SOME THOUGHTS ON IMPLEMENTING "PULL" SYSTEMS

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The following is a general discussion of "pull" systems based on my own observations of various manufacturing companies that have implemented these approaches—successfully and unsuccessfully. This is not intended to be a detailed discussion. There are far more authoritative texts on the subject than I can provide, and space precludes covering all the issues in this publication. The intent is simply to offer informed practitioners who are considering implementing such systems some insights as well as suggestions for structuring the effort, some simple tools that can help in the execution phases, and pitfalls to avoid.

Throughout this article, reference will be made to certain terms that are based on lean manufacturing principles and often reflect Japanese terminology. The space allotted to this article is too limited to address these complex concepts in any depth. For those unfamiliar with the terms, I recommend reading *The Machine That Changed the World* [2] and *Lean Thinking* [3] by Womack and Jones. They will provide an in-depth understanding of the fundamentals and applications of the techniques that are alluded to by the "buzzwords" used here.

PREREQUISITES OF PULL SYSTEMS

Many practitioners, it seems, believe that k*anban* and *pull system* are interchangeable terms. In considering pull systems, however, it is *imperative* to recognize that they go far beyond the simple mechanics of kanban. Pull systems involve a significant change in culture and operating circumstances. Further, although the usual execution system associated with pull systems is kanban, pull objectives can be achieved without it by using one of the many other techniques available in current technology. These techniques could include cumulative scheduling systems, min / max controls, MES (manufacturing execution systems), and even real-time bucketless MRP. The optimum system may in fact be a portfolio of approaches to meet the diverse needs of a particular environment. Unlike mature MRP II approaches, there is no magic bullet—no documented "proven path" toward implementation to follow. Consequently, many companies have found it necessary to use the "trial and terror" method of implementation.

There are, however, a number of simple steps that will help and can be pursued immediately. JIT deliveries and vendor stocking programs, where feasible, will help set the stage for a pull approach. Another potential lies in establishing min / max on selected lower-volume parts and products. There are additional opportunities to be pursued as well. The key lies in overcoming inertia and creating momentum.

The first opportunity lies in internal education. The management team must understand the fundamental principles of lean thinking and pull systems, and make sure that all associates are educated about the benefits and prerequisites of the system. Education cannot stop at the front office; every employee must understand the principles and objectives of a pull environment if the new systems are to be successful.

The optimum pull system requires involving and empowering the workforce. A simple initial step lies in establishing a "5S" program, which introduces the principles of housekeeping and organization of the work area and can be implemented facilitywide by establishing work teams. (*5S* represents five Japanese words that define the program sequence. Roughly translated into English, the sequence would be "straighten up, sequence, spic & span, self-discipline, standardize.") Following shortly thereafter, the more advanced approach of kaizen programs should be pursued. This is far more complicated, but again can be implemented once an internal training program is established and / or specialized consultants are called on. (The complexity of the kaizen concept precludes addressing it in detail here; for more information, refer to the book *Lean Thinking* [3].)

If kanban is to form the basis of execution systems, experimenting with kanban structure and execution also represents a key potential. It would be a real-world test of the system and at the same time provide a training tool. (*Failing in the Factory* by Keane and King [1] describes the mechanics of actually setting up a kanban system.) For this effort, I would suggest a controlled "vertical slice" experiment. That entails setting up a full-stream controlled experiment on a single selected product, from finished product back to the suppliers (excluding components common to other products), with intensive monitoring to identify and resolve dysfunctional impacts immediately. Once this has been tested and proven, the full-stream system could then be incrementally extended to other products as well, until all products have been integrated into the system.

One of the fatal flaws, which can cripple a pull system, is failing to constantly monitor and adjust the parameters on which the pull signals are based. I have seen pull system collapses that arose from a "set it and forget it" approach to the parameters. Consider that the key variables in pull system parameters are lead time and demand. If either varies by more than +10% / −20%, the parameters may need to be updated. Thus, implementing a system requires not only defining and programming the algorithms for calculating pull signals, but also identifying and programming the "management by exception" tools that will monitor the parameters in place. That can be done on a simple PC spreadsheet for the vertical slice, but must define the programmed tools that will support the full system once implemented. This developmental effort should run concurrent with the vertical slice defined above.

The transition to the min / max approach that normally forms the foundation of a pull system has many benefits. One drawback, however, lies in the fact that it eliminates time-phased visibility and, thus, a key replanning tool. There is an ongoing need to identify exception situations in which underordered or overordered positions exist. That can be done by introducing some rough-cut tools that provide a macro view of items requiring review, either through enhancing the system or separate programming on PC spreadsheets. *Overordered position* can be defined as any case in which the total of the on-hand inventory and on-order / released future quantities exceeds usage through lead time plus the reorder quantity policy for the item (plus a management-defined judgment factor). *Underordered position* can be defined as any case in which the total of the on-hand inventory and on-order / released future quantities is less than usage through lead time. The exceptions can then be analyzed for corrective action (if required).

