Investing in Industry 4.0 for the Gear Manufacturer/Job Shop (Part 2)

Assessing and modifying production systems prior to IoT implementation

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This article requires that the reader be familiar with Job Shop Lean, an approach to adapt the principles of lean manufacturing for a job shop, regardless of its size or industry sector. The following articles will give the interested reader a sufficient background on the many differences between Job Shop Lean and Lean:

1. Adapting Lean for High-Mix Low-Volume Manufacturing Facilities (*Gear Technology*, August 2012)
2. A Quick-Start Approach for Implementing Lean in Job Shops (*Gear Technology*, October 2012)
3. Remaster the Five Principles of Lean Manufacturing (*The Fabricator*, August 2018)
4. Investing in Industry 4.0 for the Gear Manufacturer/Job Shop (Part 1) (*Gear Technology*, July 2024)

A job shop typically executes a different schedule every day. Each day's schedule could have a different mix of jobs, due dates, lot sizes, and number of gear operations. Regardless of all these differences, it is important that the shop receives a feasible schedule that does not exceed available capacity constraints on key resources (machines, labor, materials, dies, etc.).

If a job shop desires to do daily work order releases that will not exceed resource capacity constraints, they should not expect their ERP (Enterprise Resource Planning) system to do this. The typical ERP system uses an MRP (Material Requirements Planning) or MRP-II (Manufacturing Resources Planning) engine to plan production and schedule operations. MRP assumes infinite capacity, fixed lead times, batch production to reduce setup times, etc. Instead of relying on an ERP system, the logical alternative is to use commercial FCS (Finite Capacity Schedulers) like *ORTEMS*, *Opcenter, Tactic* or *Schedlyzer*. It is not feasible to manually decide the set of jobs to release into production every day after taking into consideration resource capacity constraints, material shortages, changes in vendor deliveries, machine breakdowns, due dates, etc.

In the case of a manufacturing cell, there may not even be a need for scheduling software. Ideally, all the machines needed to produce any part in its part family (except vendor operations or external monuments like heat treat) will be co-located inside the cell. At the daily morning huddle, the cell's team could meet with the production controller. They could eyeball the jobs in process or in queue from the previous day and determine if the cell's bottleneck could process any new jobs. A cell guarantees start-to-finish control of the flow of its orders within a small area of the shop. Apart from unforeseen emergencies, the operators in the cell are empowered to work and execute as a team to ensure on-time completion of all jobs by their due dates. My years in industry as a full-time consultant have taught me to never underestimate the "do-or-die" determination of a cell's team to complete orders on time and below costs.

Water Spider Utilization

Once an ERP system is integrated with a commercial FCS, a job shop is able generate a feasible daily schedule for each cell—external monuments that are shared by the cells and support departments (receiving, shipping, inspection, etc.).

Next, they must release that schedule to the shop floor, execute it and, at the end of each shift, communicate the current shop floor status of all active jobs back to their ERP. The role of schedule execution and status updating in the ERP is fulfilled by an MES (Manufacturing Execution System). If the facility is large (> 100,000 sq. ft.), then there is merit in implementing a fully integrated PPC (Production Planning and Control) system comprised of an ERP (*SAP*), a Finite Capacity Scheduler (*Opcenter*) and an MES (*Factory Viewer*). However, in the case of a single-location high-mix low-volume job shop, especially a small family-owned job shop, it may not be advisable to immediately purchase an MES. Instead, I will advise every job shop to create the position of water spider(s) by freeing up one or more employees on the shop floor.

A water spider is a role centered around timely and accurate stock replenishment. The water spider team member refills the production line with the required materials to maintain a steady workflow.

