本文找出了在电子产品的组装上，时间、金钱和材料浪费的多种渠道。不幸的是，这些效率低的问题并不总是一目了然。最大的浪费因素包括大量的材料库存、生产过剩、效率低的生产程序、生产差错、等待时间、不必要的运输和移动等。本文将讨论如何避免和解决这些效率低的问题。

Lean Production in Electronics Assembly

Adrian Schärli

To be competitive, production managers must have a lean organization with increased flexibility.

Many ways exist to waste time, money and material in electronics assembly, as in every production environment. Unfortunately, these money pits are not always visible. If you feel your company may be wasting too much, here are some of the largest waste factors and what you can do about it.

Logistical analysis of different production environments shows common waste factors, of which seven are the most important (Table 1). Continuing to put effort into these factors will just increase cost, without adding any value to the product. Therefore, the customer will not appreciate it and, of course, will not pay for it. The production manager's target, then, must be to eliminate or at least reduce such blind cost and reach a lean production.

The Seven Blind Costs
• large material stock
• overproduction
• inefficient production process
• production errors
• waiting time
• unnecessary transport
• motion

TABLE 1: Common cost factors with no added value to the product.

The material stock in electronics assembly may be compared to water in a lake (Figure 1). Water flows into the lake like raw material, and a river of finished products leaves the lake. If the lake is large enough, then production seems to work perfectly and the production manager is proud of the very short delivery times and full employment. However, the high water level covers two things: 1) the stones of logistical problems that could obstruct navigation and 2) holes where water disappears.

Overproduction Reduces Liquidity

A large material pile increases stock, administration and capital cost, which is the number-one waste factor. Therefore, reduction of stock is a tool to save costs. Practically, stock reduction means having fewer components, printed circuit boards (PCBs) and consumables on stock; less work in progress; and a smaller stock of finished goods. For our lake analogy, this concept means to lift the lake's ground to minimize the amount of water in the lake. As a result, logistical problems become visible like rocks obstructing the flow.

Waste factor number two in electronics assembly is overproduction. Very often, you may hear: "If the line is set up now for this

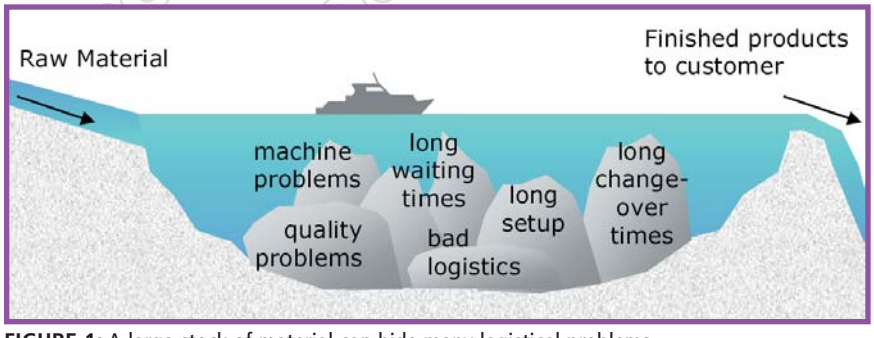

FIGURE 1: A large stock of material can hide many logistical problems.

specific PCB, producing the demand for a long period is easier than changing over the machine each time." This argument is understandable from the view of the person who does the changeover work, especially if the machines are difficult and time consuming to set up. However, additional machine time, work force and material are wasted to produce something that is not required at the moment. The customer orders an amount of products, and nobody can guarantee that he/she will order the same product again. The best case scenario will allow you to bill a couple of months later; in the worst case, though, you will throw overproduction in a bin or will have to rework it because the product functionality has changed.

If the market is growing, overproduction is generally not noticed, but, as soon as the economy is in a downturn, a company may drown in the finished goods in stock that nobody wants. The target must be to produce only what is ordered and can be billed now.

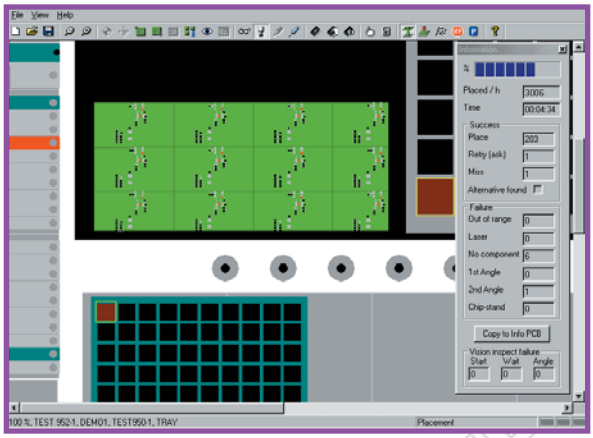

FIGURE 2: A fully graphical operating system makes automatic pick and place flexible.

