# JOB SHOP LEAN

Ed's Note: This is the second article in an eight-part "reality" series on implementing Continuous Improvement at Hoerbiger Corporation. Throughout 2013, Dr. Shahrukh Irani will report on his progress applying the job shop lean strategies he developed during his time at The Ohio State University. These lean methods focus on high-mix, low-volume, small-to-medium enterprises and can easily be applied to most gear manufacturing operations.

**Dr. Shahrukh Irani, Director IE Research, at Hoerbiger Corporation of America**

## Lean Team Building

The organizational hierarchy of the lean enterprise is comprised of executives, managers, engineers, supervisors and employees. Yet, when it comes to continuous improvement (CI) events, the literature on lean indicates an over-emphasis on the shop floor. These kaizens typically involve the plant manager, supervisors and employees who work in the department where the kaizen was done. It's as if engineers and managers are not contributing their share of the effort to improve the bottom line!

Conventional wisdom says to let all CI work be considered and implemented only by the employees themselves. Otherwise, improvements will not be accepted or solutions will be implemented in half-hearted fashion at best. Should we avoid solving those "sticky" problems that have not been solved for years just because shop floor employees may not be able to solve them? Or should we expand our choice of who we put on these problem-solving teams so that experience blends with computer skills and analytical abilities?

## Guidelines for Forming Problem-Solving Teams

In this section, I will describe the strategies that have guided the composition (team size, skills and experience of each member, extent of cross-functionality, etc.) of the continuous improvement teams that I have successfully utilized in the course of my job at Hoerbiger Corporation of America:

Plan the composition of the team to suit the scope and complexity of the problem.

Prioritize the problems based on impact on the bottom line and not who will be available to work on the team.

Insist that the project *must* improve key performance indicators (KPI) such as safety, quality, delivery, waste elimination, etc. in the area where the team will work.

Leverage external resources; in particular, student interns from a reputed industrial engineering department or on-staff industrial engineers (or manufacturing engineers).

Utilize computer-aided analytics if the problem merits it, such as the Six Sigma statistical analysis software, *Minitab*.

I will discuss the above guidelines in the context of a series of inter-linked CI projects that we are doing in the shipping department.


**Figure 1** Items Removed after a 5S Sorting Event.

## Shipping: Where our Continuous Improvement Efforts Began

The shipping department is the closest to the customer, and its main objective is to maximize shipped orders every month.

It was decided to assess how much of the current floor space in the shipping department was "dead" and therefore could easily be reclaimed. First we did a walkthrough of the entire department with the shipping team and pointed out examples of areas that were VA (value-added), NNVA (necessary-but-not-value-added) and NVA (wasted). It was the NVA areas that we focused on because they were occupied by junk. Naturally, the very first continuous improvement project was a simple housekeeping task

that lasted about two hours. We handed everybody a few red stickers and asked them to go around the department and affix their stickers to items that they were confident nobody had any use for.

It turns out that our shipping department is essentially a job shop. It stands to reason because (1) Each of the five cells in our machine shop is a high-mix low-volume job shop and (2) both focused factories in molding – cold compression molding and hot compression molding – are high-mix low-volume flow shops. The shipping department handles a mix of workflows since we serve global customers whose typical shipments involve a variety of parts. Different kits have different packaging requirements (carton size vs. wooden crate, labeling specific to the customer and country of destination, etc.). The routings that were processed in the shipping department were due to the following product mix:

- Packing Rings
- Piston and Rider Rings
- QRC Packing Rings
- Bushings and Cases
- GE Kits

The department was advised to separate the product, person and information flows for each of these routings. The spreadsheet containing the *Production Flow Analysis and Simplification Toolkit (PFAST)* Input File was then sent to Pranav Joshi, a graduate student in the Department of Integrated Systems Engineering at The Ohio State University. The *PFAST* software was made available by The Ohio State University for this project. We used the *PFAST* Analysis Report to generate five new alternative layouts for the shipping department. These layouts were designed based on guidelines such as a separate cell for each customer, a central shared "IT Hub" and other desired features.

