Solectron将注意力集中在通过消除浪费来降低成本，我们对浪费的定义是：客户不愿承担费用的活动。计划包括在世界各地的所有工厂彻底实施精益制造。我们的墨西哥瓜达拉哈拉设施被选为最先实施这个计划的几个现场之一，因为这间设施在美洲地区人数最多，工作场地面积也是最大的之一。目前，该设施在六座大楼内有几千名雇员，组装的产品是消费者电子产品。这里详细说明这间工厂如何改进生产率。

Fat Results for Lean Times

Ajay Agarwal

How Solectron's Lean program increased productivity 13% and cut lead times 68%.

Today's marketplace has caused manufacturers to rethink their business models. The days when the price of a product was determined by a simple equation (cost + profit = price) have disappeared as some manufacturers find themselves competing against companies selling even below their cost of materials. What to do?

In Solectron's case, we are focused on reducing costs by eliminating waste, defined as any activity that the customer is unwilling to pay for. The program involves implementing Lean manufacturing thoroughly across every plant worldwide.

The Solectron Guadalajara facility was selected as one of the "engine" sites to implement this program because it has the largest headcount and one of the largest square footage working spaces in the Americas. Several thousand employees are based in six buildings on the Guadalajara campus. Each building is approximately 65,000 sq. ft. and has the capacity to hold multiple SMT and box assembly lines. The majority of products assembled at this site are consumer electronics devices, such as set-top boxes and smart phones, and the rest are networking communication products (cable signal voice ports, telephones, wireless modems), computing devices (PCs and servers) and electronics equipment for automotive.

FIGURE 1: Pre-Lean, boxes of parts were stored on big racks.

FIGURE 2: Today, direct-kitting removes boxes of parts from the line, reducing inventory to only the quantities necessary in the form of the supermarket.

Lean manufacturing has a history that goes back almost 50 years, with automaker Toyota first popularizing this approach for product assembly. The primary concept behind Lean is to remove waste (muda), leaving behind only valuable, efficient processes. And we're not talking about a trim here and there. It has been estimated that between 90 and 95% of traditional manufac-

turing actually is waste, meaning a manufacturing facility fully implemented in Lean is a fierce, competitive weapon.

The Lean process starts by identifying the waste that needs to be eliminated from the manufacturing process. Experts have identified seven types of muda that need to be eliminated or minimized to reduce costs, which we call COMMWIP:

C: Correction (any rework or correction is considered waste).

O: Overproduction (considered the mother of all other wastes).

M: Motion (unnecessary or excess motion by parts, by operators or by anyone who might affect the production efficiency and parts quality).

M: Material movement (unnecessary movement of material).

W: Waiting (batch production and big inventories promote waiting).

I: Inventory (any accumulation of product is considered as inventory except standard WIP, which is a bare minimum quantity of product between workstations to maintain the smooth product flow).

P: Overprocessing (which generally happens when we do not understand the exact requirements of our customers).

The next step in the Lean process is to identify those actions for which the customer is willing to pay (value add) and those actions that should be eliminated to become more effective, productive and profitable (non-value add). This process is known as "value stream mapping" and provides an opportunity to look from end-to-end to preempt the obstacles and stoppages that may be encountered along the manufacturing process.

Finally, the implementation of Lean requires five key elements:

- **Value:** Defines the value from the perspective of the final customer.
- **Value chain:** Identifies the set of actions required to bring the specific product through three critical management tasks of any business – problem solving, information management and physical transformation.
- **Pull system:** Lets the customer pull products as needed, eliminating the need for a sales forecast.
- **Continuous flow:** Eliminates functional barriers to help improve lead times.
- **Perfection or Kaizen (continuous improvement):** There is no end to the process of reducing effort, time, space, cost and mistakes.

Once all five elements are implemented, quality improves, which is the most important factor for both supplier and customers. Productivity also improves, manufacturing lead times shorten and material flow increases. Note that in Lean terms, productivity improves when we produce just what is required but with less manpower and in less time than in traditional manufacturing.

