Production Planning and Control Term Paper

ISE 5454

Application of Quick Response Manufacturing (QRM) and Paired-Cell Overlapping Loops of Cards with Authorization (POLCA) in Manufacturing

Author: Niket Sura

May 2019

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Background and Key Principles

Most companies have one or more continuous improvement programs, often based on philosophies on Lean, Six Sigma, Theory of Constraints, or Total Quality Management. Adopting Quick Response Manufacturing, QRM, does not conflict with these efforts or make these past efforts obsolete rather it enhances existing improvement initiatives and takes them to the next level. QRM aims to address specific challenges arising from high mix, custom engineered manufacturing environments, as will be later shown in the paper. The methodology spans across order processing, quoting, supply management and new product development, thus providing a powerful tool to drive improvements. This manufacturing technique builds on the concepts of total quality management, kaizen, and employee involvement by providing specific targets and guidance for driving improvement efforts in complex manufacturing environments.

QRM comprises of four core concepts:

1. The power of time: Long lead times create many organizational costs, greater than high WIP levels and finished goods. QRM enables lead times to be decreased, by replacing traditional metrics of efficiency and utilization with QRM's goal to minimize the time the jobs spend in each station.
2. Organization Structure: The tools and principles to create QRM cells, based on the concept of cellular manufacturing, in high-mix, low-volume customized manufacturing environments are provided by Quick Response Manufacturing.
3. Systems Dynamics: The cellular structure comprising of the QRM approach is complemented by a thorough understanding of system dynamics specifically tailored for high-mix environments, leading to improved capacity planning and optimized batch sizes to achieve shorter lead times.
4. Enterprise-wide application: The time-based management principles which go hand in hand with QRM applies to a variety of applications like office operations, material planning, production control, supply chain, and new product introduction.

In a nutshell, Quick Response Manufacturing is an approach to manufacturing which emphasizes the beneficial effect of reducing internal and external lead times. Shorter lead times improve quality, reduce cost and eliminate non-value-added waste within the organization while simultaneously increasing the organization's competitiveness and

market share by serving customers better and faster. The time-based framework of QRM accommodates strategic variability such as offering custom-engineered products while eliminating dysfunctional variability such as rework and changing due dates.

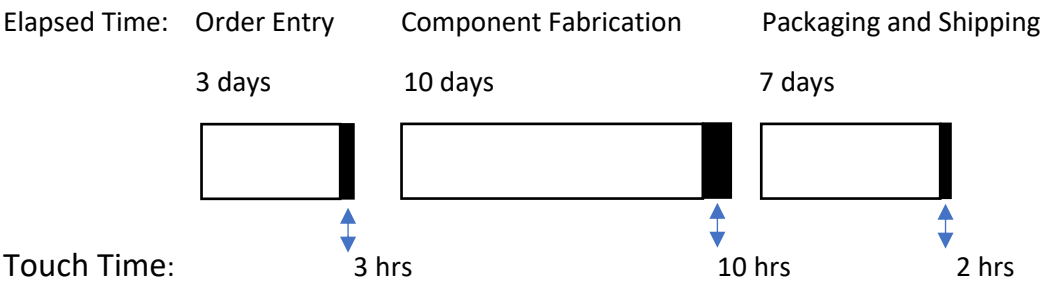
QRM extends basic principles of time-based competition while including these new aspects:

- Singular focus on lead time reduction
- Focus on manufacturing enterprises
- Clarification of the misunderstanding and misconceptions managers have about how to apply time-based strategies
- Companywide approach reaching beyond shop floor to other areas such as office operations and the supply chain
- Use of cellular organization structure throughout the business with more holistic and flexible cells
- Inclusion of basic principles of systems dynamics to provide insight on how to best reorganize an enterprise to achieve quick response
- New material planning and control approach (POLCA)
- Specific QRM principles on how to rethink manufacturing process and equipment decisions
- Novel performance measure
- Focus on implementation and sustainability
- Manufacturing Critical-path Time (MCT) metric to measure lead times.

QRM suggests that an enterprise wide focus on reducing lead times will result in improvements in both quality and cost. Eliminating the time-consuming – and often self-reinforcing – practices described above can lead to large cost savings while improving product quality and customer responsiveness. Hence, on a management level, QRM advocates a mindset change from cost-based to time-based thinking, making short lead times the yardstick for organizational success.