Presently, Clement Peng, from the IE department at Texas A&M University, plans to visit HCA-TX every Friday and completely immerse himself in the day-to-day operations of the shipping department. His goal is to develop a detailed blueprint for the final layout, including a budget and implementation timeline.

Now that I am in industry, a real-world classroom where the true relevance and need for IE is widely evident, I am able to teach Peng how lean radically changes the standard approach to facility design that is taught in any contemporary IE textbook for facilities planning. Why? Because the footprint of each and every workstation, table, aisle, rack, container, etc. in the layout is potentially bloated with waste.

Toyota either pioneered or raised the importance of concepts such as right-sizing, mobile machines, reconfigurable layouts, visual WIP management, combined operations, jidoka (automation with a human touch), parallel operations, and more. For example, Robert Lu (an employee in the shipping department) carefully places all the parts that are going to be shrink-wrapped on a GE skinboard (cardboard backing) on the packaging table. Next, he carefully picks up the GE skinboard, slowly turns around and places the kit on the table of the shrink-wrap machine. Should not the two tabletops that he works on be a single sliding table that slides into and out of the shrink-wrap machine? At least that idea made us all pause and think for a moment during one of our weekly team meetings.

## Inventory Control Techniques

While the Sort phase of a full-fledged 5S program usually yields results, the real benefits to be gained from doing 5S are when the "hidden evils" such as ergonomic risks, inventory costs, inefficient flows of people and material are banished. Since inventory costs are visual and measurable, Team Shipping decided to take a systems approach to control the purchasing costs for the carton inventory. These cartons and wooden crates are used to ship our products all over the world, often to other Hoerbiger plants.

That there appears to be excessive inventory of several SKUs (stock keeping units) of carton inventory is obvious. So we collected data on purchases of the different SKUs made from June 20, 2012, to November 7, 2012. This time series display of the data did not yield any insights. Instead, when we plotted the same data using the classical Pareto rule of 80-20, some valuable insights were gained.

Here is where looking at color printouts of *Excel* graphs doesn't necessarily match the reality of the shipping department. It was pointed out to us that the high inventory of the GE Whiteboards was an unavoidable business situation because (1) we shipped that item

