There is a solution to the problem and a way for managers to get control of their plant. The Drum-Buffer-Rope scheduling technique, founded on scientific principles and proven in practice, allows managers to understand how their plant works and where to focus their attention to maximize customer service and profitability. To examine the problem properly, let's start by defining what we are talking about.

Bottleneck

A bottleneck is a resource that is overloaded (more work than capacity) during a particular period of time. A moving bottleneck is one where the overload shifts from one resource or to another over a longer period of time. In both instances, the common issue to be understood is time. This may seem rather elementary, but it the time issue has ramifications when we examine resource dependency and variation.

Variation and Dependency

Over time, the plant experiences process variation (rework, longer than expected processing time, scrap, etc.) and demand variation (product mix and volume). Both of these create resource overload conditions when the variations exceed the available capacity. We also understand that in order to produce a product, one must follow a step-by-step process to complete it. In other words, I cannot complete operation 20 at resource B until operation 10 is complete at resource A. The consequence of these two properties is such that if we experience variation at operation 10, we must compensate or "catch up" at the subsequent operations. Typically, having WIP inventory, increasing capacity, or increasing order lead-times has compensated for the problem of variation in environments with dependent resources.

Lately, focusing on reducing variation and thus the need for inventory and long lead times has also attacked this problem. This is certainly a valid strategy, but time consuming and costly. Moreover, the problem of product mix and demand variation is unlikely to be solved at the plant level.

The Moving Bottleneck Phenomena

As I pointed out, demand and process variations have a profound effect on resource loading. There is also another policy, common to job shops and other manufacturing companies: full utilization of all resources. This policy is a rule that says all resources (machines/people) must be producing product all the time they have available. This unwritten policy drives managers to release work that is not needed immediately to keep the machines and/or people busy. The early work then moves into the shop, consuming the capacity that could be used to compensate for variation. When there is a problem, it appears as if the resources don't have enough capacity. Which resource? Who knows? Most plants are not balanced (some resources have more capacity than what the market is dictating), so the load will move around to where the capacity allows. Since there is no control over job release, there can be no control over the production flow. This policy has a far greater impact on resource loading and in my experience, is a more significant contributor to moving bottlenecks than the market or process variation.

Solving the Problem

The first and easiest thing to do is to eliminate this effect by regulating the release of material/work into the plant by synchronizing release to a control point in the system. Since the market demand is fluctuating (especially in job shops!), it is difficult to synchronize to the order due dates unless you have a great deal of excess capacity. Therefore, we pick a resource that, when the plant is full of typical[1] work, that resource is

also a bottleneck. Doing this accomplishes two things: eliminates the misallocation of capacity, and maximizes the plant throughput when the plant is fully loaded.

This does not eliminate the problem of variation, though. You can now begin to see what the true variation is, once you have eliminated the variation you introduce into the system. We have two major sources of variation to be dealt with: market and process.

The two sources of variation have to be dealt with separately, since they have subtly different effects on the plant and the source of the variation is different. Process variation tends to make orders late, and market variation creates resource load variations. Both have the same effect of causing resource load to move.

Dealing with Process Variation

Since any order has a deadline associated with it, variation in the expected completion time at any resource or operation creates pressure on subsequent resources to catch up. This variation shifts process load out into the future when capacity may not be so readily available. Therefore, we have to allow enough time to complete the order and smooth out these "bumps" in load.

The Drum-Buffer-Rope scheduling technique (from ToC) uses a concept called buffering to smooth product flow. It introduces time buffers at certain places within the process to allow for inherent (normal) variation. The buffer is sized as a function of the variation experienced and extra capacity available. Since we know that some resources have extra capacity (few plants are balanced) not all resources require buffers. However, we do recognize that the accumulation of variation will cause some orders to be delayed. Therefore, we place the buffer before the control (synchronization) point. This single buffer is a form of risk pooling, where variation from multiple sources are aggregated into a single location. Thus, the buffer can be smaller than if we were trying to compensate for each resource independently.

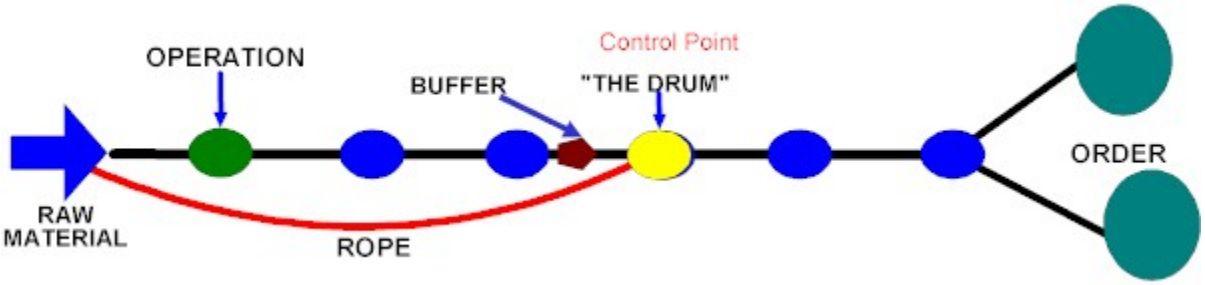

Figure 1 - DBR Diagram

Monitoring the condition of the buffer (Are the jobs arriving before they are scheduled at the control point?) will point managers to resources that are potential bottlenecks and give some breathing room to compensate by rescheduling delivery or adding capacity. Increasing the size of the buffer will provide more breathing room to take action, but has the effect of increasing lead times. Therefore, managers must choose between increasing capacity, reducing variation, or increasing the buffer. Without the buffer management procedure, it is difficult to see which choice to make, and with it, a very clear presentation of the problem and potential solutions may be made to senior management.

Dealing with Demand Variation

Managing demand variation requires that we know what the capacity situation is and how much capacity an individual order will consume at each resource. Since most organizations can't add significant amounts of capacity on short notice, the choice for job shops is to not accept certain kinds of orders (that will overload resources within the time required by the customer) or increase lead times. (Manufacturers that produce products with repeating demand have an additional choice, create inventory — either partially finished or completed.)

Assuming we are using the buffer management procedure, we will know which resources are at risk for becoming bottlenecks. When we receive orders that consume copious amounts of capacity at those resources, we can then choose between increasing lead-time, adding capacity, or refusing the order.

Solving the Wandering Bottleneck Problem

Understanding available capacity and the order's demand on it *within the required timeframe* calls for a level of scheduling sophistication that most job shops do not possess. Therefore, managers need a simple scheduling tool and must develop the skills to use it. The cost of the management of the plant resources is very small compared to the alternative, poor customer service or excess capacity to compensate for synchronization mistakes.

1 *Typical is defined by the work management desires to see in the plant, and is subject to change as market conditions and strategies change.*