Redundancy Reduces Waiting Times

From an operator's view, the above arguments may be difficult to understand. From this person's vantage point, the production cost will be reduced if he/she can produce double the quantity at once. Very often, this argument is true because outdated processes and technologies are used, which lead to high cost and changeover times—waste factor number three!

Modern machines are trimmed for simple operation and quick changeover (Figure 2). An ideal automatic pick-and-place machine could be prepared completely offline and could be switched from one product to another with no downtime. Programming should be simple if computer-automated design (CAD) data can be imported directly and presented graphically. The use of modern technologies and planning tools can make a major difference in your production organization and would allow you to produce just in time (Figure 3). A management information system (MIS) will enable

planning, steering and controlling of highly flexible production lines.

Production errors are obviously a waste—cost factor number four. Errors have the very unpleasant quality of producing further cost and delaying profitable production. Many possible errors can occur in both the consumables and the process; only a continuous analysis and elimination of the error cause will help. For error prevention, use the correct production tools and continually educate your staff concerning machines, processes and preventive maintenance. If a machine is not working correctly, you have two options: It can either be tinkered with 30 times or repaired once by a specialist. Only the second choice will reduce production cost.

Waiting times are waste factor number five, and they consist of three groups: waiting time of the operator, the material and the machine. What is the point of an operator watching a running, fully automatic pick-and-place machine—to be ready if anything happens? Watching a machine producing is very interesting; however, an automatic system should work independently, with means to alarm the operator.

Waiting times of material and machines are caused by a large material stock, overproduction, bad production planning and capacity problems. With only one high-speed production line, producing many different products may incur bottlenecks. The better production concept consists of many redundant production cells that can be used flexibly for different products (Figure 4). Such a production concept also increases the security of the whole company: If one of two identical modules fails, you will still produce 50% and will be able to bill what has been produced. If you only have one line, your output would be zero—no billing, no income and unhappy customers.

Transport is a waste of power—waste factor number six—and can be minimized with an optimized production layout. Analyze what is required for the production and decide where machines, tools, components and consumables should be stored. Good software tools are available to optimize the flow in a factory and minimize transport.

FIGURE 3: Reduce changeover time using modern technology and planning tools.

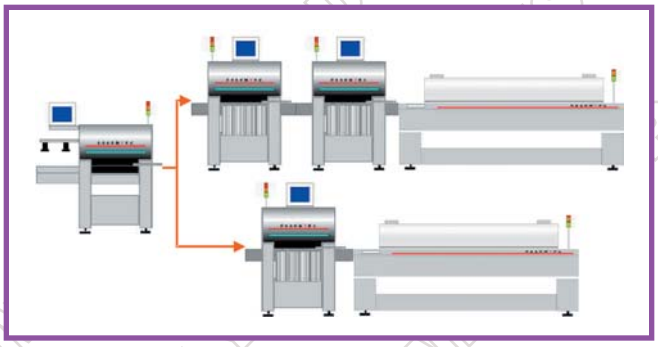

FIGURE 4: A redundant assembly layout is more flexible.

Motion—waste factor number seven—is not the same as work. The customer does not care how many miles the staff runs to produce the goods. Optimization potential exists in information management and production planning, and many changeover jobs could be saved with an intelligent production planning system. Software tools are available not only for large, high-speed productions but also for small, flexible lines where their advantage is even more important.

Reduce Changeover Times

The seven described waste factors could be minimized or even eliminated (Table 2). Some improvements can be achieved by organizational changes; some will require investment. The reward for the effort is lean production—a slim, flexible production with high efficiency.

Back to our analogy, many of the rocks and holes in the lake are due to missing flexibility in ourselves and our equipment. Flexibility requires the following actions:

- simplify setup and changeover
- change from serial to parallel tasks (changeover while running production, offline setup)
- save process parameters in programs instead of setting up the process each time
- use modern technologies such as intelligent feeders and barcodes.

In North America, the trend is high-mix, high-tech, low-volume production. To be competitive, production managers must have a lean organization with increased flexibility. Minimize blind cost by optimizing logistics and taking advantage of the latest production techniques. ■

The Seven Improvements
• reduce changeover times
• produce only what is ordered
• reduce your material stock
• use modern technologies and processes
• reduce waiting times
• improve the skills of your staff
• optimize the production layout

TABLE 2: Turn your assembly into a lean production.

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