CRITICAL CHAIN PROJECT MANAGEMENT ACCELERATES EQUIPMENT SHUTDOWN MANAGEMENT IMPROVEMENT PROCESS

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Abstract

Asset availability has been a longstanding objective in mining and mineral processing plants around the world. Enormous resources in both dollars and manpower are invested in improvement efforts to achieve higher asset availability. One dimension of asset availability is the time equipment is out of service for large scale planned maintenance activity: grinding mills, kilns, furnaces, mobile equipment, shovels and draglines are all regularly taken out of service for extended repairs and service. The speed, cost and quality of these planned outages provide an opportunity to increase asset availability.

Equipment shutdowns are projects that are executed in a compressed time period. This paper will describe how the overall time and cost of equipment shutdowns were significantly reduced at Cliffs Natural Resources Michigan Operations (CNRMO) through the introduction of the Critical Chain Project Management techniques.

Critical Chain Project Management

Critical Chain Project Management (CCPM) is the application of the Theory of Constraints to project management, first introduced in the book Critical Chain by Eliyahu M. Goldratt in 1997. CCPM is an enhancement of the Critical Path Method used to manage projects since the 1950s. CCPM improves on CPM primarily in two ways; 1) it refines the identification of the set of tasks that determines the duration of the project by explicitly recognizing resource contention, and 2) it provides a structure for protecting the duration of the project from task time variation through the use of time buffers.

The reduction of variation is a critical aspect of any continuous improvement effort. CCPM forces the recognition of task variation and explicitly accounts for it in the shutdown schedule through the introduction of time buffers. Time buffers prevent the critical path from changing during project execution. CCPM also highlights the fact that not all tasks are equally important and it provides the focusing mechanism to identify the critical few tasks from the many.

Shutdown Management Process

The Shutdown Management Process consists of six sub-processes that generally progress, with some overlap, in the following sequence:

Work Identification
Planning
Scheduling
Preparation
Execution
Analysis & Improvement

The introduction of CCPM into the shutdown management process at CNRMO impacted each process from Planning through Analysis & Improvement.

Planning Process

The entire shutdown process is broken down into individual tasks. Task dependencies are identified to sort the tasks into different streams of work.

CCPM requires that the planners account for possible task time variation associated with each work task in each stream. The planners define two task durations for each task – a "focused task time" is the median time to perform the task and a "low-risk task time" is the estimate of the time the task would be completed in 90% of shutdowns. A buffer is calculated for each stream of work by summing the difference between the low-risk and the focused task time durations for each task in the stream.

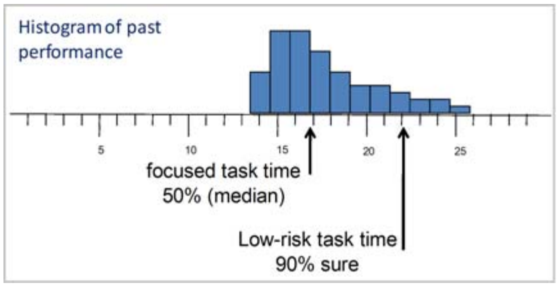

Figure 1

Forcing the planners to consider both 'focused' and 'low-risk' task times gets them to consider up front the issues that create risk or variation in the task time. The time to take the actions necessary to reduce those risks is during the planning process.

CCPM provides focus to the planning process by forcing the identification of the Critical Chain, i.e. the longest stream of work. The sum of the Critical Chain tasks' focused durations determines the minimum duration of a planned shutdown. These are the tasks that must be planned first and with extraordinary care and precision prior to the start of the scheduling process. All non-"Critical Chain" streams are referred to as "Feeder Streams".

Scheduling Process

A "Shutdown Definition Meeting" kicks off the scheduling process for the planned shutdown, imposing the CCPM structure from the start. The management team analyzes the pending shutdown to finalize its planned duration, define its structure and estimate daily manpower requirements.

The Critical Chain is then analyzed by the team for opportunities to reduce its duration. This analysis follows the thinking processes often referred to as SMED, or "Quick Changeover".

The shutdown structure is shown generically in Figure 2.