The need for a time-phased ordering may be an issue in light of certain long lead time items where vendor orders need to be estimated by delivery period. A spreadsheet-based tool can be implemented for such applications if forecasting / MRP is not a viable option, by using a variant of the TPOP (time-phased order point) approach originally developed for distribution environments. In a kanban context, doing so would project the future time periods in which "triggers" are expected to occur, factored by the estimated accumulated kanbans that would comprise the order / release quantities involved. Information on structuring TPOP can be found in most texts related to distribution planning.

I mentioned that some cases may require a portfolio of systems. Pull systems have generally proven themselves in environments in which high-volume, generally continuous production exists. But many companies offer a broad range of products with stratified demands. For those companies, products may be differentiated into three general categories:

- High-volume repetitive production
- Intermediate-volume intermittent batch production
- Low-volume batch production

In the first case, there can be little argument that systems such as kanban have high applicability and should be pursued aggressively. In the second case, kanban systems should be the objective, with current efforts devoted to reductions in setup times and lot sizes. In the interim, however, the use of MRP II systems may be appropriate, with a defined target date and action plan to phase over to full kanban control. In the case of "dogs," however, it is not uncommon for these items to be produced very infrequently (e.g., one to three times per year). The production lots at the end product level create inventory, but (until more efficient and flexible manufacturing processes are introduced) may be unavoidable. The key problem with a kanban system in these circumstances lies in the backfill of components used for the production. As soon as the components are pulled from stock, the kanban trigger seeks to immediately replenish the inventory, despite the fact that the next demand for the parts may not occur for many months. In some cases, the next demand may occur far beyond the lead time horizon for the component involved. The implications to inventory are self-evident. In such applications, I would propose that if the critical path lead time of the product is less than the time interval between recurring demands, the item be set up on a "make to order" basis with all lower-level requirements generated through an MRP-style explosion at the time an order is initiated.

THE ROLE OF FORECASTING SYSTEMS

An effective forecasting system continues to be an imperative even in a pull environment because of two key factors:

1. Pull parameters driven from historical data in environments subject to trend and quantum ramps in demand place the system at risk. We are in essence driving on an interstate by watching our rear-view mirror. Using an effective forecasting system as an input to the establishment and monitoring of parameters provides response to significant trend and / or quantum changes on a proactive ba-

sis. Further, integrating the FETS (forecast error tracking signal) capability allows more real-time recognition of such changes and consequent modification of parameters.

2. Pull systems are excellent execution tools within a reasonable planning horizon governed by the response time of the execution phase to demand. But long lead time products pose challenges to which pull systems have difficulty responding. Providing effective long-range time-phased planning *and replanning* capability is a necessity.

Thus, continued development of forecasting applications should not be viewed as a moot point in pull environments.

A key consideration lies in integrating "new" products into the system, which would seem to favor products with established demand histories and predictable demand. Unfortunately, there is no "magic bullet" to address this problem. New products require careful initial estimates to drive replenishment as well as "trial and terror" monitoring for constant refinement and updating of parameters. But there are some tools that can help in this effort.

From a simplistic standpoint, there are generally two basic reasons for adding a new product: line expansion to fill voids in a product offering and introduction of new products to cover new applications. Each of these types of introductions can be expected to have its unique phenomena associated with demand patterns. In a line expansion, demand can be expected to already exist in the marketplace at the consumer level; thus, one would expect an initial pipeline fill, closely followed by a demand pattern that would typify ongoing demand. In the case of products for new application, however, a different pattern can be expected. An initial pipeline fill demand is normal, but repetitive demand may be substantially delayed because of a host of phenomena that may each be peculiar to the individual company's market. One cannot expect every planner to have direct visibility to the dynamic for every new product. But a differentiation of "new" codes between these two types of introductions in the item master file might help the planner better evaluate and anticipate the trend that could be expected on the product. If the software system in place has a provision for notations about the product and / or an "event-driven" update file, then planners could even flag to themselves changes they expect to see in demand patterns for the "new" item type. This will help differentiate demand trends that are usable for planning versus artificial demand patterns not truly indicative of product trend.

SOME CHARACTERISTICS OF SUCCESS

In companies that have successfully implemented pull systems, I have noticed certain characteristics beyond the traditionally obvious ones we expect in Class A MRP II users. The following are based on a composite of those companies, but most of these characteristics are in place at any one particular location.