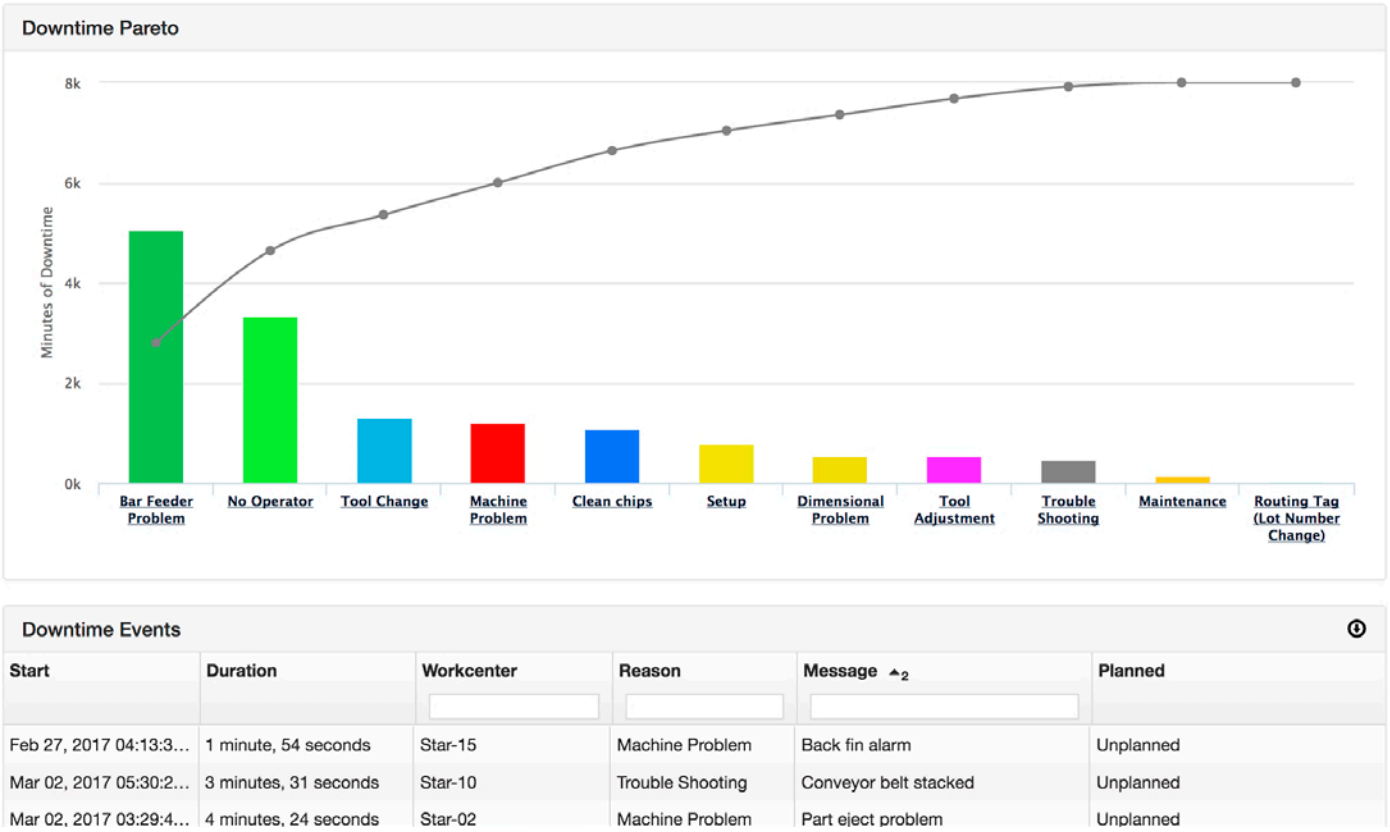
Imagine a job description for a new position that combines the work that is typically done by a material handler (who reports to the plant manager) and an expeditor (who reports to the production controller).

Water spiders will handle all shop floor logistics related to moving raw materials, in-process batches and finished parts between machines as specified in the routers of the different parts. By virtue of being all over the shop floor, the water spiders have the "situational awareness" and authority needed to execute, monitor and update the daily schedule that was released to the floor. In a recent Job Shop Lean implementation project, the two water spiders eliminated the previous practice where every employee—including the skilled CNC machinists—was responsible for moving the pair of screws that they finished on their machine to the next machine in the parts' routings. The typical process for moving a batch from one machine to the next involved (1) walking across the shop to fetch the bridge crane and docking it at their machine, (2) walking around the shop to find a cart on which the screws would be loaded, (3) returning to the machine to unload the screws off their machine onto the cart, (4) pushing the cart to the next machine and (5) returning empty-handed to their machine to wait for their next job.

Significant savings were realized once they consolidated the non-value-added walking time of all shop employees into the work done by just the two water spiders.

Machine Monitoring Implementation

The Goal is a book written by Dr. Eliyahu Goldratt that introduces his Theory of Constraints (TOC). A cornerstone of this theory is the idiom "A chain is no stronger than its weakest link". In the case of an on-demand machining cell that produces different parts in a part family, the cell can only complete as many orders as the cell's constraint machine (aka bottleneck) can complete. The cell's bottleneck is that machine which is always having orders in queue (WIP) during each shift while the other machines remain idle.