Time based QRM focus:

Flow of a job:



Where, Touch time = time that the product is being worked on = 3 + 10 + 2 hours = 15 hours

Total lead time = 3 + 10 + 7 days = 20 days

As can be seen in the above diagram, a representation of lead time and touch time, the amount of time a product is actually worked on accounts for a small percentage of the total lead time.

Many organizations aim for machines and labor to be utilized at close to a hundred percent capacity. QRM goes to show, based on queuing theory, that this method of running machines at a utilization close to 1, is counterproductive to lead time reduction and provides means of reducing such long lead times without having to make further reductions to touch time.

Need for QRM

The latest CAD/CAM technology gives us the ability to customize products for individual customers without incurring high additional costs. When combined with customer demands for personalized products and internet-based individualized ordering capabilities, this means that there will be increasing demand for customized products in the 21st century. In addition, after placing their orders both OEMs (original equipment manufacturers) and end consumers expect these products to be delivered quickly. Although Lean Manufacturing techniques can be powerful in certain situations, for

companies making a large variety of products with variable demand or companies making highly engineered products, Lean Manufacturing has several drawbacks.

Manufacturing environments where the product variety is high results in constant equipment setups and Kanban exchanges, as well as many deliveries of small lots of components. That has led to the conclusion that there is a need for better scheduling and control systems to handle such high variety, and there is a need to treat the root cause of the problem. It has also become impractical to let the manual exchange of kanban cards "pull" new orders of components into the production system and relay all production information. Another pressing concern is the cost of new model development and model replacement.

The QRM-POLCA system is the best alternative to the lean manufacturing coupled with Kanbans system. To coordinate and control flow within the QRM structure of cells, QRM utilizes POLCA (Paired-cell Overlapping Loops of Cards with Authorization). POLCA is a card-based shop floor control system, designed as the QRM alternative to Kanban. POLCA differs from commonly used Kanban systems in the type of signal it sends to move jobs/material through the shop floor. POLCA constitutes a capacity signal, showing that a cell is ready to work on a new job, whereas Kanban systems rely on inventory signals designed to replenish a certain quantity of parts. For this reason, POLCA works well for low-volume and/or custom products.

In the case of traditional manufacturing practices, the problems that are faced are:

- Products and product orders require long routes through numerous departments
- Hierarchical communication structures involving various management levels require a significant amount of time to resolve even routine issues
- Focus on efficiency and resource utilization encourages workers and managers to build backlogs, slowing the response to customer requests
- Trying to minimize costly machine setups, managers and workers resort to running large batch sizes. Large batch sizes result in long run times, leaving other jobs waiting and increasing lead times
- Making large product quantities to stock leads to high inventory, often prone to inventory obsolescence – when stored products have to be discarded because of market or engineering changes
- Low skill levels lead to low quality and high levels of rework

The above-mentioned factors increase the overall costs and lower the organization's competitiveness. QRM suggests that an enterprise wide focus on reducing lead times will result in improvements in both quality and cost. Eliminating the time-consuming – and often self-reinforcing – practices described above can lead to large cost savings while improving product quality and customer responsiveness. Hence, on a management level, QRM advocates a mindset change from cost-based to time-based thinking, making short lead times the yardstick for organizational success.

Case Study on QRM-POLCA Implementation

In this paper, the case study company is Provan, a small metalworking manufacturing company delivering manufactured stoves to customers in Europe. The customer was pleased with the manufactured stoves and wanted Provan to increase the variety of stoves it made. As the company grew, Provan's customers were demanding a lot more variety, and simultaneously, batch sizes in the orders had shrunk considerably. Yet at the same time, customers wanted more flexibility and shorter delivery times. Provan had been using its enterprise resource planning (ERP) system together with lean techniques such as kanban to manage the order flow. However, analysis showed that an increase in variety would make these material management systems unsuitable for Provan's production characteristics. With Provan's existing manufacturing practices, this increased variety would require tripling their warehouse space for intermediate components. The added complexity of production operations would also lengthen lead-times, increasing the work in process (WIP) and storage space for semi-finished parts. And most critically, the escalating investment in this inventory would burden Provan's cash flow – potentially crippling a small enterprise.