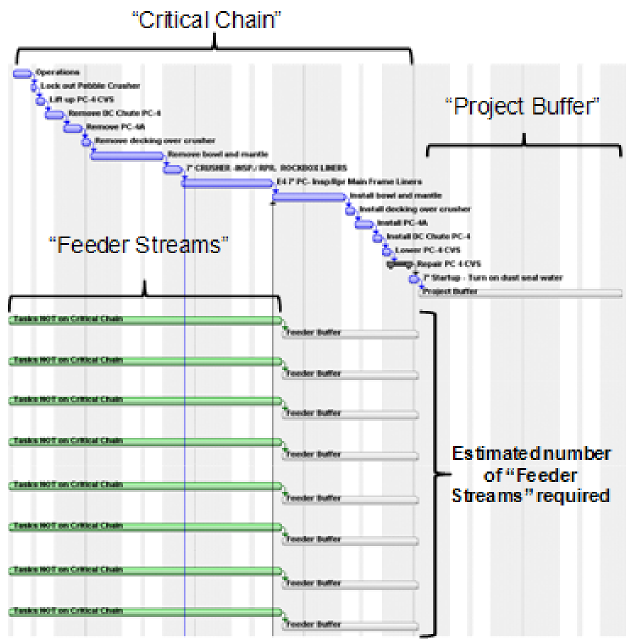

Figure 2

The buffer of the Critical Chain is the project buffer, and defines the overall shutdown duration window. All other streams of work including their buffers are scheduled to fit well within the minimum shutdown duration estimate. This ensures that variation in feeder streams will not jeopardize the shutdown duration.

The shutdown window and manpower requirements are reviewed to determine their feasibility based on business requirements and resource availability. If the shutdown is not feasible as designed, then a decision to extend the shutdown window, increase the resource levels, or reduce the total work content must be made.

Preparation Process

The preparation process sets up the shutdown for success. The application of 5S Workplace Design principles along with Standard Work processes ensures that all required equipment is tested and staged, all necessary tools are pre-positioned, parts are located in staging areas, and materials and supplies have been restocked. This ensures that when workers start a task they have everything they need to start immediately and be safe and successful.

Execution Process

The structure imposed by CCPM during the scheduling process enables the shutdown execution team to efficiently and effectively monitor the progress of the shutdown. The hundreds of work tasks that need to be monitored in the shutdown are reduced to a relatively small number of streams of work, each of which can be monitored in a manner that makes early problem detection possible, issues easy to identify, and priorities clear and unambiguous.

The buffers depicted at the end of every stream of work are expected to be partially consumed during execution. The rate of consumption of each buffer can be monitored as the shutdown progresses and compared to the expected rate of consumption, providing an early warning system for threats to the overall shutdown duration. A special kind of process behavior chart called a 'fever chart' is used to monitor buffer consumption.

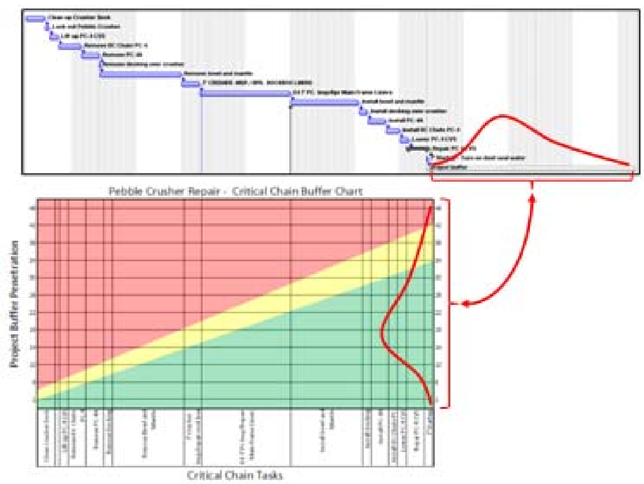

Figure 3

At regular intervals during the shutdown all work streams are polled to determine the hours remaining in the active tasks. A quick calculation determines the amount of buffer consumption that has occurred up to now and a point is plotted on the chart. No action is required if the point falls in the green zone; contingency planning starts in the yellow zone; and contingency plans are implemented if the point falls in the red zone.