Start	Duration	Workcenter	Reason	Message	Planned
Feb 27, 2017 04:13:3...	1 minute, 54 seconds	Star-15	Machine Problem	Back fin alarm	Unplanned
Mar 02, 2017 05:30:2...	3 minutes, 31 seconds	Star-10	Trouble Shooting	Conveyor belt stacked	Unplanned
Mar 02, 2017 03:29:4...	4 minutes, 24 seconds	Star-02	Machine Problem	Part eject problem	Unplanned

Figure 1—Pareto plot of capacity loss categories. Courtesy of MachineMetrics.

Dr. Goldratt proposed a five-step Process of Ongoing Improvement (POOGI) whose first step is to exploit the constraint in the cell. The focus is to "win back" all the avoidable losses of capacity such as setup time, idle time due to non-arrival of the next job, machine stoppages due to CNC program errors, unscheduled breaks taken by the operator, time to change broken tools, etc.

With the abundance of machine monitoring systems on the market (FactoryWiz, Memex, FORCAM, MachineMetrics), it is possible to do 24/7 monitoring in any job shop of the bottleneck machines in all the cells as well as the monuments. Figure 1 shows an example of one of the many reports from an MMS that summarizes the capacity losses on a CNC machine. Do you notice that "No Operator" is one of the top three reasons for capacity loss for this machine? In contrast, traditional methods such as video monitoring or random visits by supervisors project a lack of trust on the part of management. Plus, such reports can be used to conduct a series of kaizens with the sole purpose of improving value-added machine utilization thus increasing its daily order completion performance.

Figure 2 presents a systematic description of the four categories into which the time recorded by the MMS for different activities performed on any machine during an eight-hour shift can be categorized.

TEEP (Total Effective Equipment Performance) is a performance metric that provides insights as to the true capacity of any manufacturing operation. It considers both equipment losses (as measured by overall equipment effectiveness) and schedule losses (as measured by machine utilization). It is desirable that the TEEP for a cell's bottleneck be around 80–85 percent. It is not surprising that machine monitoring systems are aggressively advertised for supporting effective maintenance programs for individual machines or multi-machine cells.

Plant Not Open	Schedule Losses	TEEP takes into account Schedule Losses.
Production Not Scheduled		
Setup & Adjustments	Six Big Losses	OEE takes into account the Six Big Losses, which map to OEE Losses as follows: • Availability Loss (Orange) • Performance Loss (Blue) • Quality Loss (Purple)
Breakdowns		
Reduced Speed		
Small Stops		
Production Rejects		
Startup Rejects		
Fully Productive Time	OEE / TEEP	OEE is the ratio of Fully Productive Time to Planned Production Time. It takes into account Six Big Losses. TEEP is the ratio of Fully Productive Time to All Time. It takes into account Schedule Losses and Six Big Losses.

***Figure 2—Components of the eight hours of theoretical available capacity on any machine. Courtesy of* oee.com.**

The Reliance on an ERP System for Shop Floor Management

There is a widespread misconception that could limit US job shops from gaining additional lean benefits. Some believe lean and ERP are incompatible. ERP systems, in fact, are here to stay whereas the manual paper-and-pencil tools could go away. ERP systems can support lean in three ways:

1. They have the functions/modules to implement lean.
2. They have the data to support lean projects.
3. They can integrate with third party software that implements lean practices.

Unfortunately, the fundamental shortcoming of contemporary ERP systems is that they do not have up-to-date, complete and accurate data. In fact, some ERP systems appear at best to support accounting and customer relationship management professionals.

Here are questions a leadership team should ask their production controller regarding the symmetry between lean and ERP:

1. Can an order be accurately located with a reliable estimate of its completion date?
2. Can the daily schedule be accessed as an electronic Gantt Chart from any shop floor terminal in the shop?
3. Can the water spiders receive an accurate daily dispatch list of orders during a shift?
4. Can the water spiders communicate in real-time with the office to update the daily schedule in the ERP system?
5. Can the ERP system support daily morning huddles on the shop floor or meetings in the conference room by providing data analytics and reports on demand to support decision-making?
6. Can the ERP system plug-in to third party tools for Digital Visual Management (iObeya or Leankit)?

If any shop wishes to determine if all their IT systems are able to help them to pass my SAT (Situational Awareness Test), I encourage them to schedule a 2–3-day kaizen, invite a representative from every department, select any in-process shop floor order and determine its location and shipping status.

I can send a copy of the Job Shop Lean Assessment Tool and assess the current situation in your manufacturing facility.

leanandflexible.com

Editor's Note:

The author encourages gear manufacturers to post any lean questions they may have for a future "Ask the Expert" article in *Gear Technology*. Submit your questions to *shahrukhirani1023@yahoo.com* or *jaster@agma.org*.