<u>Problem Statement</u>

- Each stove consisting of 130 parts
- Production steps: Laser cutting, bending, threading, welding/fastening, assembling
- Parts stored in a warehouse between fabrications steps (laser cutting, bending, threading, welding/fastening) and assembly step

- Warehouse space required 600 square meters or 6500 square feet
- Stoves produced in batches of 60
- Lead time between initial laser cutting operation and final inspection about 4 weeks
- Now, company asked to produce to 3 variations of stoves
- 3 stove types, 130 components per stove
- Different routings for each stove type
- Result: 3 * warehouse space
- Thus, this would result in about 1800 square feet of warehouse space required to store the components, along with adding other problematic issues

Implementation of QRM Cell

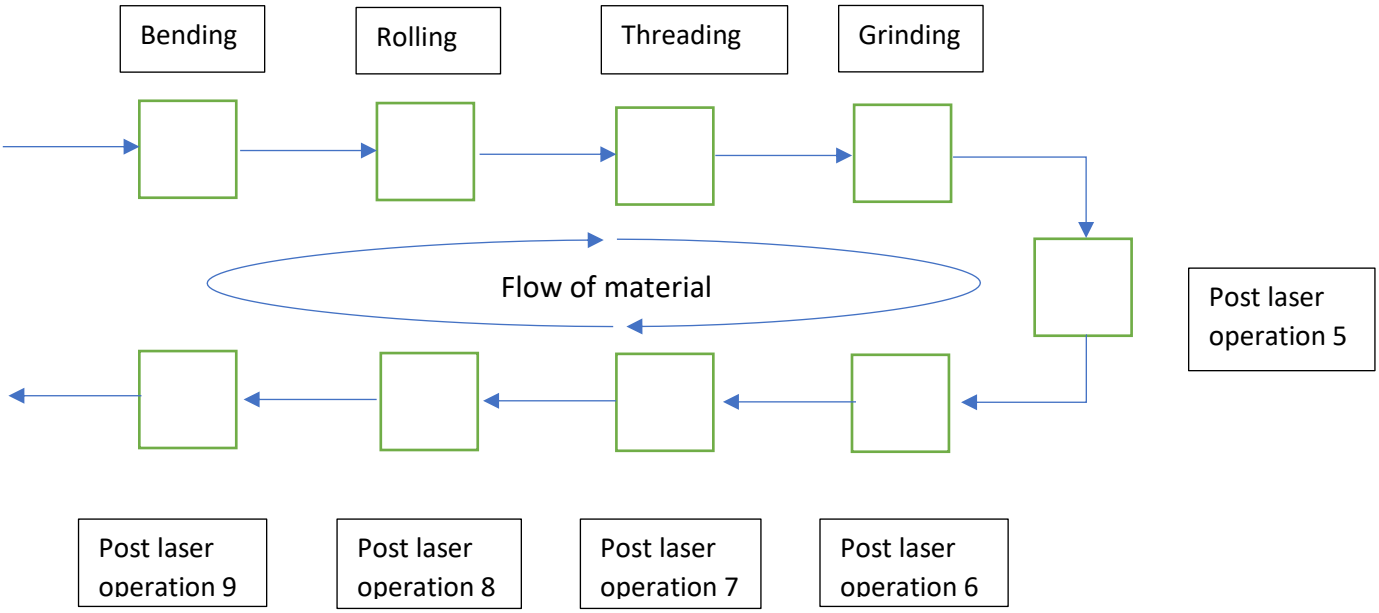
The company decided to create a QRM cell for the production of stoves thinking that it would help resolve the production problems even in the presence of high variety. QRM cells are based on the concept of cellular manufacturing but incorporate some additional features specific to QRM. These additional features that enable substantial reduction in lead time are:

- Instead of supervisors, teams have ownership of all processes with their cell
- Shop floor workers are cross trained to perform multiple tasks in their cell instead of specialists performing one function efficiently
- QRM cells are designed with extra capacity, about 15 % or more space capacity above the expected load. There is investment in spare capacity.
- Traditional metrics of efficiency and utilization are replaced with QRM's goal to minimize the time that jobs spend in the cell. This goes hand in hand with the diagram provided in the Background and Key Concepts section of this paper, that focus is on the time the job spends in the system.