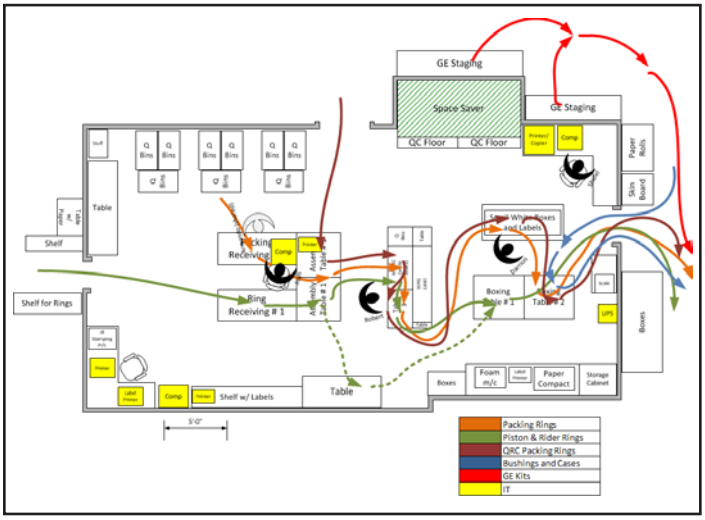



**Figure 2a Current layout of the shipping department.**

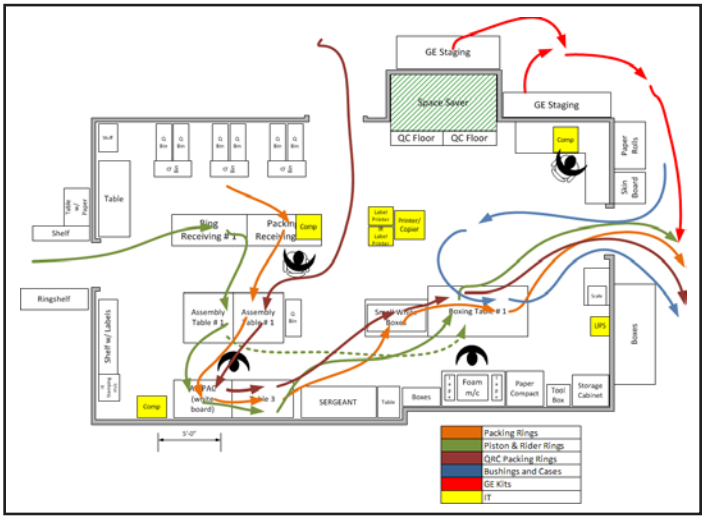



**Figure 2b New layout being designed for the shipping department.**

to sister divisions and (2) the supplier was committed to shipping a full pallet instead of split loads. So what appeared to be NVA (non-value-added) was actually N&VA (necessary and value-added). One of the important decisions taken after supervisor Charlotte Pett met with our materials manager, Anthony Herrell, was to plan purchase quantities (Average Demand + Safety Buffer) for a week-by-week planning horizon.

Here is how we are integrating lean and IE to develop a comprehensive system for inventory control. Figure 3a and Figure 3b show the "bicycle rack" that was fabricated and installed by a team of employees (Francisco Salazar, Juan Nunez and Armando Gomez) on a Saturday. The key reasons for this design are: (1) to exploit the natural shape and size of how these items are delivered to us (2) to compact all of this inventory into a smaller volume, which freed up the topmost racks where the wooden crates are stored and (3) it is easy to eyeball each slot to know how much on-hand inventory we have for that particular SKU.

Another idea that is being pursued is to utilize a moving average or exponential smoothing forecasting algorithm that uses the past few weeks' consumption for any SKU and forecasts a ballpark requirement for next week. This forecast is adjusted by Pett who has intimate knowledge of any hiccups in the shipment schedule for next week.

Darrion Lincoln, a shipping employee, is helping to collect the weekly usage and receipts data for each SKU and Shalini Gonnabathula, our industrial engineer, is maintaining the forecasting model written in *Excel*. While there is no immediate confirmation that this reliance on analytics is good/bad, at least we are trying to integrate gut feel, experience, practical logistical costs and statistical data analysis.

The data collection will also help us to sort the SKUs by volume into "Runners" (high weekly usage) and "Strangers" (low weekly usage). This, in turn, will help us to implement a 1-bin kanban system for the latter category of SKUs; i.e. the entire inventory for that SKU will be stored in the outside rack. Whereas, a 2-bin kanban system will be used for the Runners; i.e. the inventory for each of those SKUs will be split between a mobile carton stand (2-3 days usage) kept right next to the table on which Lincoln packs cartons and the outside rack (rest of the inventory). Pett is following up with this supplier (*http://www.stackbin.com/categories/carton-racks/*) recommended to her by Herrell.

In addition to the above features of our inventory control system, we received valuable assistance from one of


**Figure 3a Bicycle rack for compact storage of cartons.**

**Figure 3b Detailed view of bicycle rack.**

our suppliers—Grainger. Inmer "Ivan" Guzman is one of their onsite reps, regularly replenishing inventories of shop supplies, office supplies, etc. One day I observed him using his iPhone to swipe bar codes for items stored in the cabinets in our lunch room. That was my first introduction to a VMI (vendor managed inventory) system that starts as a bar code swipe and ends as an order quantity uploaded to their ERP system.