1. Although many companies have specific continuous improvement programs, the most successful use a matrix approach to continuous improvement activities. A permanent structure is in place, sometimes based on "5S" teams. The scope of these teams goes far beyond the scope of housekeeping that "5S" normally implies, however, and actually covers virtually all continuous improvement activities involving the shop floor. Detailed boards and logs of the activities, accomplishments, and ongoing programs of these teams are maintained on the shop floor and can be referenced by anyone in, or visiting, the cell area. In addition to the permanent teams, Hoshin or kaizen teams are organized for temporary projects to address specific issues requiring shop floor resolution.
2. Preventive and predictive maintenance programs are in place to ensure that, where feasible, major overhauls of equipment are performed on a scheduled and proactive basis. The program is supplemented by a productive maintenance program, in which the operators are charged with more frequent simple monitoring and maintenance of equipment.
3. A "last piece inspection system" is in place—tooling is inspected at the end of a production run. Required maintenance is done before the tooling is put up for storage, thereby ensuring that the next production run can be started with minimal exposure to tooling delays.
4. All key equipment is reviewed for process capability to ensure that Cpk and Ppk (statistical measures of equipment capability and performance to specifications) support quality requirements. In addition, production lines use SPC (statistical process control), and most have also initiated SMED (single-minute exchange of die, a generic term used for programs that minimize equipment changeover / setup times).
5. Quality circles are used extensively. They are often a natural outgrowth of the 5S process. In addition, extensive training is conducted, ranging from literacy and math skills to advanced problem-solving techniques.
6. The failure to ensure consistent and predictable lead times is potentially fatal to any pull system. Successful companies take whatever steps are necessary to ensure that lead times will be consistent with estab-

lished parameters, including strict enforcement of FIFO (first in, first out) disciplines at workstations on the shop floor. Manufacturing and supplier lead times are also closely monitored, and corrective action taken when deviations from standard are detected.

There are, of course, many other characteristics that have been observed, but space is limited, and I consider these the most important.

THE PROCESS OF EVOLUTION

So where might companies go with pull system implementation, and how would they get started? A number of suggestions have been described in prior discussions. The following is an overall recap of issues that must be addressed first to ensure the overall success of any implementation effort:

1. A task force working on implementation and a firm project plan for implementation are needed. The company should consider organizing a steering committee for this effort to monitor progress and provide on-site direction. Further, a cross-functional project team should be established and charged with carrying out the activities necessary to implement the system. This includes identifying key needs and establishing programs that will address and / or correct the key areas to facilitate implementation of the pull concept.
2. *All* personnel who will be affected by the system (including shop floor personnel) must be educated on the principles and benefits of a kanban system, followed by intensive training in the actual execution of the system. This should start with on-site visits of project team personnel to other sites that currently have, or are implementing, kanban systems.
3. Kaizen efforts should be instituted to provide improved processes and to foster shop floor involvement in the improvement process. A 5S program should be implemented, perhaps as a forerunner to kaizen. A full-time coordinator may be required; if so, this position needs to be filled expeditiously and the program pursued intensively.
4. A full-stream test of the kanban system needs to be done for verification purposes and to provide a basic training tool. To address this, consider a "vertical slice" prototype approach. It would entail setting up a full-stream controlled experiment on a single selected product, from final assembly back to the suppliers (excluding components common to other products). Once this has been tested and proven, the full-stream system could then be incrementally extended to other products as well, until all products have been integrated into the system.
5. SPC needs to be fully implemented on the shop floor to ensure inherent quality in production through a "quality at the source" approach.
6. Preventive maintenance and productive maintenance need to be fully in place. Preventive maintenance should provide for major preventive overhauls of equipment (replacement of bearings, motors, shafts, etc.) based on either experience rates or manufacturers' recommendations. Further, inventory of key replacement parts needs to be established. Productive maintenance should be geared toward routine, simple maintenance activities and should be incorporated in a 5S team responsibility.
7. Bill of material errors are identified and corrected on an ongoing basis in many environments; however, that tends to address errors reactively, after planning and / or production dysfunction may have occurred. A *proactive* bill of material audit program should be seriously considered.
8. Optimally, a true pull system will involve "point of use" storage. That needs to be considered in this program. Facility layout, rack design, and provision of capital for standardized reusable containers are all issues that need to be addressed.

This is not a complete list of issues, but simply a recap of some of those that are most obvious. The process must start with the formation of a steering committee and project team, and the development of timetables and targets. That will begin to provide the momentum that will make success possible.

In a multiplant environment, this effort is not a corporate project. Local management must assume responsibility and accountability for success. Delay can be fatal; it is far more difficult to overcome inertia than to sustain momentum.

CONCLUSION

Certainly, this has not been a comprehensive or authoritative course on implementing pull systems. It is intended as a basic overview to stimulate the reader's thoughts about some of the issues involved in such an implementation. If you are in a study and / or implementation mode, then accept my best wishes for success. You will be astonished at the quantum leap in benefits that lean manufacturing and pull systems can bring.

REFERENCES

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