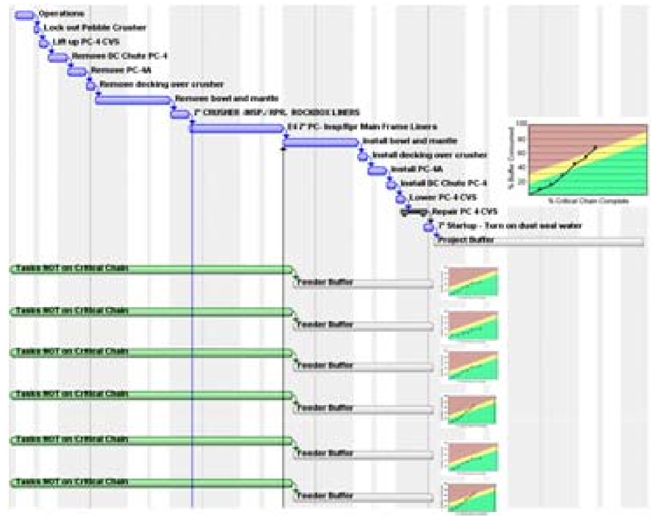

Figure 4

Fever charts are created for the project buffer and all feeder stream buffers. Fever charts make it clear where the coordinators need to spend their time. Top priority goes to the current Critical Chain task if the project buffer is in the yellow or red zone and Feeder streams in the yellow or red zones have second priority. If all fever charts are in the green zone, coordinators can concentrate on active and upcoming Critical Chain tasks. They are free to observe and interact with workers to identify issues and opportunities for improvement.

Analysis & Improvement

Analysis of the activities from work identification to execution is a continuous and on-going process throughout the duration of the shutdown. At the completion of the shutdown a formal evaluation of the entire process takes place.

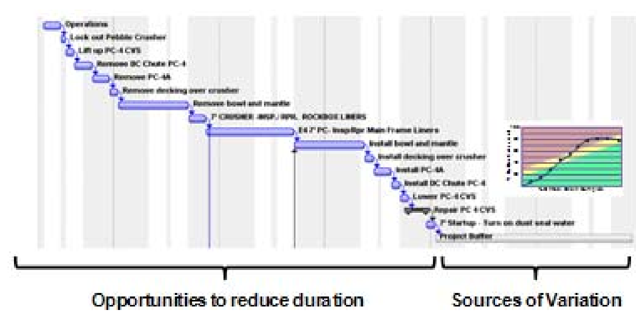

Figure 5

The formal review starts with analysis of the execution of Critical Chain tasks. Was each task properly defined in terms of content, sequence and timing? Were any opportunities for reducing task duration identified? What tasks contributed most to the variation that consumed project buffer?

Application to the Production Truck Overhaul Process at CNRMO

Changed production requirements at Cliffs Natural Resources Michigan Operations mine recently challenged management to significantly and quickly increase availability of the production truck fleet. The decision was made to focus on decreasing shop time for major overhauls. The operating plant maintenance group, in piloting the CCPM maintenance shutdown process, had significantly reduced the shutdown time for plant equipment. The Truck Shop leadership decided to apply the same technique to truck overhauls.

A team consisting of the planner, the scheduler, a coordinator, the senior coordinator, the section manager and an internal consultant was formed to learn and apply CCPM. The next truck overhaul, occurring in just 7 weeks, was targeted for the first application.

The team focused on identifying the critical chain of tasks for the overhaul. Following the CCPM planning process brought new clarity as the team worked on breaking work down into smaller, more defined tasks and creating more detailed planning of those tasks. The team also rethought the sequence of those tasks and challenged the inclusion of tasks in the critical chain. The result was the simplification and reduction of the critical chain through work externalization, component swap out, and identifying work that could be worked in parallel.

During the overhaul execution, team members spent time working with truck shop mechanics specifically focusing on critical chain tasks to identify improvement opportunities. In addition to task-related improvements dealing with parts, equipment, supplies, tooling, information, etc. that affected efficiency and effectiveness, they found ways to further streamline the schedule itself by identifying tasks that could be removed from the Critical Chain and incorporated instead in feeder streams or even in preventive maintenance opportunities not associated with the major shutdown.

The overhaul duration was reduced by 67% on this first iteration. The process continues to be refined and improved by the entire truck shop team with the result of continuing reduction in shutdown duration in subsequent shutdowns.

The team then applied the method to the overhaul of a LeTourneau loader and achieved a similar result – 58% reduction in overhaul duration, on the first application of CCPM.

The application of Critical Chain Project Management has aligned the entire truck shop organization around the improvement of the overhaul process and has launched them on a path of continuous improvement. The result has been ongoing improvements in all aspects of the truck shop, from work place design to task planning and scheduling; from crew meetings on the shop floor to management meetings on the "top floor". By providing a means to identify what actually adds value, CCPM has helped the truck shop focus their application of improvement methodologies and tools.

According to Truck shop Manager, the project intended to reduce truck shop repairs to meet short term requirements, "has changed the way our organization thinks, acts, and does business. This has been a very quick and powerful transformation".

CCPM Shutdown Management Process is now being spread throughout the entire CNR Iron Ore organization.

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