As we discussed our lean projects, he walked me over to one of his pet projects—an e-kanban system to manage supplies in our first aid cabinets on the shop floor. The numbers placed on the containers connect to the bar code for that item on the sheet stuck inside the glass door of the cabinet. If all goes well, that same system is what we will use to automate the weekly replenishment of the carton inventory held in the shipping department. Once that system is debugged we can implement the same data-driven computerized inventory control for: QRC packing boxes, GE skinboards, wooden cartons, bushings supermarket, powders and bar stock.

## The Strategic Value of University/Industry Partnership

The downside of having quickly "plucked all the low-hanging fruit" so soon during our lean journey in the shipping department is that complex problems now need to be tackled.

- Figure 4 presents the potential for reducing the number of different cartons that we buy. If we could standardize on the sizes that we use, and reduce this number, that ought to reduce our purchasing and inventory carrying costs. For example, the carton sizes 8×6×6 and 6×6×6 differ by a cubic volume of only 72 cu. in. We studied the data on the usage of these two sizes during the period October 9–November 6. If we decided to buy only the 8×6×6 size in the future, that would result in us shipping a total volume of (2×6×6×56) cubic inches of air that would have to be filled up with crumpled paper or foam padding. How does that cost trade off against being able to buy 35 more cartons of the 8×6×6 carton size? This appears to be a technical problem that could be offered to an IE graduate student doing their MS thesis. Or, we could be pragmatic and listen to Pett who has already eliminated 4 SKU's as of the writing of this column.
- Figure 5 shows that the current state of how the on-hand inventory of the many different packing rings that we make and sell to our customers is stored in floor-mounted bins (Q-bins) and the space saver (vertical lift module). What do

| Material/Size | Consumption during Oct. 9 - Nov. 6 | Inventory on 11/6/2012 | Footprint [square inches] | Volume [cubic inches] |
|---|---|---|---|---|
| 18X18X4 | 37 | 38 | 324 | 1296 |
| 16X16X4 | 99 | 58 | 256 | 1024 |
| 12X12X6 | 49 | 124 | 144 | 864 |
| 10X10X8 | 38 | 105 | 100 | 800 |
| 14X14X4 | -28 | 68 | 196 | 784 |
| 12X12X4 | 7 | 88 | 144 | 576 |
| 8X8X8 | 44 | 69 | 64 | 512 |
| 10X10X5 | 128 | 27 | 100 | 500 |
| 9X9X6 | 75 | 93 | 81 | 486 |
| 8X6X6 | 116 | 93 | 48 | 288 |
| 6X6X6 | 56 | 172 | 36 | 216 |
| 18X18X10 | 121 | 1 | 324 | 3240 |
| 14X14X14 | 17 | 37 | 196 | 2744 |
| 16X16X10 1/2 | 73 | 93 | 256 | 2688 |
| 20X20X6 | 24 | 18 | 400 | 2400 |
| 14X14X10 | 127 | 71 | 196 | 1960 |





**Figure 4** Grouping cartons with similar packing volume.

you think of the packing efficiency of the current storage scheme? Further, metallic rings must be stored in the Q-Bins while the lighter non-metallic rings are stored in the space saver. This project is included in Pranav Joshi's portfolio. He will be working with warehouse and inventory supervisor Andrew Reynolds to pursue the following goals: (1) reduce the on-hand inventory levels and (2) reduce the average pick time to collect the different part numbers that constitute a shipment, which is typically comprised of many part numbers.

- There is a rack on the other side of the shipping department where orders pending shipment are staged. One category of orders is those that are waiting for one or more line items to complete production. If the shipping department is assessed on just one KPI – total $ shipped per month – then all these orders on that rack should be seen as an easy opportunity to improve the KPI. Simply by engaging the staff in a 5 Whys discussion, we have identified half a dozen reasons why such incomplete shipments result. This is a Six Sigma project that we hope will interest Clement Peng to continue working with us while he is studying at Texas A&M University. Or, we have green belts on staff at our Pompano Beach location who could partner with Shalini on this future project.