In a Lean plant or production floor, such as the Solectron Guadalajara plant, large amounts of inventory do not pile up;

this would be contrary to the concept of flow. Product should be able to flow without any stoppage or waiting for its turn to be processed. Product flow stops frequently in conventional batch production, which is why we no longer produce in batch mode. The root problem of batch production is long changeover times – lines have to produce more at one time than the time it takes for changeover so we are forced to produce in a big batch. At Guadalajara, changeovers used to take almost 2.5 hours. Working in a conventional manner meant stopping the whole line, flushing out old product and then starting the changeover. Then, we adopted the methodology used by NASCAR for pit stops, where a team of people is on hand to make the necessary changes (interesting fact: the average changeover time on a NASCAR pit stop is 7.6 seconds). Our previous changeover method was the equivalent of Jeff Gordon himself getting out of his car to change the tires and fill the gas tank. Instead, we instituted a cascade changeover process, implementing SMED (single minute exchange of die) and combining the NASCAR concept to reduce our changeover time from 2.5 hours to less than 99 seconds.

Pull vs. Push

Migrating to a pull-based system from a push-based system has driven down overproduction at the Guadalajara plant. Our direct-kitting process is a good example of low- to medium-volume production. Instead of having boxes of parts on the line, parts are "pulled" based upon demand from production-line operators, enabling inventory to be on the line only when needed and only in the quantity necessary. This pull system has reduced the number of parts handled and has led to improved manufacturing flow by increasing on-time delivery and reducing time-to-market. Previously, our employees touched the parts nearly 24 times before they were loaded to the machine. With the pull-based system, the number of touches is 11 (a 54% reduction), with continued efforts to reduce it until there are no partially complete material kits issued to the floor. Furthermore, material is released onto the floor ready to be loaded on the machines. No counting, preparing or validation is done by line operators; these tasks are already accomplished before the material gets to the shop floor. This has allowed us to reduce lead times from five days to half a day, a 90% improvement.

FIGURE 3: Raw materials before implementation of direct-kitting were once warehoused offsite…

FIGURE 4: … Are now next to the high volume production lines, eliminating unnecessary operator motion and transportation.

When we analyzed some of our product flow, we were surprised that products traveled within the plant for a considerable distance before they got out of the floor to customers due to batch production, long conveyor systems and spread-out operations. We performed a "spaghetti" analysis and reduced that big loop to a straight-line flow.

Additionally, for the high-volume lines in Guadalajara, we used the "supermarket" inventory method to cut back on excess motion, which in turn helped to reduce WIP by 61%, from 13.8 days to six, and lowered lead times 68%, from 6.6 days to 2.1.

The supermarket method was also used for the raw material inventory. We moved it next to the production lines, rather than placing it offsite in the warehouse. A worker with a "water spider" (a lightweight cart), follows a scheduled route and delivers parts to the line from the supermarket. This enables the lines to be restocked at least every two hours, depending on consumption level and replenishment frequency. It also removes the need for operators to waste time finding and bringing the parts to the factory floor, thereby eliminating any unnecessary operator motion and transportation. Operators just need to pay attention to the product being assembled and not worry about material. As a result, the Guadalajara facility was able to reduce the risk of excess hidden inventory and obsolete parts. There is less handling of parts and no unplanned line stoppages due to material shortages. Ultimately, cost competitiveness, quality, productivity and flexibility have all improved.

As part of its Lean strategy, Solectron has developed a zero-defect commitment with a number of its customers, which ensures that any abnormalities or defects on the line are stopped as they occur. This has enabled Solectron to improve the quality of its products. In our plant, everyone working on the shop floor is authorized to stop the line if they see abnormalities or defects in the products. Audio-visual line stop alarms are installed on every line in the plant. Furthermore, we implemented a number of Poka Yokes on our production lines (Poka Yoke is the foolproof method of doing the work right the first time). Poka Yokes prevent defective products from passing to the next production stage or on to customers. It also alerts the operator to mistakes, so that they can be corrected before passing to the next station. We have mastered these simple techniques and tools to improve product quality and ultimately to achieve zero defects on our production lines. Zero defects can be achieved only through the implementation of Poka Yokes.

The end result: Solectron's Lean program has transformed the Guadalajara site from a large, high-volume manufacturing facility into a thriving, productive, highly efficient plant. The changes implemented have helped increase productivity by 13%, from 1.43 units per man-hour to 1.62 units per man-hour; product quality (yield) is up 1.9 points to 94.2%; manufacturing lead time has improved 68%, from 6.6 days to 2.1; work in process in terms of days of supply improved by 57%, from 13.8 days to six; and space utilization improved 27%.

We have not stopped there; we continue to improve through Kaizen (continuous improvements). ■

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