A problem the company faced with the creation of QRM cells for the stoves was the management of the complexity of the workflow within the cell. Questions like would a miniature ERP system have to be installed within every cell would have to be answered. Although this miniature ERP systems could be installed, they would create further issues in terms of additional complexity and other scheduling problems related to the functioning of such an ERP system.

The final solution to this problem was the implementation of POLCA, which this paper will dwell on further on. The initial step taken by the company was to create a QRM cell for all the processing steps after the initial laser cutting operation. The laser was kept out of the cell because this expensive machine was also used for many products for other clients. Buying an additional laser for the cell couldn't be justified, and it didn't seem necessary to accomplish the goals for the stove products. All the remaining workstations – involving operations such as bending, rolling, threading, grinding and welding – were moved into a U-shaped cell.

Example of a U-cell:



Visual Workflow Management – POLCA Implementation

After the QRM cells implementation, the next concept was to assign every workstation a color and then make sure that color code was clearly marked on each workstation. This is how the color-coded system worked. When parts for a batch of stoves arrived from the laser station, they were put on a set of carts in a standardized way. First, a numbered metal flag with a specific color was attached to an empty cart. The color on the numbered flag corresponded to the stove type. Hence, with three types of stoves,

three different colors were used. The number on the flag indicated which parts should be put on that cart. Multiple parts were grouped together on the cart based on their routing within the cell. Then on every cart, a row of additional colored flags was added. These flags indicated the routing the cart had to follow within the cell. The first color in the flag row corresponded with the color of the first workstation in the routing. The second color corresponded with the color of the second workstation and so on. To summarize, two types of colored flags were used to guide the material flow: The colored numbered flag indicated the product type, while the colors on the (unnumbered) flags specified the routing.

The figure below provides an example of the QRM-POLCA system for a single cell:

Take the example for a cell manufacturing stove type 1 (from the 3 types of stoves manufactured).

Assumption:

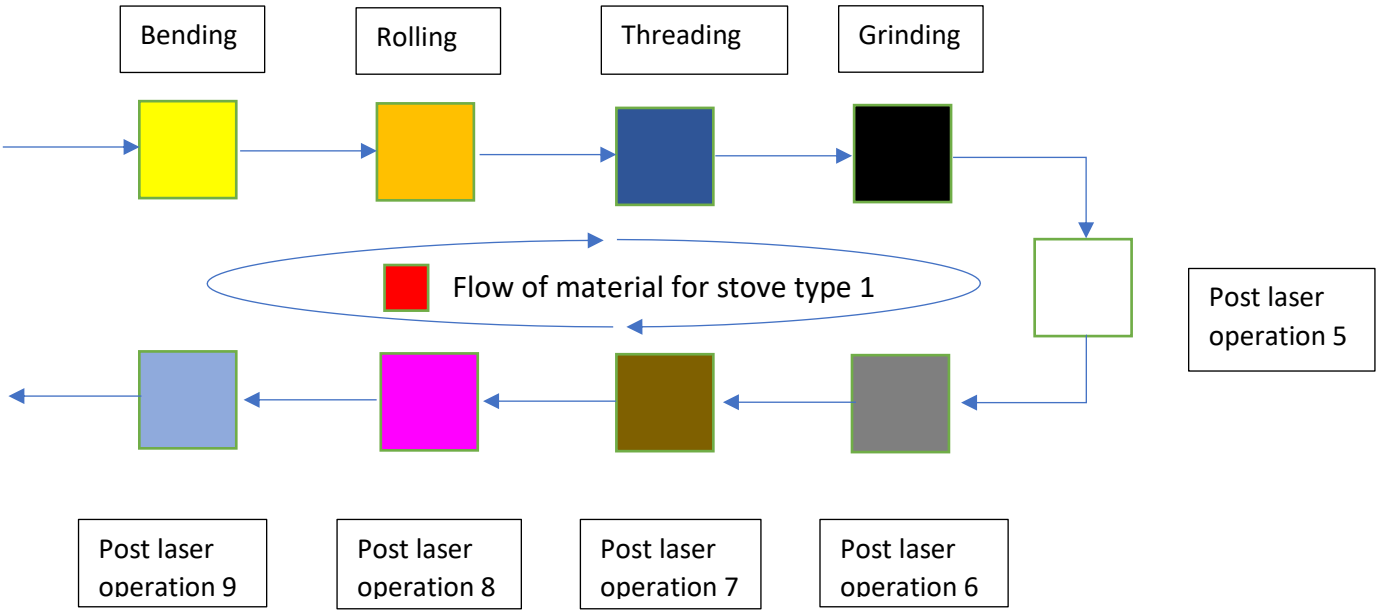
Stove type 1: Flag color red

Stove type 2: Flag color blue

Stove type 3: Flag color green

Processes in the cell: Bending, Rolling, Threading, Grinding, and 5 other processes