## How IE Research could Really Benefit All U.S. Manufacturers

Like any small for-profit manufacturer, HCA-TX is not geared to solve any complex operational problem as if it were a three-year research project funded by the National Science Foundation. The shipping department, like any other cell or department, is a high-pressure work environment that is time-constrained and resource-constrained, but luckily, not patience-constrained. Team Shipping pursues just one daily goal—receive the "stuff" coming in from one door and get it out the other door onto a truck that same day. If operational problems arise, they are solved using common sense, firefighting, thumb rules, resignation, brute force, overtime, teamwork, negotiations with customers and suppliers, sometimes even prayer. The nearest that we have by way of computer-aided optimization is spreadsheet-based solvers. And Team Shipping has done well to date.

Despite the above operational constraints, I think that there is merit in HCA-TX establishing a university-industry partnership with a couple of IE departments in the state. Once I read *Lean Thinking,* in 1999, I was convinced that lean is the correct industrial engineering that we never taught to our students in any IE department. In a perfect world, a group of practice-oriented IE faculty would first work in industry to get sufficient work experience.

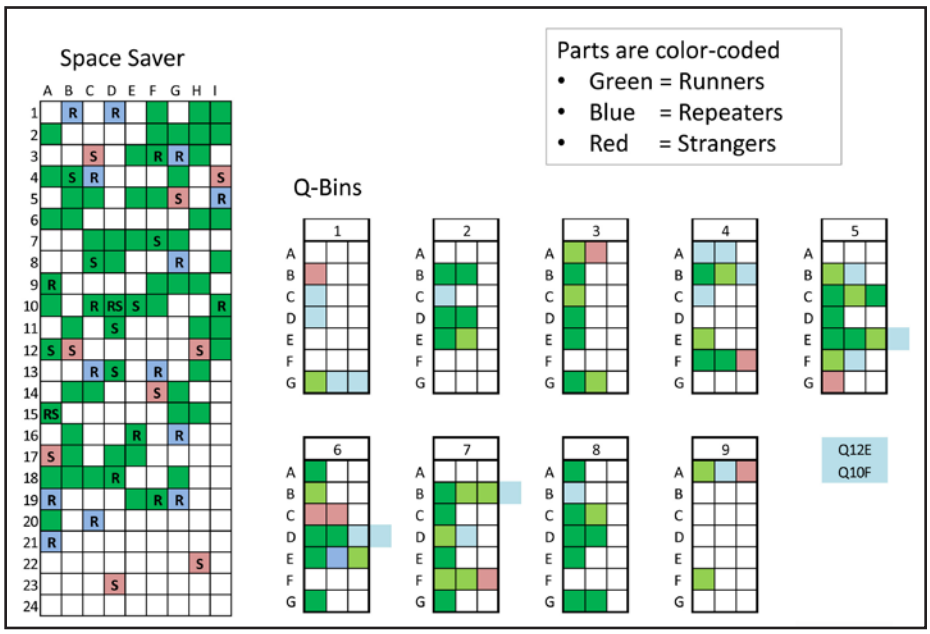
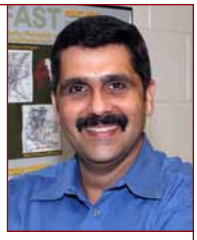



**Figure 5 Current storage of packing rings in the Q-rings and space saver.**

Then they would seek federal funding to establish a national industry-university research center in partnership with the NIST network of Manufacturing Extension Partnerships (MEP). And what would they do? Produce a slew of much-needed heuristic optimization software tools that would allow industrial engineers in the field to modernize and extend lean beyond its pencil-and-paper problem-solving tools.

**Dr. Shahrukh Irani** is the director of industrial engineering (IE) research at Hoerbiger Corporation of America (www.hoerbiger.com). In his current job he has two responsibilities: (1) To undertake continuous improvement projects in partnership with employees as well as provide them OJT training relevant to those projects and (2) To facilitate the implementation of job shop lean in HCA's U.S. plants. Previously, he was an Associate Professor in the Department of Integrated Systems Engineering at The Ohio State University (OSU). There his research focused on the development of new IE methods to adapt and scale lean for use by high-mix, low-volume SME's (small and medium enterprises). His research group created PFAST (production flow analysis and simplification toolkit), which is a software program for material flow analysis and facility layout to implement Job Shop Lean. At OSU, he received the Outstanding Faculty Award for excellence in teaching from the graduating classes of 2002, 2003, 2004, 2005, 2006 and 2009. In 2002, he received the Charles E. Mac Quigg Student Award for Outstanding Teaching from the College Of Engineering. He is a member of IIE.


# How's Your Shipping Department?

Matthew Jaster, Associate Editor

This month's **Job Shop Lean** column addresses key steps to maximize the shipping department. This area is often overlooked, given the day-to-day priorities of a typical gear manufacturing operation. By focusing on lean principles and team building, a few tweaks to shipping can maximize productivity, improve lead times and increase revenue. Best of all, it's not rocket science! A few minor improvements could result in significant savings and could be the difference in gaining or losing an important contract in the future.

## Quality/Inspection

"Many companies take for granted the fact that the shipping department is the last quality check before the product goes out the door," says Bipin Doshi, president, Schafer Gear Works, Inc. "It's essential for the shipping team and the production team to be on the same page. If the department takes a proactive approach and is very conscious of everything that is happening, they can make sure they don't ship product with any problems."

Communication between departments is crucial as well as a holistic approach to lean manufacturing that involves everyone from the ground up.

"Our greatest challenge is to improve quality and delivery time while also reducing costs," Doshi adds. "Continuous improvement (CI) initiatives have helped open communication lines between departments, so the shipping personnel, for example, know what's going in and out on a weekly and monthly basis. It's nice to have an extra set of eyes before your product goes out the door. We consider our shipping department sort of like the last line of defense before our product reaches the customer."

## Maximizing Space

"We essentially grew out of the building we were in previously," says Tony Werschky, sales/partner at Delta Research Corporation. "We moved into a new building and created a flexible gear cell that includes part cleaning, deburring, packaging and shipping. This essentially has streamlined our production process and helped us with our throughput."

Whiteboards for communication improvements keep personnel up to date on everything coming in and going out of the department. Because the company specializes in both aerospace/defense and automotive applications, documenting the entire inspection process is critical for success. "Maintaining our whiteboards and keeping the entire team aware of what projects have been completed and what projects need to still be addressed helps to accomplish our goals."

Delta also incorporates "floating personnel" throughout the shop floor. These multi-tasking employees may operate a machine one day and be pulled the next day to assist in the shipping department. "This is dictated by the amount of work in a certain area, it's nice to have the flexibility to move them around depending on our priorities," Werschky says.

Additional space in the building has also led to converting tables to work centers for the deburring crews. "This gave us room to create areas with better lighting and usable work surfaces," he adds, "which has also led to efficiency gains."

While Delta's lean manufacturing enhancements were assisted with a move to a larger building, other companies may just need to rework or reimagine their work areas in order to increase efficiency.

## Carton Count

"Maintaining the proper amount of shipping material, for example, used to be a real problem," Werschky says. "If you're packaging a special order and it's out of the ordinary, it may require a certain box size you typically don't carry. It's time consuming to chase around looking for the best material to ship the product. We try to carry the right amount of materials for our current requirements. This prevents us from not having enough shipping containers and also prevents us from carrying too much."

## Committing to Lean

Schafer Gear Works and Delta Research Corporation boast rather efficient shipping departments and lean manufacturing has most certainly played a key role. In 2009, both companies appeared in a lean manufacturing article ("Steadfast and Streamlined," ***Gear Technology***, August 2009) that discussed the benefits of lean during the economic downturn. These companies have paid close attention to the lasting benefits of continuous improvements across the shop floor. These improvements continue to pay off today.