Color of flag for each of the 9 processes are yellow, orange, purple, black, white, gray, brown, pink, light blue, for each of the processes respectively.



The red filled box is the cart with a numbered red flag. The red color of the numbered flag denotes that this cart contains parts for the Stove type 1. The color of the unnumbered flags in the cart denote the routing the cart must follow within the cell. In this case, the number of unnumbered flags would be 9, each having a color denoting the workstation color. The first workstation the cart must visit is the Bending workstation. The first unnumbered flag on the cart would be the yellow flag. The cart will be pulled to the Bending workstation, the parts that are required at that process removed, and the flag removed from the cart. Sequentially, he next unnumbered flag would be the orange flag, for the Rolling workstation. Every time an operator removes an unnumbered flag from the cart along with the parts for the particular process, the cart is put back into the middle of the cell for the operator at the next workstation to pull the cart. With this system, operators can easily spot which parts they have to process without consulting a computer system or printed shop orders. They just have to look at the colored flags to know which carts are available to be processed next at any given workstation.

This production control system provided the following benefits:

- The work in process (WIP) in the cell is strictly limited by the finite and small number of available carts. Limiting the WIP had several advantages for the cell. Material piling up can lead to all kinds of waste (searching for material, larger walking distances, damage and so on), and so all these wastes were avoided. Also, limiting the WIP in turn limited the lead-time of jobs in the cell.

- The highly visual system was easy for the operators to understand and use.
- The order status information (the status indicated by the flags) was always up to date. So, the production control system did not rely on outdated information like it did in the past.
- The workflow was completely self-steering. Employees were in control of the process, which means they felt more involved. Detailed planning of the separate workstations by a planner, as well as supervisory tasks like shifting workers between the work stations, had become unnecessary.

Improvements in production metrics

- Putting all the post-laser operations in a single production cell meant that material movement on the shop floor was reduced, and stoves could be made in batches of 15.
- The packing process could be done in half the time because the parts were already on the right pallet and weren't stored in the warehouse waiting to be picked.
- The total lead-time per batch decreased by 85 percent, from around four weeks to three days.
- Quality of products produced improved significantly such that scrap and complaints reduced by 60 percent.
- Instead of requiring triple the warehouse space, the stocks of parts have been completely eliminated liberating 600 sq. meters of space.

Summary

POLCA implementation increases the transparency on the shop floor. POLCA builds on the cellular structure in an organization and provides a simple mechanism to enable the cells to work together effectively. In a sense, POLCA combines the best of push and pull systems, while at the same time avoiding their disadvantages

Summarizing the POLCA system:

1. The use of POLCA cards assures that each cell only works on jobs that are destined for downstream cells that will also be able to work on these jobs in the near future.
2. It allows a make to order environment through flexible routings that use cells as needed.
3. POLCA cards are not linked to part numbers. This ensures that there is no excess inventory for companies that make a large variety of products or components.

The QRM approach mentioned in the report is that all the principles stem from a single theme: reduce lead times. The entire set of principles in QRM strategy are derived from one theme, yet these principles are powerful enough to span the entire organization, from the shop floor to the office, from order entry to accounting, from purchasing to sales. Such an approach is more palatable to managers than a disparate collection of ideas such as the “five S’s”, because it enables them to stick with a consistent message to the organization. Lead time reduction cannot be done as a tactic; QRM has to be an organizational strategy led by top management. To significantly impact lead times companies must change the traditional ways of operating and redesign organizational structures. Such changes cannot be made without total commitment from top management. Hence educating senior managers on QRM strategy and getting them to buy in to the roadmap for implementation must be the first step in a QRM program.